Bird Station Manual

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BIRD STATION MANUAL

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BIRD STATION MANUAL

FOREWORD

The first bird station I saw in my life was the Bradwell Bird Observatory, Great Britain. I visited it invited by Bob Spencer (who He was I do not need to explain even to younger ringers) in autumn 1959. Two days of the bird catching and 173 birds caught. For young ringer who has never ringed one full-grown bird, but pulli only, that experience was great.

In 1960 first Polish bird station started pioneering bird catching – a group of students from the University of Warsaw started to learn bird migration at the Polish Baltic coast. Our minds were fresh, we knew nothing about bird migration but we were enthusiastic – after successful catching in 1960 (one thousand of ringed birds), we started a project of setting up several bird ringing stations along the Polish Baltic coast, called later the „Operation Baltic". Because the bird migration is a huge and very complicated phenomenon, thus the main idea was „*a NETWORK working according to the standard methods*". Since that time the Operation Baltic has been working for 40 years and a number of birds ringed within the project exceeded well 1 200 000. Most of them were not only ringed but measured, fat scored and weighed. Other data were collected as well. Large number of birds forced development of working routine in such a manner that we are able to cope with huge rushes of birds and safely handle them during collecting a lot of data. These data are the main objective of the fieldwork – bird ringing must make science and not only fun.

Visiting many bird stations, from Britain and Italy to Russia and from Finland and Sweden to Israel, I found that the main problem of international co-operation is incompatibility of methods and local routines of work, which make exchange and efficient use of data files very difficult. And once more the idea of „*a NETWORK working according to the standard methods*" seems to be a proper solution. Such trials were made within „*ESF European-African Songbird Migration Network*" working three years on the SW bird migration flyway in the mid 90ties and, finally, *Manual of Field Methods* was published. In 1996 a group of ornithologists from northern and central Europe established the SEEN („*SE European Bird Migration Network*") that focuses on the SE flyway that has been poorly studied yet. Necessity of common methodical programme induced preparation of comprehensive manual that could give not only methods of the fieldwork, but also some methods of evaluation of collected material.

I am deeply grateful to all people who contributed to this manual and discussed its contents. I would be very happy to hear from the Readers what was useful for you and what should be added or changed in a future development of the *Bird Station Manual*.

I hope that the *Manual* will be useful not only for bird stations but for many ringers who ring the birds not only for fun, but whose ambition is to contribute to Science as well. Obviously, not all parts of the manual will be applicable in an individual ringing, but always it is worth to think a while when we encounter new, sometimes apparently strange ideas – especially when we plan to start a new project.

Przemysław Busse

The Author as seen (many years ago…) by his Colleague J. Weiner:
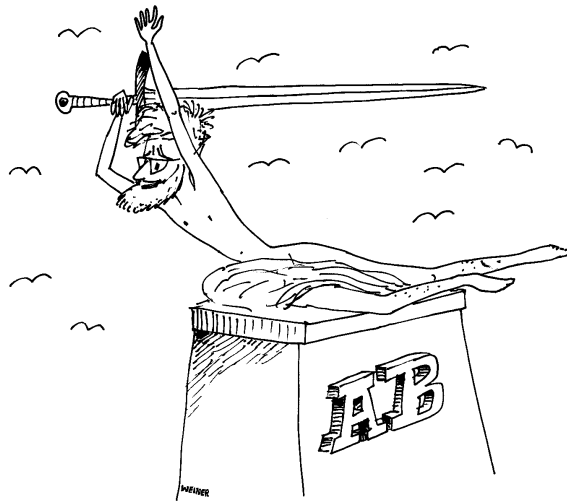
„AB" is Polish abbreviation of the Operation Baltic (Akcja Bałtycka)

PART I
FIELD DATA COLLECTING

Motto:
„In God we trust… everyone else must bring data"
– from Evan Cooch's mail

INTRODUCTION

Collaboration between the bird stations within a research network requires both standardization and flexibility. The aim must be to standardize elements of the station routine, where results will be directly compared during further evaluation of data, such as: technique for measurements, orientation experiments or monitoring. On the other hand, flexibility should allow collection of standard data as well as different specific studies performed within own projects and local agreements with various partners. One of the most important tasks when setting up the station routine is to organize the work in such a manner, that an optimum output of results will be obtained with a minimum effort. Optimum results here mean not only a maximum number of birds caught, but also collection of useful scientific data with the sources at hand. Depending on local conditions, catching devices and size of the station staff, optimisation of the station routine will need more or less attention; at any rate it will make the work easier, more effective and satisfying. So, let us try to establish the station routine in a way that is favourable to both birds and ringers!

Some working methods are used by all people catching and ringing birds, others turn out to be more habitat or bird group specific. In this book methods will be presented for catching passerines with mist-nets in land and wetland habitats, furthermore how to work with Heligoland traps, finally how to catch waders and, to a limited extent, raptors/owls with nets and traps. At times the methods described allow catching birds from other groups, but these possibilities will not be taken into consideration. According to the main focus of a station, two main types of establishments may be discerned: „passerine" and „wader" stations. Most of the chapters will contain information more or less common to both types. Special features of the wader station are presented in a separate chapter.

THE PASSERINE STATION

METHODS OF FIELDWORK

Catching methods

The point of departure for the standard of all station work is the agreed-upon number and the quality of the catching devices. In most cases mist-nets are used and their number and construction determine the possibility to stabilize the catching effort both on a seasonal as well as a long-term scale. If a Heligoland trap is in use, the only standardization problem is the operation time of the trap, which will be influenced by wind force. In modern migration research the dynamics of seasonal bird migration is the base for any interpretation of other data. So, stable operating time of traps or a standardized number of nets used during the season are an essential methodical requirement. The number of nets in use must be fixed to a level, where all birds caught can be safely handled.

According to the aims of work at a station, the catching methods must fulfil some requirements:

Aim of the study	Number of nets
1. Monitoring	stable within a season stable between years
2. Seasonal dynamics	stable within a season
3. Biometrics	recommended stable within a season
4. Special studies	recommended stable within a season
5. Ringing only	allowed variable number*

* but see p. 12 (point 5)

These requirements can be listed more in detail:

1. Collecting of monitoring data

In this case the highest level of standardisation is necessary.

1.1. The work must be planned for a sequence of years.

1.2. Time and period of work is standardized; within the season, work should be carried out continuously or, at least be made as regular and frequent sampling (this compromise, however, is not recommended!).

1.3. Equal number and equal quality of nets should be used from year to year, and where new nets are added, birds caught in the added nets should be treated separately. It must be stressed, however, that any changes affect comparability.

1.3.1. The number of nets should be stable within a season (minor changes may be compensated for when data are evaluated); the nets damaged or stolen should be replaced as soon as possible; good hint: have a few nets at hand for replacing purposes,

1.3.2. The daily netting routine should be stable; it is advised to catch continuously without closing the nets for night – in many places catching peaks do not occur regularly at the same time of the day; e.g. thrushes that have landed after a sea-crossing start to be active in the middle of the day, instead of early in the morning as usual; if possible, do not close nets during migration peaks (unless survival of birds caught is endangered – important! – but also see Working routine hints). At some sites, because of special constraints (e.g. high temperatures and insolation in lower latitudes, known and very stable daily catching pattern, living conditions of the staff) nets may be closed for part of the day. It is advisable to do this regularly at the same time (do not prolong catching because e.g. „there is a lot of birds today", or in order to finish work earlier as it seems a „poor day").

1.4. Changes of environment must be taken into consideration; three ways of minimizing the influence from such changes can be listed – (1) arranging the catching area within relatively stable environment (such habitats are, however, usually not very rich in bird species), (2) controlling growth of trees and bushes (note, however, that the surrounding area will be changing all the time), (3) actively shifting the catching plot within a bigger area of similar value (value to birds!). A combination of these methods could be applied according to knowledge of local conditions,

1.5. The nets should be located in different habitats and the distribution of nets relative to habitat ought to be stable over years.

2. Seasonal dynamics of migration

This is one of the most important types of data in any context.

The contents of points 1.2 - 1.3 (above) should be attended to, but any sampling error may affect the picture of seasonal dynamics very much (remember that during one missing day up to 20 percent of the annual catch of one species could be missed!).

3. Bird measurements

Catch as many birds as you are able to measure, but note: bird measurements without possibility to localise measured birds within migration waves have very limited value! So, adjust number of permanently opened nets to the expected high level of catching (but not to the single peaks).

4. Orientation experiments, blood sampling, parasite sampling etc.

Catch as many birds as you are able to handle with these techniques, but remember note under the point 3.

5. Ringing only

Catch as many birds as you are able to ring (with sex/age determination!); erect as many nets as you are able to handle without bird losses; eventually use tape-luring; however, remember – and once more remember – that station work is not a ringing championship, but means the collecting of scientific data. Today ringing of migrants is closely connected with collection of other types of data; seasonal dynamics must be

known when ringing recoveries are evaluated in the modern way; so, reduce your order for nets (unless you will store them as a reserve for replacements) and try to fulfil point 2 in the requirements.

Visual observations

Visual observations are frequently performed at the ringing stations. They are focused on different groups of species according to the main field of interest of the station staff. Bird counts may be performed in two different ways – (1) by counting birds in active migration flight and (2) by counting those resting within the station area. The first method is used mainly at the „passerine" stations (usually not only passerines are counted there, but other diurnal migrants as well) while the second one is used at „wader" stations (it is not possible to follow all wader migration as they migrate mostly by night). In many localities situated at guiding lines like seacoast, spits, rivers etc. the stream of diurnal migrants follows a well-defined course and this may fluctuate within very narrow limits. At other sites diurnal migration will show „broad-front" character and migrating birds will be dispersed over the whole area. In the first case the migration count will be more effective, as the birds are observed even if actual migration is not intensive. On the other hand, the count could be difficult during a mass passage when there are tens of thousand of migrants per day. Out of concentrated streams of migration visual observations could be boring as a low number of migrants are observed, but even in such cases one could collect interesting data.

Visual observation of the passage should be made from a fixed stand located at the local stream of migration, if there is one within the station area. In order to get good estimation of the total number of birds passing the observation point, all day observations should be applied, especially in localities where the intensity of the passage varies much during the course of a day – this frequently occurs at the sea coast, where some birds have crossed the sea prior to reaching the local stream of migration. Usually, when birds migrate over land, the passage is limited to a few hours after sunrise. In some coastal areas peaks of diurnal passage occur around noon or even in the afternoon. It is true, however, that observations made during the peak of passage are tiresome and boring to the observer, unless he is given a chance to rest. Because of this the observation time, during intensive passage, could be shortened.

There are some methodical variants of the migration counts used:

(1) continuous observations – from sunrise to sunset, or at least 6-8 hours. Observations are performed on a daily scale throughout the migration period; a difficult task, but the result will be the real number of birds passing by the observation point,

(2) sampling observations – observations are done on a daily scale and within a day a sampling procedure is applied (usually 15 minutes per hour) – this method allows estimates of the real number of birds passing and is not equally exhausting to the observer; the correlation of the results with the first method is at the level 0.90, which can be accepted as very good;

The recommended observation routine (Fig. I-1):

1. The observations of the passage are carried out as a 15 min. per hour sampling, starting at full hours, beginning around sunrise and continued till sunset. When there is no observable migration in two consecutive 15 min. observations, the next observation is shortened to 5 min; return to the normal routine must be applied when the observer notices intensification of the passage of at least one species. If it is evident after a few years of observation, that the particular locality has no noon and afternoon movements, visual observations could be limited to really effective time.

2. At places where intensive bird migration occurs birds are identified, by look and voices, and counted within a flexible range – for small birds the range should allow identification and count by means of the naked eye, without use of binoculars (when many birds pass there is no time to control all birds by binoculars); in larger birds (e.g. raptors when included) the range is limited to a sector within which it is possible to see the bird with the naked eye, but where identification is made with the use of binoculars. It is advisable to fix the observation point at such a place, that most of the birds migrating within the local stream pass the observer to the north and west (they are visible in a better light). As the local stream may shift a little with wind direction and force it is advisable to shift the observation stand within 100 m relative to the standard point, adjusting the actual place to better visibility (the birds passing between the observer and the sun will hardly be identifiable).

3. The birds are noted in a note-book listing their species name (by code – in observations 5 – letter code is more convenient than the 6-letter one), direction of flight (by wind-rose, 8 directions) and number; birds flying in the most commonly observed direction of the passage (standard direction must be specified at the beginning of the note-book) can be noted as numbers without the direction letters (e.g. **CASPI 40, 10, 50...**) – all others must be accompanied by the letters describing direction (e.g. **SE 30, N 25...**), but when non-standard direction is repeated a bracket could be used (e.g. **SE [30, 20, 5],**
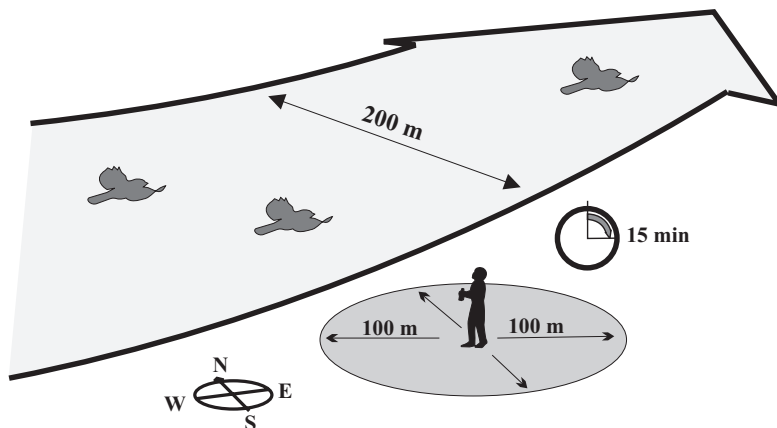
Fig. I-1. Visual observations' routine (Explanations see text)

E 15...). In the standard visual observations, when only total number of individuals per species is needed, the subsequent numbers do not describe the size of the flocks passing the observation post, but may be accumulated values for a couple of flocks pooled together (e.g. **CASPI 50** does not necessarily mean „a flock of 50 Siskins", but could mean „four Siskin flocks: 10, 30, 5, 5, altogether 50"). In this way notation will be quicker – important when a lot of birds migrate; when flock size is wanted it should be clearly stated in the local instruction.

A basic rule of noting is that the same individual makes both observations and notations – there is standardised missing of the birds which pass the point when the observer is noting the data; if other rule is adopted, e.g. noting by dictation to a tape-recorder or noting by another person, it must be applied to all observations performed, because of compatibility reasons.

Visual observation of the resting birds is usually performed at the „wader" stations.

FIELD EQUIPMENT

Mist-nets

There are different types of mist-nets in use but generally they are as shown at Figure I-2. The main parameters describing them are:

1. Thread used. Contemporary nets are made from nylon, terylene or some other similar synthetic thread. The material and finishing treatment determine softness or hardness of netting and its UV resistance (UV rays destroy the netting material and cause total damage to the net, the most UV sensitive are nylon nets). Some of the nets are very hard and may cut the bird's skin when it becomes heavily entangled. The potential danger of the net to birds should be treated as one of the most important characters when net
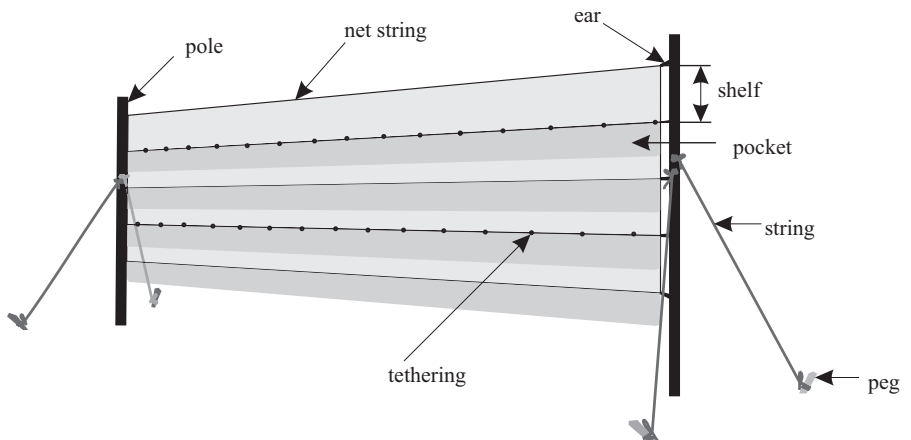
Fig I-2. Mist-net. Basic terms.

types are chosen. This feature is strictly connected with the thickness of the thread, which is characterized by the „denier” measure (weight in grams of 9000 meter thread) and the „ply” (the number of threads twined), e.g. 50d/2, 70d/2, 135d/2, 235d/2 etc. Thinner thread means lower visibility, higher catching ability, higher degree of entangling of birds (they are difficult to remove – the time spend on removing will be longer), much higher probability of skin and feather damage to birds, in addition there will be more holes made by twigs, thorns or heavy birds caught, lower UV resistance, high laboriousness of the net cleaning. Thicker thread in turn means lower catching ability of the net. However, birds are not entangled and are easier to remove (saving time!). With such a net new-beginners are less likely to injure the bird. Cleaning the thicker net is much simpler and the procedure is safe for the net. Nets of this kind also have high durability because there will be fewer holes caused by entangling of bushes and the catch of heavy birds, in addition the netting has much higher UV-resistance.

Thin nets are recommended only when the catching area is very open and the aim is to be very efficient in catching particular bird species living in such an environment (e.g. swallows, stonechats, wagtails etc.), furthermore when there is not too many birds to catch and when the staff consists of well trained ringers, and the station routine includes only few studies. On the other hand use of thin nets is not advisable when catching is done in areas where mass migration could be expected. Thin nets are much more expensive as well, especially when one takes under consideration high turnover rate of such nets.

Thick nets are recommended when the catching area includes more dense vegetation, high number of birds could be expected during peak days, untrained helpers remove birds and the station routine includes detailed examination of birds. Effective netting with thicker nets necessitates the use of more nets, which in turn means bigger effort to erect them, but much lower turnover rate of the nets makes the mist netting cheaper.

2. Mesh size. This parameter is given in two different ways: „knot to knot” and „stretched”. E.g. 16 mm knot-to-knot size is equal to 32 mm stretched (Fig. I-3). The mesh sizes used are very differentiated, depending on the species for which the effective use of the net is intended. For small passerines the mesh size most in use is 16 or 17 mm (we will use here „knot to knot” measures). It is small enough even for mass catching of

„knot to knot”   „stretched”
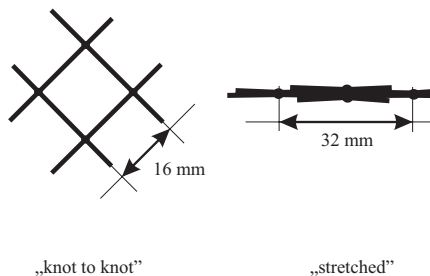
Fig. I-3. Mesh size description methods.

Goldcrests. Smaller sizes (14-15 mm) have lower catching ability. Sixteen millimetres mesh net has lower catching ability when bigger birds are involved (the size of thrushes or larger). In contrast, many small birds (as Goldcrest, leaf warblers, Reed Warbler etc.) easily pass through 18 mm mesh. Small birds will usually get much more entangled when caught in such a net. A special problem with 18 mm mesh size arises when large amounts of Starlings get caught – the 18 mm mesh just fits to the bend of the Starling wing and its first primary works as a fish-hook, so removing the wing frequently causes injury to the bird. Thrushes accidentally caught into raptor nets (mesh sizes 45-80 mm) may get very entangled.

3. Number of shelves. As a standard nets usually have four shelves. Previously the standard was three shelves and some traditionalists still use this type. Some 5-shelf nets are in use, as well as special nets with less (1-2; „pipit nets") or more shelves. The number of shelves should be considered in connection with the height of each shelf. The most efficient shelf height is app. 50 cm. Broader shelves, paradoxically, do not have higher catching ability, since the upper part of the shelf works as a dead area, from which the bird is deflected. Only a fraction of such birds will return once more to the net and get caught in another shelf. So, the optimal number of shelves may be fixed as four, giving maximum catching ability as well as easy and quick removal of birds from the net. Specially evolved many-shelf nets need to be pulled down when a bird is caught in the uppermost shelves, so they are not recommended as standard equipment at the station, especially when higher numbers of birds are expected to be caught. Such nets also make monitoring comparisons complicated (birds from them should be noted separately). In addition, one- or two-shelf special nets sometimes used for catching birds at meadows and marshes are not recommended as a supplement to the standard set of nets used for monitoring purposes. Four one-shelf nets are not equal in efficiency to one 4-shelf net of the same length.

4. Net dimensions. The height of the net depends on the number of shelves and their height – this was discussed above. The length of nets in use is very much differentiated. Most commonly used are nets of 6-7-9-12-14-18 m lengths, at times even longer. Shorter nets fit better to special locations like the front of small bushes, across ditches etc. They also may be used in order to create long rows of nets of complicated curvature adjusted to paths of vegetation. Long, straight rows made of longer nets are more economical, considering the number of poles needed to erect them. However, longer nets are more sensitive to wet and windy weather. Wet nets become longer and heavier and frequently even touch the ground. They will easily pick up surrounding vegetation when there is a wind. The catching value of one, say 14 m long net is not exactly equal to that of two 7 m long, but as an approximation they may be calculated as equivalents. It is advisable to use only two lengths of nets – short net (6-7 or 9 m) and a doubled one (12-14 or 18 m resp.). Recalculations of the catching results, e.g. per 100 m of nets, when more types of nets is used, are even less precise.

5. Tethering (wind blockades). Tethering means that the netting is fixed to the horizontal net strings with an additional thread in order to prevent the netting from slipping

along the string while there is a wind parallel to the net. Good tethering is important when many birds of average size (e.g. tits, Chaffinches) are caught simultaneously: it prevents birds from clumping together in one corner, thus impeding the catching ability of the rest of the net. One-line tethering is definitely not enough for effective wind protection – it is really close to nothing. For a short 4-shelf net optimal tethering should be double, at the second and fourth string. A tethering of this kind is symmetrical and there is no need to take a blocked string on top of the net when it is erected (as it is when there is one tethering only). Triple tethering is advisable for long nets and special ones for raptors or thrushes.

To erect single net, two poles put up vertically and four strings are necessary (Fig. I-2). The net ears are put on the pole (in proper order!) in such a way that vertical string is stretched. Poles should be as smooth as possible to simplify erecting and to avoid entangling the netting. Metal or bamboo poles are the best but they are more likely to be stolen than wooden poles. Erecting two or more nets in a row is a little bit more complicated as the nets' ears must be put on the common pole one by one from each neighbouring net. The strings at every end of the single net or nets' row must be stretched at angle that protects the nets from falling down when wind changes direction (Fig. I-4). Distal end of the string should be fixed to the ground by a strong peg or to twigs of bushes and trees. Knots made on the pole should be easy to untie allowing stretching of the net when it becomes longer after some time. Very convenient are two-tailed pre-prepared strings shown at Figure I-5.
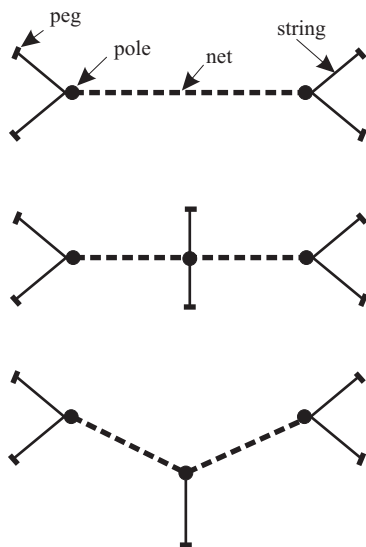
Fig. I-4. Setting up the nets: single net and two (or more) net in a line.
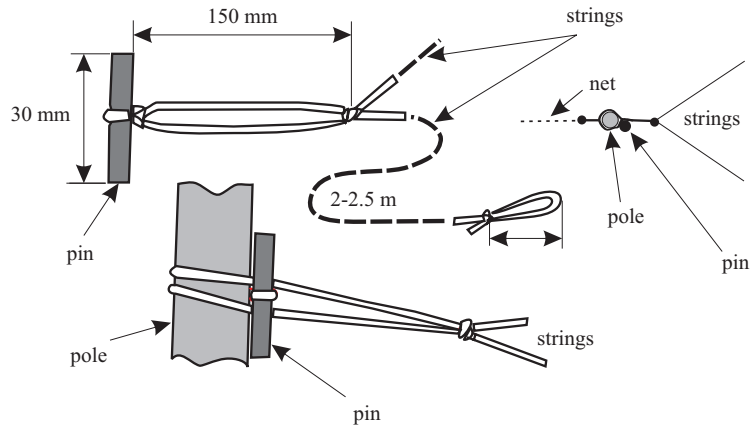
Fig. I-5. Pre-prepared string with a pin to fix the net.

Heligoland traps

The second important catching device is the Heligoland trap. Originally it was constructed on the German island Heligoland. The general layout of the trap is a funnel made of net ending with a box or a collecting room from where caught birds are removed. Constructions are permanent or temporary and their size varies to a large extent. Original traps made on Heligoland are small (around 3 m high) while the biggest Rybatchy-type ones reach heights of 20 m. Dependent on the place where the trap is situated and bird behaviour, there are two types of Heligoland traps in use. One, the so-called "active" trap, is usually a small device situated where diurnal migration does not occur. In that case, the ringer must be active and flush birds feeding or resting in the bushes into the trap. The bushes in front of such a Heligoland trap should be attractive to resting birds and offer good feeding possibilities (e.g. berries; elder, rowan etc.). A pool with drinking water is frequently placed at front of the trap as an additional attraction. In order to prevent flushed birds to turn around and escape by way of the entrance, this type of trap is usually constructed in semi-crescent form. The bulk of the birds caught in such a trap will be nocturnal migrants, so this type will serve as a substitute to nets, which are the best catching devices for nocturnal migrants. The second type, the „passive" trap, is located at sites where strong diurnal migration occurs. Birds migrating at low altitudes will enter the trap on their own and without any flushing tend to move to the ending room. The role of the ringer is limited to removing them from the trap. „Passive" traps are constructed as straight funnels since the birds seldom reverse their direction of movement. Heligoland traps of this kind are very efficient for catching some species also easily caught with mist-nets (e.g. Goldcrests, tits) as well as others less frequently caught in nets in big numbers (e.g. Chaffinch, Siskin). Heligoland traps are expensive and vulnerable to strong winds, but in some places they are the best catching device for permanent work. Big Heligoland traps work as basic catching device in coastal regions of Russia, Estonia, Latvia and Lithuania, in the interior of Ukraine and in Kazakhstan on

mountain passes. A particular design of Heligoland trap, a so called „zig-zag trap" is used at the Ventes Ragas station in Lithuania. Movable big traps were used at the Operation Baltic stations as a supplement to nets. A few technical details concerning the construction of big Heligoland traps are given below.

The Rybatchy-type trap

The Rybatchy-type trap is named after the village Rybatchy on the Courland Spit in the SE corner of the Baltic (formerly Rossitten on the Kurische Nehrung, now in the Kaliningrad region, Russia). The trap was designed and has been used from 1957 at the Biological Station Rybatchy of the Zoological Institute, Russian Academy of Sciences. The idea and the construction were due to Jan Jakshis, while Lev Belopolsky and Veino Erik took an active part in the realization of the project. The Rybatchy-type trap was widely distributed on the territory of former USSR in studies of bird migration by means of trapping and consecutive visual inspection of live birds caught.

Between 1957 and 1995 a total of nearly two million birds of 179 species were caught and ringed by the staff of the Biological Station Rybatchy, mainly at a permanent field station „Fringilla", 12 km south of Rybatchy. Up to 1996 these birds have rendered approximately 7 000 recoveries on the migration routes and winter quarters, and 20 000 recaptures at the place of ringing.

The Rybatchy-type of trap does not only catch passerines, but also owls, diurnal raptors, woodpeckers, cuckoos etc. Top trapping in one day at the Courland Spit was about nine thousand birds in three traps. Thirteen thousand birds were caught in Kazakhstan in one day.

A preliminary sketch of the Rybatchy-type trap can be found in Belopolsky *et al.*, 1959. The trap is described more in detail in Russian publications only (Erik 1967, Dolnik and Payevsky 1976). Although the Rybatchy-type trap evolved from the Heligoland trap, it differs fundamentally from the latter by three distinguishing features:
1. very large size with the operating height at the level of bird migratory flight (when the birds fly at a low altitude above the ground),
2. absence of solid rigid frame and the hoisting of the trap by use of a steel wires, resulting in a possibility to lower the trap before an approaching storm in order to protect the netting,
3. no food or water to attract the birds, resulting in a possibility to establish the trap in any area with intensive migration of birds, even in a desert.

So, the Rybatchy-type trap is basically a huge funnel made from thread net fixed to the ground and opened towards the stream of migrating birds. In most cases the birds themselves (without particular flushing) reach the terminal part of the trap, the so-called „collecting box", which they cannot leave.

Construction of the trap

Carcass (frame). The basis for the trap is the carcass made up of four pairs of pillars (poles) (Fig. I-6). These pillars are fixed in position by the steel wires. The overall length of the carcass construction is from 60 to 80 m. The front (first) pillars may range in
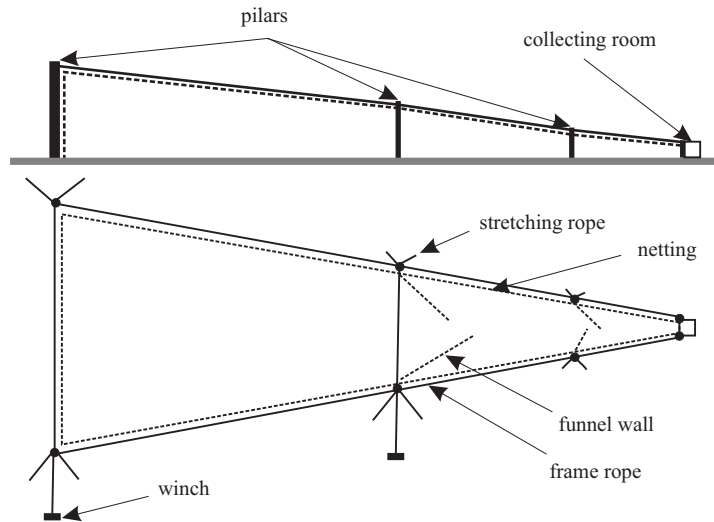
Fig. I-6. Rybatchy trap – side and top views.

height from 12 to 15 m, while the heights of consecutive pillars are 7, 4 and 2 m. The distance between the pillars of the first pair (the width of a gateway) is 30 m. The distance between the pillars of following pairs are 15, 7 and 2 m accordingly. The distance between first and second pair of the pillars is 30-40 m, between the second and third pair – 15-20 m, between third and fourth pair – 10-15 m. At the gateway guiding walls may be used. An additional pair of pillars is necessary for these additional walls.

All the pillars must be fixed not only by the upper carcass wire, but also by two stretching steel wires. One end of the wire should be fixed to the top of the pillar and the other one to the ground. Tension may be obtained from screw coupling. Wire diameters 8-10 mm will be convenient in service. The pillars may be wooden as well as different material (e.g. reinforced concrete, open-work metallic construction, metallic pipes etc.) The wood pillars, especially with concrete "feet", have some advantages over other materials: they can be mounted vertically without a crane, for example with the help of winches. However, the wood pillars are short-lived (if not impregnated enough) and must be substituted after five years of service.

The netting. The whole thread net trap should be made as one unit (walls and ceiling), separate from the carcass. The size of the netting should be smaller by 1-1.5 m than the size of carcass. Different types of netting may be used: cotton as well as synthetic thread. The cotton nets are more durable. UV rays could destroy the synthetic thread within a few months. However, netting made of synthetic thread may be more useful when it is necessary to reduce the weight of the trap and counteract a detrimental effect of strong wind in open country.

Different mesh sizes are used in different parts of the trap. For the ceiling in the front of the trap 30-40 mm (knot to knot) mesh net is used. Narrow stripes of 16 mm net are used on both sides of the ceiling. Walls of the front part and the whole middle part (from

the second to the third pillar) are made of 12-16 mm mesh net. The rest of the trap is made of 8 mm mesh netting. The durability of the trap will be prolonged if 5 mm cords attached to the net at 5-6 m intervals along the length and crosswise reinforce subsequent segments.

Inside the trap it is necessary to make two pairs of so-called „false walls". The false walls are made from the same type of net as the main walls. Their purpose is to keep birds from changing direction of flight. After passing the first false walls it is more difficult for birds to turn around than to continue to the terminal part of the trap.

Devices for hoisting and closing the trap. Metallic rings of diameter 30-40 mm made from wire of diameter no less than 4 mm should be attached to the cross cord, which is located at the level of the second pair of pillars. The steel wires (of diameter 8-10 mm) hoisting the trap pass through these rings and then go on to the winches. It is possible to hoist the trap by two cross ropes and two winches only. Different winches may be used. At the Biological Station Rybatchy the big stationary winches with carrying capacity 1.5 ton have been in use since 30 years. It is also possible to use little winches fixed on those pillars that also the ropes are attached to.

The trap should be installed and erected in the following way. The netting piece is placed on the ground inside of the carcass construction. The first rope is fixed to the top of one of the first pair of pillars. Then it passes through the rings on the trap and through the small block fixed on the carcass rope near the top of other pillar of the first pair and then it is directed toward the winch. The same sequence is repeated on the second pair of pillars. The ropes should be stretched as far as they will allow. The special marks on the stretched wires should be made at a distance of 0.5 m from the top of pillars. Then it is necessary to release the ropes a whole turn and the trap should be fixed to the ropes at these marks. After that the ropes once again should be stretched as far as they will allow, and the trap at last will come in working position. To the third and fourth pairs of pillars the trap is fixed by hands. The bottom of the trap must be fixed to the ground.

The entrance part of the trap must be closed down when strong wind (more than 5° Beaufort scale) occurs. One person is able to close the trap within 15-20 minutes. Opening it again will take 30-40 min and more than one person should do that.

Variations of the terminal part of the Rybatchy-type trap. The Rybatchy-type trap can be adapted according to local conditions (localization, financial possibilities, number of persons in the staff etc.). The differences primarily concern the final part of the trap.

In its initial form the final part of the trap is arranged in the following way (Fig. I-7). The last 10-15 m of the trap is a narrowed corridor 2-3 m wide and 2 m high. The corridor ends by the sloping wood sheet, which directs the birds into the open cone. At the height of 1.5 m above the ground the cone just go out into the collecting room or collecting box. It is possible to have a system of two cones inserted one in another.

The collecting room is made in the form of a netted box with approximate size 1.8 x 1.3 x 1.3 m. The person inside the box may take birds by hand. A second room of the same size is connected to the collecting room; it prevents birds from escaping when a person is entering the collecting room. The trap may have up to three collecting rooms with permanent or movable cones (Fig. I-7).
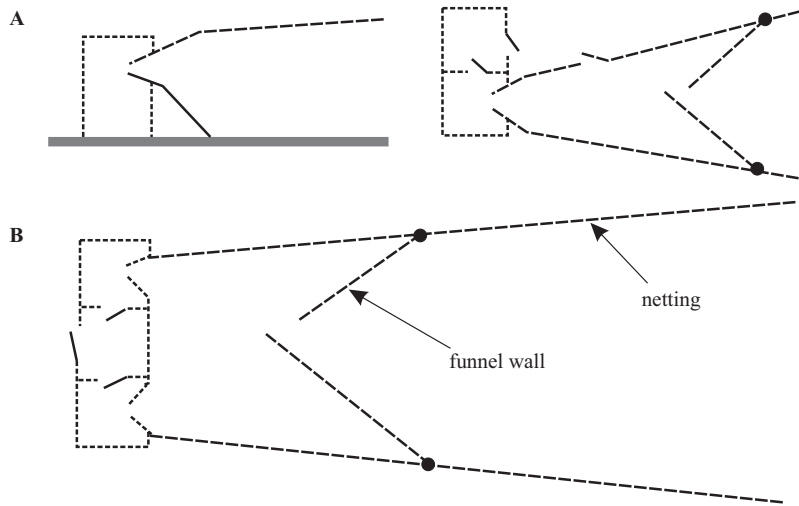
Fig. I-7. Terminal part of the Rybatchy trap. A. One collecting room (side and top views), B. Double collecting room (top view).

Collecting boxes are removable and the staff changes the box with birds against an empty one. Such boxes may be made of net or transparent plastic. They are used in different types of Heligoland traps and sometimes also in the Rybatchy-type trap. For example, at the Ladoga Ornithological Station (village Gumbaritsy at Lake Ladoga) the Rybatchy-type trap has a small removable collecting box made of a wire frame covered with netting. Such boxes are mounted on the terminal cone of the trap. In Kazakhstan, at the Chokpak ornithological station, the trap has the collecting box that is similar to one used at the Swedish ornithological station Ottenby. Birds entering the end cone of the trap fly towards the transparent window, strike upon it and slide down into the small box (Gavrilov 1968).

A collecting room has some advantages compared to the small collecting boxes. During intensive bird migration the collecting box will at times get filled with birds in an instant, and it may happen that passerines and raptors are indiscriminately mixed. The larger volume of a collecting room may save the small birds in such cases.

When the birds have been removed from the collecting room they are put into special portable boxes. These have low walls and small mesh netting top.

Maintenance of the trap

The maintenance work at the Rybatchy-type trap requires at least three people. Cases where birds are injured or killed in this trap are comparatively rare. They occur during very intensive migration when thousands of birds are trapped. The primary cause of death is overcrowding of birds in the collecting and terminal part of the trap. Ornithologists in general agree that the trapping with the Rybatchy-type trap is safe for the physical condition of the bird.

Experience shows that the trapping efficiency is affected mainly by the wind direction. Contrary and side-contrary winds of moderate force reduce the height of the birds' flight; it is under such circumstances that the majority of migrating flocks are trapped.

For successful operation of the Rybatchy-type trap it is necessary to choose the proper site for its construction. Careful observations of migrating birds under different weather conditions are very helpful, since the local habits of migrants may differ very much. For example, on the Courland Spit genera like swallows, pigeons, crows (except jays) are trapped very rarely, although migration of these birds is very intensive, whereas in Kazakhstan, at Chokpak, these birds are most numerous in the traps.

Owing to its large size the Rybatchy-type trap is not perceived as a place to be avoided by birds, and therefore no camouflage, e.g. by the special colouring of the net etc., is necessary. During summer some birds (especially Chaffinches) are not only trapped repeatedly (up to several scores of times), sometimes they even build nests inside the trap.

Zigzag trap

The zigzag trap is a new type of trap for bird catching, based on the idea of Heligoland trap; in contrast to this it allows the birds to move in two opposite directions. This is a novelty in trap design. The trap is mainly designated for catching passerine birds. However, diurnal and nocturnal raptors (mostly Sparrowhawks), Cuckoos, woodpeckers and other birds are also found in the trap very often. This trap may be used to catch birds under every possible weather condition (the only danger to the trap itself can be a cover of heavy snow). Captured birds are not entangled in nets and not injured. L. Jezerskas, the head of Ventes Ragas Ornithological Station in Lithuania, constructed the trap. Three traps of this type were built in the years 1982-1984. Jezerskas (1983, 1990) has described the construction of the zigzag trap.

A total of 162 944 birds of 128 species were caught using these three zigzag traps at Ventes Ragas Ornithological Station in five years (1985-1989). The results and catching experience have proven that this new type of trap is a very effective tool for catching birds.

Construction of the zigzag trap

In principle the zigzag trap is a system of modified Heligoland traps, connected sideways with their gateways directed in opposite directions (Fig. I-8). The size of the trap depends on the number of the sections and their size. The number of the sections is unlimited in one trap. It can be as large as the conditions of the place and the possibilities of the station allow. The size of the sections can be different in different traps, but it is recommended that one trap contains one-size sections. In the opposite end of the entrance every section has a bird collecting chamber and a basket. The chamber is shielded with a „roof". The „roof" protects the birds in the chamber from direct sunrays and rain. The top („ceiling") of each section up to the middle is horizontal, from this point it gradually ascends to the beginning of the collecting basket. Recommended dimensions of the sec-
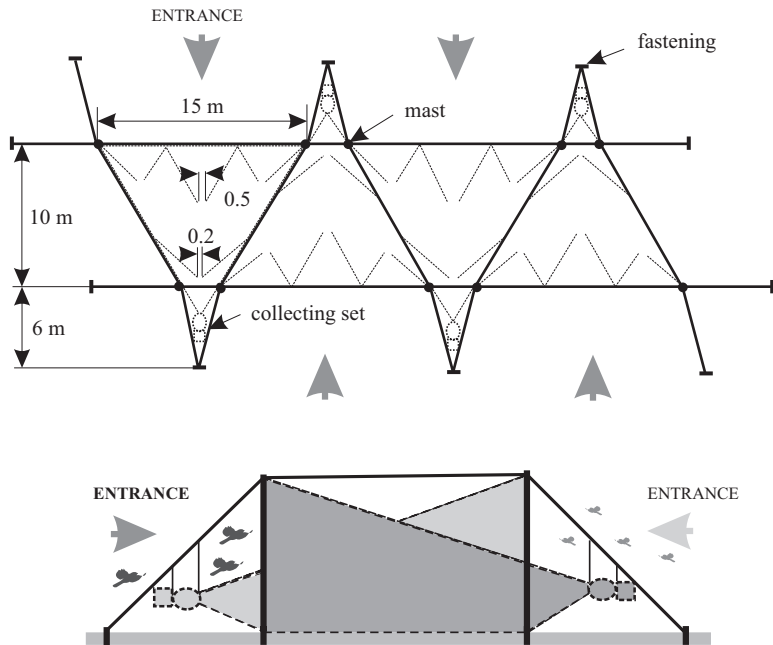
Fig. I-8. Zigzag trap – top and side views.

tions are as follows: the length (up to the beginning of the basket) – 12.5 meters, the width of the front – 15 meters and the height of the front – 6 meters.

There are three entering vertical slits, each 0.5 m of width in the front part of each section of the trap. The length of the slits is equal to the height of the trap. The first pair of „wings" forms these entering slits. There is a second pair of „wings" in the further interior part of each section of the trap. The width of slit between the second „wings" pair is 20-25 cm. The „wings" prevent birds from getting out of the trap.

Arrangement of the zigzag trap

The materials necessary for the arrangement of the two section zigzag trap (one section is not a zigzag trap yet!) are listed below. In brackets the amount of the materials necessary for each additional section is given:

– metal pivots (diameter 25-30 mm, length 0.8 m) – 8 (2);
– metal plates (thickness 15-20 mm, size 20x20 cm) – 8 (2);
– metal pipes (diameter 60-80 mm, length 6 m) – 8 (2);
– metal fastening hooks (made of pivot diameter 15-20 mm, length 0.8-1.2 m depends upon hardness of a ground) – 8 (1);
– steel rope (diameter 6-8 mm,) – around 155 (55) m;
– metal wire (diameter 6-8 mm) – around 24 (12) m;
– nylon string (diameter 6-8 mm) – around 165 (60) m;
– nylon string (diameter 4 mm) – around 165 (60 m);

– nylon net (mesh size „knot to knot" 14-16 mm) around 980 (450) m^2;
– nylon net (mesh size „knot to knot" 8 mm) around 24 (12) m^2.

Firstly the frame of the trap must be arranged. The metal pivots are beaten vertically into the ground at the points shown as dots at Figure I-8. Around 20 cm of the pivots are left above the surface (it is recommended to paint the pipes in pale colours). A hole is drilled in the centre of the metal plate. The diameter of the hole has to be around 2 mm larger than the diameter of the metal pivots beaten into the ground. These metal plates are pulled on the pivots. The masts (made of metal pipes) are put onto the ends of the pivots left over the surface of the plates. The metal plates prevent the pipes from going into the ground. In upper part of the masts (5-8 cm from the top) there holes of 8-10 mm in diameter have to be drilled. Masts are connected by the steel rope, which passes through the holes in upper parts of the pipes. The loose ends of the rope are strained and fastened to the metal fastening hooks, which are beaten into the ground. The masts fastened in this way must remain in a straight vertical position and must not move.

When the frame of the trap is ready, it is time to make a trap itself from the 14-16 mm „knot to knot" mesh nylon net. The net is cut into appropriate pieces of the necessary size, which are sewn together with a thin nylon string. The 6-8 mm nylon string is fastened (sewed) in the place where the top („ceiling") and the sides („walls") come together. The same kind of string is fastened (sewed) to the top („ceiling") front edge of the trap, on the bottom and on the front edge (which reaches the metal pipe) of the sides („walls").

The 4 mm nylon string is sewed to the edges of the first and second pairs of „wings" and at the intersection of „wings" with top („ceiling") and sides („walls"). The trap is fastened by 6-8 mm nylon strings to the metal pipes and, if necessary, to the steel ropes connecting the metal pipes. The bottom part of the first and the second pairs of „wings" and the bottom part of the sides („walls") are fastened to the ground.

There are a bird collecting basket and a chamber made at the end of each section (Fig. I-9). Their frames are made of 6-8 mm metal wire and covered with 8 mm „knot to knot" mesh nylon net. The 50 cm length „sleeves" made of the same kind of net are sewed on the side of chamber and basket. The „sleeves" are used for removing the birds from the chamber and the basket. After removing the birds the „sleeves" are tied.

The basket has a form of an egg the sharp end of which is directed towards the chamber. Its frame consists of 8 low-shaped longitudinal and the 3 circle-shaped wires connected to them: one (diameter 20 cm) at the end, another (diameter 40 cm) in the opposite end and the last one (about 60 cm in diameter) in the between. At the end where the basket joins the trap, the diameter of the circle is 40 cm. The chamber has the form of a cube the edge of which is 50 cm long. The chamber and the basket are joined together at the sharp end of the basket.

There are two downward „gullets" fastened to the each end of the basket. The diameter of the narrower end of the both „gullets" is 10 cm. The diameter of wider end of the same „gullets" corresponds with the diameters of the circle-shaped wires in the ends of
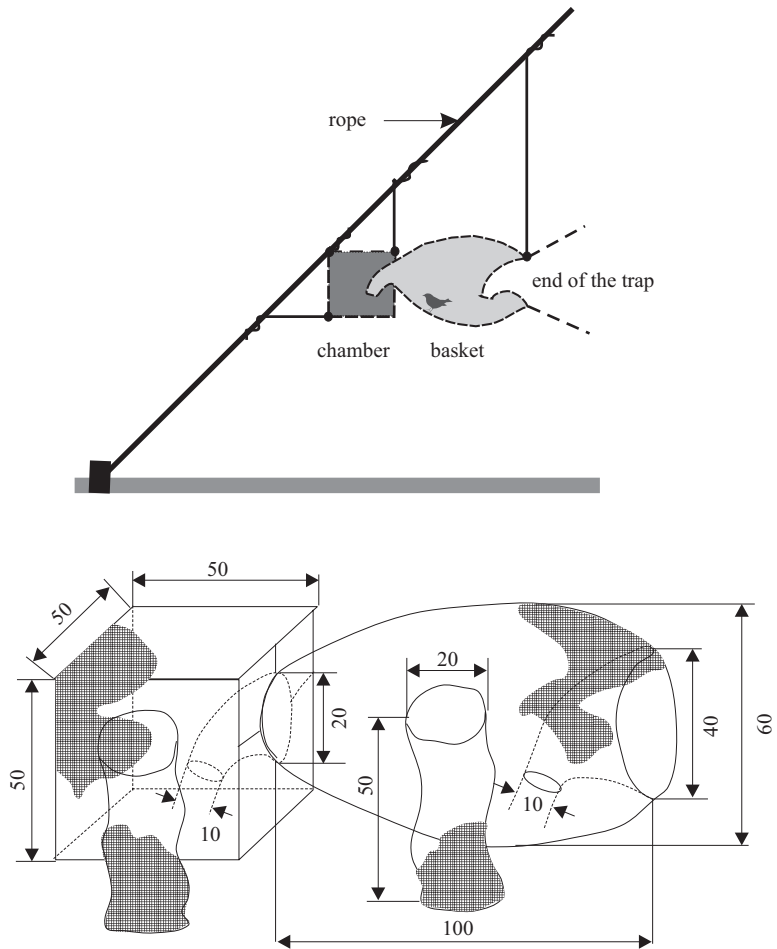
Fig. I-9. Zigzag trap – terminal part side view (upper), collecting basket and collecting chamber (measurements in centimetres).

the basket (20 and 40 cm). The bigger „gullet" is around 35 cm long and is pointed inside the basket while the smaller one is about 20 cm long and is pointed outside the basket, i.e. inside the chamber. The frames of the both "gullets" are constructed of 3-4 mm wire and covered with 8 mm mesh size nylon net.

The baskets and the chambers are hung on 6-8 mm metal wire on the steel ropes fastened to the metal hooks beaten into the ground. Chambers have roofs that are made of reeds, tarpaulin or other materials.

As the catching season comes to an end, the baskets and the chambers are removed. The trap and the frame are untied and the trap is also taken off. The trap is stored indoors till next season.

Maintenance of the zigzag trap

Usually the zigzag trap should be checked every hour. However, during intensive migration a large number of birds may get into the chamber simultaneously and the trap should be controlled more frequently. When the birds in the chambers or in the baskets are of different sizes it is recommended first to remove the bigger birds. Sometimes one can find birds entrapped between the „wings" and the sides („walls") of the trap. Such birds may easily be driven into the chamber or basket. When birds have been removed, one has to make sure that the „sleeves" are tied up again, to prevent other birds to escape from the basket or the chamber.

Advantages of the zigzag trap

In many cases it is recommendable to substitute mist-nets with zigzag trap(s). The reasons can be:

1. The process of removing birds entangled in mist-nets, especially the removal of tits (they are among the birds most commonly caught at many stations) is time-consuming, tiring and demands a lot of manpower and competence. The process of removing the birds from the zigzag trap is easy, short and uncomplicated. It can be done even by low qualified staff or by helpers.
2. In the zigzag trap, the birds are less exposed to adverse weather factors since they have ample space to move in the chamber or in the basket (there is a roof on the chamber that protects the birds from direct sun rays and rain).
3. It is almost impossible to overlook a bird in a zigzag trap.
4. It takes a lot of time to clean the mist-nets from leaves, twigs, bigger insects etc. You do not have this problem with zigzag traps.
5. Zigzag traps are efficient under all meteorological conditions.
6. Closing and re-opening of the zigzag trap is extremely easy: one only has to close or open the first „wings".

Operation Baltic transportable heligoland trap

As the Operation Baltic stations are temporary camps a special type of transportable heligoland trap was in use (Fig. I-10). The netting funnel, up to 12 m high, 20 m wide and 40 m long, was made from a nylon netting of 15 mm mesh in a front part and 12 mm mesh at the terminal part of the trap. All net-cover was divided into several segments that were stretched by crosswise nylon strings. Three short funnels made backward movement of birds less probable. The construction was hoisted on several metal tubes and fixed by ropes. Ending collecting box had different construction in following versions of the trap as the first design with a glass was dangerous to birds.

Funnel traps

Wader funnel traps are very specialized catching devices and they are presented in *Different catching techniques* in **The wader station** Chapter (p. 89). They are efficient for catching some ground-feeding passerines as well, e.g. wagtails and Starlings foraging on beaches and meadows.
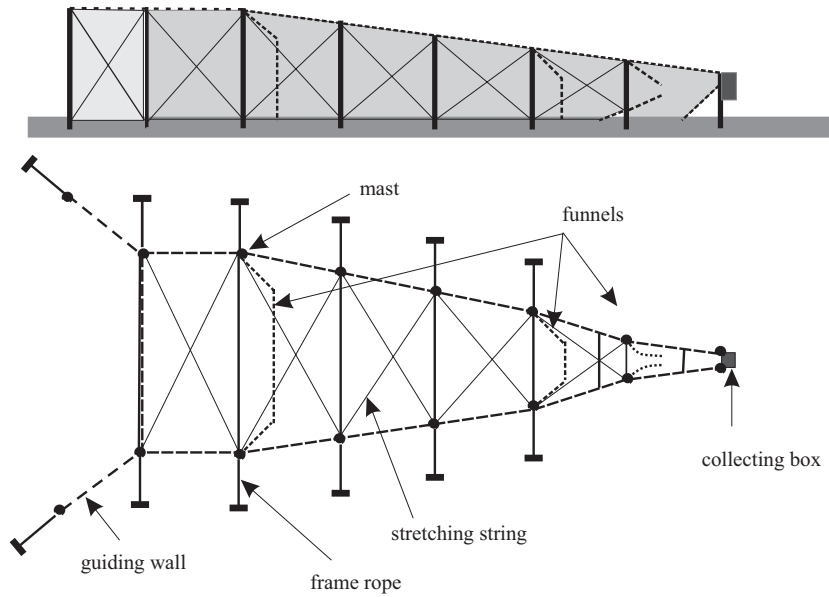
Fig. I-10. Operation Baltic transportable heligoland trap – side and top views.

Bird transport devices

The basic container for transportation of passerines to a laboratory is a linen bag closed with a soft string (Fig. I-11) that could be hung up on a special hanger at the chest of the ringer (Fig. I-12), on a binocular (very convenient solution) or, in the worst case, on a forearm, but not carried in the hand. The size of these bags may differ – a small „one bird-person" bag may be used for transporting single individuals such as rare birds or birds with foreign ring, while standard bags (approximately 20x25 cm) may be used for the majority of birds (but different number of individuals according to size – see p. 51 – Tab. I-2) and special bags for bigger birds (e.g. owls, raptors, accidental waders). Standard bags should be numerous enough (at least 100 at the station where large number of birds is expected) since they are used to transport birds from the nets and temporarily store them while they are waiting for ringing and investigation. A deficit of free bags sometimes may cause dramatic disturbances in station work during peak days; birds will suffocate in overcrowded bags. Because of this, at the laboratory, the birds should be stored (when numerous) in special storing devices like boxes or baskets, where they have more space and do not risk suffocating when wet. One type of bags in use has hard plastic bottoms. Such bottoms should be with many holes allowing excrements to drop out; in the worst case the birds will get dirty and wet – and the ringer is the cause of their impaired condition.

The most important thing when preparing bags is to use air-transparent linen. Cotton bags usually are such if they have been washed before first use (removal of chemical ap-
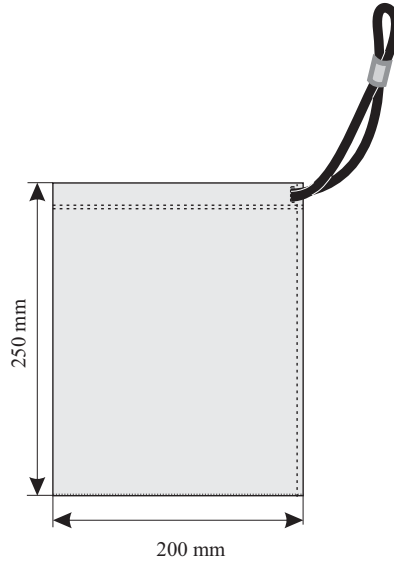
Fig. I-11. Bag for bird transportation.
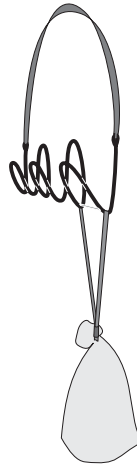
Fig. I-12. Breast hanger for bags.

ertures). A disadvantage of cotton bags is that they easily absorb water from excrement and moist birds. It takes long time for them to dry and they are more likely to be damaged by microorganisms when moist. Synthetic linens are much more excrement resistant, but they must have visible holes between threads (to be air transparent enough). Wet birds stored in synthetic bags are still wet when you remove them, but – on the other hand – wet bags could be easily dried. Bags should be regularly washed and in the meantime cleaned from droppings and feathers.

It is not advisable to use storing boxes or baskets (see below) to transport birds from the nets. There are only few exceptions when this is acceptable, e.g. when mass catches of one species occurs in a limited number of nets situated close to each other. In such a case one particular person, besides the person making regular controls, should use them, but birds should be placed in a bag first and then shifted into the box. The birds caught in Heligoland traps may be transported in the final trapping boxes if such are included in the construction of the trap.

Bird storing devices

During peak days, when a few species tend to be very numerous, it is convenient, sometimes even necessary, to use bird-storing devices where birds could wait for ringing. Such devices can be made from different boxes, baskets etc. (Fig. I-13). The most important points of construction are:

1. free access of air – at least part of the walls must be made from a small mesh netting (the meshes must be smaller than any bird head – heads must not go through!),
2. easy handling of birds: they should be easily put into and in particular easily removed from boxes at the ringing stand (boxes are used when you are in a hurry!),
3. easy to move – storing devices should be kept in a cool, dark place and then moved to the ringing stand. But note: movable does not mean „used at the nets" – this is acceptable only under special conditions – see above.
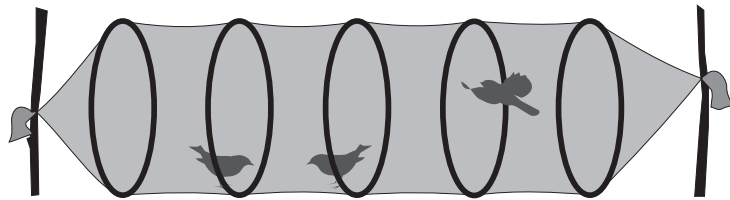
Fig. I-13. Example how to store the birds.

The holding capacity of any particular size of box or bag depends on the particular species that is going to be stored in it, this must be estimated from case to case. Each bird should be able to sit on the floor; in most species the limit is set by that area of the bottom. Some species, however, will cling to the bag walls or to the ceiling of a box (e.g. Goldcrests, tits), and the number may be increased accordingly. But watch out for indoor temperature increases when there is much stress among the birds; a bag full of „overheated" Goldcrests or Siskins (well-insulated birds!) will kill itself in no time, and losses of humidity may at any rate be harmful to birds!

It is better to have few smaller boxes than a few big ones – in one box birds from only one control, and obviously, of one species can be stored.

In exceptional cases boxes may be used for overnight storage of diurnal migrants ringed late in the evening when the weather is bad. In such case the number of birds per box should be strongly reduced (by more than 50 percent of the standard). Night migrants should be released during the night unless many owls hunt around. At roosts swallows and wagtails may be let free in total darkness when they are no longer blinded; they settle in the reeds without delay.

LABORATORY EQUIPMENT

The basic laboratory equipment should allow ringing and collection of standard measurements in an effective way and with the smallest possible effort. To some extent the working routines at the laboratory site decide the needs, and all items are not necessary at all sites.

The laboratory stand and tools presented here were carefully elaborated from an ergonomic point of view and checked during forty years of the Operation Baltic work.

Laboratory tools

The ringing laboratory tools are shown in Figure I-14**.**

Ruler. Depending on method of measurement different types of rulers are in use (Fig. I-14: 1-3). The most common one is a metal ruler with a stop at zero-end. It is used for a maximum chord measurement of the wing, while tail measurements are not possible with this type because of the stop. Wing-formulas may be measured with this ruler as well, but the procedure is less convenient. Stop rulers must be carefully checked for precision, in some cases the stop is not properly fixed. Special ruler with a pin (1.4 mm in diameter) fixed perpendicularly to the ruler at zero line is used for 3rd primary measurement. The most universal tool is, however, a ruler without the stop and cut off exactly at the zero-end. The length of this ruler is 30 cm and it can be used for wing-formula, wing-length and tail-length measurements. Wing-length measurements taken with this type of the ruler are exactly comparable with measurements taken with the stop ruler and a common opinion about their lower accuracy is unsound.

Balance. The most common type of balances used in the field is spring balance of Pesola type (Fig. I-14: 4). They are intended for different sizes of birds and measure with different degrees of precision. A full-scale load of 30 g and exactitude 0.1g is applicable for most small passerines. Balances of bigger capacity (full scale 100 g, 300 g, 1000 g) and lower exactitude come into use where heavier species are involved. For small birds their exactitude is no doubt inadequate. The birds weighed are hanged to the balance in a conic plastic tube (Fig. I-14: 6) adjusted to the size of the bird (weighing the birds in bags is not recommended). More modern, very convenient and not too expensive are electronic balances with digital reading and a battery power supply (Fig. I-14: 5). Load up to 200-250g and exactness 0.1g is ideal for most of netted passerine birds. The balance of bigger capacity and lower exactness could be useful when waders or raptors are
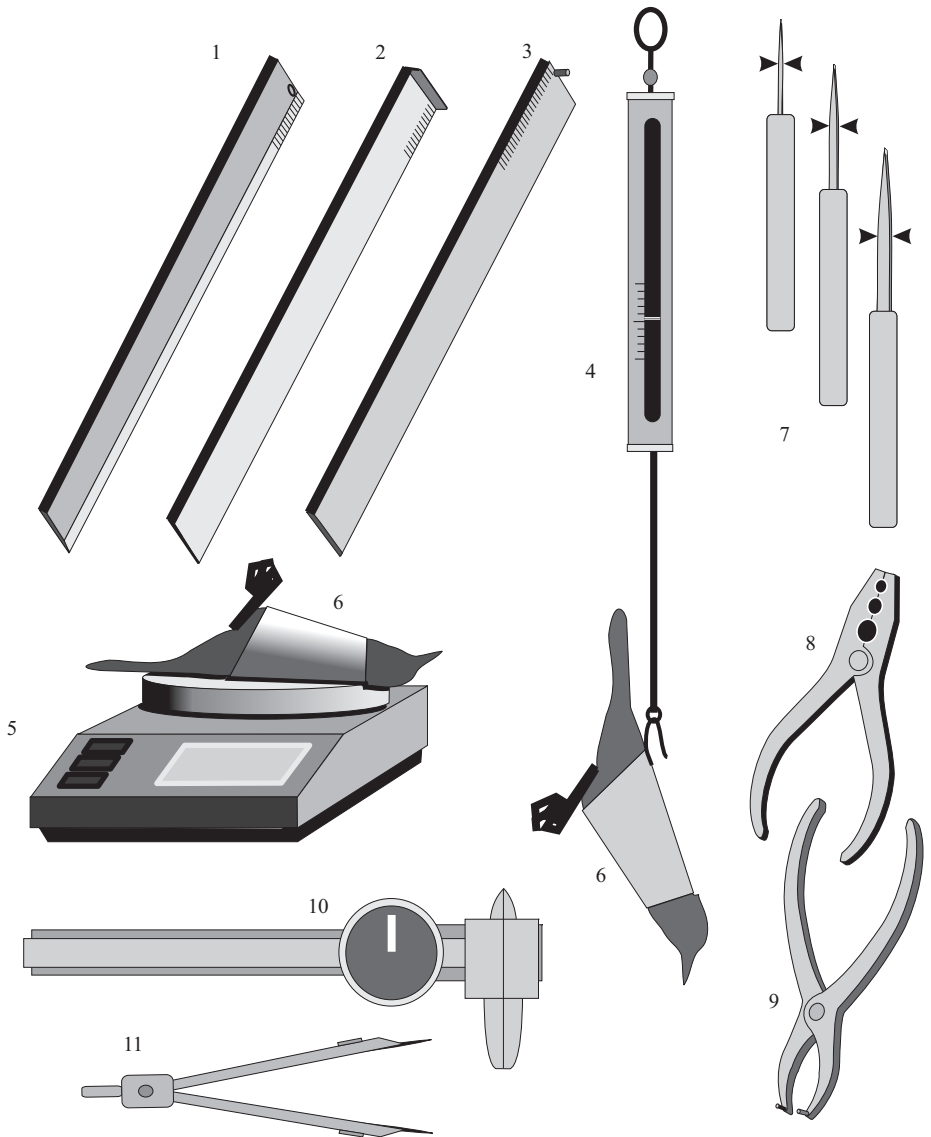
Fig. I-14. Laboratory tools. 1. ruler without a stop, 2. ruler with a stop, 3. ruler with a pin,
4. Pesola balance, 5. electronic balance, 6. tube for weighing the birds, 7. openers for opening rings
(note that from arrows to the hand side surfaces must be parallel), 8. pincers for closing rings,
9. reverse pincers for opening rings, 10. callipers, 11. dividers

caught more frequently. The birds are weighed being put on the balance inside of a conic
plastic tube adjusted to the size of the bird; there will be a resulting pull of 1 – 5 g when
the weighing in a bag and the bird flutters from side to side. The balance should be pro-
tected against wind that could disturb reading very much.

The orientation experiment equipment (Fig. I-15).

1. Circular, not transparent, uniformly coloured screen, which keeps the bird in an experimental cage from seeing any landmarks, trees, wires etc. Its diameter is 110 cm and its height 40 cm.
2. Experimental cage – a cylinder cage made of two wire circles connected by eight vertical wires distributed evenly. These define sectors used when counting results. Diameter of the cage: 36 cm, height ÷ 10 or 12 cm; the higher cages are used for testing thrushes, but they may be used in smaller birds as well, since differences between results obtained with these two heights were not found. The top surface of the cage is covered with nylon netting of 10 mm mesh. The sidewall is covered by a stripe of ultra thin, transparent plastic foil of a kind used to keep food in refrigerators (sold in rolls).
3. Piece of linen to cover smooth ground or not too slippy plate of neutral colour as a bottom surface under experimental cage.
4. Forms for noting the collected data.
5. Pointed colour marker.
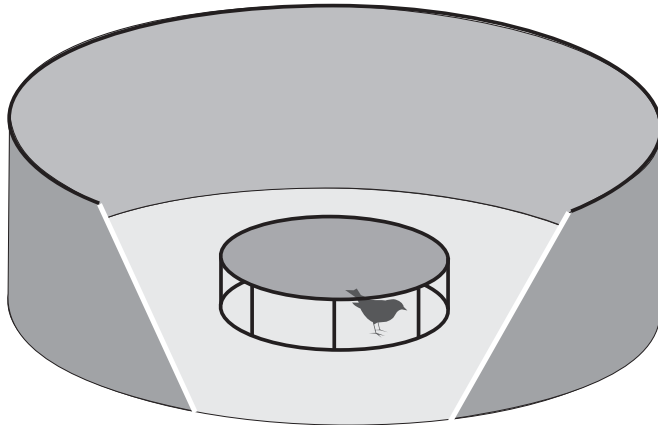
Fig. I-15. Orientation experiment set: protecting wall around and experiment cage inside.

Other tools. Bird rings may be opened with particularly designed openers (Fig. I-14: 7); if the amount is small a sharp knife or hard nail will suffice.

In many ringing schemes pincers with side holes are used for closing all rings. This gives a very exact closure of the ring - without fissure that might be harmful to the bird. In some countries small aluminium rings are simply closed with the fingers, while larger rings (with locks) and rings made of stainless steel are closed with pincers (Fig. I-14: 8). Closing small rings with the fingers will speed up the ringing procedure, but the ringer must be well trained and take care to close the rings properly. However, after a day's hard ringing work the fingers will be very sore and could be less accurate!

Special technical reverse pincers (Fig. I-14: 9) may be used when a closed ring has to be removed from a bird's leg. But note, that operations of this kind can be performed only exceptionally - when the ring is dangerous to the bird – in most cases removal of a ring is very difficult and the whole procedure may injure the bird leg. When a stainless ring is bent over it may be better not to mess up things more than they already are.

Colour rings are opened with special applicators before being put onto the bird's leg.

Callipers (Fig. I-14: 10) are used for tarsus and bill measurements. They must be of good quality, slipping easily (the bird tarsus is not made of iron!). The best, but also most expensive, are modern types with digital reading. Less expensive are plastic callipers with round, clock-like scale. The cheapest, but definitely the worst (measurement is much more time consuming) are the traditional ones.

Dividers (Fig. I-14: 11) are used for tarsus, bill and sometimes tail-length measurements. Measurements taken in this way are less precise and more time consuming.

Rings

The rings must be open and easily removable from the sticks or strings. As a rule they are supplied in an opened state and threaded on a plastic string or stored in a tube. However, to remove them from the string could be difficult during the ringing work; all rings will not slip easily from the elastic string. So, the most convenient thing is to shift them from the string to a metal wire stick of a slightly smaller diameter (Fig. I-16). Rings must be open enough to be put on a tarsus of the largest birds ringed with the particular
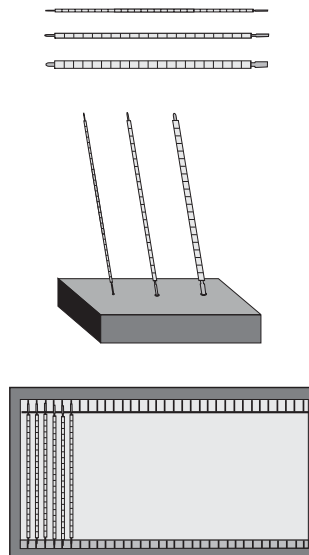
Fig. I-16. Handling of open rings: sticks for different sizes of rings, working position and a box for storing the sticks.

ring size. If they are too much closed the ringer should open them to proper fissure size in advance and put them on adequate sticks. The rings must be opened only with a proper opener. Rings opened in a wrong way (Fig. I-17) cannot be properly closed and could be harmful to the birds. The bottom side of the ring number must be down the stick. After ringing its position on the bird leg is most convenient when ring number is read during retrap handling. In addition (for rings with the ring number located at the bottom of the ring) the number is better protected against wear. Rings of rarely used sizes may be kept unopened and stored on the original strings.
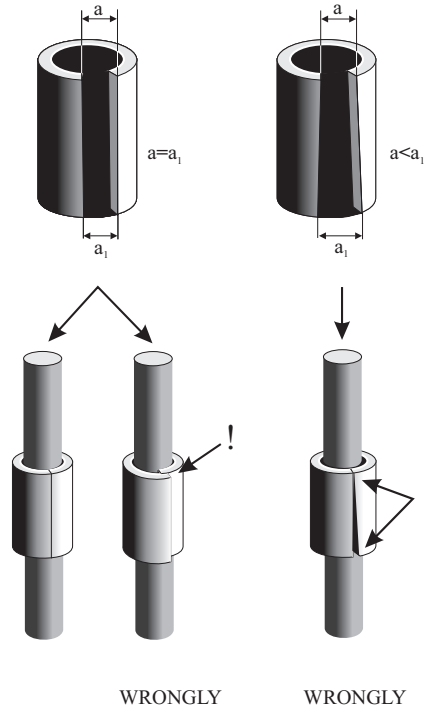
Fig. I-17. Correctly (upper left) and wrongly opened ring (upper right); correctly (lower left) and wrongly closed rings (right). Note that wrongly closed rings are dangerous to the bird!

Ringing stand

When the weather is warm enough and not too windy, the best solution is to have the ringing stand in the open, but under a tarpaulin roof protecting against rain and direct sun. One advantage with the open-air laboratory is, that the bird can be let free without delay when it has been handled and if it escapes, it can fly freely without hitting the window. In an unsheltered laboratory, however, the conditions will sometimes be a little on the cold and wet side for human beings – although nobody died because of that as far as we know – or too windy for accurate weighing. The material of the roof should be of

neutral colour (white or grey) and preferably half-transparent since good light will facilitate sexing and ageing based on subtle colour characters. The same applies to the colour of walls inside a laboratory room.

The ringing stand (Fig. I-18) should be fitted out with two or three (see *Laboratory working routine* in this Chapter – p. 80) comfortable seats (you may have to spend many
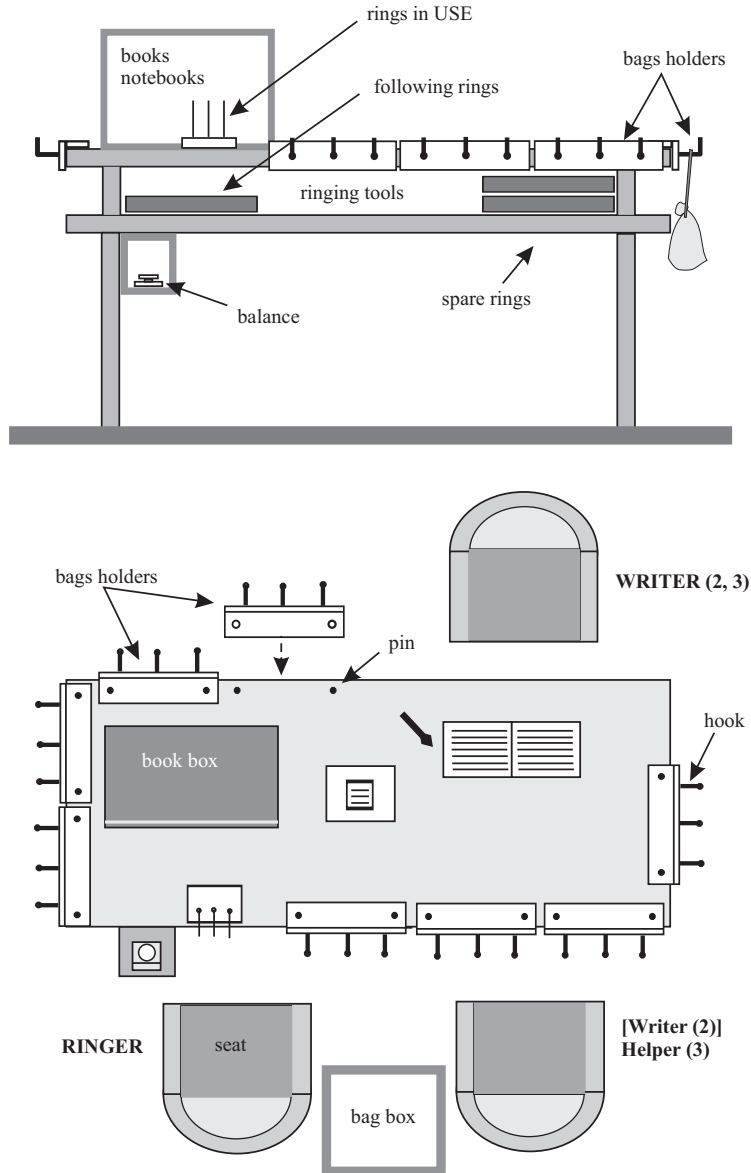
Fig. I-18. Laboratory stand – explanations in the text.

hours without a break there) and a table that allows convenient writing in notebooks. A couple of rows of hooks for bags with birds should be fixed to the edge of the table, the distance between each hook should be so large that the bags do not press each other. Every row of hooks is intended for birds removed during one control walk. It is advisable to have at least 4-5 rows, as there may sometimes be a need for more than one row. One of the rows should be within hand range of the ringer. In front of the ringer a row of sticks with rings of sizes most commonly used should be placed. The rings MUST be open and **easily removable from the stick** or string. Consecutive sticks or strings of rings should be easily accessible to the ringer and stored in top order to avoid that one of them is left out when the next sequence is needed. A set of ringing tools should always be placed within hand range: ruler, pincers (used at least for larger rings and rings of stainless steel), callipers or dividers (if used for special measurements) and scissors (accidentally used for necessary amputation of a bird tarsus). The balance should be conveniently located according to the type used and the organization of work (as to who reads the weight: see *Laboratory working routine* in this Chapter – p. 80). For the evening and night ringing a good source of light must be arranged.

ARRANGEMENT OF THE NETTING AREA

Land habitats

Nets should be located in places with good catching prospects along a control path of reasonable length. Some practice is needed in order to make any location optimal. At the beginning of work on new catching-grounds even experienced ringers may fail in this task. Do not hesitate to adjust an original location when you become familiar with local bird movements. Here are some general rules, which might be helpful:

1. Decide whether the catching area coincides with a path of active diurnal movement of birds or, alternatively, if it is an ecological island - a real island on sea or a big lake or isolated biotope surrounded by habitats unsuitable for a group of birds of interest (Fig. I-19). Diurnal migrants frequently fly along guiding lines like seas, riverbanks or shores, stripes of bushes between forests and so on. The same applies to many nocturnal migrants, especially during peak days, but in a less visible way; they move from one bush or tree to another.

2. Nets placed within an area of active movement must be oriented perpendicular to the main direction of movement. Nets placed at other angles will not catch optimally. At times the stream of migrants is so narrow that the only sensible thing is to concentrate nets within this corridor. Such peculiarities of the area will be detected during peak days of migration only. In transient locations it is advisable to locate the nets in front of more conspicuous bushes or just behind them (or both).

3. At island-type localities most attention should be paid to micro scale habitat differentiation. Locate nets between two bushes, across paths of trees and bushes, at borders between different habitats etc. Look for berries and seeds attractive to different spe-

Coastal site (N-S movement)

Island-type site

reedbed

meadow

bushes

forest

lake

river

nets

DO NOT
locate nets
within the area
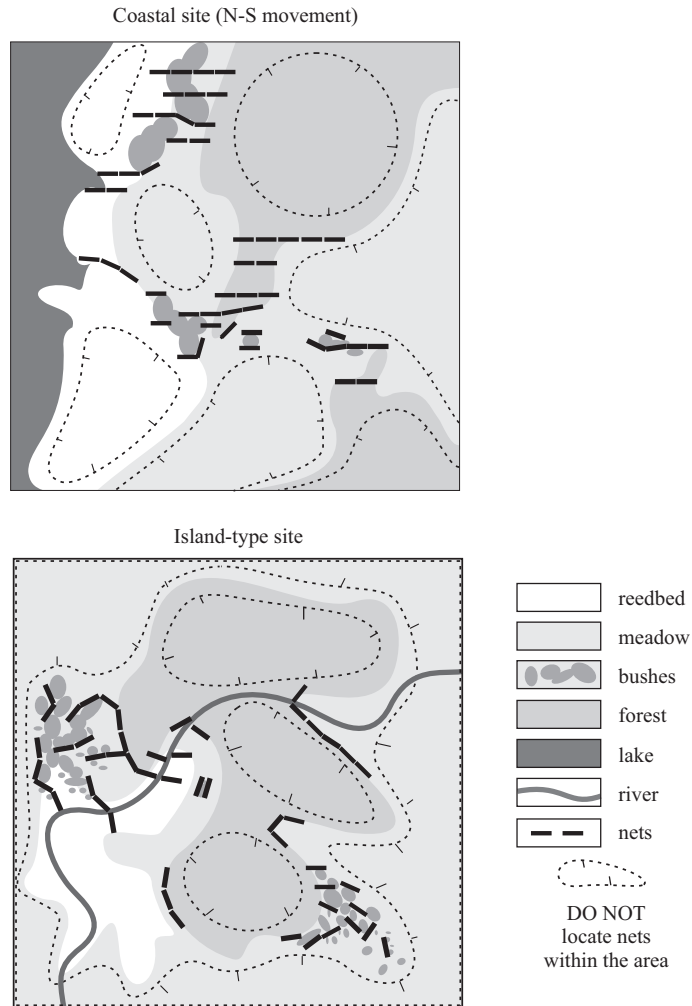
Fig. I-19. Example of properly distributed nets in two types of sites: „coastal type" site where the coast
is a guiding line for migration and „island type" site with no directional movement of birds.

cies as well as water pools that are attractive for most of them, especially within a dry
area or during a period of drought. When the area is exposed to wind look for locali-
ties, which are not exposed to prevailing winds – the best solution is to locate nets so
that some nets will be always protected from the wind, irrespective of wind direction.

Nets may be used singly or connected in rows. As a rule single nets are more effec-
tive than the same number of nets built into rows. However, local configurations of vege-
tation may necessitate the use of rows instead of single nets. Rows are frequently used in
more monotonous habitats like reedbeds, young tree plantations etc. Where nets are set
in long rows a zigzag configuration is better than a straight line. Remember that nets
should be easily accessible (for birds and for ringers) from both sides: the net should be

located far enough from nearby vegetation. This allows the bird to achieve the flight speed necessary to „open" the shelf of the net, and the ringer will be able to remove the bird without entangling himself and the net in e.g. thorny bushes. When nets get entangled in e.g. alder cones or dog rose twigs the mesh will inevitably take damage.

The length of the control path depends on locality, number of nets and anticipated number of staff during peak days. Longer paths allows a better selection of efficient netting locations, but when the birds are numerous the control tour will last too long. It is a good idea to make two or three shorter control paths controlled by different persons or by one person one after another. This allows minimising carrying caught birds as after the control of the path he/she comes back to the laboratory, leaves the birds and then goes to the next path. In general a control tour should not last more than fifteen minutes when few birds are caught. Control paths going through reedbeds and marshes should be much shorter than paths in dry habitats.

Establishment of a new catching stand needs some steps:

1. Walk around the area and carefully choose the best localities for nets. Try to look at the environment from the point of view of a migrating bird: which stripe of bushes leads in the proper direction for continued migration? Where should a bird hide when a raptor approaches? Where is food and water? Consider the number of nets at hand and the expected length of the control path – one path or several?

2. Try to connect the net places selected by a path as short and straight as possible. Avoid steep hill slopes; walking up and down hillsides may be harmful to the birds and to the ringer when the ground is wet (if there is large number of birds you may have to run along the path). If possible, avoid crossing ditches and places easily flooded by rainwater. Furthermore, the full surface of any net or any net row should, if possible, be visible from the control path (Fig. I-20). If this requirement is complied with it will be necessary to approach nets only when birds are actually caught, and during evening and night controls. The path may run along the nets or pass their ends – avoid to cross them perpendicularly – constant passage under the bottom net string may cause rupture and the ringer will lose time when in a hurry.
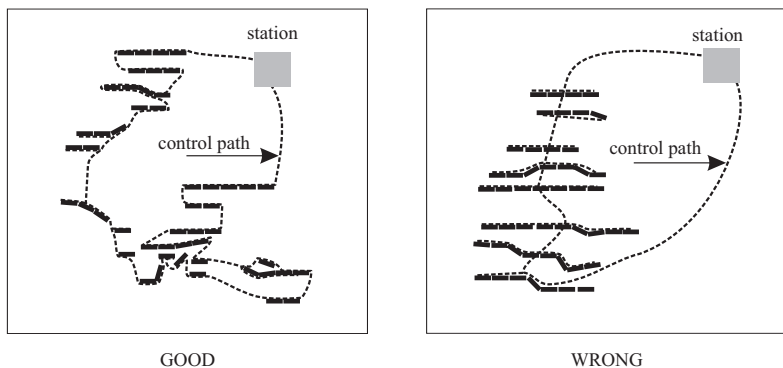
Fig. I-20. Correctly (left) and wrongly (right) arranged control paths.

3. Thoroughly clear up the selected sites, prepare and put the net poles in proper places – you will save time and not have to clear nets entangled in twigs etc. when erecting them. Also perform a preliminary clearing of the control path.
4. Erect the station laboratory stand. When the first nets have been established you will usually have good catches of local birds – readiness for this at the station laboratory is necessary, so erect it first.
5. Erect the nets and start catching.
6. Carefully monitor the catching efficiency of nets and the behaviour of birds around them. In many cases it will be prudent to adjust the location of nets and to correct the course of the control path. This is rule rather than exception: the human eye is not a bird's eye.
7. When net locations and the control path are fixed (consecutive adjustments may become necessary later on when e.g. new species start to migrate) thoroughly clear up both nets stands (Fig. I-21) and the whole course of the control path. Apply the rule: when a net is entangled in a twig or any ground plant – remove the obstacle with a clean cut (land-owners, farmers, hunters note the traces of your activities!). Particularly the ground under the nets must be well cleaned – birds caught in the bottom shelf should not be entangled or hidden in or soaked by the vegetation. This may cause their death when the weather is cold and wet, or they may be overlooked in darkness. Further, for your own convenience and for time economy: clear the control path. You should be able to walk along it without any gymnastics in order to avoid branches, twigs, fallen trees etc. When the ringer is in a hurry an eye may get hurt by a twig, a leg broken over a branch, and the birds may get killed when a bag hits the ground. And do not laugh here – this is the truth!

Starting a new season in an old area is much easier – you only have to clean young twigs and plants, which sprouted in previously cleaned spaces.
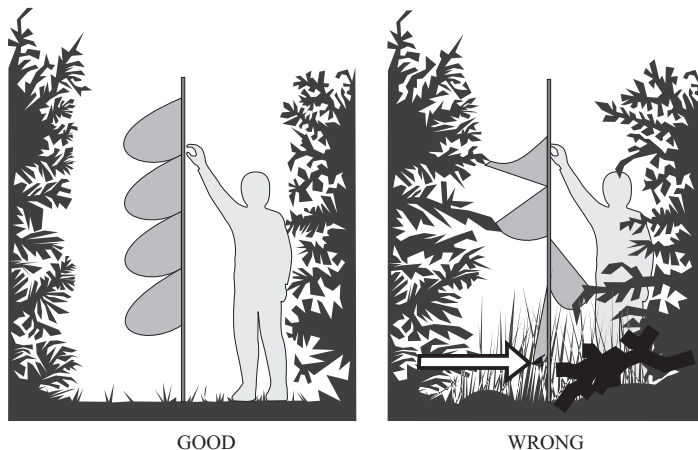
Fig. I-21. Correctly (left) and wrongly (right) arranged net stand. Arrow points at possibly overlooked bird.

Wetland habitats

When arranging the catching area in wetland habitats usually the procedure differs a little between pure reedbeds and wetland with mixed sedge-reed-willow vegetation. Good catching possibilities is one objective, reasonable time for control walks another. The latter depends mainly on the quality of the ground. In permanently moist terrain paths made of the boards fixed to wooden poles may be necessary. Where there is no possibility to use permanent paths, the speed of control walks in swampy ground covered by water will be low and the length of the path must be limited. Note that even apparently firm ground will become difficult to pass after being used a couple of times, this is particularly important to know when the path goes through standing water. The effectiveness of catching within the reed-beds differs from place to place – as a rule the most effective nets are the ones located at the borders between reed and open water or bushes and trees (this border zone is the preferred habitat of the Reed Warbler). Single willow bushes attract many birds and their sides are usually good catching places. Linearly distributed (e.g. along the ditches) small bushes and trees always give good catches – put the nets across such lines. In the core regions of monotonous reed-beds the catching result is markedly lower. Open places with dispersed and low reeds and sedge have very low catching value. When rows of nets are erected within reed-beds they should not be arranged as a straight line.

When nets are erected in wet habitats their stretching and maintenance need extra attention. „Anchoring" strings attached to the end poles of a row will guarantee permanent stretching. The net should be set so high, that birds caught in the lowest shelf will not get submerged in the water, and the security margins must allow even for heavier birds (e.g. the Water Rail). Keep in mind that wet nets are longer than dry ones.

DOCUMENTATION OF THE NETTING AREA

When the catching area has been arranged a basic documentation must be made. This includes a mapping of the area and a description of the habitats. All net locations should be indicated and numbered (independently of the custom applied - noting or not noting net numbers in a ringing documentation). A list of erected nets by numbers must be made with description of the net parameters (if differentiated) and time of function. Any further changes should be written in this document: date of removal or addition of nets; when changing the net location give the next free number as the number of a new net, e.g. „2 Sept. net no. 4 moved to 21".

Apart from a general description of the catching area, which is obligatory routine, a detailed description of the net surroundings within 20 m on each side should be done when the intention is to make a more detailed study of habitat preferences within a special project. This should be done separately for spring and autumn seasons.

The net location habitat coding after idea of W. Peach (*Manual of Field Methods –* Bairlein 1995), modified (optional):

1. Habitat type (1 letter code)

    R – habitats with reeds

    S – scrub

    W – woodland

    X – other

2. Habitat elements (2 letters code)

    For habitat types *R*, *S*, *W* habitat details are coded:

    P – reeds (*Phragmites* spp.)

    T – reedmace (*Typha* spp.)

    J – rushes (*Juncus* spp.)

    C – sedges (*Carex* spp.)

    B – bushes

    H – herbs

    G – grass

    L – broadleaf trees

    F – coniferous trees

    Uniform habitat is coded by doubling the basic code, e.g. *PP* – pure reeds; mixed habitat is coded as two letter code giving information on two dominant elements, e.g. *PT* – mainly reeds but with reedmace, *TP* – mainly reedmace, but with reeds etc.

    For *X* coded habitat type separate two letter code:

    MT – mountaintop

    ND – heathland

    AB – acid bog

    FM – farmland

    SM – salt marsh

    XX – other special habitat (describe in comments)

3. Height of vegetation (1 number code)

    Code average height:

    0 – less than 1 m

    1 – 1-2 m

    2 – 2-3 m

    3 – 3-6 m

    6 – 6-9 m

    9 – more than 9 m

4. Presence of water (letter/number code)

    No water

    N0 – dry

    N1 – wet

    N9 – dried out (water was earlier in the season, but now dried out)

Standing water

    S0 – depth less than 10 cm

    S1 – depth 10-30 cm

    S2 – depth 30-100 cm

S3 – depth more than 100 cm

Flowing water

F1 – small stream

F2 – river

5. Fruit (1 number + 2 letter code)

Presence of fruits

0 – no fruit

1 – some fruit

2 – much fruit

Type of fruit

Every fruit has two-letter code – list two commonest ones; when more than two – code *MX*; when unknown – code *XX*.

JU – Juniper (*Juniperus* spp.)

TA – Yew (*Taxus* spp.)

IL – Holly (*Ilex* spp.)

EU – Spindle (*Euonymus* spp.)

RH – Buckthorn (*Rhamnus catharticus*, *Frangula alnus*)

RU – Brambles (*Rubus* spp., includes raspberry, blackberry, strawberry)

RO – Roses (*Rosa* spp., includes dog rose and sweet briar)

PR – Cherries and plums (*Prunus* spp., includes blackthorn, wild cherry)

CR – Hawthorn (*Crategus* spp.)

SS – Sorbus shrubs (*Sorbus* spp., includes rowan, whitebeam)

RI – Gooseberry family (*Ribes* spp., includes blackcurrant and redcurrant)

HI – Sea Buckthorn (*Hippophae rhamnoides*)

VI – Mistletoe (*Viscum album*)

AS – Strawberry Tree (*Arbutus unedo* and *Rhododendron shrubs*)

AE – Ivy (*Aralieceae* family like *Hedera helix*)

OL – Olive family (includes *Ligustrum vulgare* and cultivated *Olea europaea*)

SM – Nightshades (*Solanum* spp., includes *S. nigrum* and *S. dulcamara*)

CA – Honeysuckle fam. (*Caprifoliaceae* incl. *Sambucus* spp., *Viburnum* spp., *Lonicera* spp.)

SA – *Salvadora* spp.

NI – *Nitraria* spp.

6. Habitat management (1 letter code)

O – no management

N – normal forestry/farming management

R – main vegetation completely cut back at least once per year (e.g. burning or reed cutting)

C – coppicing

G – grazing

M – artificially managed (e.g. for monitoring purposes)

X not known

For easier reading groups of codes can be separated by dots, e.g. ***S.BH3S1.1RUSO.O***

MAINTENANCE OF THE NETS

Nets must be maintained during the net control rounds. This includes checking of the tension, and keeping the nets free from leaves, twigs, bigger insects etc. (especially dung beetles can do serious damage to nets). Where a continuous catching routine has been established special attention should be paid to the net maintenance when checking the nets for the last time in the evening. A thorough cleaning of the nets before the last control is the best way to prevent any bird from being overlooked in hidden positions; a passerine will die if left in the nets overnight. In addition, the nets will be at the peak of their catching ability next morning when a new wave of night migrants arrives. Also clean the nets after a storm or heavy rainfall. They may be full of leaves and twigs after such events.

If the nets are pulled down after the morning catches, they must be cleaned up before closing – nothing worse can happen to them, except for a cow or an elephant, than being closed with leaves and twigs and then erected anew in darkness before the following sunrise! The „alarm” closing of nets (see *Laboratory working routine* in this Chapter – p. 80) does not allow to clean nets in beforehand, so the next opening could well be very difficult, time consuming and damaging to the nets, especially to the thin ones. This is one of the reasons why it is not recommended to close nets on a peak day. The nets are closed by putting all net ears together so that birds cannot get accidentally entangled. This can be done by wrapping the netting around the strings and using clips (as for linen) to fix the netting. After closing the nets for the day they should be opened in the evening rather than in the morning. This will make possible a more efficient catch of birds landing before sunrise without disturbance from ringers opening the nets and, least but not last, it will allow the ringer to sleep longer. When opening the nets in the morning (in darkness, at least one hour before the sunrise) the nets should be properly opened and stretched. This needs a lot of time and training.

HOW TO FREE A BIRD FROM THE NET

Various removing techniques are in use. They are differentiated as to effectiveness (speed of removal) and safety for the bird. The technique, in contrast to „natural” removing by a layman (which means „no rules” – trial and error method), depends mainly on the accepted standard holding of the bird. One common technique is based on holding the bird with the tarsal joints between the fingers of the right hand (or worse – of the left hand). This technique is not a quick one. Although it allows a qualified ringer to remove the bird safely, beginners frequently cause injuries to bird legs or remove the birds too slowly. The technique described below is quicker, much safer for birds and in practice less complicated than its description.

First of all the standard holding position of the bird should be trained. It is shown in Figure I-22. The point of departure is always right-hand handling. Right hand handling was chosen as standard procedure (despite the left-handed minority, sorry!) since the right hand fingers are better capable of holding the birds safely (meaning that it does not
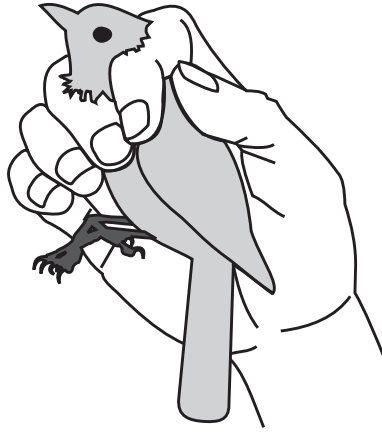
Fig. I-22. Standard holding position of the bird (description in the text).

escape) and safely (for the bird) when it is removed and handled in a hurry. Left hand handling is allowed for left-handed person when removing birds, but at the next step, during laboratory work, the right hand holding must be used (once more sorry) for compatibility reasons (see *Laboratory working routine* in this Chapter – p. 80).

  Bird removing routine (Fig. I-23):

1. Define from what direction the bird has entered the net. If this is difficult, apply the rule that the bird is on the side of the net where it has its belly. Remaining on one side and try to remove a bird that is on the other side is, although still possible, not convenient and not recommended for beginners.
2. Open the net pocket using left hand and hold the bird's body as deep as possible with right hand fingers.
3. Take out the bird with the net pocket toward your body.
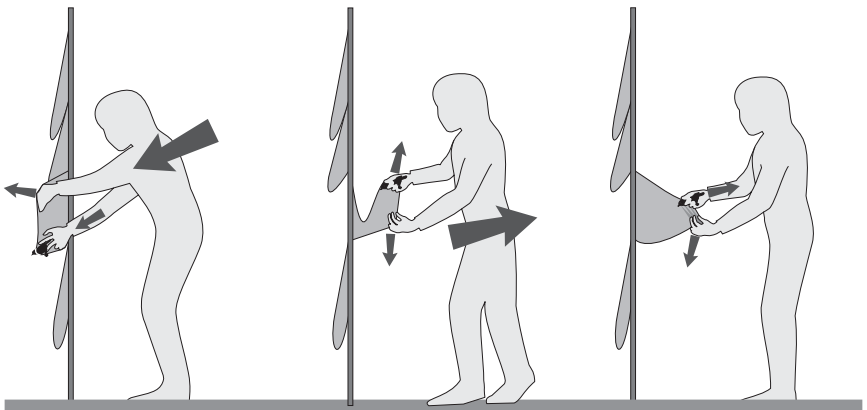
Fig. I-23. Bird removing routine (description in the text).

4. Make sure that the net threads do not lie in a leg groin - remove them if so, otherwise it will be impossible to remove the close-lying wing.

5. Resolutely but gently and carefully pull threads going from the bird, using first three fingers of the left hand. Threads should be pulled one by one at a distance of at least 5 cm from the body. In most cases wings and head will be removed quickly, but sometimes you must remove the head separately. Be careful, as the head being entangled into crossed threads is the most dangerous for the bird. The threads may be pulled relatively strongly, but not in a sudden outburst - bird's wings are very movable in all directions when pulled quietly. However, they can be broken too. At this stage of removing do not care about entangled bird legs!

6. Hold the bird with the standard grip (Fig. I-22), as described above, using the right hand (the same as you have used for holding the bird's body previously - a comment important to left-hand removers!). Changing the hand holding the bird is one of the biggest faults possible when removing it - in most cases you will entangle it more than it was previously.

7. Freeing the legs. Most birds held with the standard grip will try to escape and free their legs from the net by themselves. Now, you are ready to put it into a bag. If the bird is not that kind, take the leg using your first and second finger of the right hand and hold it at the tarsal joint (not above it - you may break the leg!). With the first fingers of the left-hand try to make threads slip by pulling them cautiously **along** the tarsus.

Where net threads are not extremely thin or hard around 90 percent of all individuals caught will be removed quickly and without problems in this way. Some birds, however, get entangled in more complicated ways and individually practised techniques must be applied. A problem we often met occurs when a thread gets hooked up on a tongue spur (esp. frequent when thrushes are caught). In such case you have to hold both legs of the bird, since the kicking of the bird may injure its tongue (the bird will often make the tongue bleed by its own force). When legs are fixed pull the thread backwards and upwards, over the spur, this will often suffice to free the bill but a very thin twig or a straw can be helpful sometimes (Fig. I-24).
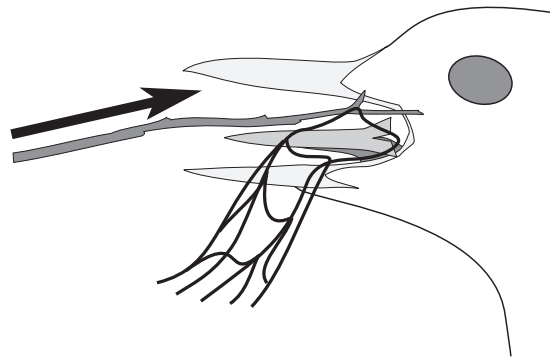
Fig. I-24. Removing a net thread from the bird tongue.

At the end of the freeing procedure you should always hold the bird in the standard fashion. Finally put the bird into a bag, close the bag by pulling its string, slip down the lock (Fig. I-11) and hang it up on a special hanger on your neck (Fig. I-12) or on an eye-piece of a binocular. This last is a very practical custom – many ringers have a binocular ready to observe a rare bird, and it is a useful hanger for bags. When more birds of the same species are caught, closing the bag after each individual becomes impractical and time consuming. The solution is to hold the bag closed with the fourth and fifth fingers of the left hand (Fig. I-25) and remember that you use only three first fingers to the next bird removing (see point 5 above). When the bird is in your right hand add it to the pre-vious ones in the bag. When the standard number of individuals is in the bag (see – in this Chapter – p. 51) close the bag and use your hanger. For Goldcrests you can, when you have a good training, use a special procedure - after removing the birds you can collect them in the right hand, holding them by your forth and fifth fingers, then remove another one and another one... With five of them in the hand put them into the bag. When this has been repeated three times you will have the standard number of Goldcrests inside. The method is very quick and it seldom happens that a bird is clever enough to escape.
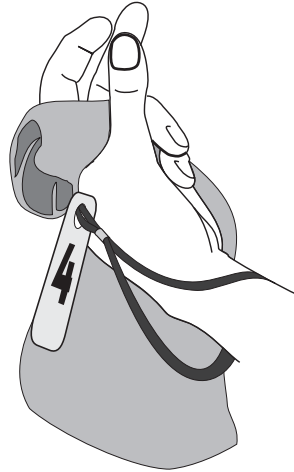
Fig. I-25. Holding the bag during removing the bird when many birds are caught. Label with number is used when numbers of nets are noted according to the station routine.

Special tips when removing the birds:

Some birds when caught may hurt your fingers or even your eyes:

Hawfinches and shrikes may easily injure your hand by the strength of their bills, so the first thing when you remove such a bird - fix its head.

Raptors and owls hit mainly with their claws and they are very quick. Surprisingly their hook-like bills are usually not as dangerous (however, some individual excep-tions!). The first thing when starting to remove a raptor or an owl – hold them by the tar-sal joint of both legs (this is an exception as to removing method!). Owls look as if they

are sleeping in the net, but the most dangerous is the first moment of removal - their legs are really like lightning. If, despite your care, the bird catches some part of you by its claws, remain calm and slowly turn the leg along the tail to the bird's back (Fig. I-26) – its claws will automatically open (because of an anatomical peculiarity of the leg). The same may help when the claws are much entangled in the net and you are unable to remove threads.
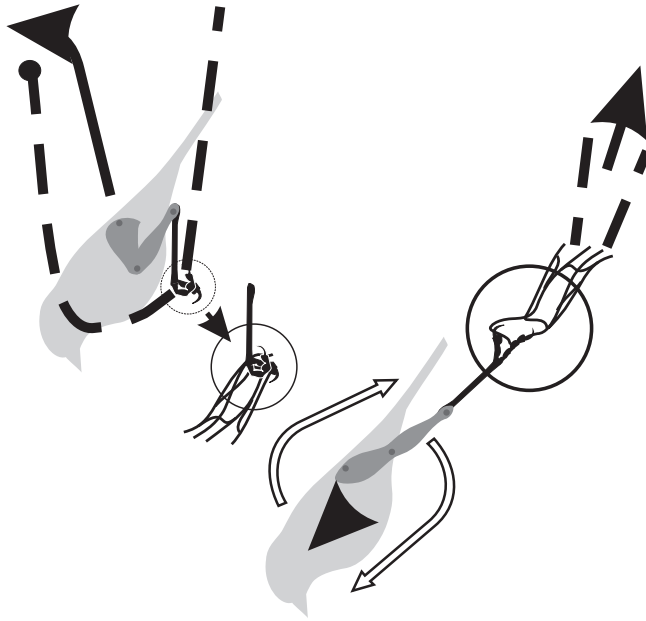
Fig. I-26. Freeing up the leg when the bird with strong toes keeps the net.
Use the same principle when you are caught by the Jay, raptor or owl.

Jays use both methods of fight – bill and claws – and your response must be to use both tactics mentioned above.

Tits are irritating by their pinching.

Special note: Little Bitterns are dangerous to your eyes when handled – they have surprisingly long necks and may hit your eye suddenly! The same applies to Herons and Bitterns, and be careful with Moorhen and Coot as well!

NET CONTROLS

Standard set of nets

The net controls should be done every hour at the beginning of every full clock hour, with start and end depending on the latitude of the station. In northern Poland (sun time – winter time is given) it is as follows in the Table I-1. The first control should begin at or

up to half an hour after sunrise. The last control of the day (after the listed ones) should be done at darkness, no later than 0.5-1.5 hour after the preceding one. When owls are migrating and special owl nets are used, night controls performed at two-hour intervals are necessary. If no owls have been caught up till midnight the next control may be skipped.

Table I-1. Time of controls in northern Poland.

Period	First net control	Last regular control
before Apr. 16th	6.00	18.00
Apr. 16th- Sept. 7th	5.00	19.00
Sept. 8th - Oct. 7th	6.00	18.00
after Oct. 8th	7.00	17.00

When the weather is wet and cold or very warm the frequency of controls should be higher in order to avoid losses among birds. These birds from additional controls should be treated as the birds caught at the next regular control.

The control walks should always be done in the same direction along the control path. This results in regular visits of the same nets and is of great help in alarm situations (see *Alarm routine*). If there are groups of nets regularly catching more than others along the path, they should be visited later on the control walk. This is important when many birds are caught; they will then, on average, be transported a shorter distance (this is for their and your convenience).

There are a few rules that should be followed when the nets are checked. They derive from the general handling system that gradually evolved when great amounts of birds were caught in the past. Applying these rules will help you in handling the birds and minimize losses. The advantages from adopting this handling routine are most obvious on peak days of migration.

1. Start each control walk with a sufficient number of bags. This is especially important at the first control walk in the morning, when unexpected rushes may sometimes occur. Returning to the station for a new set of bags will ruin the rhythm of controls. Remember this rule during all controls throughout a day as birds sometimes may come as a big surprise (esp. tits and Starlings). If, however, you must return for new bags, afterwards go directly to the net where you used your last bag – do not remove newly caught birds from the nets already controlled, otherwise you risk not to be able to finish the control walk in time.

2. Prior to the transport of birds rigorously select them by species: allow only one species in one bag. Try to remember which species is in which bag – the best is to use colour bag codes for the most common species, e.g. orange ones for Robins, blue for Blue Tits etc. When there is not enough colours, hang e.g. Goldcrests on a left hook of the hanger while Robins in a bag of the same colour hang on the right side. This rule is useful both during control (adding new birds to previously caught) and, especially, at the laboratory where all persons coming from different control paths must hang the

birds selected by species (see *Laboratory routine*). When many birds are caught in one net or rows of nets remove them by sides of the net and by species (do not close a bag before filling it – see above). It is much less time-consuming to remove all birds from one side of the net and then go to another side than to remove birds „on reverse". If two persons remove birds from one net simultaneously one of them should specialize on one and the other one on another common species (you will have less to remember „who's who" in the bags).

In some programmes a net number should be noted for ringed birds. There are two main reasons for such data collection: (1) the wish to study habitat preferences and (2) to follow territorial behaviour of the particular individuals. In the first case you only need to know that e.g. four Robins are from net no. 3 and two more from net no. 11, but not that exactly this individual is from net no. 3 and that one from net no. 11. So, you can put them all into one bag and note on a piece of paper „4 from no. 3, 2 from no. 11". In the second case you have to keep Robins from e.g. net no. 5 only in one bag – you have to carry much more bags along. One good advice is to have special plastic labels with net numbers. The label should have a hole of such size that the bag string can be easily laced through (Fig. I-25). The labels are stored on hooks at the net poles. After putting the bird caught in a particular net into a bag you place the label on the bag string and you do not need to remember or write the number of the net. After a few control walks you will, however, be forced to redistribute labels collected at the laboratory to the proper nets. This idea can be used also for marking the bird species being transported in different bags.

3. Remember that there are limitations to the number of individuals allowed in one bag. It depends on bird species and circumstances. Standard numbers are listed in the Table I-2.

Table I-2. Number of individuals allowed to be transported in one bag.

Species	Number of individuals
Goldcrest	10 - **15** - 20
Long-tailed Tit	8 - **10** - 15
Blue Tit, Coal Tit	7 - **10** - 15
Great Tit, Robin	6 - **8** - 12
thrushes	1 - **1** - 2

The central, bold numbers are valid assuming that both bags and birds are dry, in good condition and not expected to wait too long for ringing. When birds are wet or when they have to wait for ringing more than one-two hours, reduce the number (first numbers valid), while if you have just finished one control walk and birds will soon be shifted to the waiting boxes you may fill the standard bag with higher number of individuals (last numbers valid).

4. Avoid transporting full bags, hanging them in a larger number onto one another. When you really have many full bags, hang them not only on the hanger or binocular but on forearms as well. If you have full bags at the start of the control walk, and you know that you will pass nearby at the end of the walk - hang the bags on a tree (in shadow!) and do not forget to take them on your return way. In a case when you are forced to run with full bags support them from the bottom to protect them against hitting one another and your body. So, be very careful when you transport larger numbers of birds simultaneously - your mistakes could cause their death. Wrong handling of full bags is the most common cause of losses among birds caught in peak days.

5. Immediately after reaching the laboratory hang bags selected by species on appropriate hooks (Fig. I-18) and/or, after an order of the chief ringer, shift some birds caught from bags to waiting boxes. Report to the chief ringer any problem expected on the next control, e.g. „a lot of tits are coming".

Sometimes many birds can be caught during last control (particularly in nets erected in reeds nearby roosting places of Starlings, swallows or Wagtails); so good lamps (including headlamps) should be available as well as a good source of light in the laboratory.

Special netting

Within the framework of the „passerine station" some degree of special netting can be performed. The special nets for catching Passerines are sometimes built to catch the birds that make ringers nervous by flying too high to get caught into the standard nets. There are different constructions. One type consists of a normal size net pulled up and down on strings along high poles, another of very high nets (eight to ten shelves) slipped down when birds are caught in higher shelves. Such special passerine nets could make ringers happy by catching a few more birds and/or some birds that are rarely caught in standard nets. However, they are very laborious in action, as the net must be lowered in order to remove birds caught above the range of the ringer's hands. In addition, when the net has many shelves they will close when pulled down and the bird usually gets much entangled. Use of such nets as an addition to the normal set of nets outside the time of mass catching is up to the individual ringer. During the period of potential mass catching such nets should not be in use or at least they should be pulled down when a rush of birds is anticipated. Otherwise they could be a cause of substantial problems with safety of birds (see – *Laboratory working routine* in this Chapter – p. 80). At times normal sized (usually of doubled length) nets made of 25 mm mesh netting, which are more efficient in thrush, Sparrowhawk and Cuckoo catching, may be used as addition (they make good „protection" against raptors at migration sites). Such nets, although they are not on parity with normal nets in terms of monitoring data, need not be closed during the peak days.

Special nets intended to catch larger birds – usually raptors and owls – are sometimes used at the „passerine stations". These are nets made of big size netting (40-90 mm mesh) and much higher than the standard ones. Because of big mesh such nets usually do not catch small birds (but when caught they may get extremely entangled!), that are the

source of peaks in catching, but if the rush of small birds is connected with the Jay migration they can make the problems. If such nets are used during owls' migration, for catching them they are very efficient, they should be controlled during the night at two-hour intervals when good weather. If there are no owls caught till midnight next controls could be skipped as the next catches could be expected close to sunrise.

HOW TO ARRANGE TRAPPING WITH HELIGOLAND TRAPS

Special attention must be paid to the maintenance of Heligoland trap in order to make them really efficient. All ropes and strings should be rigorously stretched and the netting free from holes. Holes are dangerous to birds that may get caught and die. Other holes, even small ones, may serve as escape to a lot of birds, especially when holes (sometimes one single broken mesh) are situated at corners of the terminal room. Birds, esp. tits observe individuals that escape and instantly follow in their path. Removal of birds from the Heligoland trap differs from the freeing of birds caught in nets and depends on the construction of the trap. Birds may be removed by hand from a permanent collecting box, caught in the terminal box by means of a hand-net similar to that used for butterfly catching or taken with a collecting box that is replaced by a new, empty one. Transport of birds collected at the Heligoland trap can be done in transport boxes since the trap is the only place where the birds are collected („zig-zag" trap is an exception as there are couple of collecting boxes). When many birds are brought together in one collecting box sorting by species is necessary before the box is given to the ringing stand. Note that the potential catch of any Heligoland trap is huge and all rules of quick handling birds must be strictly observed. In Heligoland traps where the birds are caught in collecting rooms „hunting" for the last trapped individuals jumping from one wall to another is very laborious, but this must be done for the safety of these unlucky individuals. Only when a permanent, intensive flow of birds occurs some individuals can be left behind in the catching room. But after the rush all lasting individuals must be removed. A similar situation may occur in Heligoland traps with collecting boxes when some individuals hesitate to enter the box. The rules of their treatment are the same as described above.

LABORATORY METHODS

Species determination and coding

Species determination is undoubtedly one fundamental starting-point for ringing. For ringing purposes a good key or „the bird in the hand" type of manual should be used. Common „guides to...", coloured books for field identification of birds, are based on characters visible from a distance, frequently on behaviour and bird voices. These sometimes could be insufficient for correct determination of an individual caught – some field characters are no longer visible at the bird with disturbed plumage and the voice of the bird crying when removed from the net has no similarities to natural calls. On the other

hand, „the bird in the hand" manuals present species discrimination characters, which are completely invisible in the field, e.g. details of wing-formula or colour patterns of single feathers. These details should be carefully noted when rare species or species difficult to determine are ringed.

There are two main types of determination procedures in use: a key system where alternatives of characters are listed in hierarchical order, usually dichotomy form and guide system, where alternatives of different characters are given as sometimes long text describing more or less important details. The first, traditional system is easier to handle for less experienced workers, that are guided to final decisions by the construction of the key. However, misunderstanding of one step in the key sequence or misunderstanding of the description given could lead to wrong species determination. Because of this key determination must be confirmed by a careful study of the species description given in the guide form. Any doubts should be clarified at this stage of discrimination. Guide systems are good for experienced ringers who are well acquainted with the guide manner of description and know which characters are the most important ones in a family represented by the individual caught. There is less confusion from a lot of detail and, if there is any contradiction between characters, it is easier to assess the relative value of the characters in question.

Correctly identified bird species must be correctly noted in the ringing form. Because of the inconveniences of plain text writing, for ringers as well as for the person who loads collected data, different forms of species name codes are in use. They render the species name in a short form that is easy to write down under field conditions and is not time-consuming when typed on a keyboard.

For mnemotechnic reasons any number code must be excluded from the field use – letter codes are easier to remember and less vulnerable to errors. The most universal in the international network is a six-letter code based on scientific names and specially prepared to be error-resistant. The main idea is construction of the code in two segments – three opening letters from the scientific genus name and three ending letters from the species name. However, this simple rule, here called procedure A, can lead to identical codes given to different species, e.g. **PHY**lloscopus **TRO**chilus and **PHY**lloscopus **TRO**chiloides or **ACR**ocephalus **PAL**udicola and **ACR**ocephalus **PAL**ustris, so in their case some other procedure must be used. The additional procedure (*B*) uses three opening letters from the generic name and three LAST letters from the species name, thus the above-mentioned *Phylloscopus trochilus* is coded as **PHYLUS**, while *Phylloscopus trochiloides* as **PHYDES**. Note that code **PHYTRO** is not used any more as it is meaningless and „**PHYTRO**" written into the ringing form calls out loudly „I am a mistake!!!". To avoid „Czech errors" (changing sequence of letters, e.g. AC to CA) – the most common writing error – the coding system presented here excludes codes which after a Czech error in the code writing leads to a change of code meaning, e.g. **ACRRIS** for *Acrocephalus palustris* easily converts to **CARRIS** which stands for *Carduelis flavirostris*. In order to avert some of these possibilities the third code-creating procedure *C* was introduced: adding as a second three letter segment of the code some other three letters

from the species name, e.g. ***ACRUST*** for ***ACR****ocephalus pal****UST****ris*. Among all bird species listed in the EURING list of species there are 26 codes made applying procedure *B* and 12 applying procedure *C*. The exceptions from the basic rule are listed in the Table I-3. For simplicity, the code system allowed some codes, which were not redundant, and they could change meaning when a one-letter error occurs. They are listed in ***APPENDIX I***. Most of the species are rare birds, thus treated carefully, or they are ringed with different sizes of rings, which might be of help when fixing theoretically possible errors.

Table I-3. Species coded by procedure B and procedure C (explanation: see text)

Scientific name	Code - B	Scientific name	Code - C
Acrocephalus paludicola	ACROLA		
		Acrocephalus palUSTris	ACRUST
		Acrocephalus schoENObaenus	ACRENO
		Acrocephalus scIRPaceus	ACRIRP
Calidris alba	CALLBA		
		Calidris alPINa	CALPIN
Calidris minuta	CALUTA		
		Calidris minuTILla	CALTIL
Carduelis cannabina	CARINA		
Carduelis carduelis	CARLIS		
Carduelis flammea	CARMEA		
		Carduelis flaVIRostris	CARVIR
Corvus corax	CORRAX		
Corvus corone	CORONE		
Emberiza pusilla	EMBLLA		
Emberiza rustica	EMBICA		
Lanius minor	LANNOR		
		Larus miNUTus	LARNUT
		Mergus merGANser	MERGAN
		Mergus serRATor	MERRAT
Milvus migrans	MILANS		
Milvus milvus	MILVUS		
Oenanthe leucura	OENURA		
Oenanthe leucophyga	OENYGA		

Scientific name	Code - B	Scientific name	Code - C
		ParUs MOntanus	PARUMO
		PasSer MOntanus	PASSMO
Phylloscopus trochiloides	PHYDES		
Phylloscopus trochilus	PHYLUS		
Podiceps cristatus	PODTUS		
Podiceps grisegena	PODENA		
Porphyrio porphyrio	PORRIO		
Porzana porzana	PORANA		
Pyrrhocorax pyrrhocorax	PYRRAX		
Pyrrhula pyrrhula	PYRULA		
		Stercorarius paraSITicus	STESIT
Sterna paradisea	STEAEA		
Tetrao tetrix	TETRIX		
Tetrao tetrax	TETRAX		

Sex/age determination and coding

In modern ringing sexing and ageing of ringed birds is a rule. However, contrary to the species determination, it is sometimes impossible to determine, or the criteria do not give full separation. Despite this weakness sex and age determination should be performed in as many cases as possible. Where possible species-specific characters should be used according to appropriate manuals. As in the case of species determination key procedure or guide procedure could be used. In a case of sex and age determination where different characters are more diversified in terms of their power and simplicity to apply, the key system has some additional advantages. It is a psychological rule, that beginners in sex and age identification when confronted with a few characters described with no respect for mutual hierarchy make their own intuitive arrangement, which could be far from optimal. Since others do not know these solutions, the results of identifications made by different ringers may have different degrees of validity. They depend on the leading character accepted by the ringer, and need not be fully compatible. On the other hand, a hierarchy of characters instituted by an experienced specialist and presented as a key hierarchy has a chance of being optimal.

Since most age characters are connected with the bird plumage, the age coding is derived from the names of subsequent plumages, which are identifiable (Fig. I-27):

J – juvenile plumage: the bird in its first full plumage (feathers grown in the nest or first feathers following down-plumage)

I – mixed immature plumage: plumage containing some juvenile feathers and some renewed feathers of the next set

A – definite (adult) nuptial plumage, **D** – adult postnuptial plumage

N – not defined plumage, but not juvenile plumage

L or „-" – fullgrown, not checked for plumage type

for some species with more complicated pattern of plumage development a few other, detailed codes could be used:

S – first full immature plumage: second full plumage

T – second full immature plumage: third full plumage

M – immature plumage, precise type (**I**, **S**, **T**) is unknown

O – not adult plumage (either juvenile or any immature one)
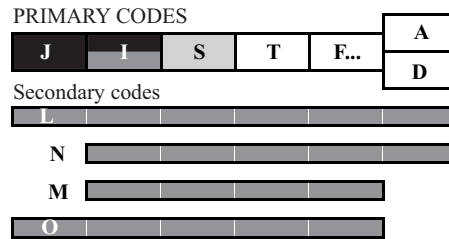
Fig. I-27. System of plumage coding (explanations in the text). Secondary codes are used when the exact plumage is not known. They could contain different combination of plumage classes as shown at the bottom of the Figure.

In the sex coding only letters **M** (male) and **F** (female) or scientific signs (♂ and ♀) should be used – any number coding (0 and 1, 1 and 2, 2 and 1) easily leads to errors!

Standard set of measurements

First one general comment: It must be emphasized that a single measurement of a ringed individual is of very low value for the study of population differentiation among migrants, their breeding origin or even of sex and age dimorphism. Despite the common belief a measurement of e.g. only wing-length certainly does not present adequate information on „the size of the bird". Different measurable bird size parameters including wing-length, feather-length, tail-length and body mass are sometimes not positively correlated (when birds of different origin are compared). These parameters change independently over the breeding range, so we may be confronted with e.g. long-winged and short-tailed birds at one station, and short-winged and long-tailed at another. At the same time, body mass depends very much on fat reserves of an individual and heavier (but fatty) birds may still have really lower lean body mass than other individuals, which were weighed when they were lean birds (see Chapters *Evaluation of the bird body mass...* and *Localisation of the breeding origin…* in Part II). Arrangement of measurements into carefully selected standard sets allows us to conduct much more detailed biometrical studies. These sets may be different in e.g. passerines and waders.

Recommended standard set of measurements for passerines contains: wing- and tail-length, wing formula, fat score and body mass. For standards applicable to waders see *Laboratory methods* in *The wader station* Chapter.

Standard descriptions of measurements

Note that the standard bird handling (described earlier) is assumed for all procedures recommended here. The ruler of 30 cm long and cut off at the zero-line is the standard tool for wing, wing-formula and tail measurements.

Within descriptions of alternative methods (see *APPENDIX I*) the manner of handling could be different and other types of rulers could be used.

Wing-length: Maximum chord measurement
A ruler with a stop can be used.

Technique

The folded wing, parallel to the body axis, rests on a ruler (Fig. I-28). The carpal joint of the wing is placed at the butt of the ruler (if the ruler has no stop, cut off at the zero-point, using the bulb of the second finger of the right hand). With the thumb of the same hand the wing is firmly but carefully pressed against the ruler; at the same time the thumb of the left hand straightens the primaries to their maximum length by smoothing the lateral curvature and applying slight lateral pressure towards the bird's body at the level of the primary coverts. The third and fourth fingers of the left hand control folding and straightening of the wing.

Precision of measurement – 1 mm.

The most common mistakes in measurement –

Wing-length underestimated:

– the wing not fully pressed to the ruler,

– the primaries not fully straightened.
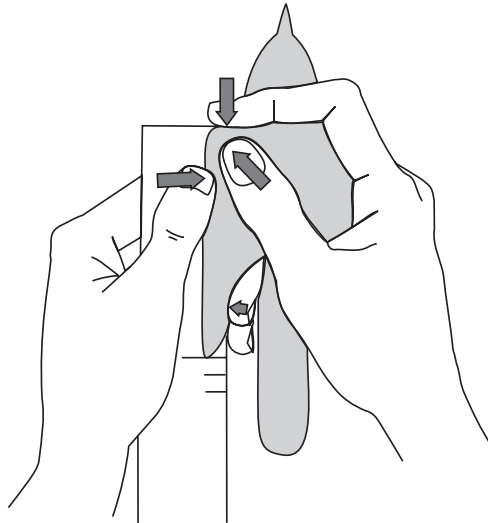
Fig. I-28. Standard measurement of the wing-length (explanations in the text).

Wing-length overestimated:
– the carpal joint not taken fully to the butt of the ruler (this is much more probable when the ruler with the stop is used).

Other techniques – see *APPENDIX I*.

Wing-formula measurement
(feather tips distances method)

The wing-formula includes measurements of distances from the wing point to the tips of the shorter primaries. The primaries from the second to the eighth (ascendantly[*]) are taken into consideration (Fig. I-29); for simplicity the first functional primary is always numbered as second, irrespective of its „evolutionary" number (even in families e.g. *Motacillidae, Fringillidae* etc., which have lost their first short primary).
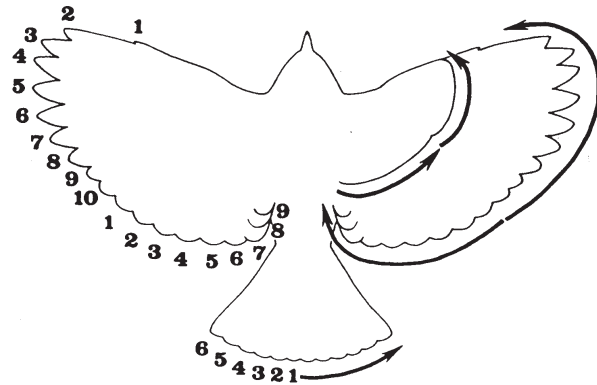
Fig. I-29. Ascendant numbering of primaries and rectrices. Typical moult directions are shown at the right side of the drawing.

Use of the ruler with the zero-stop is not convenient, though possible.

An example wing (Fig. I-30): the tip of the wing is formed by primaries 4th and 5th; 3rd primary tip is by 1 mm shorter than the wing-tip, 6th – 2 mm, 2nd is equal to the 7th and they are shorter by 6 mm, 8th is 9 mm shorter.

For recording purposes this formula would be spoken as: „four to fifth, zero-one, two, six-six, nine. The record in subsequent boxes of the form:

| 45 | 01 | 2 | 6 | 6 | 9 | |

„Zero" (in box 2) is written as an indicator for special processing.

Explanations of spoken recording:
1. in the first box – the numbers of the longest primaries are called out,
2. in the next boxes – distances (in full mm) between the tips of primaries and the tip of the wing.

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[*] Using descendant enumeration of primaries (as in moult studies) is much less convenient when talking about wing-formula
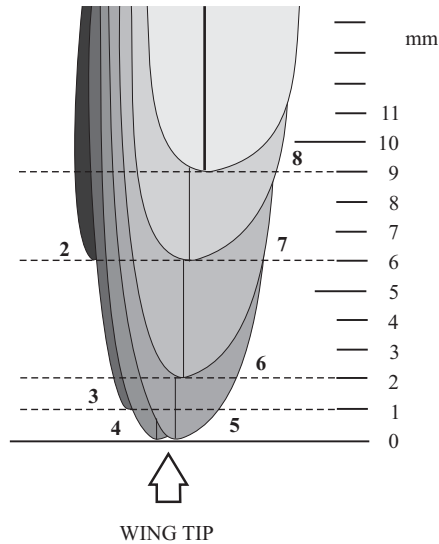
Fig. I-30. The wing-formula measurement (example used in the text). Note that this is NOT
an illustration of the technique of the measurement (see Fig. I-31).

(1) „fourth to fifth" indicates that primaries 4 and 5 form the tip of the wing (4=5). Other
    possibilities in this box: (A.) only one number (e.g. „third" – means that the tip of
    the wing is formed by one primary only (the third); (B.) two not consecutive num-
    bers (e.g. „fourth to sixth" means 4=5=6, „third to sixth" - 3=4=5=6).
(2) „zero-one" – the word „zero" indicates that the measurement given is of the distal
    primary (i.e. placed distally in relation to the longest ones; in this formula the „dis-
    tals" are the second and third primaries and the „proximals" – 6th, 7th and 8th; when
    the distal primary is equal with the proximal one the word „zero" is omitted (e.g.
    „six-six" – later in this formula).
(3) „two" and „nine" – the measurements of the proximal primaries.
    Note: if someone would like to measure all primaries – till the 10th – two boxes more
should be added into writing shown above.

Technique (Fig. I-31)
1. Before measuring spread and extend the left wing to check the state of the feathers for
   cleanliness, moult, loss or damage and to check that they follow in correct sequence;
   count the number(s) of the longest primary(ies) when the wing is closed.
2. Fix the closed wing in its natural position (as natural as possible), holding it almost
   parallel to the body axis (looking from the back side) by holding with the first and
   second fingers of the right hand near the carpal joint so that the primaries cannot
   change their position during the measurement procedure.
   This is the most difficult and critical part of the technique.
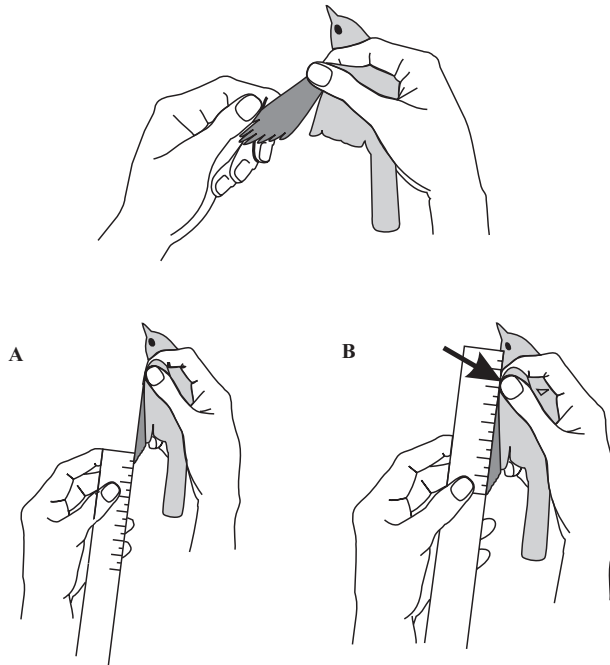
Fig. I-31. Technique of wing-formula measurement. Clearing the feathers sequence (above) and two variants (A and B – see text) are shown (below).

3. Measure the wing-formula with the methods *A* or *B* (see below). To measure the distal primaries move the hand with the bird in relation to the fixed ruler position.

A: the butt (the zero-end) of the ruler is placed at the tip of each primary sequentially from the wing tip. After each value has been recorded the ruler's end is moved to the next primary tip.

B: the tip of the wing is put at any centimetre-line of the ruler (convenient for the size of the bird) and the values are taken in the opposite direction from that normally used.

These two methods are equally good. Method *A* is convenient for rounded (e.g. Chiffchaff) or very long wings (e.g. Jay). Method B is better for pointed wings (e.g. Garden Warbler) and it is far quicker than the method *A*.

Precision of measurements – 1 mm.

The most common mistakes in measuring –

Mistakes mainly result from inaccurate handling of the bird:

– the head of the bird is pulled back between fingers,
– the wing is extended too much and not firmly fixed between the first and second fingers.

When method B is used the position of the wing tip on the ruler may change causing inaccurate measurements if the ruler is not fixed in relation to the hand holding the bird.

Comments to the other method – see ***APPENDIX I***.

Tail-length measurement

(„to the back" method[**] after Busse 1983, 1990)

Measurement of the tail with the pygostyl: a simple, very quick and safe method for the bird.

The ruler with the stop cannot be used.

Technique

The body of the bird is held vertically with the tail directed at *right angle* to the back (Fig. I-32). The ruler lies at the tail with the butt pressed firmly *to the back* (controlled with the fourth and the fifth finger under the belly). The rectrices should touch the ruler **along their whole length**. The longest tail feather measurement is read.
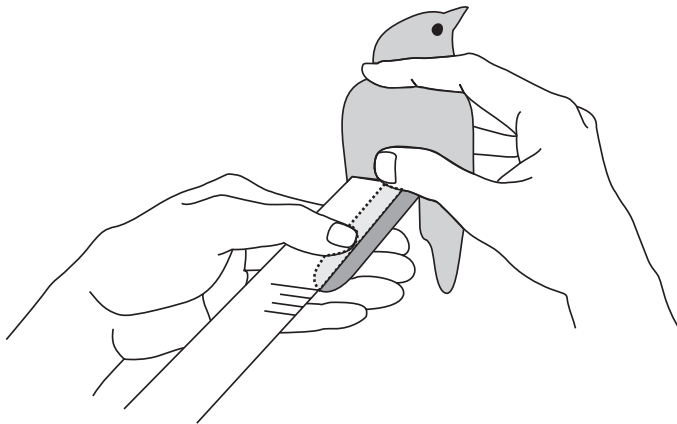
Fig. I-32. Technique of tail-length measurement (description in the text).

Proper measurements can be obtained only if bolded remarks in the description above are followed.

Precision of measurement – 1 mm.

The most common mistakes in measurement –

Tail-length underestimated:

– an acute angle made between the tail and the back (the bird body too close to the ruler),

– the ruler end not firmly located (the fourth and the fifth fingers do not press the belly),

– rectrices do not touch the ruler along their whole length (not pressed to the ruler by the fingers of the left hand),

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[**]   Note that a description of this method (and drawing) given in „*Identification Guide to European Passerines*" (Svensson 1992) is incorrect.

– false reading of some mm will result if the butt of the ruler is at the tip of the pygostyl instead of at the bird's back.

  Tail-length overestimated:

– an obtuse angle made between the tail and the back (the bird body too far from the ruler),

– the butt of the ruler touches the bird's back well above the pygostyl instead of laying on it.

  Other techniques – see **APPENDIX I**.

Fat determination

(after Busse 1983 and Kaiser 1993, combined)

  Determination of fat goes through three levels (Fig. I-33):

  Level I – belly

  Level II – furculum

  Level III – pectoral muscles

K e y   t o   f a t   d e t e r m i n a t i o n :

I. 1. Belly is without visible fat or with reddish traces only – **II A**

  2. Belly with infused bands of fat (intestinum is visible)...**T2**

  3. Belly has a fused cover of fat; intestinum is not but the liver is visible **T3**

  4. Belly is completely covered with fat, a very narrow band of the liver
     may be visible but, if this is so, the roll of fat is just above it – **II B**

II A. 1. Air -sack is visible within furculum (some fat may occur) **T0**

  2. All the interior of furculum is covered with fat **T1**

II B. 1. Fat in furculum flat or concave..**T4**

  2. Fat in furculum forms a convex cushion – **III**

III. 1. Sides of pectoral muscles without stripes of fat **T5**

  2. Sides of pectoral muscles with stripes of fat **T6**

  3. Pectoral muscles partly covered with fat **T7**

  4. Pectoral muscles completely covered with fat **T8**

  Note: In some species loss of fat does not follow exactly the same sequence in which it was attained, this results in problem with fat determination in some specimens. Anyhow, always **follow exactly** the key, as specific differences are covered by species-specific validation of the scale.

T e c h n i q u e

1. Lay the bird on its back on the palm (Fig. I-34); the neck should be between the second and third fingers of the hand; the second and the third fingers of the second hand should gently part the bird's legs; the proper position of bird is very important.

2. Blow the belly (Fig. I-34A) with a continuous stream of air and choose one of four possibilities under section I of the key; if the second or third subsection is chosen you have determined the fatness as *T2* or *T3* respectively.
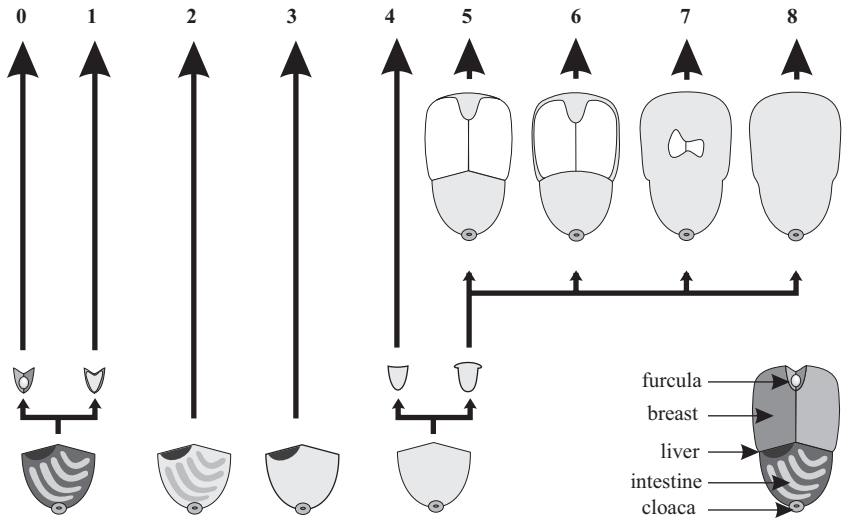
Fig. I-33. Fat scores (description in the fat-scoring key on p. 63).
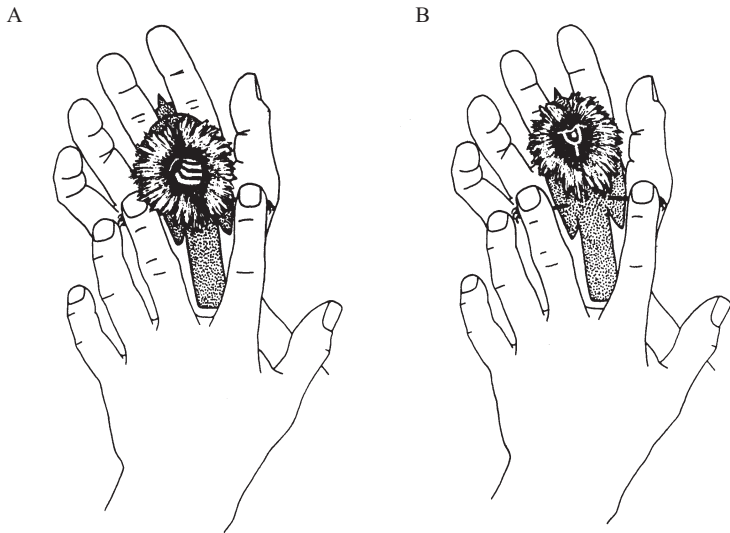
Fig. I-34. Technique of the fat scoring. A – blowing to the belly, B – blowing to the furcular depression.

3. If *II A* or *II B* are chosen, you must direct your blowing to the furculum (Fig. I-34B) and choose one of the two subsections under *II A* (fatness *T0* or *T1*) or *II B* (fatness *T4* or higher – *III*).
4. If your choice is *III*, look at pectoral muscles and choose fatness *T5 - T8*.

The most common mistakes

Mistakes are usually made when someone has a tendency to „liberal" interpretation of rules, e.g. when the bird has a thick cover of yellow fat on the belly but part of the intestinum visible; this should be *T2* but is classified as *T3* because it „looked like a fatty bird". Some mistakes are possible when the bird is not properly handled when the furculum contents are evaluated.

Note that the fatness of an individual bird properly determined twice at the same time may be different. This is because in border cases different tension of the bird's belly muscles at the moment of blowing may expose (or not expose) the intestinum or the liver from under the fat layer. Difference in determination cannot, however, exceed one degree of fatness.

Additional measurements and scores

Additional measurements and scores can be used optionally.

Feather-length of the third outermost primary
Description from „*Manual of Field Methods*" (Bairlein 1995):
„*Measuring feather-length takes little time and can be accurately done when the following instructions are observed (Figure* I-35*):*
Use a ruler with vertical pin of exactly 1.4 mm diameter (Figure I-14:3*).*

second outermost primary (F9)
third outermost primary (F8)
first outermost primary (F10)
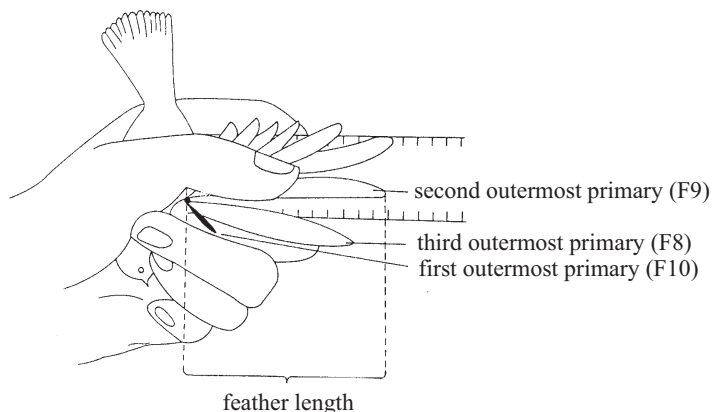
feather length

Fig. I-35. Technique of the feather-length measurement (after Vogelwarte Radolfzell, from Bairlein 1995).

The ruler has to be fixed onto a block of wood or onto the table and the bird has to be held with both hands. Do not hold the ruler free-hand. By using this method the inter-observer variance of the measurement is significantly reduced.

Hold the wing at the carpal joint between your thumb and index finger. Take the second outermost primary (F9) with the other hand and open the wing slightly and place the pin between 2nd and 3rd outermost primaries until it firmly touches the skin. This point is easily found and well defined.

The primary now has to be completely straightened by first bending it outward a little (to get maximum length). The length is read to the nearest 0.5 mm.

Make sure not to interfere with primary coverts, i.e. the primary covert should be on the same side of the pin as the corresponding primary.

Do not use excessive force, and be as cautious as possible to avoid any injuries."

Comments. The method presented, although it seems to be very exact, has a number of disadvantages. First of all, the measurement cannot be repeated on the same individual as the second and subsequent measurements are regularly 0.5 to 1 mm longer (fixed during calibration courses where trained ringers participated). This means that there is no possibility to control whether the newly trained person measures the bird correctly. Secondly, the pin diameter is many times too thick to measure the feather-length in small passerines (a distance between primaries at the level where they go out from the skin is around 0.2 mm). Thus, a wide possibility to use the excessive power to press the pin „until it firmly touches the skin" – when 1.4 mm thick pin is pressed into several times narrower fissure, the skin may be broken or at least slipped along the feather shaft. Subsequent, longer measurements show that this is not only theoretical speculation. Discussion of the method by Gosler *et al*. (1995) shows that it should not replace wing-length as a standard measurement.

Wing-shape measurement

The wing-shape measurement as described in „*Manual of Field Methods*":
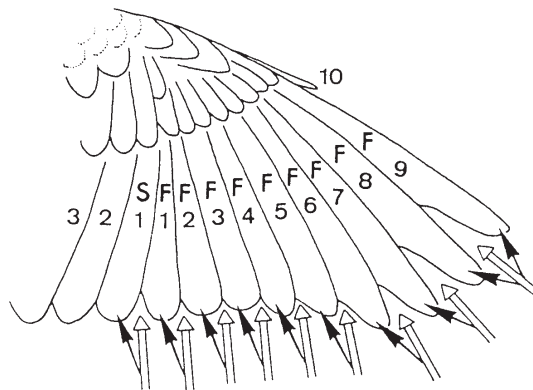
Fig. I-36. Idea of the wing-shape measuring (after Jenni and Winkler 1989, from Bairlein 1995).

„*To measure wing-shape, the length of each individual primary (except the outermost F10) and the first secondary is measured using the feather-length ruler and the method described above (feather-length measurement). With the exception of primary 9 (F9, the second outermost) which has to be measured with the pin inserted between F9 and F8, the pin has to be inserted on the „outer" side (distally) of each primary/secondary to be measured (Fig.* I-36*). For wing-shape read feather length to the nearest 0.5 mm.*

It does not matter how the ringer holds the bird and which wing is measured."

For more detailed description of the method see "feather-length".

Comments. Firstly, as stressed earlier and in the description above, this is not the wing-shape measurement but a set of ten independent measurements of ten bird feathers. This is easily done and the result, obviously, may be elaborated according to specific needs. However, the lengths of subsequent primaries do not describe the wing-shape, as they are located under different angles and in different places along the carpal part of the wing. So, the real wing-shape is derived from both lengths of subsequent feathers and from peculiar features in their distribution along the wing. Secondly, the measurement of the outer primary is taken from another side of the feather which means that it is not comparable with the other measurements: the primaries are located step-like along the wing so, the measurement „from below" is not equal to the measurement „from above" of the feather. Additionally, comments to the feather-length measurement should be applied here. Apart from that, this method is extremely time consuming, so in practice not useful in mass ringing.

Bill-length measurement

The usefulness of bill-length measurement differs very much in various groups of birds: this is a standard, very useful measurement in waders but of a very limited value in passerines. It can be done using callipers or dividers as shown at Figure I-37.
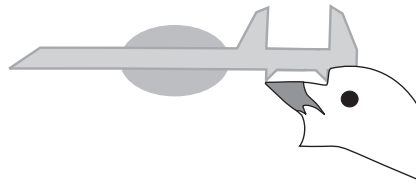
Fig. I-37. Measurement of bill-length to the skull in passerines.

Tarsus-length measurement

The usefulness of tarsus-length in biometrical studies also differs much – although it may be useful in wader studies, nobody has shown the same thing for migrating passerines.

In passerines two methods are used.

Measuring by means of dividers as given in „*The Ringer's Manual*" (Spencer 1972):
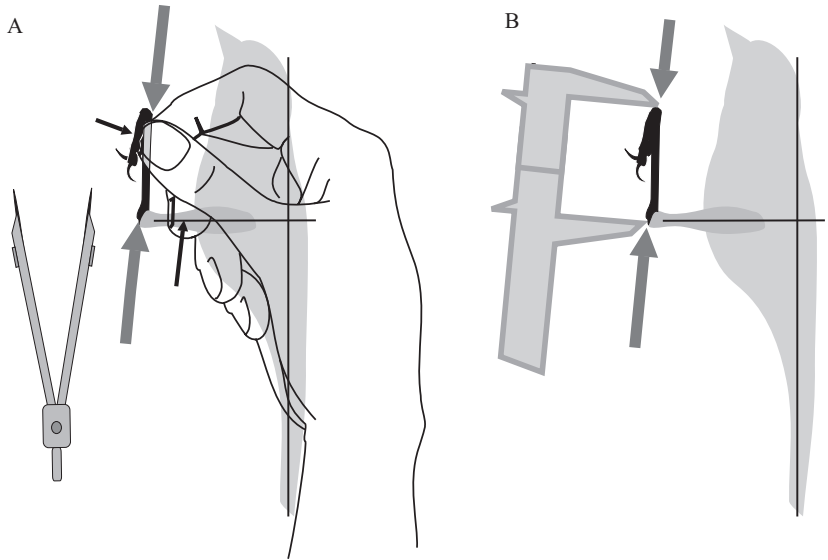
Fig. I-38. Two methods of the tarsus-length measurement. A – using dividers, B – using callipers.

„*The measure is taken from the depression in the angle of the inter-tarsal joint (the „knee") to the base of the last complete scale before the toes diverge (Fig.* I-38A *). It is the length of the tarso-metatarsal bone that is measured. It is recommended that the tarsus should normally be measured to the nearest 0.5 mm but to the nearest 1 mm in species with tarsi measuring 60 mm or longer.*"

Measuring using callipers is presented in „*Manual of Field Methods*" (Fig. I-38B):

„*The following instructions for measuring tarsus are for a right handed person. For a left handed person: reverse left and right hands. The position of the right leg of the bird will be somewhat different. Use easily running slide callipers, and be careful not to bend the tibiotarsus.*

1. Take the bird, lying on its back, in your left hand with the bird's head between your index finger and your middle finger.

2. Hold the right (meta)tarsus between thumb and index-finger, fold the toes backwards and also hold them between thumb and index-finger. For birds with a very short tarsus one should use the extreme tips of the fingers.

3. Position the tip of the middle finger behind the tibiotarsus, such that the tibiotarsus makes a right angle to the body and the metatarsus makes a right angle to the tibiotarsus …). This positioning greatly improves the within and between observer repeatability of the measurement.

4. Make the measurement from the notch on the metatarsus to the top of the bone above the folded toes (Fig. I-38B*), and read the callipers to 0.1 mm.*"

Muscle-score

Description after „*Manual of Field Methods*" (Fig. I-39):

„*Beside fat, which is the primary energy fuel for migrating birds, migrants also use muscle proteins in flight. The size of the breast muscle is a further valuable indicator to body condition of migrants. In birds whose flight muscles are not covered by fat the shape of the breast muscles can be easily recorded and scored. Muscle score is assessed visually and by sweeping the thumb over the sternum.*"

Score class 0:
 sternum sharp,
 muscles depressed

Score class 1:
 sternum easy to distinguish
  but not sharp,
 muscles neither depressed
  nor rounded

Score class 2:
 sternum yet distinguishable,
 muscles slightly rounded

Score class 3:
 sternum difficult to distinguish
  due to rounded (full) muscles
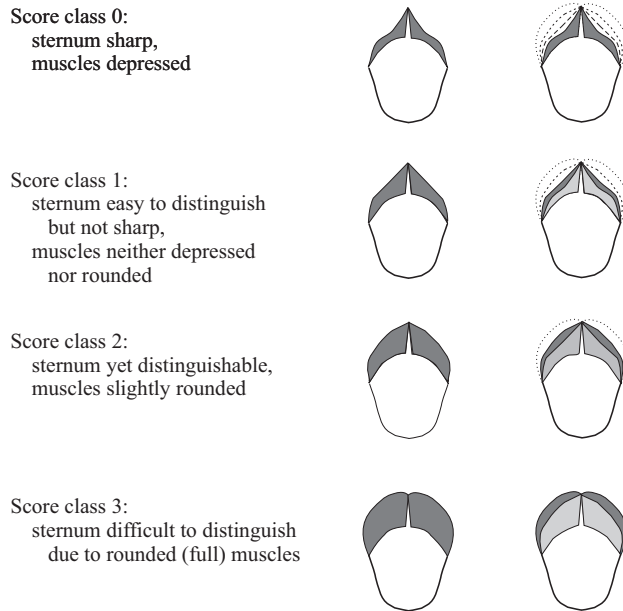
Fig. I-39. Muscle scoring (after G. Wallinger, from Bairlein 1995, modified).

Comments. It seems that this scoring is useful for the birds of low or very low fat reserves. In assessing the muscle-score one must remember that there are distinct specific differences as to breast muscle appearance – some species have nearly always a „good look" while others always have a „slim" appearance.

Training the beginners in measuring birds

Measurements are of value to science when they are compatible, i.e. do not depend on the individual characteristics of the person. That measurements are compatible does not imply that two persons present identical results for each bird measured independently by them – but it implies **statistical identity for a series of measurements** done by a number of persons measuring the same sample of birds. This situation is attainable when the standard techniques are carried out strictly according to the rules described. The system of instruction must guarantee correct interpretation of these standard

descriptions of techniques, ensure correct execution of measurements and crosscheck the results of this instruction.

   Measurers are trained step by step as follows:

1. The measurer reads the standard technique descriptions and the instructor explains them in order to cover any doubts that might ensue.

2. The instructor demonstrates the correct way of making measurements (slowly, with comments) and provides specimens showing typical fat deposit patterns. A small number of birds.

3. The measurer practises his fresh knowledge on a few specimens, under the control of the instructor. The goal is to attain measurements matching those of the instructor (he has measured the bird beforehand). Measure about 20 birds in this phase.

4. The measurer independently measures birds previously measured by the instructor. He compares these results to those already noted and corrects his errors. When more regular errors are perceived he should discuss his shortcomings with the instructor. (About 100 birds)

5. Initial checking:

a. the beginner measures a series of about 50 specimens independently and without recourse to comparative measurements. His results are noted separately on a training chart. This series should involve birds of comparable size. The optimal, full control involves birds of the Goldcrest, Great Tit and thrush size in order to detect possible size-dependent errors in measurements,

b. after completion of the series, the beginner's results are compared with the correct measurements and all deviations are noted using coloured numbers at the corner of every line on the chart where results differ. These deviations are summarised algebraically for every parameter separately and the mean deviations are calculated. Deviations of less than 0.2 are treated as a correct result,

c. if a greater mean deviation occurs, the instructor should carefully check the probable reasons for incorrect measurements, repeat stages 3 and 4 of the learning process and superintend until correct results have been achieved.

6. Final checking

   Following a positive initial check the beginner should measure some hundred birds alone and the checking, as under point 5, is repeated. It is worthwhile to check the beginner in the following season when his performance should have stabilized or individual divergences have emerged. The check is best performed if all the beginners of the research group can be compared with the „group-standard" or even the „country-standard" person.

Special studies

Directional preferences of nocturnal migrants

   The new method of studying directional preferences in nocturnal migrants includes a new field technique and pays special attention to the inconsistency of directional behaviour pattern in an individual bird. It may be used under real field circumstances, by

professionals as well as amateurs: the equipment is simple and cheap, the technique easy to learn in a standardized form. In addition the experiment routine allows collection of big amounts of data since tests may be performed in both night and day. Diurnal tests under an overcast sky have the same value as tests done with good sky visibility, which is not the case in nocturnal tests. Analysis of local vectors in a directional behaviour pattern seems to be of use in the studies on local migratory directions and the overall population composition of migrants (see Chapter *A field study of directional preferences …* in Part II).

The experimental stand. The place of experiments should be a flat area, top of a hill etc., without trees, wires, poles, that may be seen by a bird above the protecting screen.

The experimental routine. Tests can be done at any time, both night and day. There are meteorological limitations, however; tests should not be done with rainfall or snow nor with wet fog causing condense on the foil of the experimental cage. With wind force exceeding 5° Beaufort experiments are not recommended.

Caught birds can be tested immediately after catching and ringing or kept in not transparent bags or cages for at most two hours.

1. Preparation of the cage for the experiment (Fig. I-40) includes covering its vertical side wall with a stripe of a foil from a roll of width adjusted to the height of the cage (with an extra 2 cm for folding): fix the beginning of the stripe to one of vertical wires of the cage by transparent sticky tape, then cover the side of the cage with straightened foil, fixing its upper end, finally cut the stripe off the roll after connect the ends. The foil should be carefully handled to avoid making scratches, holes etc. which could subsequently be taken for the signs of bird activity. The cage may be prepared in advance, but longer storage of the cages in a moist air is not recommended as the sticky tape used to fix the foil may come loose.

2. Locate the experimental cage at the centre of the protecting screen with one of the wires directed to the North (indicated by a previously fixed pole outside of the screen,
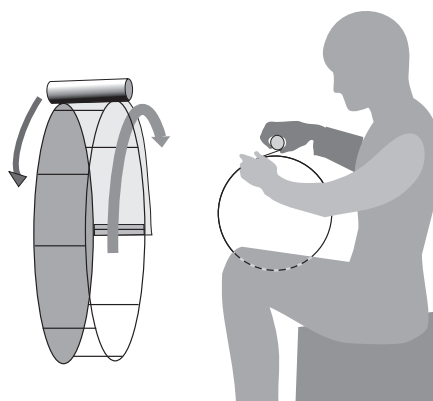
Fig. I-40. Putting-on the foil on orientation tests cage.

not visible to the bird). It is handy always to direct the wire where the foil stripe is fixed to the North; this protects against wrong identification of sectors when noting the results.

3. Transport the bird to the experimental stand in a not transparent bag or cage, remove it and put it into the experimental cage inside the screen protecting it from seeing land-marks. The direction from which the bird enters the cage does not seem to influence the results, but the custom of putting it from one side (e.g. always from the south) could be a rule. After entering the bird the observer should leave the place quickly, note the time (precision 1 minute) and after the agreed experiment time (10 minutes proposed as standard) quickly return and remove the bird from the cage. If the bird is earmarked for other experiments it must be caught by hand (which is not too easy and many escape). During the experiment time the bird should not be disturbed by sudden noises or things coming into visibility. When larger birds as thrushes are tested, the cage should be fixed to the ground to avoid that the cage is upset by their fluttering.

4. After the test the results of the experiment should be noted. Count signs of the bird ac-tivity sector by sector. Starting always from NNW direction is convenient when you handle the cage with its bottom side to your belly (Fig. I-41). Count the signs of acti-vity – holes and dots made by bill as well as holes and scratches made by claws of bird when it hopped against the foil. Sometimes these signs of different origin are not easy to separate, so counting them altogether is the best solution. The behaviour of the bird in a cage is to some extent species specific and in one species bill signs are more common, while claw marks are in majority in another. Some practice is needed, but individual differences between observers, if they do exist, concern the number of counted signs and not their distribution. Every counted sign must be instantly marked with colour marker to avoid double counts. It is a good custom to write numbers on the foil first and then rewrite them into the form. Note that, if you handle the cage as recommended above, the correct direction of writing into the form is the opposite

Fig. I-41. Counting the scratches on the foil.
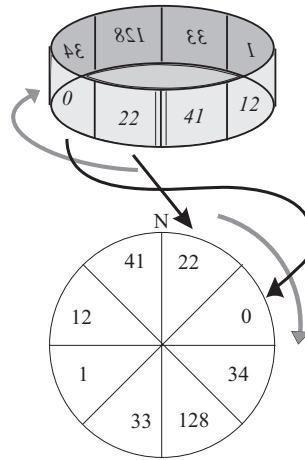
Fig. I-42. Noting the results of an orientation test.

Species		
Ring		
Status		
Sex/Age		
Fat-Weight		
Date-hour		
Experiment	from	to
Day/Night		
Sky		
Sun/Moon		
Wind dir.		
Wind force		

Fig. I-43. Orientation tests – the data form.

(Fig. I-42). Longer storage of cages before counting is not recommended because of a danger of unstuck or accidental damage of the foil. However, as it is easier and quicker to count the signs made by the bird in good light conditions, cages from the night experiments may at least be stored till next morning (if there are enough cages for all planned experiments). Used foils cannot be handled or stored after removing them from the cage.

5. Filling up the experiment form (Fig. I-43) includes the filling of a couple of boxes with information complementary to the main data: Species, Ring no, Status (A – freshly ringed, first test, B – next test...; R – retrap), Sex/age, Fatness (the fat-scale used is specified on p. 63), Date – hour of catching, Experiment time (from – to, given

as hour and minutes), Day/night (D, N), Sky visibility (0 – none, 1 - small: cloudiness 7 to 9, 2 – medium: 4 to 6, 3 – good: 0 to 3), Sun/Moon (S – the Sun, M – the Moon visible, „–" none of them), Wind direction (accuracy to 1/8 of the wind-star; 0 – no wind), Wind force (0 – no wind, 1 – 1° to 2° Beaufort, 2 – 3° to 4° B, 3 – over 4° B).

The existing input software is adapted to specified set of additional data.

After filling up the experiment form the foil is removed from the cage and the cage may be prepared for the next test. One single person working at one experiment stand may without problems handle six birds per hour (included: count of results and preparation of cages) if the experiment stand is not too far from the station. Working at two stands requires some help from a second person serving with the birds.

The study of moult

Moulting strategies and the timing of moult are highly dependent on population. Since various populations migrate over Europe and the Middle East records of moult in migrants offer many possibilities for interesting moult studies. One course of action is to collect moult data using „moult cards". The moult card design for passerines and its filling-up rules are presented below (Fig. I-44) after instructions of the Swiss Ornithological Institute:

„*This moult card shows both wings. For general use, fill in moult cards for every bird belonging to one of following categories:*

1. *In summer/autumn: All adults in moult and all adults having renewed part of the plumage; all first-year birds with growing or renewed secondaries or primaries.*

2. *In winter/spring: All birds in active moult of primaries, secondaries, tertials, rectrices or greater coverts; all birds after moult with renewed secondaries or primaries.*

If possible record all feathers, but data for restricted tracts only (e.g. primaries and secondaries) are welcome as well.

General information (first three lines) -

– *Sex/age*

– *Feather-length, weight, fat score: this is optional on ringing stations where this information is recorded in the ringing lists.*

– *Skull pneumatization: This is important additional information. Give either score or tick the appropriate box.*

Moult data -

Always fill in one side (wing and tail) completely. If time allows, complete both sides, especially if they are different or deviate from „normal" moult patterns. If you hold the bird with the head towards you, you might turn the moult card.

Write codes into the white feather boxes. Use horizontal lines to indicate that the same code applies for a series of feathers.

Give the approximate percentage of old, new and growing feathers for body feathers, marginal („lesser") and median coverts. If body feathers are composed of three generations, the additional column may be used (explanations in the comment section).

Fig. I-44. Moult card of the Swiss Ornithological Institute.

Codes: The aim is to assign each feather to the moult when it has been grown. Codes 0 - 5 are the same as those used in the BTO moult card.

0 – old

1 – feather missing or pin

2 – feather just emerging from sheath or up to 1/3 grown

3 – feather between 1/3 and 2/3 grown

4 – feather more than 2/3 grown, but still not full grown or with trace of sheath remaining at base

5 – renewed in summer/autumn in the breeding range (postbreeding/postjuvenile moult)

6 – renewed after autumn migration during (late autumn) winter/spring („prebreeding" moult)

7 – In winter/spring: older than 6, either 0 or 5. This code may be used in winter/spring for feathers which appear much older than 6, but for which it is uncertain whether they have been acquired during the postjuvenile/postbreeding moult or earlier; In summer/autumn: older than 0. This code may be used in late summer/autumn for feathers, which have been retained during the previous prebreeding moult (e.g. adult Muscicapa striata, Oriolus oriolus)

8 – older than 6, either 5 or „early 6". This code may be used in winter/spring for feathers which appear somewhat older than 6, but for which it is uncertain whether they have been acquired during the postbreeding/postjuvenile moult before autumn migration or during an early „prebreeding" moult in late autumn/winter

9 – impossible to assign"

Field ringing/data-collecting form

Field data collecting forms used in the station work are specially designed sheets bound into field-books which prevent from accidental loss or damage and allow easy handling of the contents both in the field and when later used for data input.

Note: It has been suggested that field data can be directly entered into laptop computers, but such a procedure is extremely unsafe because of high vulnerability to typing errors – everybody, even accidental helpers, is capable of writing numbers and text to the form in a correct way, while only well trained people can type quickly (and correctly!) on a keyboard.

The Network basic data form contains a space for main ringing data, standard set of measurements/scores and additional data fields for optional data collected at the particular station.

Filling-up the ringing field-book:

1. The cover page (Fig. I-45) -

– station symbol

– year

– season (spring - autumn)

– running number of the field-book

SE EUROPEAN BIRD MIGRATION NETWORK

Station	Year	Season	No.

RINGING

From: To:

Date		Date	
Hour		Hour	

Ring type	Ring numbers
	–
	–
	–
	–
	–
	–

Data input:

Fig. I-45. Bird ringing notebook – cover page.

CODE	Name	From (date, hour):	To (date, hour):

SPECIAL EVENTS affecting ringing (extremal weather conditions, loss of nets etc.)

Date	Details

Fig. I-46. Bird ringing notebook – front page.

Note: there are three field-books used simultaneously, numbered separately: two for the most commonly used ring sizes (types – see below) and the third – for all other ring types.
– date and hour of the first and last item noted

Date o	Hour		Ring (o)		Stat o	Net	Species code	Sex	Age x	Fat x	Special data		
	|	type	serie...	no.		|	|	|					

Fig. I-47. Bird ringing notebook – left and right pages.

– ring type and ring numbers (from – to) included into this field-book
– a box filled-up when data are already entered into the database (sign of the person who entered the data).
2. The front page (Fig. I-46) has a space for listing the ringers, with their codes written to the form and their periods of ringing - it is highly recommended to have only one responsible ringer at a time.

   Special events affecting ringing (as e.g. extreme weather conditions, loss of nets, low number of staff etc.) should be noted in the lower table on this page.
3. The main data sheet is spread into two neighbouring pages (Fig. I-47). Each individual set of data is written on one row, divided into columns containing the data in a sequence. The division is adjusted to the sequence of dictation from the ringer (see *Laboratory working routine* in this Chapter for details).

   The same sheet is used for both ringings and retraps/controls – this simplifies input of the data and saves time.

   Each column is characterized by one of three special proprieties, symbolized by a special character below the column head:
| – vertical strokes or lines are allowed when the content in subsequent rows is repeated. This speeds up the filling of columns containing data frequently repeated for many individuals: hour, net no., species code and sex,
o – vertical strokes are not needed in the column: Date is as default the same as at the beginning of the page unless part of a page is demarcated by a horizontal line and a new date is entered. Ring type and ring series are by default the same unless specified by new input. Ring no. must be filled for all individuals. Status is empty by default for all newly ringed birds. Ringer code is assumed to be the same for all pages unless the ringers change.
x – vertical strokes or lines are not allowed in the column – in some cases (Age, Fat) a stroke could be misread later as letter „*I*" or number „*1*" or when repetition of the same value is rather rare (Wing, Tail, Weight).

   Subsequent columns contain:
Date – formats allowed: e.g. *1.9, 1.09, 01.09* (Sept. 1st); it must be written at the beginning of every page and when the next date starts.
Hour – formats allowed: e.g. *6* or *06* (for a nets control at 6.00); full hours only.

Wing-formula (x)								Wing x	Tail x	Weight x	Rngr o	Comments o
(tip)						(8)	(10)					

Ring type – one or two letters or up to two digits when ring type is described by first number digits; when only one type of rings is noted within a sheet only the first box on the sheet should be filled; when more types – write the type when changed; at retraps and controls write the type in each case.

Series... – newly ringed bird: all digits of a number **except** last two; if only one type of rings – write only once at the beginning of a page; retraps and own controls: write full ring number here,

No. – newly ringed bird: **last two digits** of the ring number; retraps and own controls: leave **empty**.

Stat. (status) – leave empty for newly ringed bird,

R – retrap (a bird ringed within the same season),

C – control (a bird ringed elsewhere in the country or at the site during previous seasons),

V – foreign bird control;

D – bird dead but measured.

Net (optional) – net number (if appropriate) or net symbol (if special net type)

Species code – five or six letter code.

Sex – **M** (male), **F** (female) or **zoological signs** (♂, ♀); leave empty when not known.

Age – *J* (juvenile), *I* (immature), *A* (adult), *N* (not defined)... (see p. 56)

Fat – fat score *0 – 8* (see p. 63)

Special data – optional, according to the station needs.

Wing-formula – (tip) – numbers of primaries (ascendant) being the wing-tip, e.g. *3, 34* (3=4), *35* (3=4=5) etc.

– distances of subsequent primary tips in relation to the wing tip;

– for outer (distal) primary measurements add „*0*" (zero) at the beginning;

– when distal and proximal primaries are equal, write the same number in two subsequent boxes;

– (8) last box when standard (to the eight primary) method used.

Wing, **Tail** – write in full millimetres.

Weight – formats allowed: e.g. *16* or *16.0* when full gram.

Rngr – ringer code (once per a sheet when no changes).

Comments – plain text comments or the station free use (up to 40 characters)

LABORATORY WORKING ROUTINE

An optimal laboratory routine is essential for the collection of good and numerous data without danger to the birds. This routine should be parsimonious and at the same time as effective as possible. On one hand it should be flexible, on the other hand separate operations should be strictly standardized for compatibility reasons.

A few routine levels will be described:

1. normal routine where a standard set of data is collected,
2. extended routine where all planned additional data are collected,
3. reduced data collecting routine as a part of the „Alarm routine" when too many birds are caught to perform standard working procedures.

It must be stressed here that „normal" and „extended" routines may be differentiated according to the station preferences, based on its scientific scope of work and/or concentration on different groups of birds.

Depending on the number of birds waiting for treatment and the existing routine, the work performed at the laboratory may be organized according to one of two guidelines: (1) if the number of birds is low or moderate the working team is made up of two people, and (2) when birds are numerous – the team is made up of three people. The meaning of „numerous" is decided by the experience of the people involved and their training in the work as a team.

Note that it is very inefficient that one and the same person rings and at the same time enters data; this situation should be avoided as much as possible – it is very time-consuming and is the cause of many errors.

The laboratory routines are based on strict attendance to the rules earlier presented, particularly those in the *Net controls* and *How to arrange trapping with Heligoland traps* sections in this chapter. In short: the birds transported to the laboratory are hanged in bags on a row of hooks at the edge of the laboratory table (Fig. I-18) and they are sorted by species (only one species per bag and bags with the same species in a row) and by ring sizes (all species ringed with the same ring type should neighbour at hooks). The sequence of ring types should be permanently fixed in order to obtain the same working procedure, e.g. the smallest type always to the left of the row and subsequent sizes following to the right. The position of the bags is decided on by the present working team. The seats of the two persons taking part in the working procedure must be placed side by side, with the ringer seat to the left (right-handed persons assumed). The seat for a third person in the three-person working group should be located at the other side of the table so that the writer is able to hear dictation from both working persons. The most useful seat for the ringer is a soft, comfortable armchair (you sometimes spend quite a few hours when the birds rush) of such height, that his thighs are situated horizontally when he sits with knees close together and feet a little bit apart. This position will allow the ringer to put his ruler on the thighs while not using it for a moment between measurements. Seats for the other persons should be more elevated, in order to make writing on the field-form lying on the table comfortable enough. Sometimes, in the two

person procedure, it is preferable to have the field-form resting on a piece of plate situated on the thighs of the writer, while he sits in exactly the same position as the ringer – this is more comfortable when the birds are to be passed to the ringer.

Normal routine

Two person procedure:

Out of the two persons working in the team one is (as a basic rule – see below) pointed out as the ringer. He rings and takes all measurements, while the second person acts as writer noting dictated data in the field-form. In order to simplify noting the ringing/measuring procedure must be done in a strictly defined order, fixed according to the sequence of columns in the field-form. Strict standardization of the working procedure is very useful when many persons take part in the laboratory work, changing their roles in the bird processing or alternating between bird stations working within the network.

In normal procedure the ringer removes the bird from the bag (holding the bird in the standard manner) and starts with ringing. It is a good custom to start a new hour ringing with the same species which was the last input of the particular field-form, e.g. if the last bird ringed was a Robin – start with the Robins, if there are any (this saves time when entering the data into the computer file). If this rule causes any difficulties (we do not know in which bag the Robin is) – skip it.

Standard dictation goes as follows:

Hour – this is dictated only when birds from more than one control are waiting – otherwise Date and Hour is written by the writer without dictation and it is within his/her responsibility to make correct input,

Ring number and Status –

1. For a new bird, not yet ringed, the ringer dictates ring type and the two last digits of the ring number; if the ring is the first one on the ringing-sheet the writer calls for a full ring number and the ringer gives it; after that the writer must check whether the number given is a subsequent ring number – if not, the writer must stop the procedure and the problem must be solved (lack of a ring?, wrong sequence of rings? false ring type? new series? retrap or control?) – the writer is responsible for the correct ring number being noted. The first part of the ring number (ring number without last two digits) is written into the column „Series...”, the last two digits into column „no.”. Subsequent numbers in row are noted as only two last digits in the column „no.”
   Note: the ringed individual is then measured according to the established standard (see below).

2. A retrapped bird is reported by the ringer first as „retrap”, following that the full ring number with heading letters (ring type) is dictated. The writer notes type of the ring in the column „Type” and FULL number into column „Series...”; then he writes „*R*” into column „Status”.
   Note: retraps are not measured, but fat score and weight are noted.

3. Control – a bird ringed elsewhere with ring issued by the same ringing centre or ringed at the station in previous seasons – the ringer reports it first as „control" and dictates full number; then he asks the writer to read noted ring number and compares noted number with the ring. For controls, as for retraps, full ring number is written in the column „Series...". The status of such control is noted as „*C*".
   Note: Controls are measured according to newly ringed birds standard.

4. Foreign control – the ring number is noted in „Comments" at the end of the row following rules specified for controls (re-dictation; the ring number last column should be filled with sign „–"). Status is noted as „*V*".
   Note: Foreign controls are measured according to newly ringed birds standard.

5. There are a few sporadically used codes for the bird status:
   Z – ring changed, *A* – ring added are used exceptionally when existing ring is damaged or heavily worn (if it is possible to remove it without risk of injuring the bird– change the ring, if not – add another ring on the second leg). NEVER put the second ring on the same leg.
   D – individual dead before ringing.

   Species name – is coded as explained earlier – the ringer must dictate the code – not the bird name – unless the writer is a qualified ringer. If same as the previous individual, the bird name may be left out and the writer fills the name position with a vertical stroke. Note, however, that this is a slightly dangerous custom – the writer should be cautious and he should control the ringer; generally it is allowed only when the writer is well trained.

   Sex and age – dictate codes unless the writer is trained; sex should be dictated with words when scientific symbols are used in noting. Note – sex and age notations can be fixed after fat scoring (the ringer is able to see some sexing/ageing characters, e.g. sex of the Great Tit, when studying fat deposits) or after Wing-formula – in many cases opening the wing is needed both for age discrimination (e.g. contrast within greater coverts) and for starting wing-formula measurement.

   Fat scoring,
   Wing-formula,
   Wing-length,
   Tail-length,

   Weight – these are dictated according to rules specified in standard descriptions of methods. Such sequence is because a sequence of measurements, done with the same ruler, will save time. It was carefully optimised from the ergonomic point of view – the bird and the ruler moves are much limited (this is very important when the number of birds becomes high!).

   Ringer – ringer's code is written at the beginning of every sheet without dictation.

   This basic two-person procedure can be a little modified according to number of birds and experience of the writer:

(a) he can remove the bird from the bag or box and pass it to the ringer, or, if very well trained – ring it and pass it to the ringer, who becomes the measurer. This option requires remembering of some data and sometimes can lead to errors,

(b) he can be the person who reads the weighing result.

Applying a three-person and not standard version (a) of the two-person procedure requires quick and safe passing of the bird from hand to hand. Passing of the bird when both persons hold it by the standard holding method is quick, and the birds seldom escape (Fig. I-48): the bird holder catches the bird's bill with the left hand and gently pulls it – the birds neck becomes longer – and simultaneously the right hand turns the bird's body slightly and holds it with the tips of four fingers; the bird receiver creates a fissure between his index and middle fingers of his right hand and directs it to the bird holder. The bird's neck is placed between two fingers of the receiver. The receiver need not look at the passed bird and he closes fingers when he feels the bird's neck between them. The passing procedure should be trained in advance before there is need for it during a rush of birds.
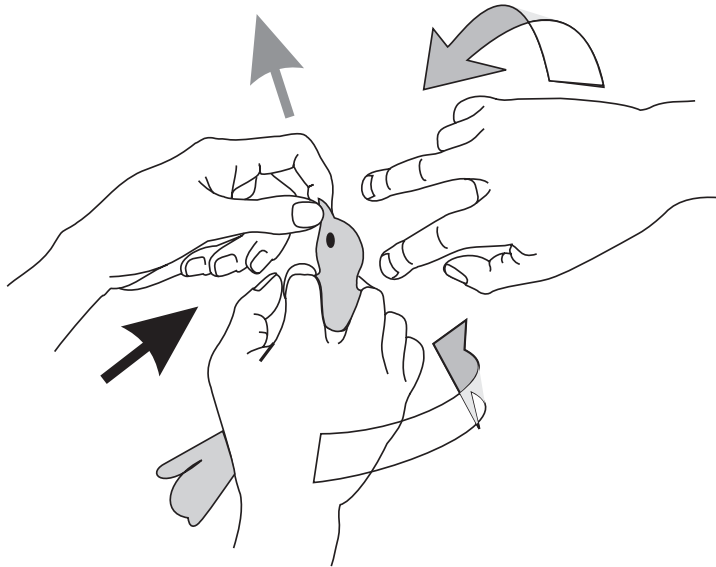
Fig. I-48. How to pass the bird quickly and safely.

Three-person procedure:

The number of birds that can be processed by a two-person team is limited, so if many birds are caught a three-person team is much more efficient. One person is the ringer, the second is the measurer and the third the writer. The course of the procedure is still the same, but two working persons process two birds simultaneously – the ringer removes the bird from the storing device (bag or box), rings it and performs sexing and ageing – the next person does all measurements. Both working persons – the ringer and the measurer – dictate data one by one (not simultaneously – this is the crucial point to be well synchronized!) and the writer must write the data correctly filling two rows in the field-sheet. The best possible synchronization is reached by dictating the next bird dur-

ing the weighing process, which is the slowest element in the procedure. The writer's role is difficult but still possible to perform when he is well trained. It is important to have silence in the laboratory – if silence is a possible state when hundred tits are waiting for ringing! In reality the silence means „no one talks around". A well-trained team is able to process the bird, on average, within 20-25 seconds – taking all standard measurements using recommended methods and strictly following recommended routines.

Extended routines

Contrary to the normal procedures, where a high level of standardization must be observed, there are some possible arrangements of different extended routines. They depend on the set of data collected and the preferences given to the studies performed. The choice is most free when the number of birds is limited and there is enough time to work slowly. Most problems arise when the number of birds rises and there is competition for time between different studies performed. This will be discussed in the *Alarm routine* chapter. In all cases, however, the routine applied should be defined in relation to the standard working routine.

When the additional data collected are few the problem is rather simple and additions may easily be incorporated into the normal routine. Additional measurements/scores may be taken after sex/age discrimination (or fat scoring – if applicable) and wing-formula measurement – in the field-form there are optional fields located for additional data. Another reason for making additional measurements all together is that that they are usually done by means of special tools – not the standard ruler. Sometimes, however, they can be done at the end of the standard procedure. This is usually the case when they are really treated as data of secondary importance and they may be abandoned with no grief.

When the non-standard data collection is more time-consuming and the study is regarded as important it is advisable to do them separately after the standard procedure has been performed on all birds caught at the control walk. This rule should be applied particularly to moult studies, examination for parasites, blood-sampling etc. Orientation experiments can be done parallel to the ringing, since one special person usually works with experimental birds – he may start just when the first individual of the species studied has been handled in the normal procedure. Individuals selected for special treatment should be put singly into the bags (they will wait a while for the further examination) and then hang separately from other birds.

Alarm routine

Occasionally, a very large number of birds is caught at the station, and this possibility must be taken into consideration before it occurs. It is important that the chief ringer as well as all helpers are psychologically prepared to this extreme stress situation. People not prepared for a sudden rush of birds (migration peaks are always sudden!) frequently lose their mind and may do totally irrational things.

First of all constant maintenance of the rules for normal procedure mentioned in earlier chapters is recommended. All elements stressed there combine to successful solutions of problems caused by an extreme bird rush. Here the most important advices are summarised:

1. The net round should be as simple as possible and cleared so that workers are able to run along it without colliding with twigs, strings and stumbling on laying branches, stones etc.; passages under the nets and strings should be avoided.

2. The nets should be of a kind allowing quick removal of birds - any nets with very thin thread should be taken out of use when mass trapping is expected; specially designed nets which must be closed or slipped along poles when the birds are removed should not be used at all or opened only when one is sure that there is no rush of birds - if the rush comes suddenly such nets should be immediately closed.

   The nets must be clean of leaves, twigs etc. and not caught on trees and bushes.

3. The equipment should always be ready for use – the number of dry bags adequate, boxes or baskets are necessary; it is a good custom to have a special reserve of fresh, not used before, bags in readiness for a special situation like a rush of birds, particularly in wet weather. Sometimes many birds are caught on evening controls, then a good source of light should be available.

4. There should always be enough rings of all sizes – opened and ready to use, particularly the ring sizes most commonly used; it is better to have a surplus of a thousand rings than a hundred too few – having to open rings when the stock is exhausted means a total disorganisation of the work.

5. The staff must be trained in the correct removal of birds from nets, in selection by species, and in hanging bird bags on proper places in the laboratory. Furthermore they should be trained in how to pass birds from hand to hand and how to register data in the field-forms on days with a limited supply of birds. Individual aversions to drill and dull, standardized work should be overcome, people must be carefully trained and motivated to useful routines so that they can „save the birds from death" when a rush occurs. NOTE: the „real" rush with several hundred birds at one single control is hardly imaginable to people who start their practice at the station when twenty birds are caught per day!

6. At the outset of the control walk, particularly the first one in the morning, always bring many more bags than probably needed – on a peak day the actual need may be ten times (or more than that) higher than on a normal day. Lack of bags may seriously disturb the rhythm of controls and has been the cause of birds' death (when too many birds are put together because the helper doesn't want to return for more bags) in more than one case, therefore it is a good custom to assess the number of birds in the first nets and estimate whether there could be a coming rush already at the outset of the control walk. If there seems to be a need for more bags, return quickly to the station and warn the chief-ringer about such a prospect; sometimes the expectation may turn out to be unfounded, in other cases it will save birds' lives and the ringer from the stress connected with a collapse of routines and a load of responsibility for the birds. Also keep in mind that the staff will be grateful for smooth work and smooth routines;

at the beginning of a day, where the ringer gets notice of an approaching rush, he should immediately wake up all personnel and order who will be a writer and who will go where.

7. Remove the birds by species from the nets when there are many birds of two or more species (the bag should not be closed after each bird – see „*How to free a bird...*" – p. 45); strictly follow the rules restricting the number of birds in a bag and their transportation. The decision whether to put the birds into boxes or baskets is taken by the chief-ringer – he decides which species should be stored in such a manner and which storing devices that are going to be used. Do not mix birds from two controls – it must be absolutely clear which birds were collected simultaneously.

8. In most cases the net control is done by one person or by two going together for training or simply for social reasons. When a rush occurs there are two options when two persons work on the same control path:

(1) many birds are known to be waiting for removal and the staff is numerous enough to allow two persons to work together on one control path. They walk together following the normal course of the control (a fixed direction of walk); remove different species when working together at one net or work on two sides of the net when birds have been caught from both sides,

(2) one single person went for the control walk and did not return within the expected time. In such cases the second person sent by the chief-ringer must go in the opposite direction, and when he runs across the first one the two together should return to the laboratory without removing new birds from the nets that are passed for the second time!

9. Keep the time schedule of the control walks! Keeping the time schedule during a peak of catching means being no more than fifteen minutes late. Remember that birds staying in the nets for a longer time get more entangled and, so, make removing slower.

10. Work with the three-person or at least the two-person procedure at the laboratory; one-man-work is highly inefficient. There may be a gain of momentum if the ringer assists in removing birds at the first control walk and then returns with a helper to work in the laboratory as a two-person team – since there are enough birds for continuous work, and handling speed is a key factor on peak days. He must then stick to the laboratory with one or two helpers, according to the procedure, because if the whole staff concentrates exclusively on removing birds not before long bags and other storing devices will be full of birds waiting for treatment. People working in the laboratory should be asked for silence – only necessary directions and information should be received by the working team – any additional voices disturb the rhythm of dictation and can lead to repetition of measurements and errors in writing.

There is no single formula for winning the battle with hordes of birds in such a way, that all requirements of this strategic game will be fulfilled – the birds fly to their migration goal ringed and measured while you and your staff will be still alive and happy because of a good work done.

Finally: all people must be psychologically prepared to make a maximum effort at any position, as ringer, writer or helper. The most important thing when a rush occurs is

that the chief-ringer does not panic; this usually leads to unwise decisions, resulting in avoidable deaths of birds or at least unnecessary losses of data, while peak day data could be of a great scientific value.

There are a few general observations, which could be helpful when it comes to evaluating a „rush" situation:

(1) in practice a really huge rush of birds seldom lasts more than three to five hours, so at the moment when you are close to desperate decisions – this stage is usually reached during the third hour of the rush – you are also close to a report from the helpers „we have ten birds from the last control walk". The timing of peaks differs a little and is both species and site dependent, e.g. at Mierzeja Wislana – thrushes: only at first control walk, the Robin: the first two walks, tits: mostly the three – four first hours (sometimes later in the day, but for a shorter time), the Goldcrest – three to four hours, but starting from the second control walk etc. But on a grey and misty October day Goldcrests may also move about till dusk; this means 12 hours of uninterrupted ringing by exhausted staff! The possibility of *reversed* migration in the afternoon should always be kept in the corner of the chief ringer's eye. An outbreak of starving Siskins will last from dawn till dusk, and spring arrivals of Chaffinches, Robins and Goldcrests on islands in the Baltic and Kattegat may last till well in the afternoon; a number of *ringing catastrophes* are known to have occurred under such conditions. It is recommendable to have a look at earlier catching files of the station in order to learn the patterns of different species.

(2) dead birds are inevitably connected with the level of catch – when more birds are caught the theory of probability tells us that there will be more dead birds. In addition the probability for unavoidable deaths (due to predation, strangulation, exhaustion) is higher on peak days than on quiet days, when few individuals are caught; the total catching mortality is a weighed sum of these probabilities and it never equals zero; on a peak day accidental losses, like a couple of dead birds in a bag, caused by e.g. instinctive stronger hold of a bag full of birds falling down from the bag hanger, are much more probable. Such singular losses, however, are a far way from the real ringing catastrophe.

The chief-ringer is the only decision-maker at the station unless there is another well-qualified ringer to whom the chief-ringer could pass responsibility to decide on duties of the staff members. The decision-maker must be well informed about what is going on in the field – how many birds there are from the current control, if the birds are very active etc. Apart from decisions concerning the organization of work the chief-ringer must take some other key decisions alone, and these depend on his appraisal of the staff's abilities to cope with the expected number of birds (taking into consideration the expected time distribution of other potentially occurring species, see above). A few standard emergency decisions will be given here in order of importance:

1. close special nets that are time-consuming when active. If these nets are not designed for a special study, the decision should be automatic when a rush of birds is observed,

2. stop any additional data collecting. This should be done as soon as it is obvious that the day is a peak day – unless the data have a very high priority within the station programme. In such a case the following decision (3) could come first,

3. inhibit the taking of standard measurements. It is very important and must be emphasized: stop **all** standard measurements at once, not in a few steps; only ringing and sexing/ageing should be continued; this is a key decision for the data collection and it should be undertaken in a situation when there is real danger to the birds (but not because we are hungry and tired!): (1) the birds become weak because of poor physiological condition – low fat reserves caused by a long flight and/or bad weather. (Some exhausted birds are always observed during intensive migration and they are selected both by catching stress and natural migration risk – a really dangerous situation occurs when ringed and released birds do not fly away but stay around the ringer – most of them after a short rest go farther, but some die – the key species is always the species in the worst condition.) (2) the ringer estimates that he is not able to ring all waiting birds within a reasonable time even if the birds seem to be in sufficiently good condition; (3) the birds are wet and it is dangerous to have them stored in bags; and (4) there is lack of bags and storing devices which may cause disturbance in the rhythm of control walks,

Time limits for storing caught birds

Average fat score	T0	T1	T2+
Time limit*	2 h	3 h	4 h

* counting from the nominal hour of the control of nets (e. g. birds from the control at 6.00 and scored as T1 should be free till 9.00)

4. when the weather is favourable and there is a group of nets with much lower catching ability at the end of the control path, it is possible to have them checked only every two hours (this is an exception and the decision should be based on a good knowledge of local catching distribution. The rush in itself may mean new conditions at these nets!),

5. the most difficult decision is to close the nets – this always means an interruption of the seasonal dynamics of the station and a vacant space in its monitoring data; in addition, the proper closing of nets takes time that could be spent on removing birds from other nets – these birds will have to wait longer and hence become more entangled.

Every emergency decision should be cancelled as soon as the chief-ringer estimates that the situation is no longer dangerous: the number of birds waiting is low enough, the individuals are in good condition and the rush is over. It must be remembered that when the standard set of measurements is started anew, the set should be complete.

When the rush is over – no earlier – the staff may quietly have its lunch (for breakfast it is too late), clean the laboratory (there is usually a mess of lost feathers, excrement, dirty bags and boxes) and ... start to open rings for the next day – peak days often come in a sequence at many sites. During such circumstances it may be worthwhile to wake up people earlier than normal and let them have breakfast prior to the first control walk.

THE WADER STATION

At the wader ringing station birds are usually caught in walk-in traps or in mist-nets. In addition cannon nets or rocket nets may be used under favourable circumstances. The methodics of work with traps and nets is completely different from each other. Mist-nets may be used parallel to walk-in traps, particularly after dusk when waders usually do not walk into the traps.

Considering the frequent need for redistribution of the traps and the high dependence of catching numbers on external factors, the number of birds caught during the day in traps or mist-nets should not and can not be used to illustrate migration dynamics or monitor population numbers. For these purposes every-day counts of waders resting and foraging in the surroundings of the station are recommended.

DIFFERENT CATCHING TECHNIQUES

Walk-in traps are selective catching devices and their use produces some biases. They are less effective for long-legged species (however, the earliest recommended models were quite effective in catching large waders). In addition waders with a visual foraging technique (e.g. *Charadriidae*) are not as easy to catch as tactile feeders. Thus, the species structure of birds trapped does not reflect the structure obtained from counts. Furthermore, juveniles are more likely to be trapped than adults. The same problems were reported when mist-nets or cannon-nets were used at the ringing station.

Walk-in traps

Walk-in traps are very convenient in use and safer for waders than mist-nets. Moreover, catching in walk-in traps is almost independent of weather conditions, except those influencing the water level. It is worth noticing, that this kind of trap could be used also for catching Wagtails, Pipits, Rallids and dabbling ducks. Walk-in traps could be placed in different habitats, e.g. on sandy seashore, at small, shallow muddy bays, sewage farms, wet meadows. They differ in shape, dimensions, localization of capture chamber, types of entrance and material used for their construction (wire netting or thick fish netting). A variety of different types is shown in the book of Bub (1991). Based on Water-bird Research Group KULING's experience we recommend two types of walk-in traps (Fig. I-49). The first one has the capture chamber located at one side and is described as safe, limiting the mortality of trapped birds. The second one has its capture chamber placed in the middle. This type has been used in Poland since the sixties. Both traps are lightweight and can be carried by one person. They are made of wire frames and a cover
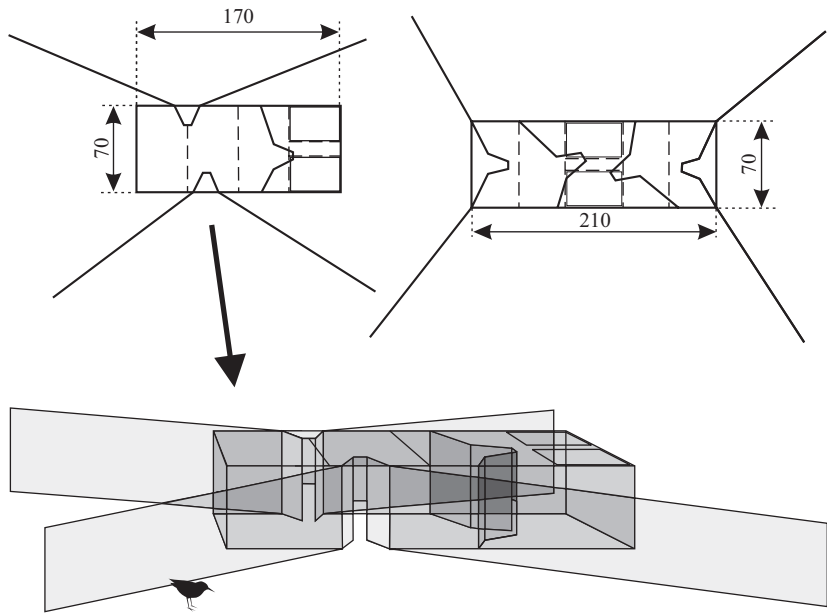
Fig. I-49. Funnel traps for waders. Measurements in centimetres.

of thick fishing net (thread no less than 1 mm thick, mesh 18 - 19 mm). Fish netting is less durable than wire netting with a protective zinc surface, but the latter causes more injuries and plumage damages in trapped waders – particularly to Snipes when they run their heads against the roof while fluttering inside the trap. Frames are connected with pieces of wire, but different fixing methods could be applied (welding is the best). Both models may be produced in folded (this is the rule in Poland) and unfolded versions. In unfolded version less wire is needed, but this model is less convenient for transporting and storing. Moreover, when the net is damaged at some point, it is easier and quicker to exchange one frame from the folded version trap than to take the whole trap from the catching place for repairing. All frames should be made of stainless wire, preferably zinc-plated. It makes them last longer, especially in marine habitats. Unprotected wire of 5 mm diameter rusts completely after 3-4 years of use.

The total height of a trap should not exceed 40 cm; such a trap will catch a wide spectrum of species (up to Oystercatcher size). Higher traps (e.g. 50 cm high) seem to frighten off smaller wader species, but they are quite effective in trapping the larger ones.

The form of the entrance is essential for good function (Fig. I-50). In our opinion a funnel-shaped entrance with proper „depth" is better than the „curved-wall" type, because fewer trapped waders manage to escape from such traps. „Funnels" should not be placed in front of one another; the first entrance will lead the bird directly to the „exit" so that a bird once caught easily escape from the trap.

Another important part of the trap is a „fence" that leads the foraging birds to the funnel. It is convenient to have fences fixed to the trap, because it makes redistribution of the traps easier and quicker. Other options are to have fences with additional „legs" to
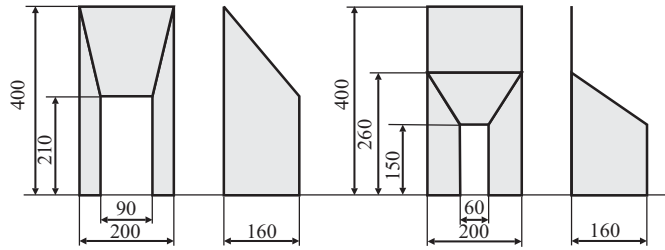
Fig. I-50. Funnels for funnel traps (see Fig. I-49). Measurements in millimetres.

put into the ground (Fig. I-51). The fence is the most susceptible part of the trap, particularly in marine habitats. Thus it may be useful to have some spare fence stored at the ringing station.

The other type of walk-in trap (the so called tent-like type) is quite effective, and when folded could be carried even in one's pocket. Traps of this kind are made of fishing-net and thick rope, and frequently erected along the edges of small pools. The tent-like type may prove inconvenient in cases where it is necessary to move the trap often from one place to another (Fig. I-52). Therefore, it may be used in places with stable water level.
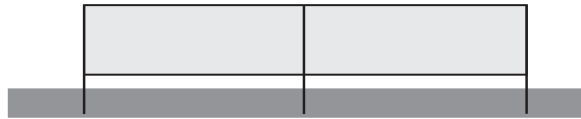
Fig. I-51. Guiding fence for funnel traps.
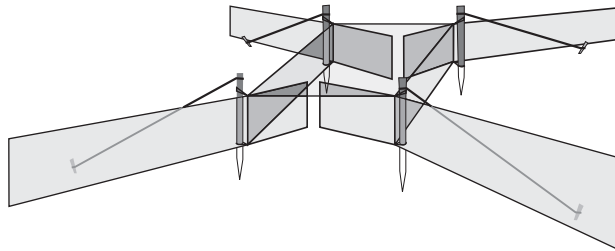
Fig. I-52. Soft netting („tent-like") funnel trap.

Mist-nets

A standard wader-net with 30 mm mesh, three shelf, 110d/2 ply, 9 or 12 m long will catch most wader, duck and tern species. The net must be double tethered, say, one knot in every 50 cm. Longer nets are not practicable because of the wet surroundings; they will hang in „bridge curves" as soon as there is a change in atmospheric humidity. Poles

should preferably be of aluminium, painted black, nets should be erected with maximum tension and set so high over water (if there is water) that, say, 10 % of all birds fly below the lowest shelf. These nets cut, and birds should not be allowed to hang for long, nor should they hang when there is a wind stronger than 5 m/s. Larger species (Whimbrel, Curlew, Oystercatcher, even Godwits) get very entangled in a short time; they should preferably be *cut free* by means of a pair of scissors. (It may suffice to cut one or two threads, creating a hole, through which the bird is freed). This gives the satisfaction of perfect condition in the birds handled, there is no excuse for ringer sloppiness in these matters. Count the holes made and repair the same number + 1 when at home; wader-nets are easy to repair! (Use polyester sewing-thread – not cotton! – if there is no original thread at hand).

Background is essential to all mist-netting, particularly so when birds are caught more or less in the open. When waders or small ducks (Teal, Wigeon) are caught in marshland, useful background may be obtained in a simple way: by cutting out small „glades" , at most 25x25 m in bogs, rush beds (*Carex*, *Scirpus*) etc. Geometrical arrange-ment of the nets, e.g. four nets on four poles in a square, is to be recommended. The birds are forced to enter such apertures in a homogenous surrounding slightly from above, this may give the necessary background for catching even in broad daylight, particularly if there is a surface of blackish mud or soil. Banks of seaweed may serve the same purpose; Dunlins descending in the early morning are quite catchable with wader nets for 3 – 4 daylight hours in this manner.

Where the background is poor there are still two ways of getting close to waders: by erecting nets over guiding lines (particularly the waterline, what the Germans call the „Spülsaum") or by exploiting local crowdings (caused by congregations of prey or by high water levels). The odds are against substantial catches in the daytime, but this tech-nique will yield tenfold or hundredfold when applied in darkness, and particularly so if a tape lure (better: several tape lures playing different species) is added. In the wind flats of Southern Scania there is only sand and water as far as you can see where nets are erected, a total void with no background whatsoever – and the „job" is done by the tape recorder. Still, if there is a change in water levels, nets will have to be moved; an opti-mum catch is achieved by the combination of tape lure with strong sound volume and correct setting of nets. When waders are caught alongside the waterline *one single net* set (or two nets, one across the waterline, one in the water) perpendicular to this border will suffice (other nets will not catch), but when they enter a seaweed bank from the seaside a row of nets (with one tape recorder attached to each pole) parallel to the water-line will be the best arrangement.

In recent years this technique has turned out to work well with the Common, Arctic, Little and – in particular – Sandwich Terns as well. Moonlight is of no great disadvan-tage if the site contains many birds, the sound volume is crucial; the sound should, if pos-sible, carry one kilometre. Use rechargeable Ni-Cd batteries for recorders and lights, or better: solder leak-proof 9 V or 12 V lead cells to the battery sockets.

LABORATORY EQUIPMENT

Wader transport and storing devices

In the case of waders, bags should not be used to carry the birds. This is particularly important for larger species (e.g. Bar-tailed Godwit, Whimbrel, and Greenshank), which are sensitive to detainment. For carrying waders special containers or wicker baskets of the dimensions: length 50-80 cm, width 30-40 cm, height 40 cm, should be used. The walls of such container must be airy, the floor hard and the „roof" covered with water-proof material (this prevents the birds from getting wet in rainy weather). The flooring should be cleaned from time to time, so it is handy if it can be removed. Such container can be e.g. a metal frame covered with fabric, with the removable floor made of plywood or plastic. Birds are removed through the entrance; this must be fastened and large enough to bring out even the larger wader species without any problems. If wicker (or plastic) boxes are used for carrying birds one should remember that their tangle should be very thick (holes no larger than 1 mm). If holes are wider waders may thrust their bills or toes into the holes, which may end up with a fracture or with the leg being sprained.

When the container is carried, it must not be shaken or waved. For that reason, holding the basket firmly in one hand is better than hanging it on the arm. Different species may be carried together, but the containers must not be overcrowded. The birds must have ample free space in the box.

For storage of waders (when there is a „ringing queue") the same containers used for carrying are usually adequate. At the station at least one larger container should be provided (where the birds may be put if numbers are very large) and no less than 5-6 carrying baskets.

Ringing tools

In most cases waders are ringed with steel rings and therefore a set of special pliers for clenching rings should be available at the station. The most convenient arrangement is to have separate pliers for each ring-size with the hole for the ring placed close to the gripping arm. The shape of the hole should be slightly elliptical (Fig. I-14: 8), this will slightly flatten the ring when it is clenched. It is important that the pliers open and close easily and have a right profile to clench the ring properly in only two moves: the first – closing a chink of the ring and the second - giving the right shape to the ring after turning it for 90° and final closing the chink. The use of improperly profiled pliers may prolong the handling time twofold!

For measurements callipers (clock or digital ones are recommended) and a ruler with a stop are used.

ARRANGEMENT OF THE CATCHING AREA

The method of setting traps depends on many elements of the habitats in which they are used, first of all on the presence of a clear boundary between water and land. The

traps should be set only where birds forage, while resting-places are no good for catching. At the shore of a pond, a lake or the open sea traps should not be set in direct contact with the water, but rather placed a bit „inland" while the fence prevents the birds from passing them on the water side. If the shore bank is wide, the setting of a second trap or additional fences on the landside will remarkably increase the catching efficiency (Fig. I-53). In places where there is no clear demarcation between the water body and more or less dry land (mud, wet meadow) traps not linked with each other will not be very effective. In such cases a line of several traps with extra long fences will give the best results. A V-shape arrangement like on the water pond bank as well as a single line of fences starting from the inside of the entrance may be used.
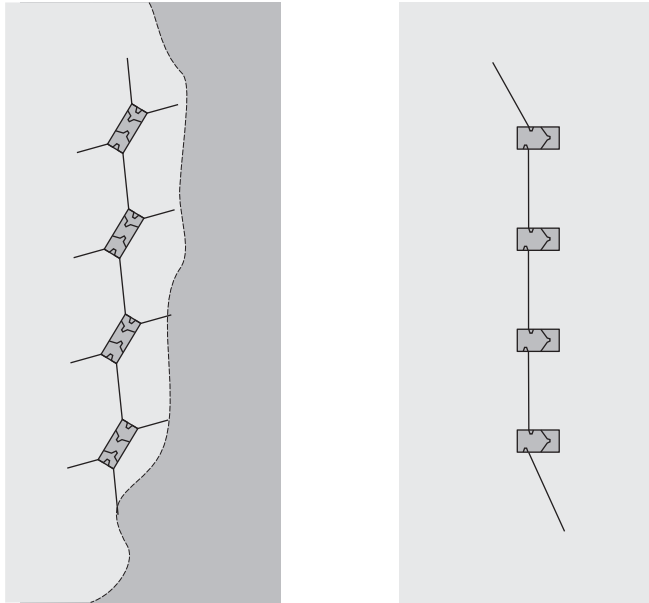
Fig. I-53. Arrangement of the catching area with funnel traps.

It is important for the safety of trapped birds that the capture chamber is set in a dry place, else some sand or cutgrass may be put in it. In this way birds trapped will be dry even when the traps are placed in mud or on a wet meadow. Lightweight walk-in traps may be settled on floating beds of seaweed or other water plants as well, but there is a risk that they will sink within a few hours. In such cases wood poles should be placed under the trap along or perpendicular to its longer walls.

MAINTENANCE OF THE TRAPS

When pieces of water plants or soft mud float in the water, the trap becomes caked with them very quickly. „Dirty" traps are less effective and should be cleaned to make

their walls transparent. This is very laborious; sometimes it takes an hour to clean them. In such a case, it is better to remove such a trap from the catching area. If there are many dirty traps it is better to limit the catching and have a cleaning session with the cages. This will disturb the rhythm of controls and lower the number of birds caught, but in the long run it can't be avoided, since birds are unwilling to enter traps caked with vegetation or mud.

When controlling the traps always bring pieces of wire and rope for small reparations and carefully look for damages to the net covering the traps. Even one single broken mesh may serve as an „exit" for small stints and wagtails, particularly when the hole is situated in the corner of the capture chamber. If only one mesh is broken it may be quickly repaired in place. Otherwise the whole trap must be replaced at the next control walk. If there are many damages the trap should be taken to the camp and repaired there. Be careful to close all flaps (covering the hole through which birds are taken) and always keep the capture chamber dry.

In areas where rapid changes of the water level can be expected (e.g. rivers, marine environments) traps must be displaced when the water level is rising. The number of staff and traps at a particular ringing site should be adjusted to this need. Since there is a constant need to displace, clean and repair traps (particularly in marine environments), 2-3 persons should take part in each control walk so that all these tasks are done quickly and efficiently.

The water level of the water body where the traps are set should be continuously monitored, and in the case of a rapid increase one should not wait for the control time to move the traps. It is convenient to fix a suitably marked pole, visible from the camp, so that the water level can be easily read. Ringing stations situated on riverbanks or in marine areas are well advised to tune in to reports about water levels in the river or fishermen's weather forecast (meteorological sites on the web are very useful!). This will allow the staff to forecast major changes of the water level. If a rise of water levels is expected overnight, it is better to move the traps beforehand, to avoid their being flooded.

CONTROL OF THE TRAPS

It is worthwhile to have the traps arranged so that they need not be passed twice, this creates unnecessary disturbance to the birds. Also try not to set traps too densely; this may discourage birds from feeding at that particular section of a beach or riverbank.

Walk-in traps should be controlled every two full hours. The first visit should be made 1 – 2 hours after dawn, the last no later than one hour after dawn. A control walk should not last for longer than 30-40 minutes. Exceptions may be situations where it is necessary to move or clean the traps between the controls. Even then, however, the break between the subsequent controls should not exceed 2 to 2.5 hours.

Waders will enter walk-in traps not only during the daytime. In some areas, particularly in late autumn, waders very often feed throughout even overcast and dark nights. Trapping under such circumstances often may be more rewarding than trapping in broad

daylight. It is very important to check this possibility from time to time; when night foraging occurs traps must be checked every two hours the same way as in the daytime.

LABORATORY METHODS

Standard set of measurements and scores

The **total head length** (Fig. I-54) is measured with callipers. The most comfortable way is to use longer arms of the calliper for this task. The bird is held by the bill very close to its end, one calliper is adjusted to meet the tip of the bill and kept in place with the thumb and the second finger (Fig. I-55). The outer calliper is pressed to the most exposed part of the occipital bone. Slight movements of this calliper will help to find the right position. It is important that a correct angle is maintained between the calliper and the horizontal axis of the head; in other words, the axis of the bird's head should be placed parallel to the calliper axis. The pressure of the callipers should only just press contour feathers to the skull but must never curve the tip of the bill. In the case of short-billed species be careful not to close the nostrils! When this measurement is trained, it is recommended first to find out the most exposed part of the occiput with one calliper, then open the other calliper slightly (the one fixed to the occiput stays in place) and find the correct length by moving it back to meet the point. With this procedure the proper pressure of the callipers is easily attained.
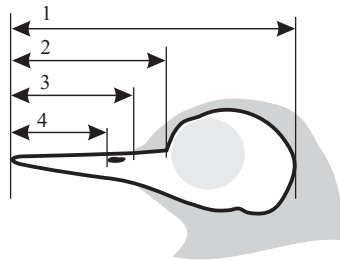
Fig. I-54. Measurements of the head details. 1 – total head length, 2 – bill-length to the skull, 3 – bill-length to the feathers, 4 – bill-length to nostrils (nalospi).

The most frequent errors:
1. Underestimation of the head length
a) too strong pressure of the callipers causing change to the shape of the bill tip
b) wrong angle between the calliper and the long axis of the bird's head
c) wrong contact point between the calliper and the occiput
2. Overestimation of the head length
a) the calliper not close enough to the occiput
b) the calliper is fixed to the muscles of the upper part of the nape
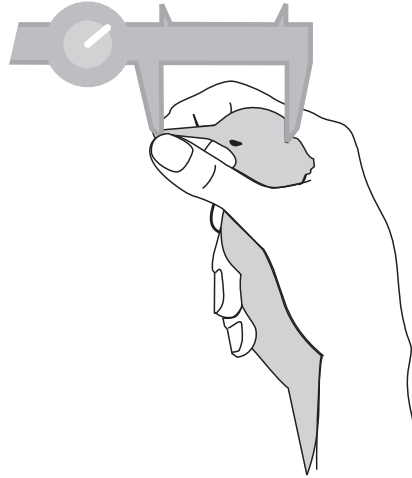
Fig. I-55. Technique of head-length measurement.

The **bill-length** is measured with callipers. The bill should be held the same way as when measuring the head length, but the bill tip is fixed to the end of the calliper (not to its wide part). Find the most distant point of the edge of the sheath of the bill with the outer calliper (its tip) - (Fig. I-56). Keep in mind that part of the bill sheath is very elastic in some species. Therefore, be careful to take the measurement in its natural position and do not try to tighten it when the calliper is fixed.
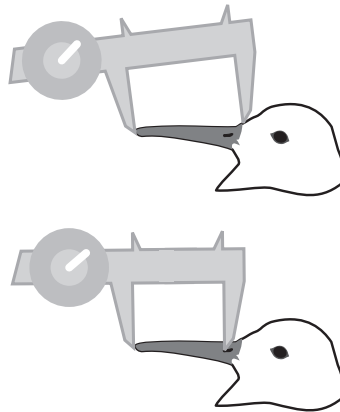
Fig. I-56. Technique of bill–length measurement: to feathers (above) and to nostrils (below).

The most frequent errors:
1. Underestimation of the bill length
a) too much tightening of the calliper to the bill causing change of the shape of the bill tip

b) wrong angle between the calliper and the long axis of the bird's bill fixes the bill tip to a point other than the end of the inner calliper

c) the calliper is fixed to the wrong section of the edge of the bill sheath or stretching it with the end of the calliper in the direction of the bill tip

2. Overestimation of the bill length

a) the calliper is fixed to the wrong point of the edge of the bill sheath

b) the bill sheath is stretched in the direction of the head with the end of the calliper

This measurement is not very accurate in species where the border between the bill sheath and the feathered parts of the bill is poorly demarcated (majority of the species in the genus *Tringa*). In these species instead of bill length the distance from bill tip to nostrils can be measured (nalospi – see p. 99) or the measurement can be left out. There is a strong correlation between the bill length and the total head length and in most cases the analysis of both these parameters in individuals with finished bill growth gives similar results.

Wing-length – see p. 58. A stop at the zero end of the ruler will facilitate the measuring of waders, since their wings usually are longer and more „stiff" than e.g. passerine wings.

Length of tarsus + toe (without claw) (Piersma 1984) – is measured with a ruler with a stop. The tibiotarsus (tibia) is pressed against the stop and the tarsometatarsus (tarsus) to the surface of the ruler. Push the tibia to the stop with the right hand fingers and straighten the tarsus and the longest toe along the ruler surface with the left-hand fingers (Fig. I-57). Both parts of the leg should be pressed to the ruler so that the correct angle between them is maintained. Pay attention that the whole toe adheres to the ruler. When reading the value, do not include the claw.
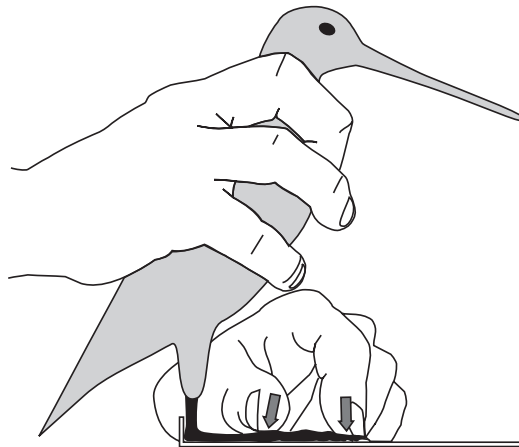

Fig. I-57. Technique of tarsus and toe length measurement.

The most frequent errors:
1. Underestimation of the tarsus + toe length
a) too small angle (acute angle) between tibia and tarsus
b) toe not adhering to the ruler
2. Overestimation of the tarsus + toe length
a) too large angle (obtuse angle) between tibia and tarsus
   Index of the **moult of primaries** – see p. 74

Additional measurements and scores

Tarsus-length – is measured with callipers. See p. 67.

   Nalospi (Prater et al. 1977) - the distance between the tip of the bill and the proximal edge of nostrils, measured with callipers (Fig. I-56). This measurement is recommended in the case of species in which the border between the bill sheath and the head feathering is poorly demarcated. It is strongly correlated with the head length. Some difficulties may occur while fixing the calliper to the proximal edge of the nostril. The bill sheath is a bit supple here and it is easy to deform it. Sometimes, when the bird has narrow nostrils, it is difficult to find the right place to fix the calliper.

   Third primary length – see p. 65.

   Fat score scale – the measurement of the fat score scale consists of two values – the first is the value describing amount of the fat under the skin in furculum, the second – under the wing. These values should be given according to the following scale:

Furculum:
0 – complete lack of fat in furculum, the bottom of the furculum dark or in the colour of
   the body
1 – fat only in the bottom of the furculum (the colour is lighter than that of the sides of
   the furculum)
2 – fat fills the furculum, the surface of fat in the furculum concave (lower than the line
   of clavicles)
3 – the surface of fat is not concave, reaches the line of clavicles
4 – the surface of fat is distinctly concave, protrudes the line of clavicles
Underwing (Fig. I-58):
0 – total lack of fat under the wing
1 – a small stripe of fat adjoins the „hole" of visible air-sack from one side or it forms an
   asterisk or „V"
2 – an area of fat surrounds the „hole" – there can be some distance between the „hole"
   and the fat
3 – the „hole" not visible, a stripe of muscles visible outside the hole
4 – the „hole" invisible, muscles invisible
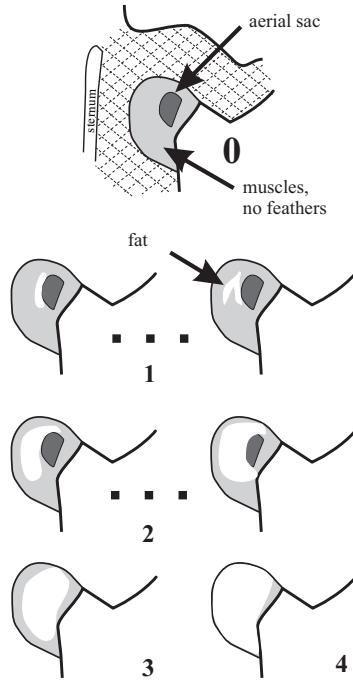
Fig. I-58. Fat score scale in waders – underwing.

Muscle score – see p. 69

Wear categories of primaries and secondaries – the timing and pattern of flight feathers moult could be important not only in ageing of waders, but also could be used to recognise different populations that differ in moult schedule. The categories of wear described by Prater *et al.* (1977) are used commonly (Fig. I-59). The magnifying glass is very helpful for distinguishing among these categories.
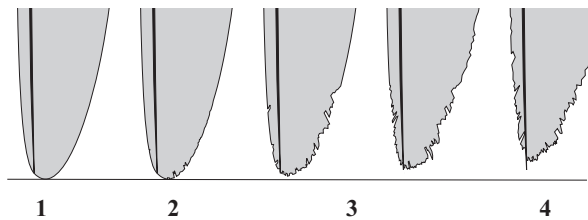
Fig. I-59. Wear categories of primaries and secondaries

During the field study the numbers from 0 (fresh feather) to 3 (very worn feather) could be attributed to subsequent wear categories and it is convenient to use notation as in the case of moult index of primaries.

Example: 3^3 4^2 2^1 1^0

– three outermost primaries – very worn (3)
– next four primaries – worn (2)
– next two primaries – slightly worn (1)
– the innermost primary – fresh (0)

Note that the sum of exponents must be equal to the number of primaries (10 in case of waders).

Features relating to the **plumage colours**.

Some features relating to the plumage colours may be very helpful in distinguishing different populations. For example, in the Bar-tailed Godwit and Whimbrel a relation between the colour pattern of underwing scapulars and breeding area has been established. A similar relation probably exists also in the Dunlin and concerns the presence of median wing coverts of the „adult-buff" type (Gromadzka 1989) and the extent of white reaching the shaft on inner primaries. Elaboration of a scale to note this type of features starts with description of the range of variation in the feature and goes on to define a succession of criteria, allowing distinction between each category of the given characteristic.

LABORATORY WORKING ROUTINE

The routines and rules of the wader ringing station are very similar to those of the passerine station. Attention should be paid to recommendations resulting from different trapping methods and a slightly different set of measurements.

When at the station species vulnerable to a long retention should be ringed first, i.e. Godwits, Curlews, Whimbrels, Greenshanks and Spotted Redshanks. If any passerine were brought (e.g. wagtails) they should be ringed in a second turn. After ringing, the age and (if possible) the sex of the bird should be noted together with the ring number. This usually requires opening of the wing, and so the moult score and other notes referring to the wing may be taken at the same time (e.g. features connected with the colouring of feathers) and the wing length can be measured. Once the ruler is held in hand, the next measurement taken should be the tarsus+toe length. After that the callipers are produced in order to measure total head length, bill length and possibly other measurements taken with this tool (nalospi, tarsus). Finally, the bird is weighed.

In order to shorten the time of retention the best thing is to work with a 3-4-person team while ringing. One person takes birds out of the basket and clenches the ring, another takes all the measurements, a third weighs the bird and releases it while the fourth one takes notes (or the third person is doing that while not weighing birds). When releasing waders in the daytime they will fly away by themselves. Larger species may be carefully thrown in the air, taking care that there are no bushes or lines in their way. At night a bird taken out of the laboratory should be given time to adapt to darkness before being released. This lasts longer than in the daytime, and therefore the person weighing birds cannot release them at the same time. The bird must under no circumstances be allowed

to leave the ringing station „on foot". If it is unable to fly but can walk and is not injured, it is better to bring it to the feeding place and release it there. After some time most of these „immobilized" birds will fly again.

WADER COUNTS

When waders are counted, adult and juvenile birds should be noted separately (if it is possible in a given species). From such data the breeding success of a species may be estimated and the migration dynamics of both age categories established. In contrast, the age structure obtained by means of catching in walk-in traps will be biased since adult birds are less likely to enter the traps. Furthermore, the phenology of adults differs from that of juvenile birds (in most species adults migrate much earlier than juveniles) and the trapping efficiency may change also during a season in the effect of changes of water level and the foraging conditions. At the same time it should be borne in mind, that we do not know the extent to which we deal with individuals counted on a previous day when birds are counted every day. The age structure monitored in any given season also partly depends on the length of birds' stopover at the study area, and the duration of stay may (and will) differ between adult and juvenile birds.

Counts should be done only by persons who are capable of recognizing all species in the field and estimate the size of flocks. The best time for counting is around noon, when few birds walk into the traps, and the majority of them are resting, which also makes counting easier. Remember to add the number of birds caught in the traps to the overall count! Many waders species present a tend to prefer one particular type of habitat, thus e.g. Curlew Sandpipers or Bar-tailed Godwits are seldom met within a wet meadow, while for example Sanderling and Turnstone practically always feed on sandy beaches. Therefore, it is to be preferred if the area where birds are counted includes all habitats found in the immediate neighbourhood. A strict definition of the limits of the census area is important as well. The area should – if possible – have natural demarcations; a meadow or a muddy bay should not be divided. On the other hand the area must not be too large; walking around it and counting the birds should not take more than 1-1.5 hour. If the count is done by a ringer it should be started immediately after all birds from the previous control walk have been ringed, so that birds brought from the next control walk will not have to wait for the ringer to return. A light telescope is very helpful in counts. It should be remembered, however, that some genera (snipes) are very shy and spotting all individuals in the vegetation is practically impossible with the use of a telescope. Therefore, places where snipes congregate should be walked over in a zigzag pattern, trying to flush all individuals on the wing.

BIRD MORTALITY AND THE BIRD'S WELFARE

Migrating birds are evolutionary adapted to overcome migration barriers, compensate for losses of fat deposits and endure stress from being exposed to raptors in alien and unfriendly habitats, etc. In the case of birds caught, the ringing station and we, the ringers, constitute an additional stress factor, and contact with ringing activities adds to the risk of dying before the next breeding season, when the bird has a chance to pass its genes to the next generation. At any rate a majority of all birds present in late summer, in passerines as much as 70-80 percent, will die on migration and in the winter season, irrespective of their meeting ringers or not – they are condemned to death within some hours, days or at least months. These statements give some distance to very emotional and sometimes hot discussions on the problem: are the catching losses in birds acceptable? Let's face the truth and try to discuss this very serious problem in more detail.

Mortality among birds caught by bird ringers has many different objective causes[*].

Some birds die or are injured due to faulty catching technique, some are killed by raptors when caught and unable to escape, some die during the ringing process or soon after being released. This mortality, however, is not reason enough to stop ringing or other studies where caught birds are involved. We must keep in mind that ringing results may and will save many more birds in giving some advice on how to protect birds and their environments more effectively. At the same time the fact that there is unavoidable mortality connected with ringing presents a strong obligation on ringers to make every effort in order to reduce losses among birds in their custody. This is the main reason why bird safety is a main topic in this Manual. The preventive theme is given particular emphasis in the *Alarm routine* chapter. In the following section a few more general comments are given, and a short summary collects advice presented in various parts of the text.

Mortality and injuries are due to many various causes:

1. Catching devices

The methods used when catching birds for scientific purposes are generally safe for the birds. However „generally safe" does not mean that there are no birds injured or dead because of the catching device.

(a) Nets. Nets made of thin thread are intended for smaller species; when they catch larger species they are more likely to cause injury than nets made of thicker thread. The most common injuries are scars to the skin and cut-off tongues. Cases where birds hang themselves are comparatively rare; they occur in strong wind when birds are lifted out of the shelf and one mesh is pulled tight around the neck. Note that 17 or even 15 mm mesh

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[*]   Irresponsible behaviour by ringers is another matter; here lies the only real threat to bird ringing in the future.

size always will strangle a few crossbills, Grosbeaks and Waxwings! Remedy: use thicker thread for standard catching; 19 mm mesh for special purposes.

Exceptional, although occurring, are unexplainable cases of death, where the bird hits the net and falls down into the shelf as if no longer alive. Sometimes, however, it may still be alive but one could say: has fainted. This is probably caused by a psychological shock similar to that occurring in human life. The fainted bird may suddenly fly away – so do not put a bird apparently dead in your pocket! Remedy: accidents of this kind are unavoidable.

It seems as if waders are more susceptible to injury in mist-nets than passerines living in woods or bushes. The latter are used to being rubbed or bumped against leaves and branches, and their bodies are stockier. Waders, on the other hand, are adapted to open and flat spaces and to running, but not to perching on branches. That is why they are more „soft-bodied", and therefore also more susceptible to injuries from the impact with mist nets (Meissner 1992). Moreover they fly with greater speed than passerines and the thin tread of wader-nets is more likely to cut the skin than the net designed for passerines. Still, mist-nets are very useful for wader-catching and in some areas they are the only method available. Even at the ringing station, where the walk-in traps are the main catching tool, mist-nets may be used as an additional tool e.g. for catching birds attracted by tape lures in the night-time. When mist-nets are used to catch waders they should preferably be watched all the time, and birds caught freed immediately. Old-fashioned, light-collecting binoculars will allow the ringer to check the nets from a distance!

(b) Heligoland traps. In the big Heligoland traps made from soft netting (not metal net) a bird may get stuck and strangle itself in the top section of the trap – the dimensions of the construction and the fragile walls in many cases render all rescue attempts futile. Since accidents of this kind are more probable where the netting is broken, loose or incorrectly fixed to the construction lines, regular maintenance of the trap and stretching of the netting will serve as at least partial remedy against these losses.

In Heligoland traps with a terminal box where birds fly against a glass pane, death as well as injury of birds entering the box with high speed occurs relatively often – blood effuses into the brain or eyes. Such constructions should not be used or at least the possibility for hitting the glass with high speed should be reduced.

During mass trapping, the number of birds simultaneously collected in the final box should be limited by more frequent controls.

(c) Wader traps. Birds already caught in traps are vulnerable to raptors, since the latter learn very quickly how to exploit this source of prey. Mammals will prey on trapped birds mainly at night or at dawn, whereas birds of prey or Corvids and Gulls will be active in the daytime. When raptors begin to penetrate the traps, night catching must be abandoned. In the daytime the traps are easily guarded (raptors are more shy than waders), in addition a special spring-trap on the roof of the walk-in trap will act as an effective deterrent. A bird of prey caught in that way should be removed immediately and transported at least 10 km from the ringing station. Good effect is obtained by placing

additional fences along the walls of the capture chamber. They should be mounted with a slope and fixed to the trap. A second solution is to drive long twigs forked at top into the ground; this will make attacks by bird of prey from the air difficult (Fig. I-60).
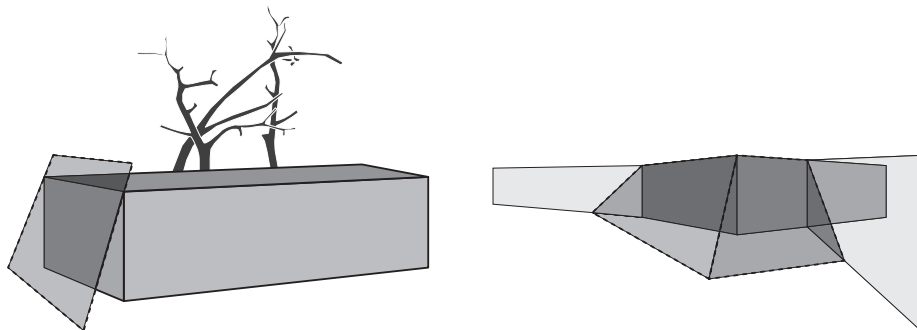

Fig. I-60. Protection of funnel traps against raptors – additional walls and twigs.

2. The catching process

All birds caught are readily accessible to raptors, and this is when the bird is hanging in a net.

Avian raptors (especially the Sparrowhawk and Great Grey Shrike) hit the birds in the nets frequently. Local individuals are especially dangerous as they learn quickly that the birds in the nets could be a source of food. However, they also learn quickly, that they can be caught either. Remedy: there are limited chances to reduce such losses – in extreme cases transport of a local individual far off the station area could be undertaken (if the bird will be caught). From the other point of view, however, these raptors naturally kill some birds to survive, so by netting potential victims we make their hunting easier; any case some bird individuals are killed.

On spring migration tits (especially Great Tits) in poor condition may kill other birds caught in the nets, sometimes birds the size of thrushes. The brain of a killed bird is eaten first, then the rest of the body and the ringer will find only bones and skin in the net. Tits are often caught when killing other birds and they usually continue to eat after being caught. Remedy: there is no possibility to eliminate such cases; the only action, which might reduce the losses, is not to remove killed birds as long as there is something to eat on them – new tits will not kill new individuals but clean the old corpses. This is a difficult strategy where visitors come to the catching area, however. Sometimes feeding the hungry birds with tallow from your butcher will help, but usually feeding is not overly effective since the birds are not residents at the catching site.

The most common wild mammal raptors killing birds in nets and traps are Foxes, Raccoons and different *Mustelidae* species. These animals are most active in the nighttime, therefore they are most likely to attack owls and night migrants landing in the catching area early in the morning. Sometimes, however, specialized individuals of Marten and Ermine will attack and kill birds in broad daylight; Marten may develop into

a sourge in reedbeds. Remedy: in practice there is no effective remedy against these raptors where mist-nets are used; in some cases blood flour, used to intimidate stray dogs or spraying the net stands with fetor chemicals (e.g. some phosphoroorganic pesticides) may help; endangered wader traps should not be active in the night-time.

Domestic animals harm netted and trapped birds mainly when they are wild. Wild grown cats may pose a threat to netted birds, while wild dogs bring about more damage to trapped waders. Remedy: use of cat traps may solve the problem.

3. Birds and the weather/habitat factor

This is a parallel to the bird-in-the net/predator problem: birds in the nets and traps are exposed to weather and they may be drowned by rising water.

(a) A bird caught in a net is practically immobilized; its feathers pressed to the body, its head often pointing downwards and its legs locked above the body. This unnatural position will affect the thermoregulative abilities of the individual, at the same time the whole body is exposed to heat, cold, rain, insects more than usual. Low temperatures will cool the body below the physiologically acceptable level, and the bird will die if not removed soon enough. A similar threat is posed by high temperatures (30°C) day or exposure to direct sunrays in sheltered place. The impact of cold is aggravated if the bird gets wet. So, the first remedy to losses of this kind is regular and more frequent checks of the nets, particularly in rainy weather or when the fog condenses on the birds. Usually short showers are harmless to the birds, but a heavy rain during a thunderstorm will kill small species. Birds removed from nets in rainy weather are wet and must be dried as soon as possible. In most cases storing them in dry cotton bag is enough, but note: synthetic fabric has a very low capacity to absorb water, and the bird in such bag should be dried with an artificial heat-source (do not overheat it!). When the bird is soaked through and stiff cold, the best drying method is to put it against your breast (directly, not in a bag or between shirt and sweater!) – the method is not pleasant to the bird holder (especially if the birds name is e.g. Woodpecker) but remember that you are responsible for the situation! It is a good custom to change the control rhythm when a thunderstorm is approaching. E.g. many reedbed birds become very active and are caught more frequently just before the storm. So, weather losses may be partly reduced by good attendance to the nets.

Birds caught in mist-nets, particularly the ones hanging in the lowest shelf, also run the risk of being overlooked at a regular control walk. Under normal conditions the leaving of a bird for one hour does not endanger its life. When the control is the last one in the evening, however, the bird will hang in the net for a couple of hours and the following morning it will be dead. So, the evening control must be very scrupulous, using a good lamp and checking the whole length of each net. Shaking of the net up and down when lighted will reveal birds caught in the bottom shelf or near the top string (such sporadic catches are frequently overlooked). Cleaning of the nets from leaves in the evening will facilitate the night controls.

(b) Birds netted in reedbeds, where water is standing under the nets, run the risk of being drowned. At sites where the water level is stable, strict adherence to the advice in

„Arrangement of the netting area – Wetland habitats" will reduce accidental losses. In reedbeds where the water level changes much, netting is much more risky. First of all the lowest string must be held much higher than in the stable water places, the water level should be continuously monitored and when a flood is expected the nets should be pulled high.

Wader traps frequently get flooded by rising water and the birds run the risk of being drowned, particularly on sea-shores and in lagoons subject to the changes of the overall sea level. The sea level changes with tides, currents, air pressure and direction and force of winds. In the daytime the distribution of traps must be adjusted to changing water levels and weather. Any decision to leave active traps overnight should be based on knowledge of the local water situation – if there is any doubt, move the traps from the catching area to higher ground.

4. Removal and transport of birds caught

The removal of birds from nets and traps is a potential source of loss and/or injury.

(a) when birds are freed from a net it must be remembered, that bird legs and bird wings in spite of their flexibility must not be moved too rapidly or with excessive power; never apply force perpendicular to a leg – this usually leads to a fracture (the most common injury when removing birds from nets). The same thing – injury to the bird – may happen if it is allowed to much flapping with the wings – one single strong wing-beat may break the air sack connecting the body sack with the wing bone (or cause blood effusion to the lungs) and the bird will be unable to fly (at least for a couple of days). Most vulnerable to this kind of injury are juvenile (in juvenile plumage) Bullfinches, Chaffinches, Greenfinches, flycatchers and Tree Pipits. Other species, like Goldcrests, Yellow Wagtails and hirundines seem to be totally unaffected.

Much bird mortality results from incorrect handling of birds during transport. Remedy: strictly apply all advice given within appropriate chapters above (see pp. 31, 51-52) – in spite of how inconvenient they may be to you – follow them!

5. Laboratory work

Laboratory work is relatively safe to the birds. On peak days apply the advice given in the *Alarm routine* chapter. Remember that even under normal conditions birds must never wait for ringing and/or additional processing exposed to direct sun radiation. The ringing procedure frequently reveals all mistakes made by the staff when removing and transporting the birds: the ringer may find dead or injured birds in the bags, others are unable to fly after being ringed. (Discuss the matter with the people responsible!) Dead birds should be noted in the field-form and the cause of death, if known, should be given as a comment. This procedure does not help the dead bird but it can serve to explain losses and find remedies against them.

Injured birds should be treated according to the particular kind of the injury:

(a) A bird with broken wing bones or leg fracture above the tarso-metatarsal joint should be put to death, since it has no chance for a normal life or at least must pay for life with prolonged pain.

(b) A bird's leg with an open fracture of the tarso-metatarsal joint or tarsus should be amputated ca 5 mm below the joint (use sharp scissors). Birds with cut-off tarsi are ob-

served rather frequently in the nature as victims of natural hazards, and they may be in quite good condition. Releasing such birds without amputation will cause prolonged pain and the broken leg may be fixed in an unnatural position, handicapping the individual for the rest of its life-time.

(c) A broken tarsus, where the bones are not displaced, should not be amputated since there is a chance that ends may join in a natural process; it is obvious that the bird should not be ringed on that leg and/or do not ring the bird at all.

(d) Birds that are unable to fly will be handicapped in different ways – some of them temporarily paralysed by fright (it is relatively common in thrushes) – and within a couple of minutes they suddenly fly away showing no flight handicap whatsoever. Others can not fly because of a broken air-sack or internal blood effusion – allow such birds to walk away on foot as there is no way to help them: some of them will die, others will be taken by raptors but some will recover and continue their migration (a Bullfinch with such an injury was recovered seven days later several hundred kilometres south of the ringing place).

Some wader species are especially vulnerable to stress after catching. This mainly applies to long-legged species such as the Bar-tailed Godwit, Curlew, Whimbrel and larger species of *Tringa*. One effect of stress may be a leg cramp. Birds affected in this way look healthy but are unable to stand on their legs. Relatively few such cases occur when waders are caught with walk-in traps, more often when cannon or rocket nets are used, and most frequent with mist-nets, particularly if the birds are allowed to hang for some time. The possibility for stress myopathy also increases on hot days. In order to minimize these effects particular attention should be paid to the regularity of controls and to the proper construction of containers for birds. Vulnerable species and individuals that sit in the container instead of standing up should be ringed first. If a leg cramp occurs and the bird is unable to stand up and fly away, it should be left in peace away from people (preferably in a place where other individuals of the same species stay) for about 30-60 min. If this does not help the bird should be placed in a spacious and high (ca. 50 cm) container with free access of air and light (but not exposed to the sun!). The bird should not be disturbed – the staff must avoid to appear in the bird's field of vision and to handle it any more. Water must be available in the container, but the edge of the vase containing water (rather deep) must be placed at the ground level. If the leg cramp does not cease, it will be necessary to feed the bird. Smaller species quite willingly feed in captivity. Food should contain live „worms", e.g. earthworms, tubifex, nereids. The best way is to place them in a separate vase and supply 2-3 times a day. When the bird is unable to eat on its own it must be fed „by force". In addition a solution of glucose may be given every 2 hours. In most cases such a bird gets better within 5-6 days and can be freed. Some authors recommend giving ca. 0.5 mg, or in case of large birds – 1 mg of Valium with water and food just after the leg cramp has occurred. After such a treatment the bird will sleep up to ten hours or even more. It should be left in peace in a warm place. When it wakes up it should be able to walk normally.

(e) A separate group of handicapped birds are those exhausted by the migration journey and then caught; they may lack energy reserves even to fly away from the laboratory. After some time most of them will be able to move to nearby foraging areas and have a chance to rebuild their fat reserves, however. But some of them, regrettably, are unable to fly even this short distance and usually die. Such birds may survive if heated for a while or being given a glucose solution (one tee-spoon per hundred grams of water). Otherwise they will be victims of, a little bit artificial, selection pressure eliminating the weakest individuals from the population. At any rate, try to act as selection tool as little as possible!

If possible use the corpses of dead birds for special studies. Sex criteria may be checked by inspecting the gonads, the lipid contents may be investigated, internal parasites collected, blood samples taken etc. In that case the death of a bird will not only mean loss. All corpses not needed should be instantly buried for sanitary reasons and to avoid bitter comments from the public.

APPENDIX I

ALTERNATIVE METHODS OF HOLDING AND MEASURING BIRDS

In some ringing manuals other methods than described here as a standard methods of the bird holding, are described and shown at illustrations. Sometimes they are recommended for general use, sometimes to perform a separate measurements.

A left-hand handling is in common use as shown by figures in „*The Ringer's Manual*" (Spencer 1972) – Figure I-61 – or in „*Identification Guide to European Passerines*" (Svensson 1992). The first method is very similar to that recommended here as the standard holding method apart from the hand used for holding bird. The second one is completely different as the bird is handled in opposite direction – with the bill to the wrist. According to these methods of holding a standard descriptions of some measurements are adapted and given below.

Fig. I-61. Handling the bird – two methods after Spencer 1972.

Comments. The left-hand holding of bird derives from an old custom of ringers, even those working at the bird stations, that the same person handles the bird – rings and measures – and writes data into ringing form. When one uses this method there is no necessity to move the bird from one hand to another when writing data: most people are right-handed and they write using right hand („so, the right hand should be free of the bird"). In a modern way of work, in a team, there is no such necessity any more and the speed of work can be much higher than before. As it was stressed in the description of the standard holding, the right-hand holding allows to manipulate the bird more quickly and safely to the bird as the right hand „feels" bird body much better.

Wing-length measurement

As the method of wing-length measurement used earlier – **unflattened** wing – is nearly not in use any more it will be not described here. It was rejected from the practice as its results are not enough repeatable and possible to be standardised.

Wing-length **flattened chord** measurement after „*The Ringer's Manual*" (Spencer 1972):

This is basically the method described in „*The Handbook of British Birds*" (Witherby *et al.* 1938-41): *„The ruler is slipped under the naturally flexed (but unspread) wing and the carpal joint is pressed gently against the stop. The wing is then flattened against the rule by firm but gentle controlled pressure on the median or greater coverts. This removes some or all of the camber along and across the wing, but the primaries are not straightened, so that they lie along the rule with their normal lateral curvature undisturbed."*

Comments. Although this method is capable of producing a reliable measurement of a wing, it should be noted that variation in the degree of pressure applied in holding the wing to the ruler will produce small differences in the measurements obtained. For this reason, the results obtained are less reproducible between ringers or, sometimes, even by the ringer himself. Nor is the method any more successful than method of unflattened wing at making allowance for unavoidable alteration of lateral curvature.

Wing-length **maximum chord** measurement after „*The Ringer's Manual*" (Spencer 1972):

„In this method, in addition to applying firm pressure on the wing as in method „flattened wing" to remove all camber along and across the wing, the lateral curvature is also eliminated as far as possible. This is done by sliding the wing forward along the rule until it meets the stop, straightening the bastard wing so that it falls into line (as far as possible) with the longest primary, and then straightening and extending the longest primary to its maximum length by stroking the thumb of the free hand along the shafts of primaries, from base to tip, pressing firmly against the rule all the while (Fig. I-62). It must be emphasised that no attempt must be made to pull the wing straight from the tip; a firm stroking action is required. Small differences in measurement may result from variation in the degree of straightness achieved, but the method reduces errors due to alteration of the lateral curvature during trapping and handling, or occasioned by dampness. It is, however, essential to keep the wing closed, and parallel to the long axis of the bird's body.

Rule with the stop is used. For birds small enough to be measured with a 30 cms. rule it is recommended that the wing should be measured to the nearest 1 mm."

Wing-length **maximum chord** measurement after „*Manual of Field Methods*" (Bairlein 1995):

„Wing length is determined as maximum chord which is the length of the flattened and straightened wing, and it is the distance between the bend of the wing and the longest primary.

Use the ruler with a stop at zero. Read to 0.5 mm.
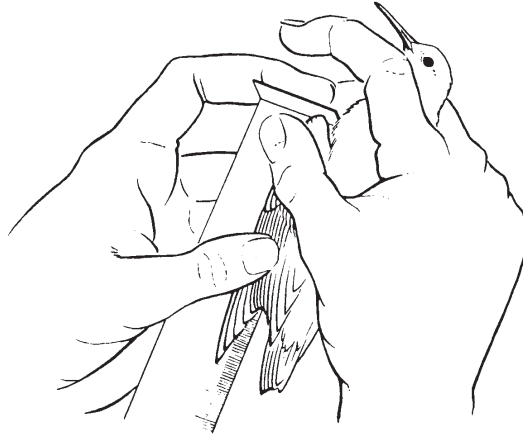
Fig. I-62. Wing-length measurement after Spencer 1972.

The wing should be <u>folded</u> („resting position"; Fig. I-63). The wing is then flattened against the ruler with a gentle pressure on the primary coverts with a thumb. The primaries are <u>straightened</u> by pushing the thumb sideways (Fig. I-63B and C) until the primaries are parallel with the ruler. It is also of good help to adjust the position of the primaries with your index (2) or ring finger (3).
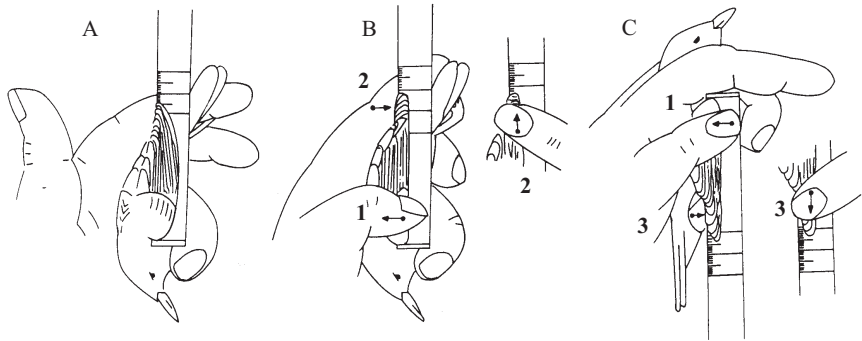
Fig. I-63. Wing-length measurement after drawings by G. Wallinger (from Barlein 1995).

Straighten the wing, still flattened against the ruler by strokes with the thumb outwards along the shafts of primaries. Do not move the bend of the wing off the zero stop. Do not use excessive force, and be as cautious as possible to avoid any injures to the fragile wing bones and muscles."

Note that two methods of bird handling are applied in that description.

Comments. Differences in description of the maximum chord method as presented here, in the ***Appendix I***, in relation to that recommended as the station standard are derived mainly from the other method of holding bird. The description derived from „*The Ringer's Manual*" is very close to that recommended in the standard description given in the main part of this manual: note the right-hand holding of the bird and position of index finger. Position of index finger here differs from that shown at Figure I-63C illustrating the measurement given after „*Manual of the Field Methods*". The position of index finger is important to exact feeling of location of the wing bend in relation to the ruler - the finger tip is most sensible to feel pressure of the wing bend to the stop of the ruler. Exactness of control of the position of the bend in relation to the ruler is even higher when the ruler without stop is used. There is high possibility to have longer readings when the ruler is placed as it is shown at Figure I-63C, especially when one has tendency to much pull the primaries along the ruler. The left-hand holding of the bird does not influence the wing-length measurement if this is the only difference from the standard description or the description given in „*The Ringer's Manual*".

Holding the bird with the bill to the wrist, as shown at Figure I-63B and in „*Identification Guide to European Passerines*" (Svensson 1992), can be commented as in „*The Ringer's Manual*" -

„...a method of measuring a wing with the bird held in the reverse grip. It is possible to measure equally accurately using this technique but it is potentially dangerous if a 30 cm. rule is used (because of difficulty of controlling both the wing and the heavy rule with one hand), there is nothing to recommend it." In addition, it should be stressed that there is no other measurement which could be done quickly and precisely enough when this method of the bird holding is used.

Wing-formula measurement

There are two other, than described in this manual, wing-formula measurement methods that formally intend to describe a wing-shape.

The method given in „*Identification Guide to European Passerines*":

„When studying the wing-formula of a small passerine, it is often helpful to hold the bird in the left hand with the head towards the wrist and with the left wing very slightly spread between the right thumb and index finger. (...)

Make sure that the primaries generally forming the wing-point are not in moult, in which case they may not yet have their full length. Check both wings. When feathers are still growing, you will see generally the glossy, grey or greyish-white feather-sheaths at the base of the feathers (or gaps where feathers have been dropped) if the coverts are carefully lifted up with pliers, or by blowing on them. (The sheaths have a bluish tint during the first stages of growth). If one traps a bird with an unusually blunt wing, one should examine the bases of the outermost primaries by lifting up the under wing-coverts and look for remnants of the sheaths. Check also if any feather is accidentally lost or broken before studying the wing-formula. In museum specimens this will often be the case due to shots.

Gently put the tips of the feathers in order - they may become blunt while the bird is kept in a box or a bag. Make a note if the feathers are much abraded (edge of tips ragged). A heavily worn longest primary can easily be 3-5 percent shorter than its full length when fresh. To determine the position of the tip of the second primary, or a notch on the inner web of the second or third, spread the wing **as little as possible**. *When you measure the distance between the tip of a primary or a secondary and the tip of the wing, use either dividers or a ruler (preferably transparent) placed to naturally folded wing, with the scale visible right against the tips (...). Do* **not** *measure the individual distances between the tips, a method which will be less accurate if the measurements are summed up. It is advisable to include the distance from the wing-point to the tip of the outermost secondary among these measurements.''*

Comments. This method is basically the same as our standard wing-formula measurement (it comprises distances between tips of subsequent primaries from the wing-tip). However, the method of the bird handling and measurement technique described do not allow to use it for wing-formula differentiation studies on live birds as very inconvenient and extremely time consuming - trials of applying it into the station routine lead consequently to rejecting this very important measurement from the station practice. In practice it could be used for single individuals when the wing-formula measurement is needed in the identification process (and the method description really suggests such use of it). It should be stressed that the comments on checking whether the primaries are not growing are of great importance for any wing-formula measurement.

The method given in „*Manual of Field Methods*" after Jenni and Winkler 1989 and called „wing-shape" measurement has really close to nothing meaning for description of the real wing-shape of the wing treated as a functional unit – it contains several measurements of the length of subsequent flight feathers – so, the description of this measurement is given in the *Additional measurements and scores* chapter.

Tail-length measurement

There are a few methods of tail-length measuring taking the tail-length from the base of rectrices to the tip of the longest one.

The method given in „*Identification Guide to European Passerines*" – measurement taken from below the tail:

„Start with a moult examination and put the tips of the feathers in order. Preferably use a thin ruler with the scale starting from the outer (very thin or pointed) edge of one end. Place that end under the tail between the tail-feathers and the under tail-coverts and push it gently against the root of the central pair of tail-feathers (...). Measure to tip of the longest tail-feather when the tail is naturally folded.''

Another version of the method given in „*The Ringer's Manual*" :

„Alternatively, dividers may be used, as shown at Figure I-64. *Hold the dividers in the same plane as the tail so that is the side of the point which impinges against the body.''*
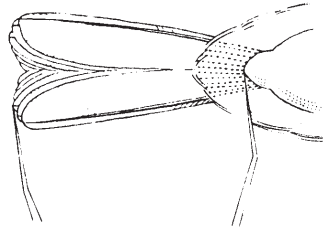
Fig. I-64. Tail-length measurement using dividers (after Spencer 1972).

The above described variants of the measurement taken from the below the tail have their counterparts in such measurements taken from the above of the tail - between the tail-feathers and the upper tail-coverts.

Comments. All these methods give different results not only if one compares themselves but also in comparison with the standard method "to the back" described in this manual – so, the method of measurement must be stated. These methods could be a little bit risky to the bird, especially those which manipulate with pointed tools close to the preen gland. The classic method (for skin studies) as described in „*The Handbook of British Birds*" – use dividers perpendicularly to the tail surface with one divider leg located between central rectrices cannot be used for alive birds as the risk of damage to the preen gland or pygostyl is high.

Fat-scoring

The alternative method of the fat-scoring is recommended in „*Manual of Field Methods*" (after Kaiser 1993):

„*The size of the visible fat depot is determined with the use of a 9-grade score (0-8) – Figure* I-65.

Two of the most important fat deposits are checked, the furcular (intraclavicular depression, „tracheal pit") and the abdominal. A specific positioning of the bird's body is necessary to make the determinations.

The bird is laid on its back in one hand, and the legs are held by the other hand. The neck must be stretched slightly so that the furcular deposit is well visible, and the feathers must be blown aside. Legs of the bird should be spread aside, not pulled up or down – it will move the fat.

*Additional requirements are (1) the use of bright light, which intensifies the contrast between yellowish fat layers and red muscle tissue, and (2) the determination of the amount of the visible fat **before** the bird is weighed to avoid biasing the measuring process.*

The scores from 0 to 8 are taken in the following manner using the subclass description (Table I-4*). At first, estimate the fat class at the furcular region. For example, if the fulcular is „filled", i.e. not concave or convex bulging, the subclass corresponds to 4.00, 4.25 or 4.50.*

Secondly, check the abdominal area. If the fat deposit covers abdominal structures completely, and the liver is not visible, but the abdominal fat layer is not convex bulging, total score is 4.

However, some individuals do not follow the process in fat deposition as shown in Figure I-65. *For example, the abdominal area may have a slightly rounded pad of fat with intestinal loops not visible (3.50), while the furcular depression is still not completely covered with fat (1.75). Thus, the average amount of fat score is. 2.6, recorded as main fat score 3.*

Use only main fat classes 0 to 8".

Comments. The method is based on the same idea as the standard description in this manual. However, description of the subclasses is much more complicated and less easy to apply. From the observation of trained persons: using the method of averaging the subclasses results to final main classes is purely theoretical – especially in a hurry – and the results are based on personal judgement depending on one fat deposit only. It was
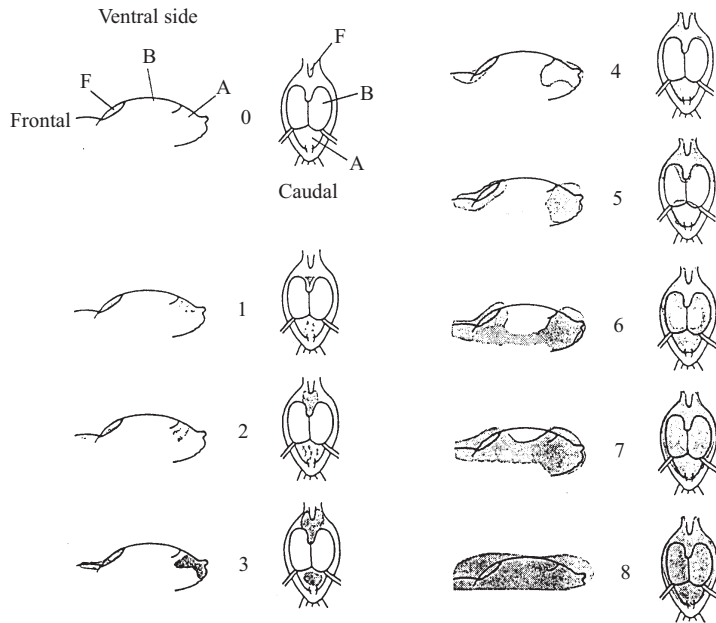

Fig. I-65. Fat scoring after Kaiser 1993 (from Bairlein 1995) – compare Table I-4.

checked that because of psychological reasons, one person could believe more the furcu-
lar depot while other is more convinced with the abdomenal one. So, the results are less
comparable, although derived from the procedure, which seems apparently more precise.

Table I-4. Description of the fat classes (from Kaiser 1993, after Bairlein 1995)

Main class	Subclass	Furcular depression	Abdomen	Colour of the considered areas
0	0.00	no fat	no fat	dark red
	0.25	barest trace, very narrow stripe	fat deposits not yet delimited	
	0.50	small stripe	as above	red
	0.75	wedge-shaped	small trace, patchy	light red
1	1.00	wide wedge	trace, very small stripes around intestinal loops (mm)	light red
	1.25	half of fulcular depression is covered	trace, stripes 1 mm wide	yellow-red
	1.50	almost completely covered with fat	trace, stripes smaller than intestinal loops	yellow-red
	1.75	small amount, almost completely covered with fat	wide stripes (2 mm)	yellowish
2	2.00	completely covered, shape deeply concave	slips of visceral fat, area between intestinal loops completely filled	light yellow
	2.25	completely covered, shape deeply concave	some subcutaneous lipid, not yet forming pad	light yellow
	2.50	completely covered, shape deeply concave	very small pad	light yellow
	2.75	completely covered, shape deeply concave	small pad, at least 2 or 3 intestinal loops still visible	light yellow
3	3.00	moderate fat reserves cover ends of interclavicles	flat pad, one loop still visible	light yellow
	3.25	concave	slightly rounded pad, one loop sometimes visible	yolk-yellow
	3.50	still concave	slightly bulging, loops completely covered	yolk-yellow
	3.75	almost filled	bulging, liver visible	yolk-yellow
4	4.00	filled up to distal portion of interclavicles	conspicuously bulging (2-4 mm), liver sometimes visible	yolk-yellow
	4.25	filled up to distal portion of interclavicles	further increase in bulge (4-5 mm), liver sometimes visible	yolk-yellow

	4.50	filled up to distal portion of interclavicles	abdominal structures completely covered, liver not visible	yolk-yellow
	4.75	slightly bulging with central depression (concave)	abdominal structures completely covered and bulging	yolk-yellow
5	5.00	convex bulge	extreme convex bulge, increasing thickness	yolk-yellow
	5.25	just covering flight muscles from either furc. or abdomen	extreme convex bulge, increasing thickness	yolk-yellow
	5.50	covering border of flight muscles a few mm	covering border of flight muscles a few mm	yolk-yellow
6	6.00	covering flight muscles by several mm	covering flight muscles by several mm	yolk-yellow
	6.50	fat reaches flight muscles from sides of wings		yolk-yellow
	6.75	fat covering flight muscles conspicuously		yolk-yellow
7	7.00	three quarters of flight muscles covered		yolk-yellow
	7.25	large rounded fat-free area in middle of breast		yolk-yellow
	7.50	small rounded fat-free area (red)		yolk-yellow
	7.75	very small fat-free area still visible		yolk-yellow
8	8.00	flight muscles not visible, fat layer covers underside/ventral side of the bird completely		yolk-yellow

LIST OF NOT REDUNDANT SPECIES CODE-ITEMS
* - code-items constructed according to special procedures (B or C),
° – code-items derived from synonyms frequently used

Anthus berthelotti	ANT.BER	ANT.CER	
Anthus cervinus	ANT.CER	ANT.BER	
Anthus godlewskii	ANT.GOD	ANT.HOD	
Anthus hodgsoni	ANT.HOD	ANT.GOD	
Calandrella cinerea	CAL.CIN°	CAL.CAN	CAL.PIN*
Calandrella rufescens	CAL.RUF	CAP.RUF	
Calidris alpina	CAL.PIN*	CAL.CIN°	
Calidris canutus	CAL.CAN	CAL.CIN°	
Calidris ferruginea	CAL.FER	CAS.FER°	
Calidris fuscicollis	CAL.FUS	CAL.PUS	
Calidris maritima	CAL.MAR	CAL.MAU	
Calidris mauri	CAL.MAU	CAL.MAR	
Calidris pusilla	CAL.PUS	CAL.FUS	

Calidris temminckii	CAL.TEM	CAL.TES	
Calidris testacea	CAL.TES°	CAL.TEM	
Caprimulgus ruficollis	CAP.RUF	CAL.RUF	
Casarca ferruginea	CAS.FER°	CAL.FER	
Cercotrichas galactotes	CER.GAL	CIR.GAL	
Charadrius mongolus	CHA.MON	CHA.MOR	
Charadrius morinellus	CHA.MOR	CHA.MON	
Chettusia leucura	CHE.LEU	CHL.LEU	
Chlidonias leucopterus	CHL.LEU	CHE.LEU	
Circaetus gallicus	CIR.GAL	CER.GAL	
Colymbus stellatus	COL.STE°	POL.STE	
Dendroica striata	DEN.STR	DEN.SYR	
Dendrocopos syriacus	DEN.SYR	DEN.STR	
Dryobates major	DRY.MAJ°	DRY.MAR	
Dryocopus martius	DRY.MAR	DRY.MAJ°	
Emberiza caesia	EMB.CAE	EMB.CAL°	
Emberiza calandra	EMB.CAL°	EMB.CAE	
Emberiza chrysoprys	EMB.CHR	EMB.CIR	
Emberiza cia	EMB.CIA	EMB.ICA*	EMB.CIN
	EMB.CIO	EMB.CIR	EMB.CIT
Emberiza cineracea	EMB.CIN	EMB.CIA	EMB.CIO
	EMB.CIR	EMB.CIT	
Emberiza cioides	EMB.CIO	EMB.CIA	EMB.CIN
	EMB.CIR	EMB.CIT	
Emberiza cirlus	EMB.CIR	EMB.CIA	EMB.CIN
	EMB.CIO	EMB.CIT	
Emberiza citrinella	EMB.CIT	EMB.CIA	EMB.CIN
	EMB.CIO	EMB.CIR	
Emberiza rustica	EMB.ICA*	EMB.CIA	
Ficedula narcissina	FIC.NAR	FIC.PAR	
Ficedula parva	FIC.PAR	FIC.NAR	
Garrulus glandarius	GAR.GLA	LAR.GLA	
Hippolais caligata	HIP.CAL	HIP.PAL	
Hippolais pallida	HIP.PAL	HIP.CAL	HIP.POL
Hippolais polyglotta	HIP.POL	HIP.PAL	
Hirundapus caudacutus	HIR.CAU	HIR.DAU	
Hirundo daurica	HIR.DAU	HIR.CAU	
Larus atricilla	LAR.ATR	PAR.ATR°	
Larus cachinnans	LAR.CAC	LAR.CAN	
Larus canus	LAR.CAN	LAR.CAC	
Larus delawarensis	LAR.DEL	LAR.MEL	
Larus glaucoides	LAR.GLA	GAR.GLA	

Larus melanocephalus	LAR.MEL	LAR.DEL	
Luscinia megarhynchos	LUS.MEG	LUS.MEL	
Lusciniola melanopogon	LUS.MEL	LUS.MEG	
Melanocorypha calandra	MEL.CAL	MIL.CAL	
Merops apiaster	MER.API	PER.API	
Miliaria calandra	MIL.CAL	MEL.CAL	
Motacilla cinerea	MOT.CIN	MOT.CIT	
Motacilla citreola	MOT.CIT	MOT.CIN	
Parula americana	PAR.AME	PAR.ATE	
Parus ater	PAR.ATE	PAR.AME	PAR.ATR°
Parus atricapillus	PAR.ATR°	PAR.ATE	LAR.ATR
Parus cyanus	PAR.CYA	TAR.CYA	
Pernis apivorus	PER.API	MER.API	
Phalacrocorax aristotelis	PHA.ARI	PHA.TRI	
Phasianus colchicus	PHA.COL	PHY.COL	
Phalaropus tricolor	PHA.TRI	PHA.ARI	
Phylloscopus bonelli	PHY.BON	PHY.BOR	
Phylloscopus borealis	PHY.BOR	PHY.BON	
Phylloscopus collybita	PHY.COL	PHA.COL	
Phylloscopus fuscatus	PHY.FUS	PHY.LUS*	
Phylloscopus trochilus	PHY.LUS*	PHY.FUS	
Polysticta stelleri	POL.STE	COL.STE°	
Porzana carolina	POR.CAR	POR.PAR	
Porzana parva	POR.PAR	POR.CAR	
Prunella modularis	PRU.MOD	PRU.MON	
Prunella montanella	PRU.MON	PRU.MOD	
Puffinus gravis	PUF.GRA	PUF.GRI	
Puffinus griseus	PUF.GRI	PUF.GRA	
Sterna paradisaea	STE.AEA*	STE.ANA	
Sterna anaethetus	STE.ANA	STE.AEA*	
Sylvia borin	SYL.BOR	SYL.HOR	
Sylvia cantillans	SYL.CAN	SYL.CON	SYL.NAN
Sylvia communis	SYL.COM	SYL.CON	
Sylvia conspicillata	SYL.CON	SYL.CAN	
Sylvia hortensis	SYL.HOR	SYL.BOR	
Sylvia nana	SYL.NAN	SYL.CAN	
Tarsiger cyanurus	TAR.CYA	PAR.CYA	
Tetrax tetrax	TET.RAX*	TET.RIX*	
Tetrao tetrix	TET.RIX*	TET.RAX*	
Tringa flavipes	TRI.FLA	TRI.GLA	
Tringa glareola	TRI.GLA	TRI.FLA	

PART II
APPLICATION OF COLLECTED DATA

Motto:
„Science is like sex: sometimes something useful comes out,
but that is not the reason we are doing it" – Richard Feynman

INTRODUCTION

We collected a lot of data in a field and we had a pleasure from that activity. But it is not enough. We should not collect the data only for pleasure, but we should try to make something useful with them. However, this is often our weak point – there are huge data-bases at bird stations, but the number of evaluations is relatively low. One of many reasons is that when we use data from a single station, collected with varying methods, not stable number of nets and in accidental time-periods, the results we get are not easy to comment and conclude. This is obvious, as we see only small pieces of a large picture, but this is much discouraging. In some cases comparison of data collected with standard methods at different stations could help and the results become clearer and more interesting. For this reason we tried to standardize data collection.

Let us assume that our source data are rich and standardized enough. Now we must cope with differentiated elaboration methods. Technically and statistically simple methods were used in the classic papers. Some of them are efficient till now, but in many cases classic methods of evaluations are based on silent assumptions that seem to be not valid any more according to contemporary knowledge. However, they are still in common use and authors follow them automatically repeating „elaboration standards", while some of them could lead to wrong conclusions. Some of the methods could be useful for special set of data and totally wrong if raw data were collected in different way. So, any method used for defined set of data should be discussed and verified once more and once more.

This part of the *Manual* gives selection of analytical methods that were useful when the Operation Baltic data or general ringing data were analysed. Some of the methods presented here require data collected over a very long time and/or at several ringing stations simultaneously. So, your data, already collected may not match some requirements of the method and you will not be able to use it just now. But we are trying to show some perspectives for the future. Sometime, somebody, somewhere can find them useful…

METHODS OF BIRD PASSAGE STUDIES
AND FACTORS CHANGING THEIR EFFECTIVENESS

Proper interpretation of data on bird passage dynamics requires an analysis that includes also effects of different factors that alter a real pattern of migration, which results from changing intensity of passage. Resultant deviations come from several external factors influencing effectiveness of method that was used in the study. This chapter is an attempt to point some factors that could have an influence on the data that are final results of the ringing programmes. This analysis is based on the Operation Baltic data.

Two methods of bird passage studies are used at the Baltic Operation field stations. First one is the visual count of migrating birds carried out from dawn to dusk by one observer as a 15 min. per hour sampling, starting at full hours. The second one is all-day bird catching with a use of several dozen of nets placed close to the bushes and low trees (rarely also heligoland trap was used). These studies are carried out every spring and autumn.

Descriptions of methods used in bird migration studies only exceptionally include assessment of their effectiveness, error analysis or comparison of different ways of collecting information on the passage.

Ulfstrand (1962), without an analysis of mathematical evidence, states that the results of catching and visual observations of migrating tits (1949-1960 at Falsterbo) are quite consistent. Also in this paper, author gives a very rough description of some external factors (wind, changes of catching equipment, individual characteristics of an observer) that influence the results of the studies and states that catching data are more reliable as estimate of a yearly index of fluctuations in tits' migration activity than visual observations.

Enemar (1964) gives description of an experiment of 4 observers that simultaneously but independently counted passing birds. Differences in a number of species and individuals that were registered were around 30 %. This experiment also shown that a single observer was able to see only 50-60 % of individuals and 50-70 % of bird species passing. The author noticed also that the mistakes made by a single observer could show some regularity.

Kallander *et al.* (1972) describes similar experiment with several observers involved. It documents well individual differences between a real and registered numbers of passing birds. An average variation in results noted by different observers was 5-12 % in comparison with the results of a control group. The observers counted 85-106 % of individuals of a species dominating in the passage, and none deviation from this number was correlated with an intensity of migration. An analysis of flock size assessment shown that the results of different observers differ from the results of a control group by, on average, – 10 % to + 20 %. In less numerous species differences in the results of the observ-

ers were ca 50%. Single observers in comparison with a control group, registered 30-60 % of passing birds.

Ross (1979) gives an analysis of results of visual observations that were carried out in different time intervals in comparison with results of continuous observations made throughout the whole day. Spearman rank correlation coefficient of continuous observations carried out from dawn to dusk and those made according to the Operation Baltic methods is on average ca 0.97. This shows high precision of 15 minutes sessions' method and proves that statistical samples chosen according to this method give quite faithful picture of the passage.

List of some possible errors

The list given below includes most reasons that can deform the collected material. This list does not include some cases when an observer and/or ringer do not follow the principles of scientific method used in the study.

The reasons that cause divergence between results of the visual observations and an actual bird passage:

1. Source of divergence is independent of an observer:

1.1. registered numbers are lower than the numbers corresponding with an actual intensity of passage:

1.1.1. at least some birds are out of the observation range:

– passage stream moved out of the observation range,

– altitude of the passage is above 200 m;

1.1.2. at least some birds that are within the observation range cannot be seen, identified or counted:

– passage is so intensive that the number of birds exceeds abilities of one man to register them all,

– birds pass very quickly within the observation range,

– unfavourable light and acoustic conditions as well as reduced transparency of air limit possibility of noticing, identification or counting the birds;

1.2. registered numbers are higher than those corresponding with an actual intensity of passage:

1.2.1. at least some birds that are within observation range are not on passage:

– foraging birds and birds moving on a very short distances are registered (multiple registration of the same individuals is possible);

1.2.2. some birds pass an observation point more often than once in the season:

– birds continue their migration in a proper direction after they moved back in a return passage.

2. Source of divergence is related to an observer who:

– usually lowers or overestimates number of passing birds,

– makes mistakes in the counts,

– incorrectly defines proportions of individuals of different species in the mixed flocks or in the stream of the passage,
– incorrectly identifies bird species thus number of individuals is written down under different scientific name,
– does not notice, identify, count or write down number of birds because of lack of self-confidence, oversight, inattention, forgetfulness etc.,
– adds species and number of birds that were not actually seen by him because of in-attention, mistake etc.

Reasons that cause divergence between results obtained by catching and an actual bird passage:
1. Registered numbers are lower than those corresponding with an actual intensity of bird passage:
1.1. at least some of birds are out of catching equipment range:
– stream of the passage moved out of catching equipment range,
– birds pass the catching equipment over in non-stop flight,
– habitat changed and became less attractive to birds;
1.2. birds are within the range of catching equipment:
– weather conditions reduce birds' activity,
– birds are driven away from among the nets,
– physical properties of catching equipment changed (higher visibility, unfavourable change in mechanical properties, damage),
– caught birds die in nets and/or traps.
2. Registered numbers are higher than those corresponding with an actual intensity of passage:
– migrating birds stopped their passage and started to forage,
– intra- and interspecies competition increase birds' activity,
– altitude of passage is lower and birds tend to sit on the trees, bushes etc.,
– birds that are already in the nets, traps lure the others,
– change in habitat made it more attractive to birds,
– birds frightened by a flying raptor hide close to the catching equipment.

Influence of weather conditions

Taking into account influence of weather conditions on the research methods, ease to notice some disturbance in data collection. As it was shown by the list given above, methods' effectiveness is influenced much by: (1) light and visibility conditions, (2) wind, (3) fall.

Bad visibility and poor light can improve catching ability by reducing visibility of nets to birds on one hand, but on the other it is much more difficult for an observer to notice and identify passing birds. Good light conditions and visibility (air transparency) ease the birds to see the nets, thus reduce the catching ability. However when observing the birds it is easier to notice much more individuals and correctly identify the species.

Light conditions mean: light intensity, angle of its falling, colour and degree of diffusion in atmosphere. These elements change according to season, daytime, air moisture and clearness, structure and degree of cloud cover.

Wind can shift stream of the passage or reduce its height, can alter speed of flight, force the birds to quickly change their places (mix) in the passing flock, these make all estimates difficult. Stronger wing makes also identification of bird species by their voice more difficult. Wind is the main reason of disturbance in catching – it blows the nets or makes them flutter thus eases caught birds to escape and reduces much the chance that birds would become entangled. Usually birds just reflect from the nets tensed by wind. Strong wind, however, can improve catching ability of the heligoland trap by reducing the height of the passage and forcing the birds to sit on the trees and bushes.

Fall, when it does not stop the passage, reduces visibility, makes observation with the binoculars impossible and makes identification of bird species by their voice more difficult. Rain and snow, as well as fog, frost etc., make the nets more visible because of the drops that stay on them thus birds can avoid catching.

We have to realize that differentiation in the results of our research comes from the external factors that influence both the effectiveness of the method and the passage itself that means the birds in fact. Both these phenomena have to be separated and their influence on the data has to be considered separately. To decide which peaks and minima of the passage reflect real changes in the number of passing birds, and which of them are just an effect of the weather conditions that influenced the results of work, they have to be compared with the local weather forecast and if necessary with the notes of the observer.

Influence of the weather conditions on the passage that means their influence on the behaviour of migrating birds, is still not well studied. Lots of notes about this subject can be found in literature, but for precise data and extensive elaboration we have to wait. The paper that focuses on relations between the passage and weather conditions more thoroughly, is work by Alerstam and Ulfstrand (1975). It describes relation of direction, height, speed of flight and wind. Authors found that the passage on the seacoast became more intensive when the wind blew from the land and its direction was more less opposite to the direction of migration. At the same time height of the passage lowered, and that, of course, increased probability of registration of higher number of migrating birds. In-land passage was not influenced so much by the wind direction and force; over the sea birds migrate at high altitudes (1500 m) with the wind.

Relation between the passage and wind is quite clear and often described, but it is hard to find well-documented data on the effects of other weather factors on migrating birds. It is known that the passage can be interrupted by fall and fog, but there are no well-documented observations on this phenomenon and obviously no detailed studies. It should be assumed that weather factors and their changes play some role in determination of bird behaviour, especially during migration. Presumably for birds (from physiological point of view) not each absolute, linear change of a single factor (e.g. temperature) is important, it is rather exceeding critical biological thresholds that influences their behaviour, but for now we are not able to determine these limits. It can also be assumed

that birds react to a complex of weather factors rather than a single one. The elements of the climate and weather that are separated by the researchers because of their different physical nature and different methods of their measurement, can be in fact integrated because of their physiological importance for a bird organism (e.g. cooling effect of moisture, temperature and air flow).

Influence of the factors depending on an observer

Personal abilities of an observer are a very important factor that influences the results of visual observations of the passage. An observer that has no adequate abilities and is not well-trained adds many subjective and hard to find mistakes to the collected material. Good, experienced observer can avoid almost all mistakes specified as possible when using this method, and the numbers registered by him reflect an actual course of the studied phenomenon.

The basic in credibility of the observer is his efficiency in identification of birds in flight, counting individuals and estimation of flock size. As important as the merits are psychophysical abilities of the observer, i.e.: concentration, divided attention, memory capacity, quick reactions and decisions, ability to count quickly small objects; eyesight characteristics – sensitivity for low intensity light, accommodation abilities, degree of colour resolution; hearing characteristics – sensitiveness to high tones, resolution and ability to localise the sound; quick writing. Also thoroughness and precision are important because when somebody avoids oversights, technical mistakes in counting and writing as well as strictly observes terms and time of the observations, then collected material is more valuable and possibility of its wrong interpretation decreases. Each observer has relatively stable tendency to commit just the same mistakes all the time, e.g.: too low or too high estimation of the flock size, tendency to omit birds that are in some distance from the observation place or to count lower number of birds below some critical values of light intensity. It has to be remembered that accuracy of results depends also on physical and psychical abilities of the observer, his internal activity rhythms and bio-weather conditions.

Results of bird catching do not depend on a single personality of the researcher so much. Difficulties, that also mean probable changes in the results, come when the number of birds exceeds 200 individuals per hour. Caught birds wait longer in the nets, then in the baskets or bags when they wait for ringing. These increase probability of death of some birds before their registration. If the nets are not emptied on time during very intensive passage, their catching ability changes much. The net full of birds already caught, will catch less passing birds. Birds already caught can frighten away other individuals that potentially could be caught or, the other way round can lure other birds as it is with the long-tailed tits and the tits. In such case organisational abilities, composure and manual abilities of the researcher and/or ringer determine proper and not disturbed data collection.

Difficulties in data comparison

Factors that make comparison of different parts of material difficult (this refers mainly to long-term studies) are an additional source of inaccuracy in description of migration dynamics. They are as follows:

1. Changes in the vegetation – every year young trees that the nets are scattered within become higher thus more birds fly over the nets instead of being caught;

2. Changes in the placement of the nets – after some time when the trees exceed 2-3 meters, the catching area is moved thus relative probabilities of catching of different bird species change also;

3. Each displacement or serious damage of the catching equipment, changes in their numbers or type always alter probability of catching of different bird species;

4. Change of the observer is always connected with the change of a whole set of subjective mistakes that also disturb homogeneity of the collected material.

Each year, along the Baltic coast different number of birds migrate; it is a result of fluctuations of migrating populations. These fluctuations as a phenomenon are the one to be found with the methods used in the studies on migration and this is the main reason to reduce influence of factors that make comparison of different parts of data difficult. Perfect solution would be to maintain the nearest and far surroundings of the station in, as much as possible, stable state, to maintain catching equipment placed permanently in top condition and to count birds by one, experienced and particularly professional observer.

MODELLING THE SEASONAL DYNAMICS
OF BIRD MIGRATION

Seasonal dynamics of bird migration is rarely studied as a separate problem. Usually it is shown as descriptive data being a background for discussion of other problems, e.g. influence of weather factors on migration or shift in migration timing over a large territory. As typical example of weather influence on migration authors give occurrence of pronounced daily peaks of the species number as well as days when the species is not observed there. These peaks and minima are assumed as deviations from an ,,ideal" course of migration pattern which is silently assumed to be a normal distribution of numbers of migrating birds. The same assumptions are made when shift in migration time is studied. In this case, however, irregularities of migration pattern are frequently taken into consideration and statistical problems whether mean date of migration should be an arithmetic average or a median are discussed. To describe migration dynamics better some percentile values are added to the median. In many papers seasonal dynamics is presented as graphs where pentad or decade totals are given. Standard numbering of pentads is given in *APPENDIX II*.

Contrary to assumed normal distribution of seasonal migration pattern of the species some authors consider migration to be rather wave-like than one-mode distribution. They look for various reasons of such pattern, suggest migration of different populations or suspect physiological processes as a background, which create the waves of birds that start their migration from the same area but in differentiated time. Despite various mechanisms, which could ,,produce" waves along migration route, the wave-like dynamics cannot be described by means of neither arithmetic average nor median and percentiles. All these statistical measures of migration timing are incorrect in such case as they depend not only on the time of migration of the species, but on frequencies of birds migrating in subsequent waves. Subsequent waves can contain completely different populations migrating from several breeding areas to some separated winter-quarters (see Chapter *,,Ringing and migration patterns…"*).

An aim of this chapter is to discuss how to describe the seasonal dynamics of the bird migration. The problem of influence of the migration dynamics on long-term monitoring studies is discussed in the Chapter *,,Studies of long-term population dynamics…"*

MATERIAL

The material presented in the chapter, as an illustration of the methods of seasonal migration pattern analysis, was collected in years 1961-1990 at the Operation Baltic bird stations Bukowo/Kopań (54°21'N, 16°17'E/54°28'N, 16°25'E) and Mierzeja Wiślana

(54°21'N, 19°19'E) located at the southern Baltic coast. The seasonal dynamics is described here as a number of individuals caught every day throughout autumn migration season with mist-nets of a stable number. Details of the field methods were given in the paper by Busse and Kania (1970). The Willow Warbler (*Phylloscopus trochilus*) was chosen as an exemplary species, because it is relatively numerous and shows a long period of migration. Altogether 13 946 individuals were caught at Bukowo and 10 201 at Mierzeja Wiślana, as shown in the Table II-1.

Table II-1. Catching periods and numbers of Willow Warblers caught.

Year	Bukowo		Mierzeja Wiślana	
	Catching		Catching	
	period	*N*	period	*N*
1961	14.09-15.10	14	13.09-14.10	0
1962	10.09-10.10	12	20.08-3.10	57
1963	5.09-15.10	31	16.08-30.10	133
1964	3.09-15.10	231	16.08-25.10	560
1965	6.09-15.10	76	15.08-25.10	1159
1966	4.09-25.10	120	16.08-26.10	419
1967	16.08-25.10	255	16.08-27.10	371
1968	16.08-25.10	274	16.08-25.10	904
1969	16.09-25.10	305	16.08-25.10	478
1970	5.09-11.10	39	16.08-1.11	723
1971	16.08-22.10	240	16.08-1.11	681
1072	14.08-29.10	127	14.08-1.11	170
1973	14.08-29.10	221	14.08-1.11	286
1974	14.08-28.10	263	14.08-1.11	482
1975	14.08-28.10	104	14.08-1.11	325
1976	14.08-1.11	218	14.08-1.11	363
1977	15.08-1.11	178	15.08-1.11	380
1978	14.08-1.11	202	14.08-1.11	330
1979	15.08-1.11	160	14.08-1.11	88
1980	14.08-1.11	140	14.08-1.11	80
1981	14.08-1.11	851	14.08-1.11	374
1982	14.08-1.11	1122	14.08-1.11	395
1983	14.08-1.11	507	14.08-1.11	98
1984	14.08-1.11	190	14.08-1.11	82
1985	14.08-1.11	188	14.08-1.11	94
1986	14.08-1.11	91	14.08-1.11	156
1987	14.08-1.11	39	14.08-1.11	284
1988	14.08-1.11	36	14.08-1.11	272
1989	14.08-1.11	54	14.08-1.11	194
1990	14.08-1.11	234	14.08-1.11	263

<div align="center">THE PROBLEM</div>

Typical patterns of seasonal dynamics of migration of small passerines are presented at Figure II-1. Raw (daily catches) and smoothed data are shown there. Both are expressed in a percent of an average number of individuals caught per day in a particular year. The smoothing was four time repeated 5-day running average using the formula:

$$D_x = 0.06*d_{x-2} + 0.24*d_{x-1} + 0.40*d_x + 0.24*d_{x+1} + 0.06*d_{x+2},$$

where: D_x – smoothed value for a day X; d_{x-2}, d_{x-1} ... – raw values for 2 and 1 days respectively before day X and after it; 0.06, 0.24, 0.40 – y values of normal distribution with $SD = 1$. The chosen weights force forming quasi-normal distributions. Similar idea of smoothing weights other than traditional was applied by Ader (1993) to follow large-scale bird migration waves.

The Willow Warbler migration at Bukowo station (Fig. II-1) is composed usually of five distinct waves, which can include one or more peak days. They are more or less distinctly separated by days with no migration (e.g. in 1975 from 9th to 15th September) or days when migration was clearly less intensive than in the peak days (e.g. in 1967 on 14-15 Sept.). Periods when such waves pass the station are relatively stable in different years. This phenomenon was found in many species (Busse 1976, Busse and Maksalon 1978, Maksalon 1983, several diploma works at the University of Gdańsk). However, an analysis of 30-years data show that sometimes two neighbouring waves touch each other or some of them seem to disappear in this particular season.

Leaving apart nature of waviness of migration, which is not a matter of this discussion, the phenomenon can be described listing the periods when peaks of waves can be found or border dates between subsequent waves. Last method was used when the main problem of a study was population differentiation of migrants. To compare biometrics of the groups passing the station one must divide the migration period into periods when passage of different groups is suspected. Individuals caught within such period of time are assumed, in the first approximation, as members of one population. When species is so numerous that every year a number high enough represents subsequent groups of individuals caught, the problem is simpler and every year birds can be analysed separately. Unfortunately, many species are less abundant and so detailed analyses are not possible. However, as it was stated earlier, the wave pattern of seasonal migration seems repeating throughout years. According to this bird's measurements taken from individuals caught in the same wave (e.g. wave number 3) but in different years can be pooled together to reach sample size big enough for statistical calculations. This idea was applied earlier when Song Thrush migration was analysed (Busse and Maksalon 1986b).

Figure II-2 shows border days between waves estimated for the Willow Warbler at Mierzeja Wiślana. Procedure that is used to obtain this picture is somewhat subjective as every year migration dynamics (such as those at Figure II-1) was cut into pieces according to border days that were estimated from more or less clear patterns of peaks and minima. However, the wave pattern seems to be acceptable as estimated variation between years is not too high (Table II-2). So, according to this procedure, five waves of Willow Warblers passing Mierzeja Wiślana were set up.
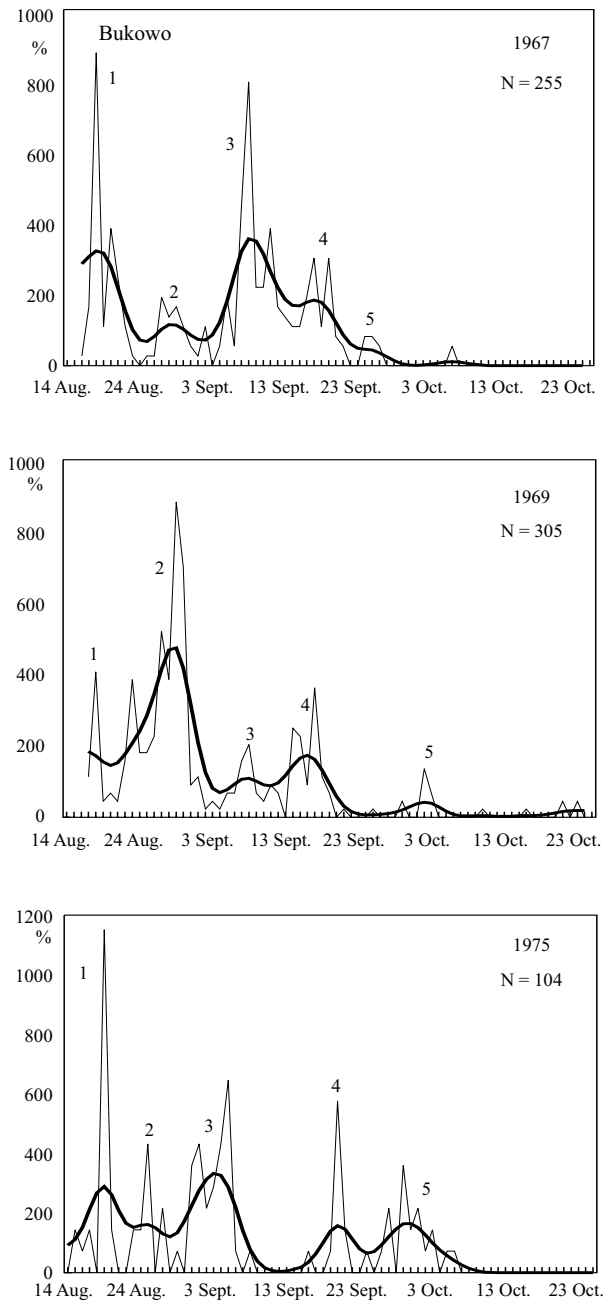
Fig. II-1. Examples of seasonal dynamics patterns of the Willow Warbler at Bukowo. Raw (thin lines) and smoothed (thick lines) data are presented. Subsequent main waves are numbered.
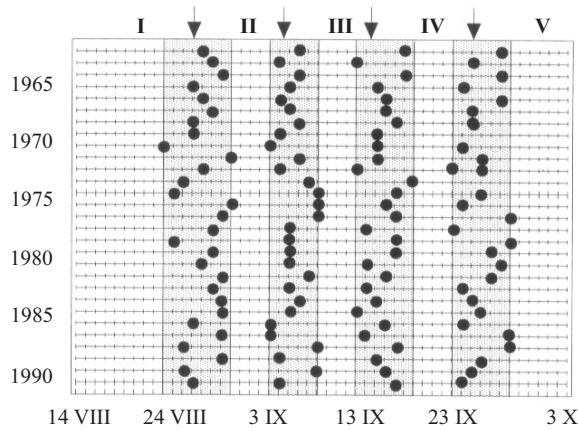
Fig. II-2. Distribution of wave border days in different years (Willow Warbler, Mierzeja Wiślana).

Table II-2. Estimated wave border days at Mierzeja Wiślana.

	Estimated wave borders (dates)			
	I/II	II/III	III/IV	IV/V
Mode	28 Aug.	4 Sept.	15 Sept.	23 Sept.
Avg. date	**26 Aug.**	**4/5 Sept.**	**13/14 Sept.**	**24 Sept.**
Avg. day	26.1	4.4	13.7	23.9
SD	1.87	1.57	1.56	1.87

The most controversial point of this method is the subjectivity of divisions. Let us check whether the estimation procedure is good enough.

Assumptions:

1. Waves are a real phenomenon,
2. Timing of waves passing through the station is constant from year to year, disturbed only by random fluctuations (caused by e.g. weather conditions)

Expected when one sums up all yearly data:

1. Visible wave-like pattern.

To avoid too strong influence of years with a very high numbers of caught birds every year data were recalculated to percents of yearly average daily catches and then pooled as not-weighed average.

The pattern obtained for Bukowo (1961-1990) is shown at Figure II-3. As expected, smoothed curve shows a row of waves. The number of waves is as shown at Figure II-1. However, it is worth to mention that day-to-day differentiation of pooled values is surprisingly high. All main smoothed waves include at least two peaks, which suggest that intra-wave differentiation not found yet by applied estimation procedure is possible. So, the wave structure could be more complicated than expected.
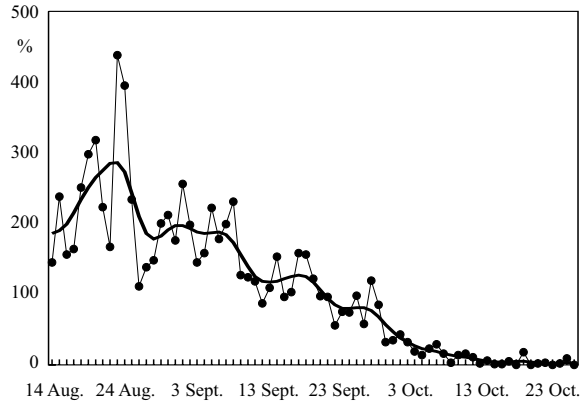
Fig. II-3. Total seasonal migration dynamics pattern at Bukowo (1961-1990). Raw (thin line)
and smoothed (thick line) data are shown.

Figure II-4 shows that the total wave patterns at different stations can be clearly different. More detailed analysis of this phenomenon opens new possibilities to study general migration pattern of the species.

The problem is whether we can describe in more detail time-location and size of subsequent waves of migration.
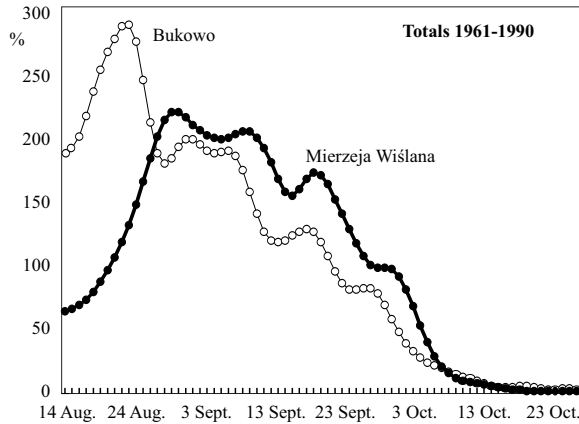

Fig. II-4. Comparison of the total smoothed seasonal migration dynamics patterns for Bukowo
and Mierzeja Wiślana.

BASICS OF THE MODELLING OF THE SEASONAL DYNAMICS PATTERN

Smoothing procedure as described above has some consequences, which must be taken into consideration when seasonal migration patterns are analysed:

1. Every single peak of birds number (e.g. 100 birds in day „0" at Figure II-5) is transformed by one pass of the smoothing procedure into normal distribution with the average equal to the original value (zero), *SD* equal 1 (exactly 0.98) and total number of birds within distribution (sum of abscissa values) equal starting value (100).
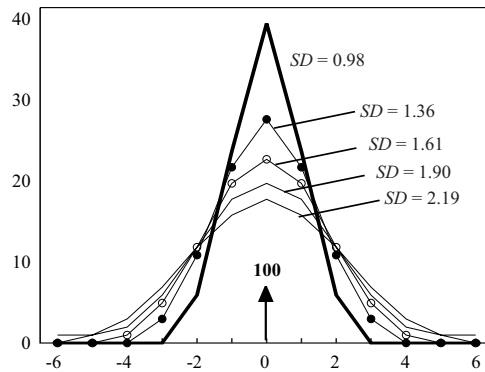

Fig. II-5. Illustration of the results of repeated smoothing procedure. The starting value is 100 individuals in a day „0"; *SD* of subsequent smoothed distributions is given.

2. Subsequent passes of smoothing procedure do not change average and total values, but subsequently enlarge standard deviation of the distribution which covers more and more days.

3. Application of smoothing to the normal distribution altered by random deviations (Fig. II-6) force the shape of the curve to return into symmetric quasi-normal distribution with variation (*SD*) a little bit larger than original. Smoothing can cause loss of precision in estimating wave boundaries, but do not change total number and localisation of distribution maximum. A general assumption in the modelling is that the seasonal dynamics pattern is a composition of a row of waves. Every wave is assumed to be a normal distribution of a number of passing birds that belong to the particular wave. These distributions can be altered randomly by different environmental factors.

The shape of the overall pattern that is a sum of two source distributions depends on three parameters of distributions included: their numbers (N_1, N_2), variation within (SD_{r1}, SD_{r2}) and distance between source distributions averages which can be expressed in relation to the variation of the source distributions (D_r). Figures II-7 and II-8 give some idea how result distribution look like when two groups of different parameters are added. When both numbers and variations of source distributions are equal (Fig. II-7) result distributions are symmetric and they are unimodal when the distance between peaks is less than around 2*SD_r. The only difference from the simple normal source distribution is that resulting *SD* (SD_s) is higher than that of the source ones. As we do not know natural variation in the original data therefore such distributions cannot be separated from a single wave case. Border date between source distributions can be found when bi-modality is visible. The border day is defined as a day when both source distributions have the same
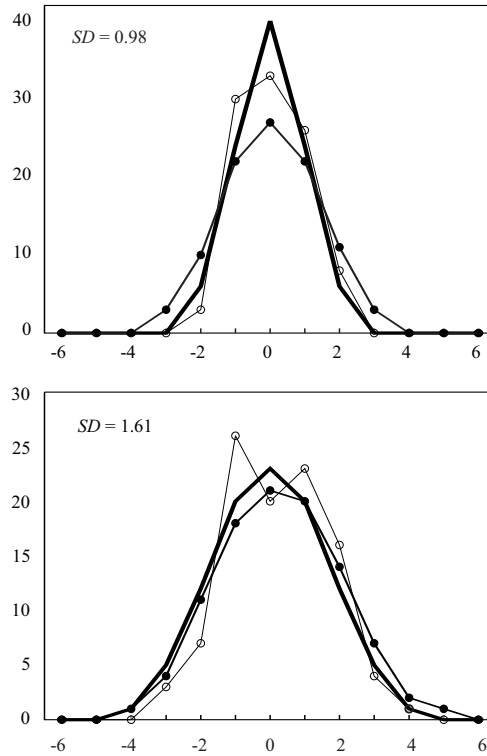
Fig. II-6. Comparison of the results of smoothing (black circles) of normal distributions altered
by random (generated by a computer) numbers (open circles) with source normal distributions (thick line).

number share. Distribution composed of two other not equal as to a number of birds (Fig. II-8) is unimodal when distance between peaks is less than around $3*SD_r$ (but this level depends on difference in numbers between both source distributions). Such unimodal distribution is usually clearly asymmetric that can be checked by a calculation of a skewness index value. Estimation of the border day is possible in some cases of a clear bend along the tail of the distribution. When bi-modality is visible the border day can be more easily estimated. Depending on distribution parameters estimation could be more or less exact. Generally, it can be stated that the estimated border day tends to be shifted from the correct one towards the peak of more numerous source distribution.

Figure II-9 shows simulated seasonal dynamics pattern composed of six source distributions that differ in numbers and distances between peaks. To simplify, all source „waves" within one graph have the same raw standard deviations. Depending on this parameter „wave" contents of the result distribution is more or less visible – when leptocourtic distributions (lower SD_r) are combined, wave composition is better visible and border days can be better estimated, when more platycourtic ones (higher SD_r) are combined the wave composition is less visible and border days can be sometimes hard to estimate. As an extreme when there is a small wave located between two more numerous ones, it could be not found at all.
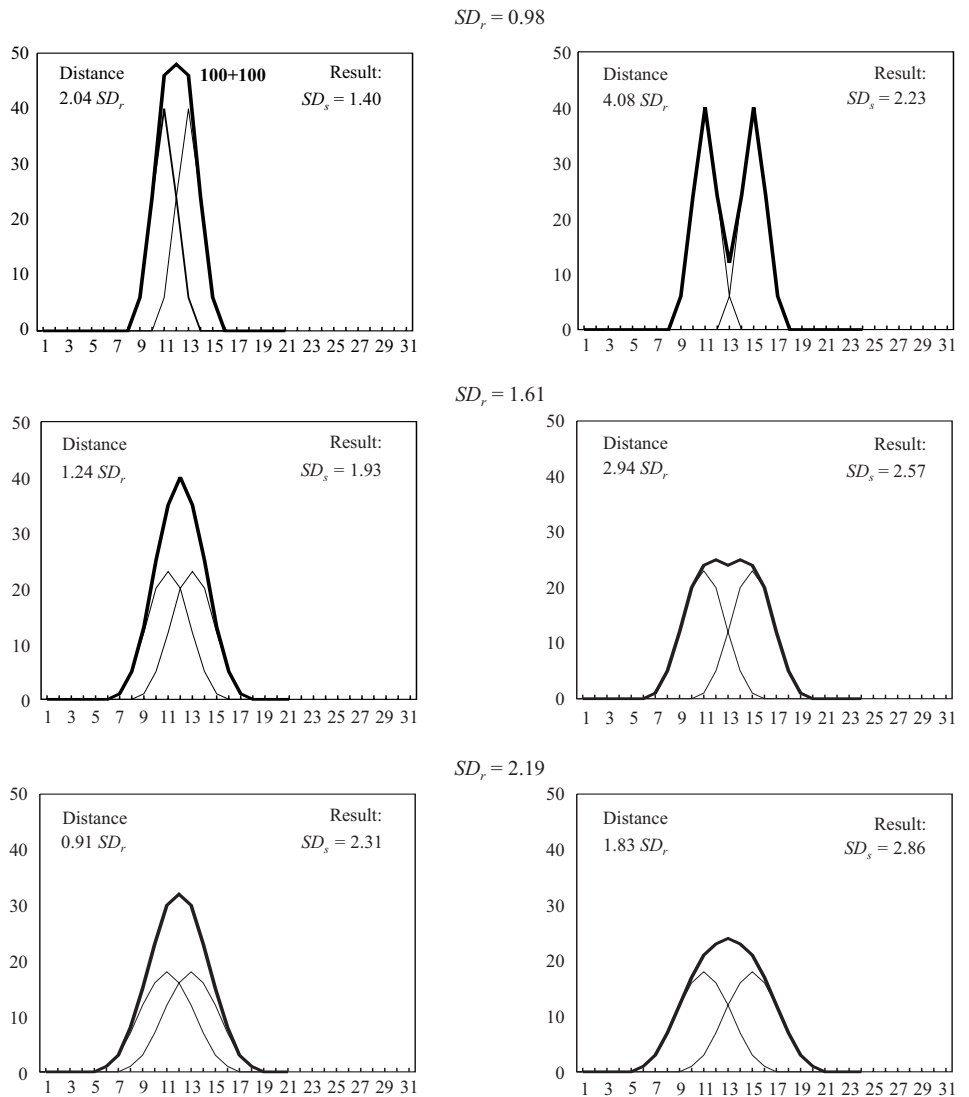
Fig. II-7. Results of pooling of two normal distributions equal in numbers and variation. Three levels
of source variation (SD_s) are shown. Distances between averages of distributions are expressed
in relation to source distribution variation (SD_r). SD_s – standard deviation of the total distribution.

The basic idea of the modelling is when we know the border days between source
distributions or, at least, we can estimate them precisely enough, we are able to recon-
struct source distributions from the observed composed pattern. The basic procedure of
modelling is as follows:

1. choose estimated border days (basing on a shape of the total distribution),
2. cut the total distribution data into pieces limited by border days; border days values
should be divided by two (the shares of bordering waves are equal here) and these
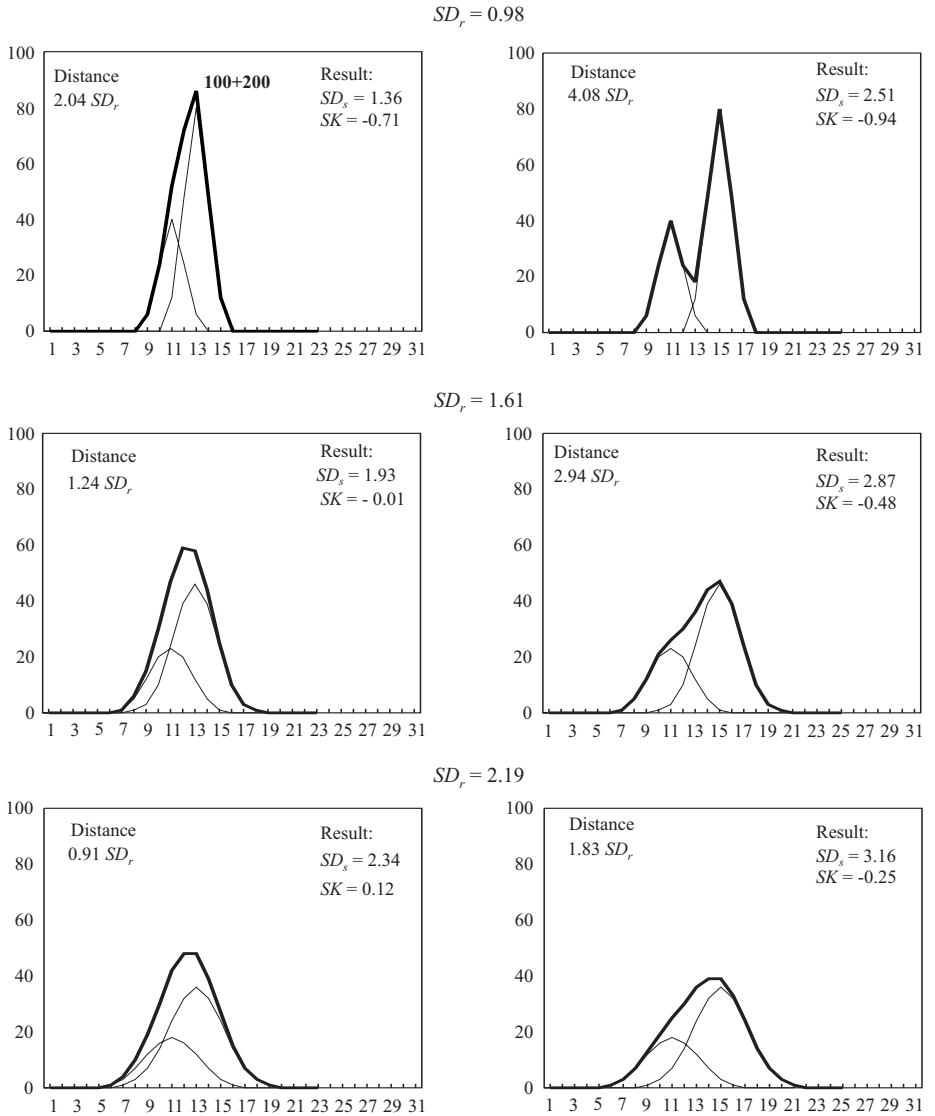
Fig. II-8. Results of pooling of two normal distributions not equal in numbers, but having the same variation. *SK* – skewness index. Other explanations as at Fig. II-7.

halves should added as this day values to both waves; when we decide to put the border between two days (e.g. in a case of two equally low number days) we add the earlier day value to the earlier wave and respectively the later one to the later wave,

3. smooth the values in every part of data separately, using the smoothing formula mentioned earlier; the smoothing procedure adds lower and upper tails to the modelled distribution (wave),

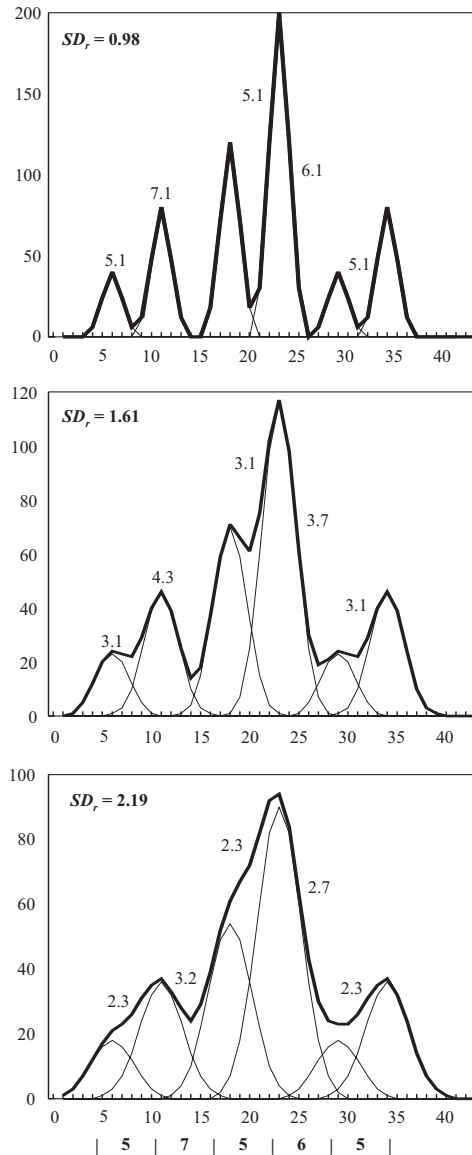4. plot obtained distributions against the time scale.

Fig. II-9. Simulated seasonal migration pattern composed of six subsequent waves different in size (100, 200, 300, 500, 100, 200), but having the same variation. Three levels of variation are illustrated. Distances between peaks of distributions are given in days (below the graphs) and in relation to the variation within the source distributions (SD_r; values on graphs).

Let us check the idea on simulated distributions shown at Figure II-9. The case of the most leptocourtic source distributions ($D_r = 0.98$) will be omitted. Figure II-10 presents the results of the described modelling procedure. Agreement of reconstructed distributions with the original ones seems to be good enough. The only larger deviation can be
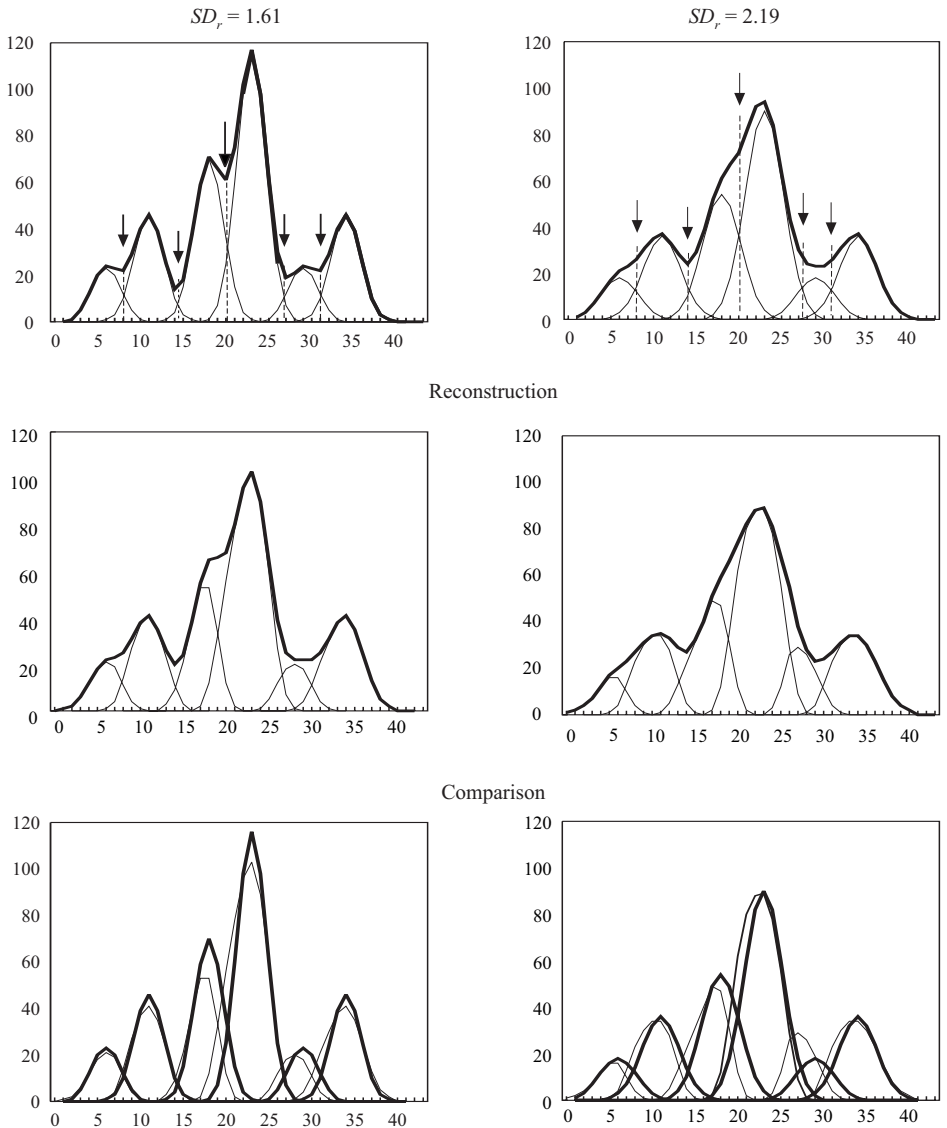
Fig. II-10. Reconstruction of source distributions from the simulated seasonal dynamics pattern
(see Fig. II-9). Two levels of source distributions variation (SD_r) are shown. Top graphs:
thin line – source distributions, thick line – total distribution, arrows – border days used
in reconstruction (selected as they really were); middle graphs – reconstructed waves;
the lowest graphs – comparison of source (thick lines)
and reconstructed (thin lines) distributions.

observed in the situation mentioned earlier when small wave is located between two big-
ger ones. The deviation is larger when the source distributions variation is higher. To
check total exactness of the reconstruction the composed distribution and distribution
being a sum of the reconstructed waves are compared at the Figure II-11. Differences are

negligible (Table II-3), so proposed modelling procedure could be accepted as enough robust.
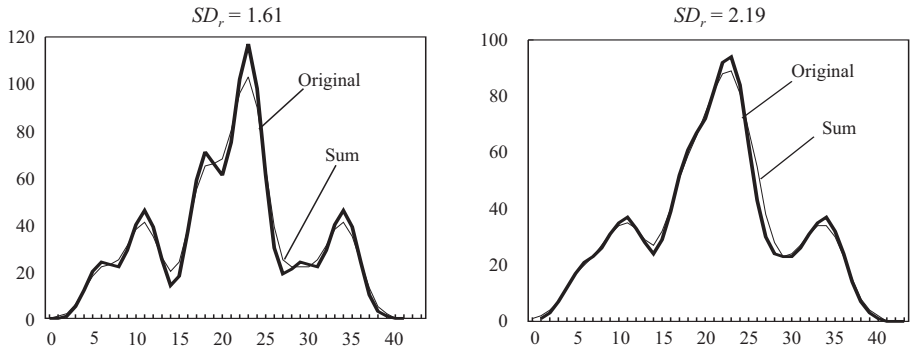

Fig. II-11. Comparison of backward summed up reconstructed distributions and original simulated seasonal dynamics patterns (see Fig. II-10).

Table II-3. Reconstruction of simulated 6-wave seasonal migration pattern (see Fig. II-10). Deviations of the estimated peaks from the correct date are given in days.

Groups (N)	Border (no. of day)	Peaks (no. of day)	Distance (days)	Reconstruction of peaks (deviations)	
				$SD_r = 1.61$	$SD_r = 2.19$
100		6		0	0
	8		5		
200		11		0	-0.5
	14		7		
300		18		-0.5	-0.5
	20		5		
500		23		0	0
	27		6		
100		29		-1	-1
	31		5		
200		34		0	0

Next problem in such modelling is vulnerability of the method to inaccuracy of the estimated border days. The example test is presented at Figure II-12. The same as at Figure 10 total distribution is cut on waves by incorrect border days. After first reconstruction one of the resulting waves is clearly bimodal, which is not acceptable according to the general assumptions of the method (the pattern is composed of normal distribu-

tions). It is necessary to correct the wrong border date to the most probable one. Second reconstruction gave acceptable shape of the second wave, but the third one is still asymmetric which suggests second correction. After the second correction reconstructed
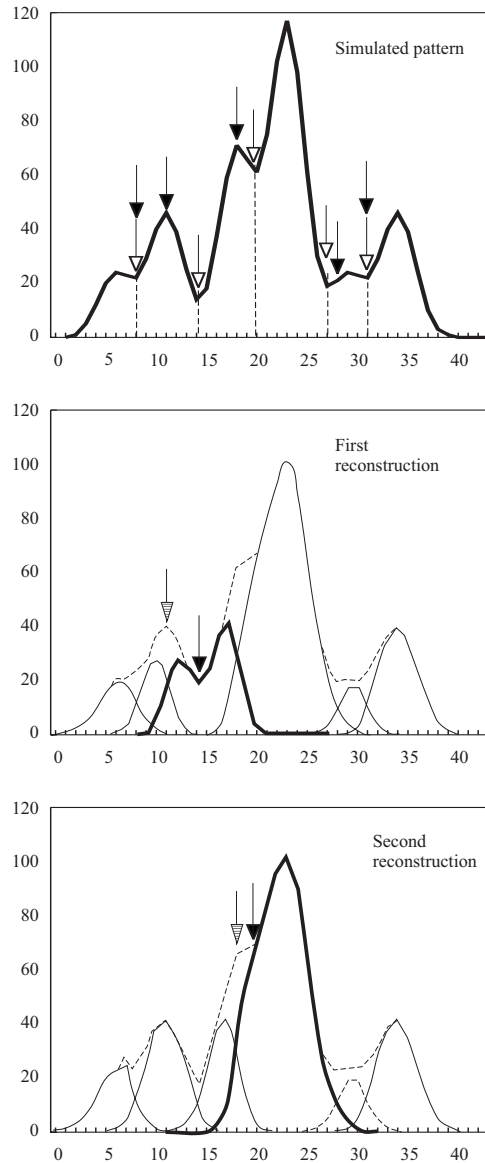

Fig. II-12. Iterative modelling of source distributions from the simulated seasonal dynamics pattern (see Fig. II-9) when first attempt was made with intentionally misallocated border days. White-headed arrows – exact border days which should be used for efficient modelling (as at Fig. II-10), black-headed arrows – these used for reconstruction, hatched-headed arrows – erroneously selected border days corrected in subsequent iterations.

waves are quite acceptable (Fig. II-13, Table II-4). Table II-4 points at an additional rule which is important when one wants to estimate size of possible errors in location of the waves peaks – these errors are at level of half of the size of the errors made in estimation of wave border days.
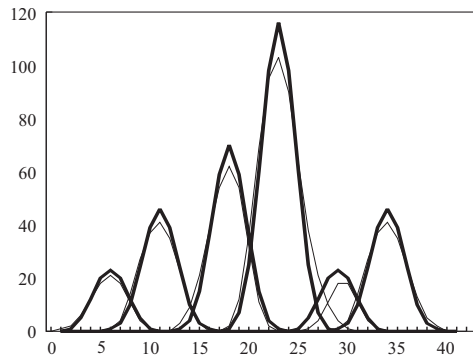

Fig. II-13. Comparison of source (thick lines) distributions and these reconstructed (thin lines)
in second iteration as shown at Fig. II-12.

Table II-4. Deviations in peaks' estimation when simulated pattern is reconstructed
with false borders of waves (see Fig. II-12).

Groups	Real borders	Real peaks (no. of day)	False borders	Resulted peaks	Corrected borders (1)	Resulted peaks	Corrected borders (2)	Resulted peaks
					Deviations from the real values			
100		6		0		0		0
	8		0		0		0	
200		11		-1		0		0
	14		-3		0		0	
300		18		-1*		-1		-0.5
	20		-2		-2		0	
500		23		0		0		0
	27		+1		+1		+1	
100		29		+0.5		+0.5		+0.5
	31		0		0		0	
200		34		0		0		0
Sum of deviations			-4	-1.5	-1	-0.5	+1	0

* – additional peak found

MODELLING THE WILLOW WARBLER SEASONAL DYNAMICS PATTERN

As an example of the modelling pooled Willow Warbler seasonal dynamics data (1962-1990) from Mierzeja Wiślana are used. Figure II-14 contains summarised daily data and smoothed patterns for this station. As at Bukowo station (Fig. II-3) the summarised data show quite pronounced day-to-day differentiation in a number of birds. The first pass of smoothing does not smooth out all differentiation and the pattern shows at least eight peaks. The third pass of smoothing suggests that there are four main waves of migrating Willow Warblers. Figure II-15 presents the results of modelling procedure. In the first step the pattern was cut into four pieces according to the most pronounced border days. These days were selected on the basis of raw data close to minima of the smoothed curve. The first step of reconstruction gave four curves, most of them irregular. Irregularities are visible both on reconstructed and once more smoothed distributions. So, corrections were necessary and additional five border days were selected according to minima at curves obtained in the first reconstruction and adjusted using raw data curve. Second reconstruction gave nine waves, three of them a little bit irregular. As these irregularities are small the modelling stopped at this stage.
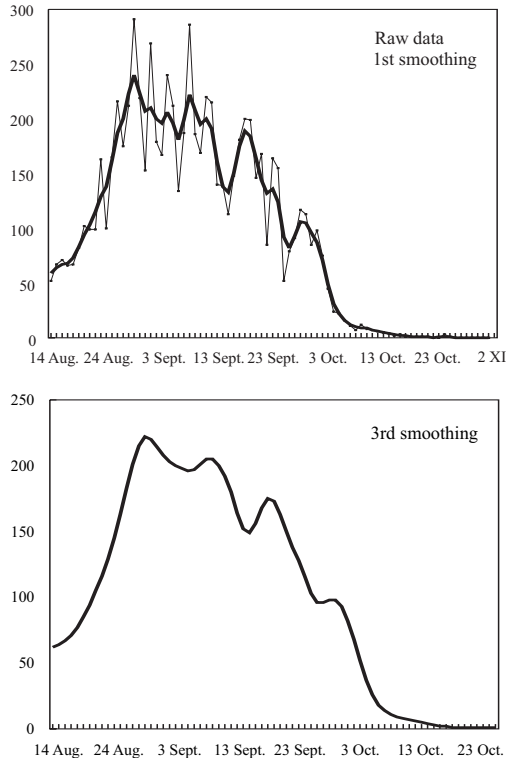

Fig. II-14. Total seasonal dynamics pattern of the Willow Warbler migration at Mierzeja Wiślana (1962-1990). Thin line – raw data, thick lines – 1st and 3rd smoothing.
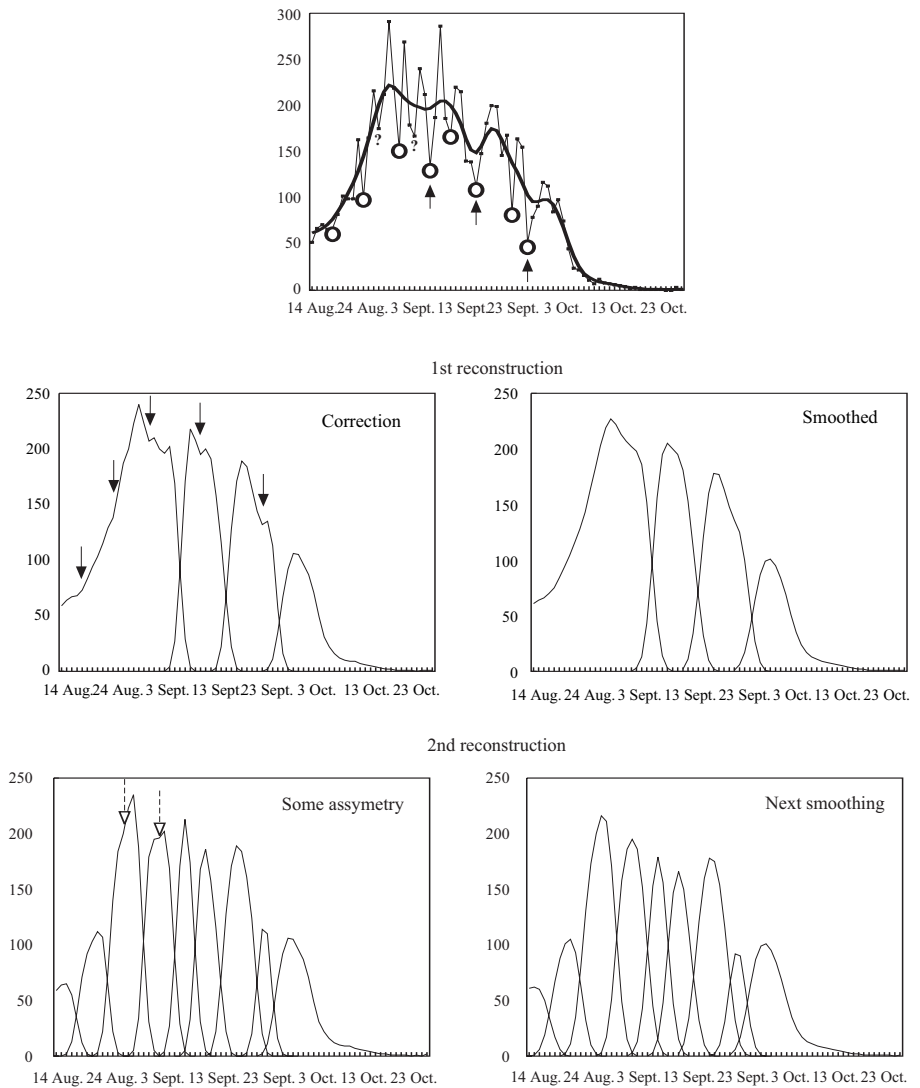
Fig. II-15. Iterative modelling of the wave structure of an overall seasonal migration pattern shown at Fig. II-14 (Willow Warbler, Mierzeja Wiślana). Top graph: total pattern with locations of more pronounced minima (circles), black-headed arrows – minima used as border days in the first step of modelling; middle graphs: result of the first step of the modelling, arrows show additional border days used in the second step of the procedure; bottom graphs: results of the second step of the modelling, arrows point at some residual asymmetries within waves.

It is a matter for discussion how to check obtained wave pattern. Some additional data on peaks distribution and border days between them can be obtained when year-by-year analysis of seasonal dynamics of migration is made. For every year some most pronounced peak days of migration dynamics and top days of smoothed yearly dynamics pattern (Fig. II-16) are selected. Then, for each day of the migration, a number of found

peaks is counted. This is made separately for daily peaks and top days of the smoothed patterns. Obtained distributions point at days when peaks of migration occur most frequently in the long-term. After smoothing these distributions can be compared with each other (Fig. II-17). Agreement of the patterns obtained by these three methods is very good and one can conclude that at Mierzeja Wiślana four main waves occur and additional one at the beginning of migration is suggested by distribution of peaks at smoothed yearly patterns. It is natural that daily peaks in this time are rather low in relation to these from the main migration period, so they were not counted as conspicuous ones and they are not shown at the daily peaks pattern.
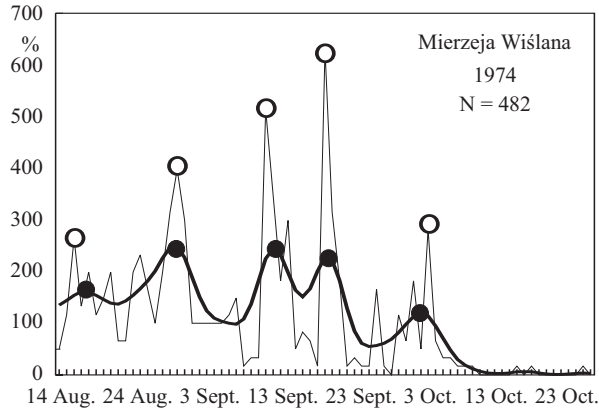
Fig. II-16. Example of peaks selected from seasonal migration pattern of the Willow Warbler at Mierzeja Wiślana for use in supplementary methods of the modelling. Open circles – daily peaks of migration, black circles – peak days of a smoothed curve.
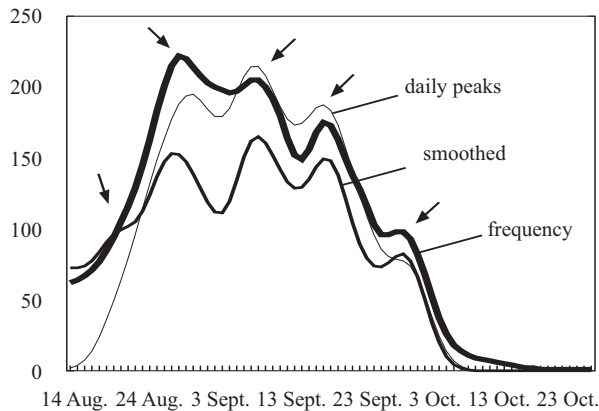

Fig. II-17. Wave structure of the Willow Warbler seasonal migration pattern at Mierzeja Wiślana according to different methods: total frequency, yearly daily peaks and yearly smoothed peaks.

A general model of Willow Warbler migration over Mierzeja Wiślana can be summarized as shown at Figure II-18 and in the Table II-5. The most detailed division of the migration into nine waves was obtained by means of iterative reconstruction of the wave composition. This method bases on the assumption that the general seasonal dynamics pattern is the result of summing up of series of normal distributions, representing subsequent waves of migrants. Other methods applied in the analysis focus on the most pronounced differentiation and they all point at five main waves (I-V), which are equivalents to waves 2nd, 3rd, 5th and 9th found according to the wave modelling method. Agreement in the estimation of peak days by means of all methods is very high (Table II-5).
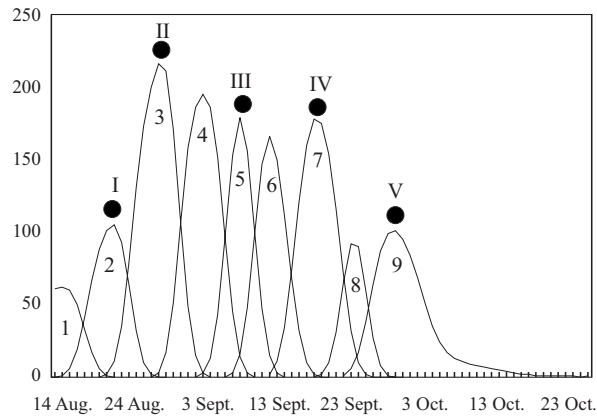

Fig. II-18. Wave structure of seasonal migration of the Willow Warbler at Mierzeja Wiślana according to the modelling procedure (waves *1* to *9*). Main waves as shown by other methods are pointed by black dots and roman numbers (*I-V*).

Table II-5. Seasonal peaks of migration of the Willow Warbler at Mierzeja Wiślana according to different methods

Wave (estimated)	Yearly peaks		Total (smoothed)	Reconstructed	Wave (see Fig. II-18)
	daily	smoothed			
	-	-	-	16 Aug.	1
I	-	21 Aug.	-	21/22 Aug.	2
II	30 Aug.	28 Aug.	29/30 Aug.	28 Aug.	3
	-	-	-	3 Sept.	4
III	8 Sept.	9 Sept.	9 Sept.	8 Sept.	5
	-	-	-	12 Sept.	6
IV	18 Sept.	18 Sept.	18 Sept.	19 Sept.	7
	-	-	-	23/24 Sept.	8
V	29 Sept.	29 Sept.	29 Sept.	29 Sept.	9

The method was checked and developed on the Blackcap migration data by Kopiec-Mokwa (Kopiec 1997, Kopiec-Mokwa 1999). It was suggested there that more detailed divisions could be made basing on less smoothed data and careful analysis of year-by-year peak distribution.

ESTIMATION OF RELATIVE FREQUENCY OF BIRDS IN DIFFERENT WAVES

Comparison of seasonal migration dynamics patterns at different bird stations shows that relative abundance of migrants passing the stations can differ very much as it is shown e.g. at Figure II-4. At Bukowo the most numerous is the first main wave while at Mierzeja Wiślana the most intensive migration takes place 10 days later. In this context estimation of birds frequencies in subsequent waves of migration could be important for monitoring analyses. Some data, both published (Petryna 1976) and preliminary ones (diploma theses written at the University of Gdańsk) show that different waves of migrants can have their own long-term population number dynamics.

As it was mentioned earlier (p. 137) smoothing procedure does not change the total number of the smoothed distribution. Because of that one can accept a sum of values within the wave as an index of a number size of the particular wave within the whole migration. The other possibility to estimate relative frequencies of birds in different waves is to compare top values of the reconstructed distributions. This measure would be exact only when variance within every wave is the same. However, as it can be seen at Figure II-18 and in the Table II-6, it is not a case when we deal with distributions derived from a real data. Table II-6 shows that some estimation made by comparing the peak values differs much from the values obtained when variance within the waves was considered. Despite that an average size of deviations is lower when higher level of smoothing is used, it seems that this last method of estimation is not acceptable for monitoring purposes.

Table II-6. Estimated variance and size of Willow Warbler waves at Mierzeja Wiślana

| Wave (see Fig. II-18) | SD | Number index | | Distribution maxima | | | | | |
| | | | | 1st smoothing | | | 2nd smoothing | | |
		Value	%	Value	%	Deviation	Value	%	Deviation
1	1.62	290	3.8	65	4.6	0.8	62	4.8	1
2	2.21	629	8.3	112	7.8	-0.5	105	8.1	-0.2
3	2.36	1404	18.5	235	16.5	-2	216	16.7	-1.8
4	2.22	1210	15.9	202	14.2	-1.7	195	15.1	-0.8
5	1.76	810	10.7	213	15.1	4.4	179	13.8	3.1
6	1.98	854	11.2	186	13.1	1.9	166	12.8	1.6
7	2.39	1140	15.1	189	13.3	-1.8	178	13.7	-1.4
8	1.59	387	5.1	114	8.1	3	92	7.1	2
9	4.77	865	11.4	106	7.4	-4	101	7.8	-3.6
Average size of deviation						2.23			1.72

CONCLUSIONS

1. Seasonal dynamics pattern of the species is composed of a row of waves of birds migrating through the particular location one after another.

2. The pattern of the passage is repeated year-by-year with quite high accuracy being, however, altered by random fluctuations of environmental variables.

3. The average seasonal migration dynamics can be described by pooling yearly dynamics data into the total distribution.

4. Subsequent waves can be reconstructed from the total pattern as a row of quasi-normal distributions by means of iterative modelling procedure:

   I. choose estimated border days (basing on a shape of the total distribution),
   II. cut the total distribution data into pieces limited by border days; border days values should be divided by two (the shares of bordering waves are equal here) and these halves should be used as these day values in both waves; in a case when we decide to put the border between two days (e.g. in a case of two equally low number days) we add the earlier day value to the earlier wave and respectively the later to the later wave,
   III. smooth the values in every part of data separately using smoothing formula given above in this chapter; the smoothing procedure adds lower and upper tails to the modelled distribution (wave),
   IV. plot obtained distributions against the time scale,
   V. check unimodality and skewness of the resulted distributions; when any of them is still asymmetric or polymodal, add next estimated border days and repeat procedures I to IV as the next step of iteration.

5. Obtained reconstruction of the contents of seasonal dynamics pattern can be used for the estimation of relative frequencies of birds in subsequent waves. These results could be useful for more detailed monitoring studies and comparisons between passage patterns at different bird stations.

6. The wave-like structure of the seasonal migration pattern makes that attempts of the statistical description of the pattern by an average day (and the standard deviation) as well by a median day and percentiles biologically meaningless.

RINGING AND MIGRATION PATTERNS
OF EUROPEAN PASSERINES

Migration patterns of birds have always been of interest to man since, from the very earliest times bird migration was a conspicuous event in spring and autumn. Where do the birds go? Where do they come from? These are questions posed by the inhabitants of different areas at different times of the year. The general answer to these questions is simple: birds move from the cold regions of the north to the warmer countries of the south. During the nineteenth century this simple, but not completely correct picture was more precisely drawn with the huge developments of birds systematics, faunistics and zoogeography. However, since the beginning of the twentieth century, it has been possible to mark birds individually, using rings, and it is this that has changed many of the early theories about bird migration.

The earliest, classic papers summarizing the results of ringing were so impressive, because of their spectacular maps, that this new picture of bird migration was deeply imprinted in the brains of many ornithologists. Unfortunately this imprinting is real block on recent studies of bird migration and it has even forced some ornithologists to urge that bird ringing should stop: arguing that migration patterns of most European birds are now well known and nothing further can be discovered. Happily there are new methods of analysis generated nowadays and the first results develop our knowledge both about the general picture and about the fine details of migration.

DISTRIBUTION PATTERNS

From a zoogeographical viewpoint bird migration is written on a large scale composed only of three elements: the breeding range of the species, its passage routes and its winter range. This is shown schematically on Figure II-19. If we can see, on the distribution map, all three elements – i.e. winter range separated from the breeding range by areas where the species is observed on migration alone (e.g. as Fig. II-20 – the Sedge Warbler, *Acrocephalus schoenobaenus*) we can speak about long distance migration. Such patterns are relatively common among European passerines with 63 species of which 49 are African and 14 Asian migrants. A large group of European passerines (69 species) has their winter range beside or overlapping the breeding range, e.g. Fig. II-20 – the Song Thrush (*Turdus philomelos*) and the Blue Tit (*Parus caeruleus*).

Such a zoogeographical pattern does not tell us if all individuals of the species are migrants. It is possible that they are sequential migrants i.e. southern groups of birds migrating to the southern part of the wintering range, while northern ones winter within the southern part of the breeding range. The other possibility is a „leap-frog" migration
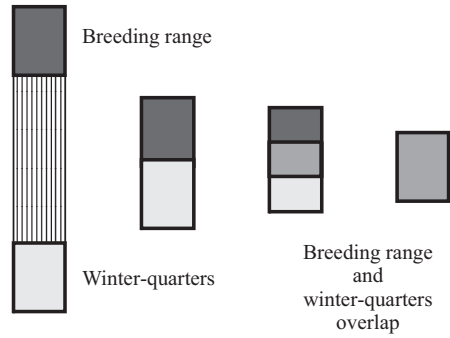
Fig. II-19. Diagram of distribution patterns of birds. From left to right: long distance migrants, two patterns of short distance migrants and the pattern of a sedentary species. Dark crossed – breeding area, dotted – winter- quarters, light crossed – overlapping breeding and wintering ranges, vertical hatching – area of migration.
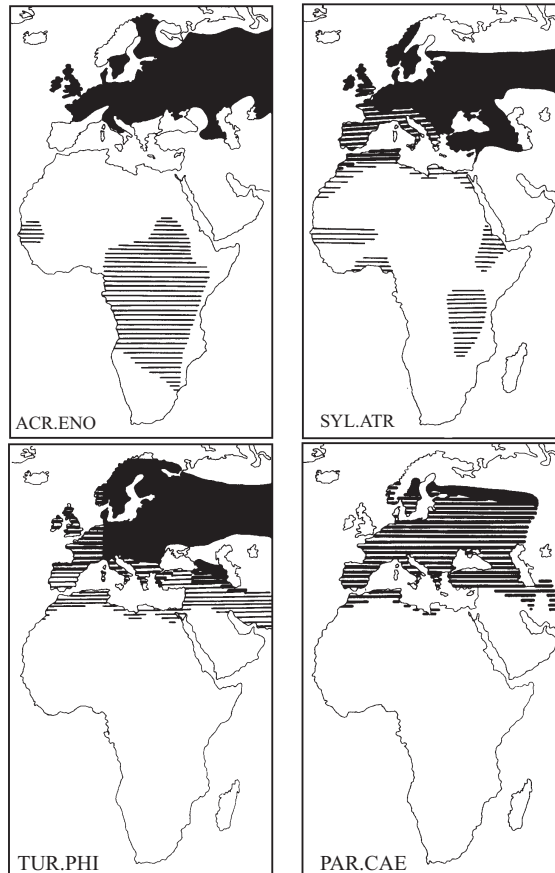

Fig. II-20. Distribution patterns of the Sedge Warbler (ACR.ENO – *A. schoenobaenus*), Blackcap (SYL.ATR – *S. atricapilla*), Song Thrush (TUR.PHI – *T. philomelos*) and Blue Tit (PAR.CAE – *P. caeruleus*).

where the southern groups are sedentary but the northern ones migrate south of the breeding range „jumping" over the sedentary birds. For many of these species it is not known which strategy is used but the problem can be solved, where subspecies occur, by faunistic methods.

Two European passerines show very special distribution patterns in between these two groups – the Blackcap (*Sylvia atricapilla*) (Fig. II-20) and Sardinian Warbler (*Sylvia melanocephala*) have wintering birds both far away (in Africa) and close to the breeding range (Mediterranean or purely European areas). At the other extreme of the clearly long distance migrants is a group of 35 species of passerines in which the winter range completely covers the breeding range. The migratory status of these birds is not clear through distribution maps alone. There is still the possibility of partial migration, irruptive movements as well as all the birds of the populations remaining resident at all times of the year.

This short review of distribution patterns shows clearly that such a simplification of bird migration is completely insufficient and one must have more detailed studies.

RESULTS OF RINGING – CLASSIC STUDIES

Bird ringing, the method used for migration studies since the beginning of this century, documents the data on the displacement of an individual bird from the place where it has been ringed to a place where it has been met again (caught, shot, found). To plot the movements of group of birds the classic ringing studies have mapped together the ringing and recovery places of individuals grouped by area of ringing, sex and/or age. As ringing developed over the years most vigorously in northern and central Europe the first and most important question posed by the scientist was „Where do our local breeding birds go to winter?". This brought about many papers presenting the collected recoveries from local studies. Logically the idea is very simple – map the recovery place of the birds ringed at delimited breeding area (most of the birds ringed at the start of ringing were nestlings and breeding adults) and their movements will be shown. Since the early studies of Mortensen, and regrettably even today, this sort of analysis contains mainly the maps of recoveries collected some time after the birds were ringed. Frequently the maps include lines connecting ringing and recovery places, which may obscure the real migration pattern and force on the reader a false association about migration routes. Such studies are usually very descriptive in character with particular attention being paid to the listing and discussion of „curious" recoveries – singular recoveries of individuals found far from concentrations of other birds. These often consist of comments about unusual deviations from „normal" wintering areas for the population. In this case, the word *population* means simply the group of birds from the study area. Typically such a study area contains birds ringed in only that part of their breeding range delimited by administrative or political boundaries. Even the analyses of all European recoveries of a species are often split up in this manner or by other formal regions as discussed many years ago in *The Ring* (Rydzewski 1959, 1966, Busse 1967a) and adopted in the newest rules of recovery coding (Spencer 1979).

Such classic analytical techniques can, however, give a good picture of migration patterns of the native population of an area where the birds inhabiting the area are homogeneous in their migration habits. In such cases the picture of migration can be clear and the wintering grounds and/or migration routes precisely delineated (Fig. II-21). In such cases one can easily speak about different migrational population and even of narrow-angle migration.

However some other classical local analyses have met serious problems in the interpretation of the picture so obtained – birds from a limited breeding area can migrate to an astonishingly wide winter range (Gromadzki and Kania 1976, Zink 1973). An excellent example is the recovery pattern shown by the Blackcap ringed in central Europe (Fig. II-22).
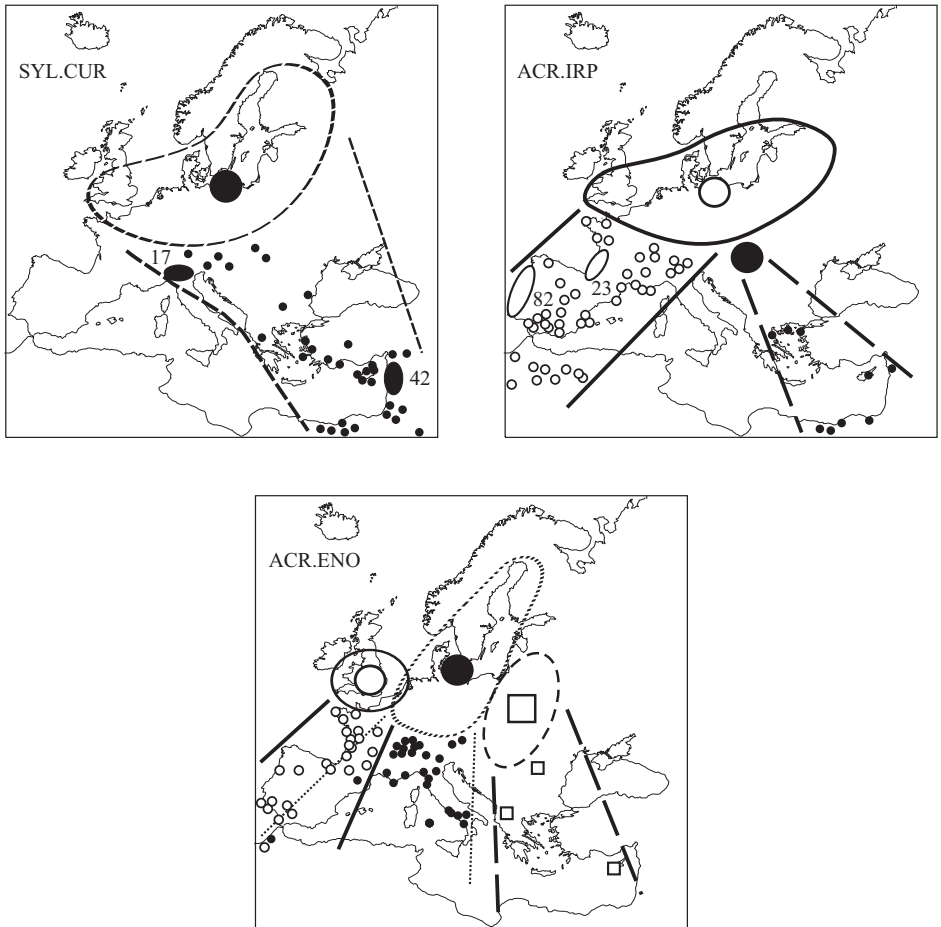

Fig. II-21. Recovery patterns of the Lesser Whitethroat (SYL.CUR – *S. curruca*), Reed Warbler (ACR.IRP – *A. scirpaceus*) and Sedge Warbler (ACR.ENO - *A. schoenobaenus*). Each small symbol shows the recovery place of the bird ringed at the area designated by the bigger symbol. The number shows the number of recoveries from a pointed area.
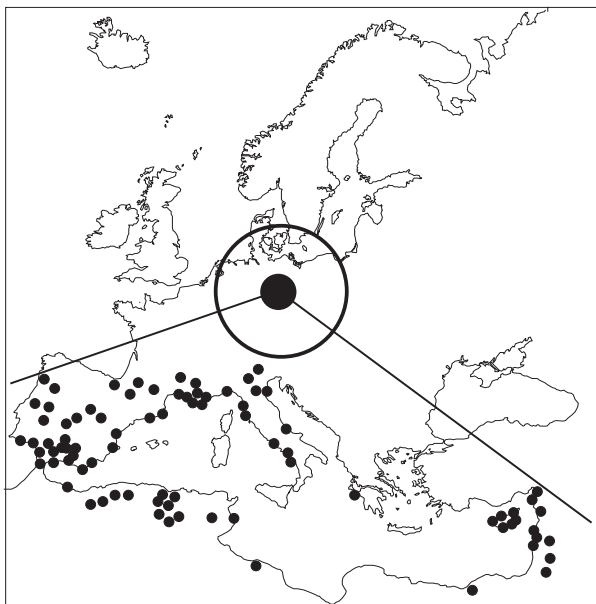
Fig. II-22. Recoveries of Central European Blackcap as an example of wide-angle migration pattern.
Explanations as in Fig. II-21.

Such a pattern must be further investigated. Explanations put forth such as „transitional
populations" (Gromadzki and Kania 1976) or the assumption of the massive influence of
the Alps on migration seem doubtful.

The analysis of the recoveries of birds ringed as migrants is generally much more dif-
ficult than that of birds ringed as natives within an area. Heterogeneous migrants show,
in most cases, a very wide angle of further migration and often a changing recovery dis-
tribution when subsequent groups of migrants are compared (e.g. Robin, *Erithacus rube-
cula* – Pettersson and Lindholm 1983). Detailed explanation of such patterns is not easy
and it can lead to very controversial conclusions. Generally speaking most cases of a
wide-angle migration cannot satisfactorily be explained when only the recovery pattern
is considered.

When one finds, in the course of research, a complicated pattern of migration com-
posed of groups with both narrow- and wide-angle migration, as is the case with Euro-
pean Blackcap (Fig. II-23) or Garden Warbler (*Sylvia borin*), one is forced to look for
new and much more efficient methods of study.

THEORETICAL MODELS IN AN INTERPRETATION OF RECOVERY PATTERNS

After one hundred years of ringing and collecting of recovery data and after the pub-
lication of scores of papers evaluating spatial distribution of recoveries, migration pat-
tern is treated by some ornithologists as already known for most species. More careful
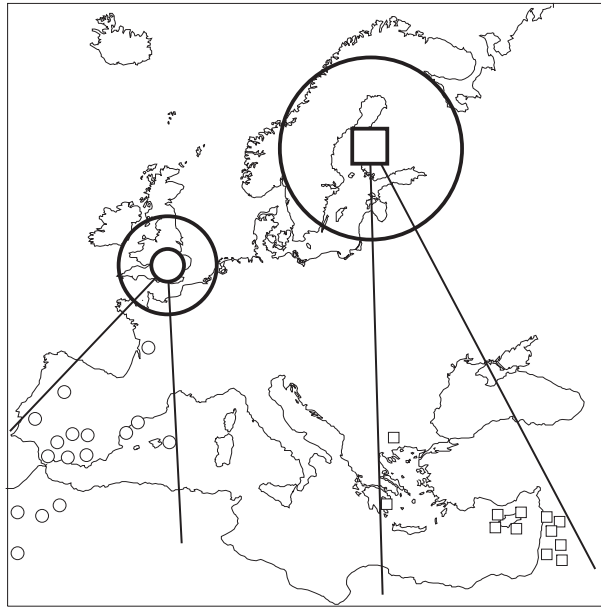
Fig. II-23. Recoveries of Blackcaps ringed in Britain and Scandinavia as an example of narrow-angle migration patterns. Explanations as in Fig. II-21.

analysis of contemporary works shows, however, that they are still methodically rather simple and traditional, closely resembling the old papers devoted to this problem. There are no quantitative estimates of the spatial distribution of migrants. The assumptions underlying the interpretation of patterns are not clearly stated. A method of quantitative estimation of spatial distribution of ringed birds was presented elsewhere (p. 169), while methods of interpretation of recovery patterns are discussed in this chapter, which contains a generalization of conclusions of some earlier publications (Busse 1969, 1986a, 1986c, 1987a, 1987b; Busse and Maksalon 1986a).

Types of recovery patterns

A starting point for any evaluation of the spatial distribution of ringing data is a map with ringing and recovery localities shown, with additional information on the time enabling to separate subsequent parts of the bird life-cycle (especially migration and wintering periods). In evaluation of ringing results two main kinds of data are used: (1) recoveries of birds ringed in their native areas (pulli and breeding individuals), and (2) recoveries of birds ringed as migrants both at permanent ringing stations and caught by individual ringers accidentally. This last group of recoveries is hardly applicable to evaluations and in many cases should be omitted. Evaluations of recoveries of birds ringed during wintertime are rather scarce.

The first step in the evaluation of the spatial distribution in winter is the presentation of the recovery pattern of birds ringed in a specified ringing area (breeding ground or

a bird station). Usually these ringing areas are delimited by political or administrative borders and constitute formal units without any biological significance. Generally in European migrants two rather clearly separated recovery patterns can be found (Fig. II-24): (1) narrow-angle recovery pattern (angle between the most distant west and east recoveries being under 60) and (2) wide-angle recovery pattern (with the angle above 90). They are the simplest patterns to be interpreted in local ringing evaluations (for a relatively small breeding area or a single ringing station).
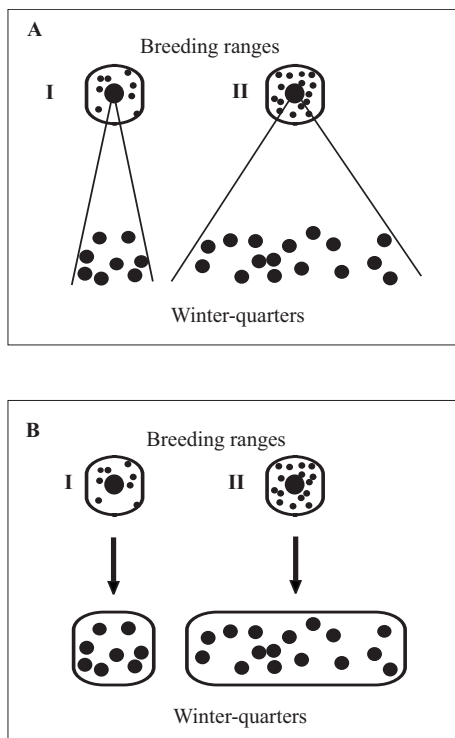

Fig. II-24. Scheme of elementary recovery patterns (*A*) and their interpretation by means of the cline model (*B*). *I* – narrow-angle recovery pattern, *II* – wide-angle recovery pattern. Ringing and recovery localities shown by dots.

More complicated recovery patterns can be found if a study contains analysis of birds ringed within a wide breeding area or at number of bird stations. In this case, results of the analysis frequently depend on hidden assumption underlying the interpretation but not explicitly discussed. The most common assumption, though usually not stated, is that of the homogeneity of the sample under study. This assumption is a basis for one of the models of migration discussed later, while if heterogeneity is suspected a quite different interpretation may result.

Models of migration

Different pictures of migration idealized from recovery evaluations can be reduced to two essential models defined by the assumptions, which are the basics of the model construction.

Cline model

Assumptions:

1. the breeding and the wintering area are occupied by a homogenous bird population, within which all its characters (both morphological and behavioural) are changing clinally;
2. the birds are forced into seasonal movements by existing environmental circumstances, which define destination area, route and timing of migration;
3. the problem of inheritance in orientation and navigation is ignored.

Conclusions:

1. the word „population" used in the context of this model can be treated as a shortened form of an expression: „a group of individuals inhabiting a defined study area". It does not imply that any genetic difference between such „populations" exists;
2. the winter recovery pattern shows the wintering area not differentiated into separable winter-quarters;
3. any differences in recovery patterns of birds originating from neighbouring areas are due to a clinal change of environment at the breeding or wintering areas or result from presence of migratory barriers;
4. any differences in recovery patterns of birds migrating through a bird station in subsequent parts of migration period are due to clinal change of migration time of birds originating from a number of sub-areas localized side by side at the breeding grounds.

Methodical consequences:

1. migration patterns can be sufficiently presented as maps of recovery places of birds originating from breeding sub-areas, ringed at some bird stations or migrating during different parts of migration period;
2. the migration pattern of birds originating from one study area or migration period can be described by an average direction of migration (the mean direction being calculated from all data from the period defined), and by average co-ordinates of recoveries;
3. wide-angle recovery patterns should be explained additionally by the occurrence of contemporary ecological barriers or instability of orientation mechanisms of migrants, as such patterns are not explained by the model itself;
4. curved migration routes found in some species must be forced by the presently operating circumstances of migration (e.g. prevailing winds).

Population model

Assumptions:

1. the wintering area of European migrants can be divided into separate winter-quarters localized at late ice-period refuges of the species **(**Fig. II-25**)** or created from them by
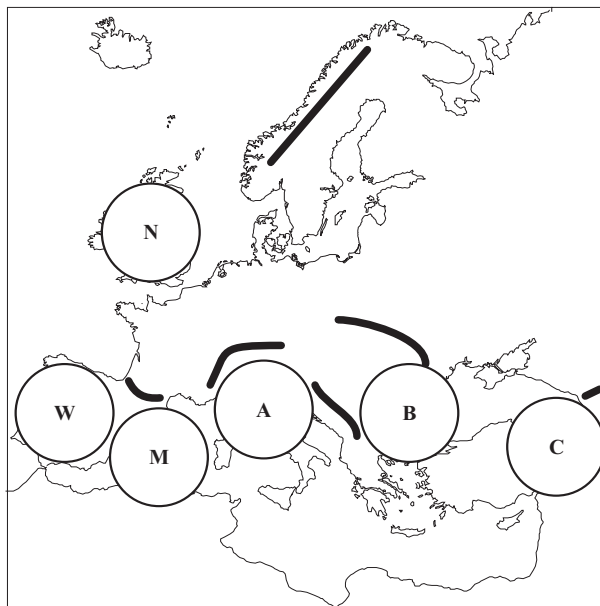
Fig. II-25. Distribution of primary winter-quarters in Europe as accepted in the population model. Main European mountain ridges shown.

shortening of the migration route (secondary winter-quarters – Busse 1969); for long-distance migrants these areas are the first parts of Europe occupied in the past by the populations invading the continent from the south – this determines the present-day pattern of migration;

2. winter-quarters are occupied at wintertime by a defined population, members of which are genetic descendants of birds that started their expansion from this area to central and northern Europe in the period after the Ice Age;

3. wintering at defined winter-quarters is genetically encoded; individuals that are hybrids of parents of different population origin have inherited tendency to migrate towards different winter-quarters;

4. present-day migration routes are inherited and repeat the history of expansion of populations from refuges to central and northern Europe; they can be, modified continuously by a selection pressure of natural or human origin;

5. if a population winters at secondary winter-quarters or migrates by a modified migration route the recovery pattern of first-year birds reflects older migration customs of the population, while the recovery pattern of adults shows the most recent wintering area.

Conclusions:

1. The word „population" in the context of this model has a defined genetic meaning: „A group of individuals which are descendants of birds originating from a specified ice-age refuge and having inherited migratory behaviour involving wintering at the same winter-quarter and migration by a historically evolved route". Population mem-

bers can breed at separated areas or at mixed zones (these are inter-population hybrids). As membership of the population is defined by genetic characteristic of an individual, hybrids can demonstrate features of two or even more populations;

2. winter-quarters are homogenous regarding the population of wintering birds, while breeding areas can be occupied by a pure population or by individuals of mixed-population origin;

3. the shape and localization of pure population areas and/or mixed zones and present-day migration routes can be a basis for hypotheses explaining the post-glacial history of the species;

4. differences in recovery patterns of migrants ringed at a bird station in subsequent parts of migration period are due to the differentiated population composition of migrants in these parts. Trespassing individuals can originate from pure population areas, from mixed zones or at the bird station there can be a crossing of migratory routes of populations originating from quite different breeding areas;

5. it is not necessary to explain curved migration routes by present-day environmental constraints.

Methodical consequences:

1. the migration pattern presented in a paper should describe winter-quarters, migration routes and breeding areas of populations;

2. after a preliminary analysis of the distribution of winter-quarters it is necessary to map the ringing localities in the breeding grounds of those birds wintering within specified winter-quarters; they will create a basis for the delimitation of pure population areas and mixed zones;

3. a wide-angle recovery pattern means that the breeding area lies at a mixed zone of two or more populations, so calculation of mean direction and/or co-ordinates is not justified;

4. a curved migration route can be explained by the history of population expansion, if there are no other clear causes;

5. a shift of recovery patterns of birds ringed at a station in subsequent parts of migration period means that there is a population mixture and that the calculation of average directions and/or co-ordinates is not allowed; the population structure of migrant waves can be reconstructed from the changing relations between numbers of recoveries at defined winter-quarters;

6. if there is a suggestion that the studied sample is composed of members of a number of different populations (because of a shift in the recovery patterns of the migrants), than it is necessary to use special methods of analysis for elaboration of biometric data (see Chapters *„Localisation of the breeding origin…"* and *„Correlative topography…"*).

Interpretation of recovery patterns

Elementary recovery patterns

Elementary recovery patterns occur when recovery data from a relatively small breeding area or one ringing station are studied. After the cline model theory these pat-

terns are interpreted as denoting the winter area of local population or migrants passing through the station. The population model suggests that a narrow-angle recovery pattern means that the studied area lies at the pure population breeding area, while a wide-angle pattern occurs because the area under study lies, at least partly, within a mixed zone between populations. In the case of bird station recoveries – the former pattern implies that migrants are recruited from one population, while the second – that they are a mixture of members of different populations. The latter statement makes it necessary to further study the migrants, and to take under consideration at least time-dependent differentiation of recovery patterns.

Complex recovery patterns

Complex recovery patterns occur when the ringing area is wide (Fig. II-26, II-27) and it can be divided into several sub-areas, or when ringing data from several ringing stations are evaluated, or when ringing data from one station are divided into time-dependent sub-samples of migrants (Fig. II-28).
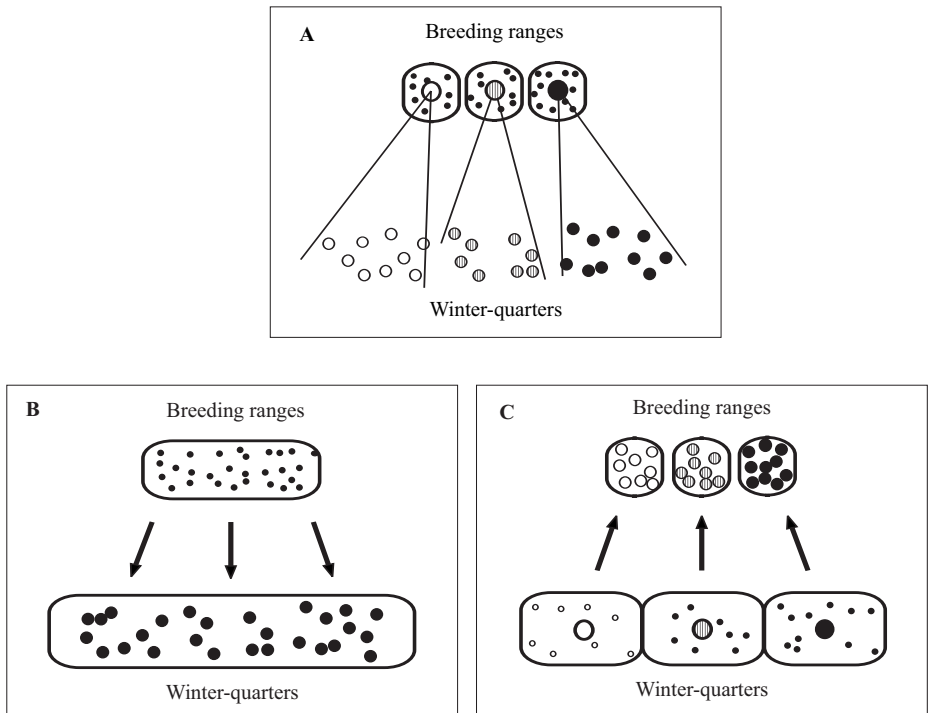

Fig. II-26. Scheme of a complex recovery pattern of native birds and its interpretations: components are exclusively narrow-angle patterns, *A* – not interpreted recovery pattern; *B* – interpretation of the pattern *A* according to the cline model; *C* – interpretation of the pattern *A* according to the population model. Ringing and recovery localities symbolised by dots.
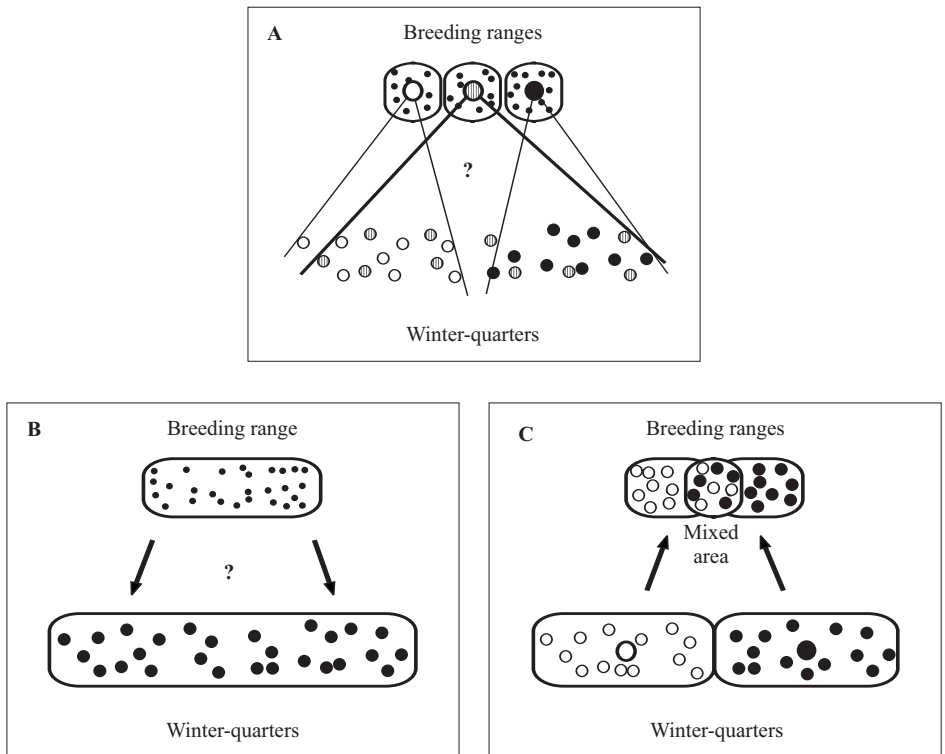
Fig. II-27. Scheme of a complex recovery pattern of native birds and its interpretation: components
are both narrow- and wide-angle patterns. *A* – not interpreted recovery pattern; *B* – interpretation
of the pattern *A* according to the cline model; C – interpretation of the pattern *A* according
to the populational model. Ringing and recovery localities symbolised by dots.

While working with recoveries of native birds, a situation may occur when all component elementary patterns display a narrow-angle recovery pattern (Fig. II-26A). Interpretation by means of the cline model gives a simple picture (Fig. II-26B) of homogeneous breeding area from which the birds migrate on a broad front to a wide wintering area of the species. The population model (Fig. II-26**C**) interpretation suggests that there are population differences within the breeding area (since the winter area contains several winter-quarters) but the borders chosen by an analyst agree with population borders at breeding grounds. Mixed zones between populations are so narrow that the studied sample of birds does not show their existence. Figure II-27A depicts the most common situation, when a complex recovery pattern contains both narrow- and wide-angle patterns. The cline model explains this type of pattern only with difficulty (Fig. II-22B) – it assumes homogeneity of both breeding and winter areas, suggesting the same explanation as in the case of narrow-angle patterns. Additional hypotheses about environmental conditions having forced the birds originating from central sub-areas to migrate in different directions become necessary. However, such an interpretation contradicts the assumption of inheritance of orientation mechanisms and must be supplemented by additional
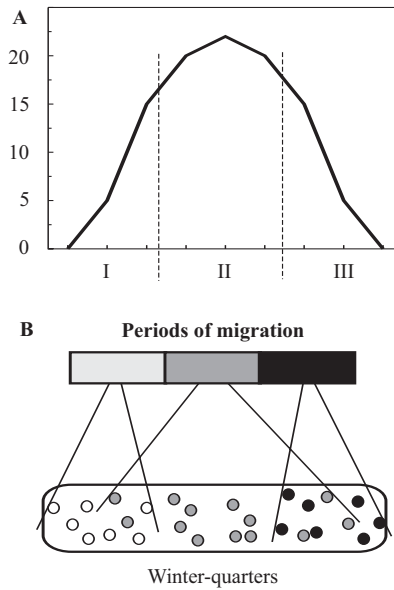
Fig. II-28. Raw data in study of recovery pattern of birds ringed as migrants at a bird station.
A – migration dynamics pattern: *I, II, III* – periods of migration; *B* – recovery patterns
of birds ringed in subsequent periods.

assumptions. Interpretation by the population model (Fig. II-27**C**) shows two winter-quarters and two population areas at breeding grounds overlapping in their central part. Migration of birds from this territory in the direction of two winter-quarters produces a wide-angle recovery pattern. Individuals living there are inter-population hybrids and they may be genetically able to choose different directions of migration. This choice can depend on actual weather conditions (when the individual starts to migrate) or may be accidental. In both cases the migrant individual is steered by one of inborn programs of navigation.

Working with recoveries of birds ringed at a bird station during migration time one can take additional data into consideration. Such additional information can be used in migration dynamics (time and/or waves of migration) evaluation, which allows one to find time-dependent changes in recovery patterns (Fig. II-28). The lack of time-dependent differentiation of recovery patterns reduces the problem to an analysis of the elementary pattern. More interesting is the case when recovery patterns change in subsequent parts of migration period offering a combination of narrow- and wide-angle recovery patterns with a shift of concentration of recoveries within the wintering areas. Interpretation of such complicated patterns clearly depends on an accepted model of the structure of breeding bird population. Accepting the assumption of the cline model on the homogeneity of the breeding area (Fig. II-29), the assumption of a continuously changing starting time for migration has to be agreed on, as well as the homogeneity of the wintering area. As a consequence there is a homogeneous interpretation of migration dynamics, which does not require further, e.g. biometrical, studies of the migrants.

Fig. II-29. Scheme of interpretation of a complex recovery pattern of migrants passing one station, according to the cline model. Above - assumed homogeneous structure of breeding area and winter-quarters. In the middle - concluded migration patterns of individuals passing the same station in subsequent periods of migration (*I, II, III*); large circles represent the same station in three periods of migration; arrows show routes of migration and point at mean longitude of recovery places. Below - resulting image of migration dynamics structure - one homogeneous group of migrants in passage is symbolised by one circle.

The population model assumes the splitting of the breeding area into three sub-areas (Fig. II-30): – pure population areas P_X and P_Y, and a mixed zone XY. Populations X and Y have different average times of migration (in Figure II-30 large difference in the timing of migration is assumed to make the explanation clearer). Only in this case can one find shifting recovery patterns. In the first period of migration only members of population Y migrate, in the second one – members of both populations, while in the last period – only members of population X. They all direct to their own winter-quarters. The population model easily explains curved migration routes. In conclusion, the structure of migration shows the differences between the migrants and suggests a further study of their origin, e.g. through biometrical differences in the samples.

Discussion of the models

The cline model of migration is a classic one, widely accepted by analysts of ringing recoveries, although never formulated as a set of assumptions constituting a base for interpretation of recovery patterns. It dominated in published papers, helping to evaluate both local and Europe wide ringing data. Interpretation by means of this model is simple and easy for discussion when local (one country or one station) data are analysed. Its assumptions allow for the use of statistical calculations for the presentation of data (mean direction and/or mean co-ordinates) that are thought to be a modern way of presenting migration patterns. There are, however, some weak points in the model:

1. wide-angle recovery patterns and curved routes of migration must be explained additionally as they do not correspond with the current knowledge of navigation mechanisms,
2. its assumptions obscure the picture of migration by neglecting internal differentiation of the sample and discourage students from more complex and deeper studies on migration dynamics and biometrical differentiation,
3. the final results of evaluation are descriptive in character and are difficult to be presented in a synthetic form when a large breeding area is studied.

The population model limits the value of local studies (nation-wide or one-station data) by showing that they cannot solve problems of the distribution of populations. The full analysis based on this model should contain several steps:

1. primary identification of winter-quarters by classic mapping of recovery locations,
2. delimitation of populations breeding areas and mixed zones,
3. evaluation of data describing migratory routes,
4. control of differences in migration pattern between young and adults, and
5. reconstruction of evolution of the species migration pattern.

The desired complexity of evaluation makes it more difficult for less advanced students and needs much more effort. The advantages of the model are, however, quite numerous:

1. the picture resulting from the evaluation – population pattern with mixed zones and more or less defined routes of migration – explains all elements of the migration pattern (wide-angle patterns and curved routes of migration),
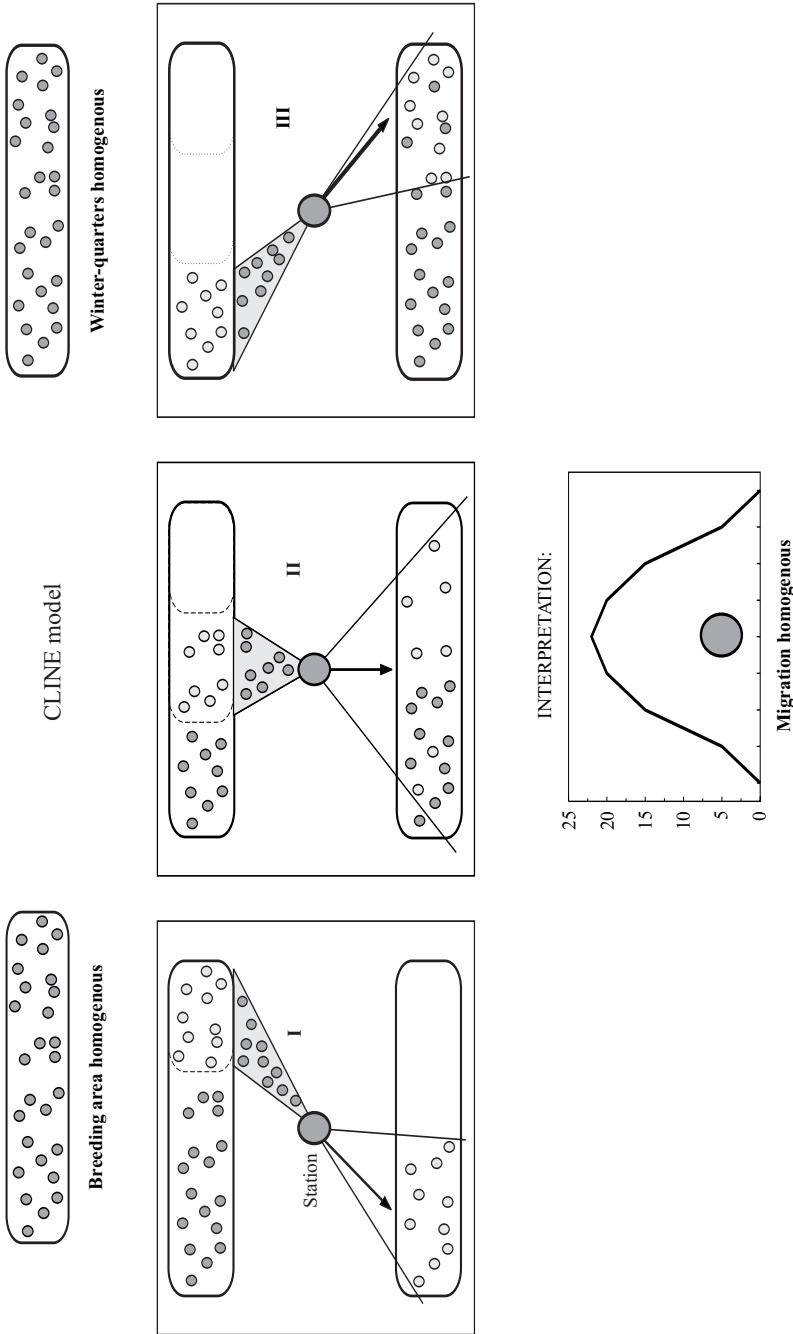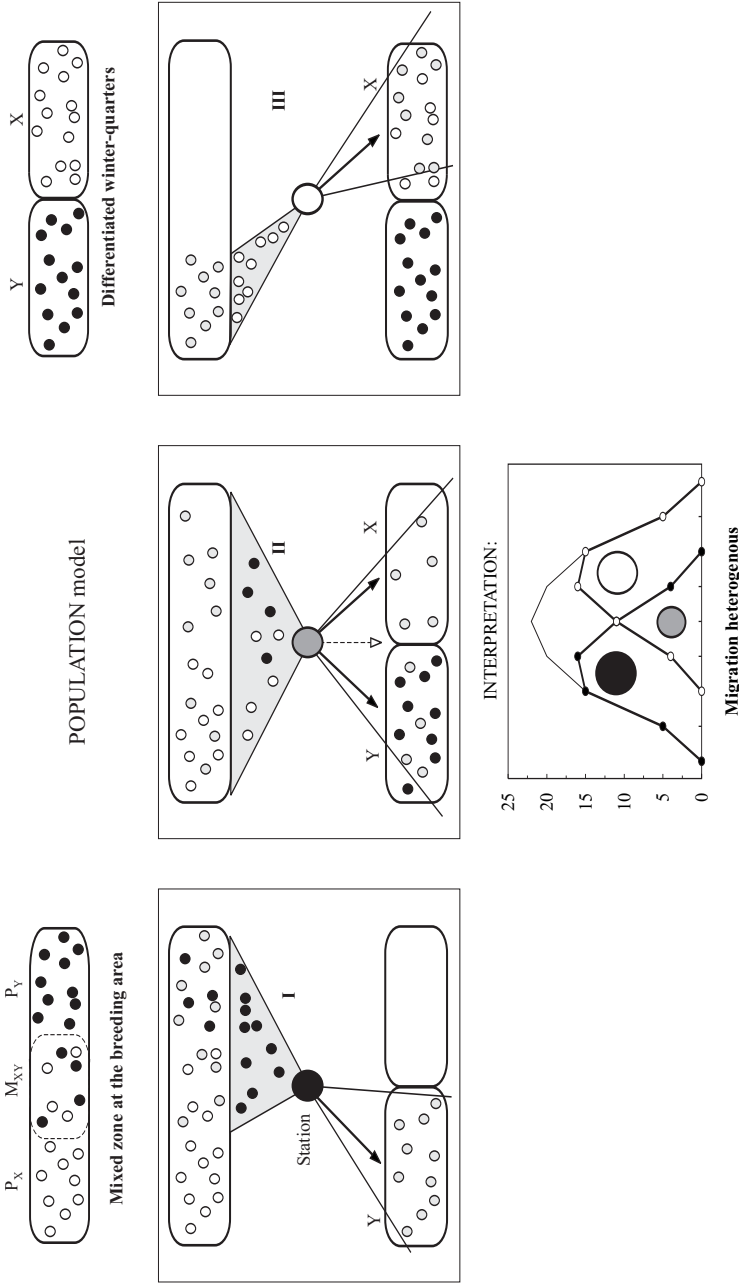
Fig. II-30. Scheme of interpretation of complex recovery pattern of migrants passing one station according to the population model. Above – assumed heterogeneous structure of breeding area containing pure population areas $(P_X, P_Y$ and mixed zone $M_{XY})$ and heterogeneous winter-quarters $(X$ and $Y)$. In the middle – concluded migration patterns in subsequent periods of migration (I, II, III) of individuals representing populations X and Y and passing one station: the circles representing the station are differentiated because during three subsequent periods population X (I), mixture of individuals belonging to populations X and Y (II) and population Y (III) migrate, black arrows – routes of migration of "X" and "Y" population members, in period I and III they show mean longitude of recovery places, but in period II they do not (mean recovery longitude is pointed by a white-headed arrow). Below – resulting image of migration dynamics at the station is composed of two elements (curve of migration dynamics of population X and that of population Y); circles symbolize population composition as station symbols above.

2. evaluation of age-dependent migration patterns reveals contemporary trends in the evolution of migratory habits of the species, which encourages studies of evolutionary causes (of climatic or anthropogenic character) of observed changes,

3. the model provides a theoretical basis for quantitative analysis of recovery distributions by means of probability methods,

4. comparison of population patterns of various ecologically different species allows for the reconstruction of the development of bird communities in different parts of Europe,

5. the model facilitates complex studies of migrants as it stresses the possibility of internal differentiation of samples.

   The population model is logically more general than the cline model. The latter can be treated as a special case of the former: interpretations are identical if the birds from a pure population area migrate to one winter-quarter only.

   A rough analysis of recovery patterns of about forty species presented in the Zink atlas of Passerines ringing recoveries (Zink 1973-1981) and some more detailed studies (Busse 1969, Busse and Maksalon 1986a) adequately support the population model.

RECOVERY PATTERN AND DISTRIBUTION OF RINGED BIRDS

   One of the most important tasks of ringing is to determine the distribution of the birds after migration (e.g. from breeding to winter grounds). It is often done by showing the recoveries on the map, assuming that their distribution corresponds to that of the ringed birds. Such an assumption usually is not true (e.g. Busse and Kania 1977, Perdeck 1977), as the detection coefficient (ratio of number of the recoveries to the number of ringed birds present in the area, Busse and Kania 1977) is changeable in time and space. Time changes can refer to years (e.g. the reporting rate of White Storks, *Ciconia ciconia*, in the middle-east Africa was higher during the colonial time than now), seasons or even shorter periods (e.g. rings found on waterfowl are reported much more often during the hunting season than beyond it). It is also known (e.g. Payevsky 1973) that the detection coefficient varies from area to area. It can be null in an area uninhabited by man and close to 100% in the case of birds carrying rings readable by binoculars and staying for a longer time in the restricted area, which is densely populated by ornithologists (e.g. arctic geese and swans wintering in some parts of Western Europe).

   The detection coefficient depends on many factors, e.g. density, hunting customs and cultural level of people, place where the ring is fitted – tibia or tarsus, kind of address written on it – Sales (1973a), habitat, predator pressure, which all are hard or impossible to quantify. Thus the calculation of their influence seems to be impossible.

   Ringers can meet influence of detection coefficient on their work looking for number of recoveries obtained from ringed birds (recovery rate – number of recoveries per hundred ringed birds). In passerines recovery rate is usually low, as detection coefficient for these birds is low too. However, it can be low, very low or very, very low. How low it is depends in Europe mainly on migration pattern of the population. As an example the re-

covery pattern of Robins ringed at the Operation Baltic stations could be given (Fig. II-31). It suggests that nearly all Robins migrating through the south coast of the Baltic are moving SW-W, while only single individuals SE. This is in clear contradiction with results of orientation tests performed at the Operation Baltic stations and elsewhere (see p. 194). The situation is similar to that at Figure II-32 where only two recoveries of Song Thrush ringed at the same area came from the Balkan Peninsula. In the last case studying recovery rate of birds ringed at different bird stations could help to solve the problem of migration pattern in this area. We can use here values of the index of ringing efficiency (x) that is handier for presentation.

$x = N/V$,

where: N – number of ringed birds, V – number of recoveries.

The index x gives the number of birds that must be, on average, ringed to obtain one recovery.
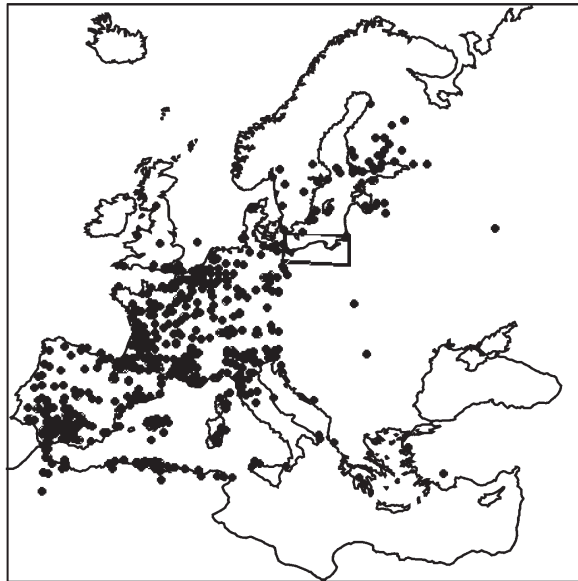
Fig. II-31. Recovery places of Robins ringed during the Operation Baltic work at the Polish Baltic coast and recovered south of Poland ($N = 557$). A few recoveries SW of the map boundaries.

In discussed case differentiation of x values is very well pronounced and distribution of the high values of x index (Fig. II-33) suggests direction of migration of some birds to the null-rate reporting area somewhere in SE Europe. The stream of such birds is concentrated in the central part of the Polish Baltic coast (Bukowo station). The example shows that reporting rate can influence ringing recovery evaluations very much.

However, an approximate picture of the distribution of the ringed birds can sometimes be obtained by means of a method presented below. The basic requirement of the

Fig. II-32. Breeding grounds of the Song Thrush populations wintering on the main winter-quarters.
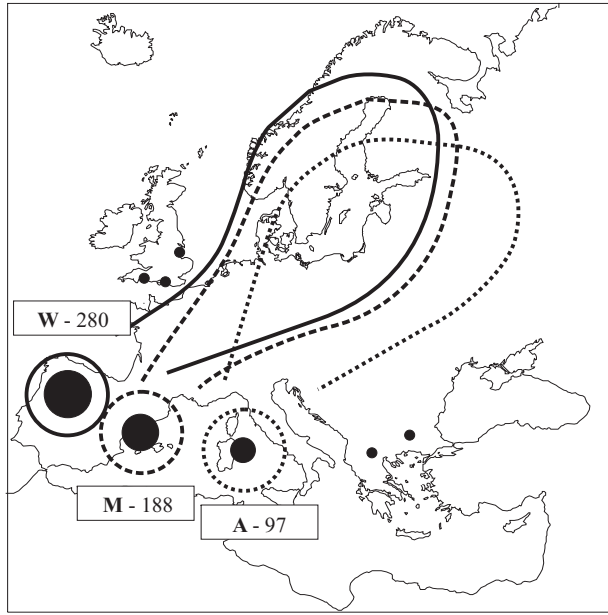Black dots – recoveries outside main winter-quarters. Numbers of recoveries used are given.
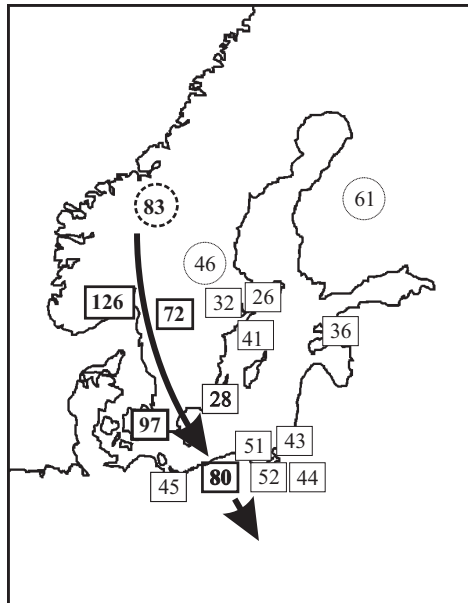

Fig. II-33. Effectiveness of ringing (*x* values) of Song Thrushes ringed at different ringing stations
(in squares) and at various areas (in circles). Estimated flyway of birds directed to Balkans is shown.

method is that the ringed birds must be dividable into some groups (spatial or temporal) and these groups must winter at the same set of winter-quarters (Fig. II-34). The method gives a point estimate. The problem of estimating its confidence limit is still open. But just as direct inspection of the recovery map is, in spite of above criticism, a proper preliminary approach. An application of the method may sometimes be very useful in closer examination of the data.
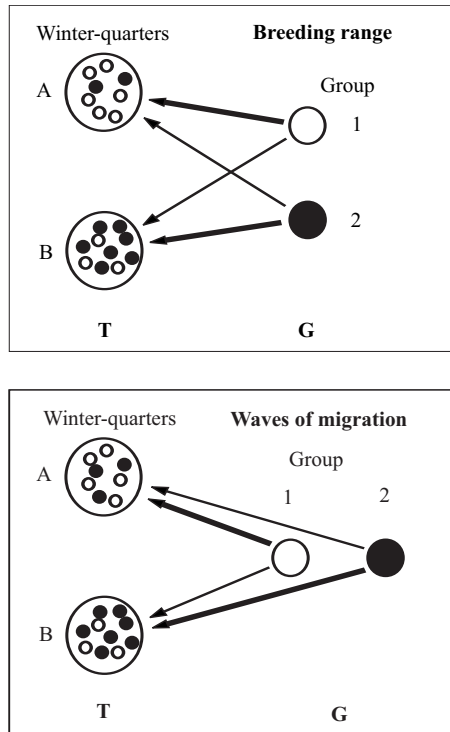
Fig. II-34. Schemes of ringing-recovery patterns suitable for estimation of the ringed birds dispersal. Above – „spatial differentiation": the birds originated from some areas or passing some stations (G – groups *1* and *2*) migrate to some winter-quarters ($T – A$ and B). Below – „temporal differentiation": the birds passing one station in subsequent waves (G - groups *1* and *2*) migrate toward some winter-quarters ($T – A$ and B).

The method was first published in the *Notatki Ornitologiczne* (Busse and Kania 1977), used in two papers by Busse and Maksalon (1978) and Kania (1981), and next presented (together with an application) in the bulletin *The Ring* (Busse 1981). Here the method is described after Kania and Busse (1987) in a simpler manner than in the original publication, but with all the details important to its user included (some details of calculations are given in the original paper).

The method

A basic question in the spatial analysis of ring recovery data can be formulated as follows. How many ringed birds of the species or population under investigation, migrate potentially to each destination area, e.g. wintering area? That is, for instance, what are the values of $N_{1A}, N_{1B},........., N_{1K},$[*] for group *1* in Fig. II-35?

Fig. II-35. A model of migration of some groups of ringed birds to some destination areas.
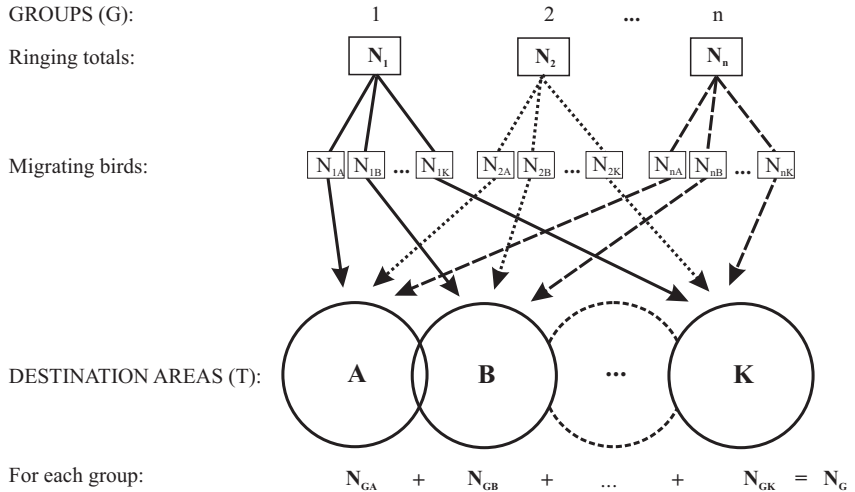*N* – number of ringed birds. Indices *1, 2, ... n*, generally *G*, denote bird groups; indices
A, B, ... K, generally *T*, denote destination areas.

When all the birds under investigation are treated as a whole, the answer to the question seems to be impossible. But if they can be divided into groups (e.g. groups *1,2,......, n* in Fig. II-35), migrating in different proportions to various destination areas (e.g. areas *A, B,....., K* in Fig. II-35), the answer can be given. We take into consideration potential migrants to the destination areas – that is, including the birds, which would migrate there if they were not killed, caught or exhausted before starting migration or during it.

The number of ringed birds from group *G*, potentially migrating to the area *T*, (N_{GT}) can be calculated from the formula:

$$N_{GT} \quad V_{GT} \quad x_T \tag{1}$$

where: V_{GT} is the number of recoveries of birds from the group *G*, found in the destination area *T*; x_T, the ringing-recovery ratio for area *T*, is the number of birds potentially migrating to area *T*, which, on average, have to be ringed to get one recovery from that area. The ringing-recovery ratio is specific for every area and, as for the detection coefficient, is practically impossible to asses by evaluation of the influence of the natural envi-

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[*] Indices *1,2, ..., n*, generally G, denote bird groups. Indices *A, B, ..., K*, generally *T*, denote destination areas.

ronment and human activity. However, a set of equations can be constructed, which makes finding values of x_T for each area possible. There is one equation for each group in the set. Each equation is an expansion of the formula from Fig. II-35:

$$N_{GA} \quad N_{GB} \quad \ldots \quad N_{GK} \quad N_G \qquad (2)$$

obtained by substitution of N_{GT} (i.e. N_{GA}, N_{GB}, ...,N_{GK}) according to formula (1). The set is as follows:

$$
\begin{array}{l}
V_{1A} \; x_A \; V_{1B} \; x_B \; \ldots \; V_{1K} \; x_K \quad N_1 \\[4pt]
V_{2A} \; x_A \; V_{2B} \; x_B \; \ldots \; V_{2K} \; x_K \quad N_2 \\
\quad . \\
\quad . \qquad\qquad\qquad\qquad\qquad\qquad (3) \\
\quad . \\[4pt]
V_{nA} \; x_A \; V_{nB} \; x_B \; \ldots \; V_{nK} \; x_K \quad N_n
\end{array}
$$

An example

Let us examine a hypothetical application of the method (Fig. II-36). There are two groups of birds numbered *1* and *2*. The total numbers of birds ringed are known (N_{1A} and N_{1B}). Those birds migrate to two wintering areas, called *A* and *B*. The numbers of birds recovered there (V_{1A}, V_{1B}, V_{2A}, V_{2B}) are also known. Our question is how many ringed birds from both groups choose each of those two areas potentially, i.e. what are the values of N_{1A}, N_{1B}, N_{2A}, and N_{2B}? To obtain those, first the values of x_T have to be calculated, using equation set (3):

$$100 \; x_A \quad 10 \; x_B \quad 10000$$
$$60 \; x_A \quad 24 \; x_B \quad 15000$$

These give: $x_A = 50$, $x_B = 500$.

Knowing x_T, the values of N_{GT} can be calculated from the formula (1), as follows:

$$N_{1A} = 100 \; 50 = 5\,000, \qquad N_{1B} = 10 \cdot 500 = 5\,000,$$
$$N_{2A} = 60 \; 50 = 3\,000, \qquad N_{2B} = 24 \cdot 500 = 12\,000.$$

The picture of winter distribution of birds from both groups, obtained in this way (lower part of Fig. II-36) is quite different from the one obtained when assuming that the recovery distribution corresponds to the ringed birds distribution.

The requirements

It is possible to obtain the point estimate of the bird distribution over the destination areas by means of the method presented above only if the following requirements are met:

1. The investigated birds can be divided into groups.
2. The total area, to which the birds migrate, can be divided into some destination areas.
3. No destination area is omitted (which can be the case when the area has an extremely low, near-zero recovery rate).
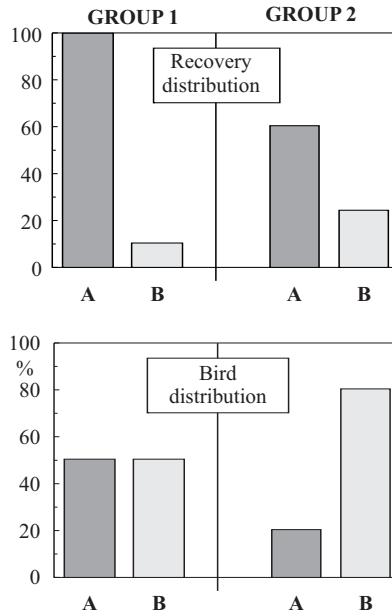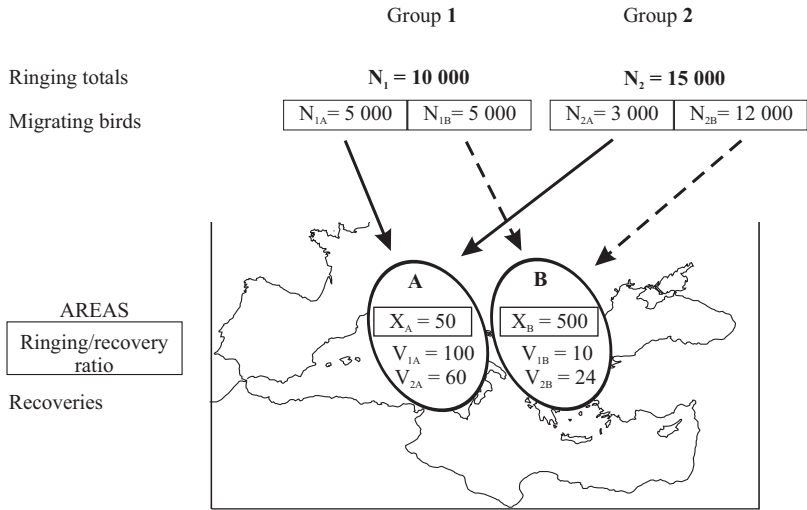
Fig. II-36. Schematic diagram of distribution of two hypothetical groups of ringed birds on wintering areas, each of them migrate to both destination (wintering) areas, but in different proportions. Above – the unframed numbers denote known data, the numbers with the frames denote calculated values. Below – recovery and bird distributions on areas shown above.

4. The number of groups (or equations in the set) is not smaller than the number of destination areas (or unknown variables). If the number of groups is bigger than the number of destination areas (the number of equations is bigger than the number of unknowns), the set of equations is insoluble, because the requirements (6) and (7) cannot

be fulfilled and (9) only sometimes. In such case one has to look for the probably closest to real ones values. Such values can be the numbers, which, after substituting the unknowns, will yield the lowest possible sum of the squared differences between the right and left members of the equations of the set (3). This is achieved by differentiation.

5. If the numbers of groups and destination areas are equal (number of equations = number of unknowns) none of the equations can be identical with another, because it reduces the number of equations used in the calculation of the unknown variables (x_T) below the required minimum.

6. The ringing-recovery ratio is the same for each part of any destination area or the distribution of each group over any area is the same.

7. Birds from each group have the same probability of being reported. When the groups represent geographical populations, their breeding grounds have to lie close to each other and have to be small, when compared with the distance to destination areas, so that it can be assumed that factors influencing mortality of birds from those populations after ringing, and before reaching the destination area, operate with equal power. When destination areas are arranged in such way that to reach some of them birds have to cross the others, there is a problem in analysis of the recoveries from the migration period. In the case of those destination areas through which some birds migrate further, the only recoveries that can be included are those which are found after the end of the migration to the furthest destination areas, and before the beginning of the migration from there. Of course, all recoveries with an uncertain date of death or capture should be excluded, as well as those concerning weak or injured birds when found, as they could stay at the place they were found only because they were unable to continue migration. In the case of furthest destination areas all the recoveries can be included. However, then the values of x_T are lower and can be used only to calculate the values of N_{GT}, and cannot be compared with x_T from areas closer to the ringing place.

8. The number of recoveries is not too small.

9. The recoveries are from a period when the ringing-recovery ratio does not alter. The alterations can be due to modifications in the hunting season or quota, political changes, wars etc. Such alterations have no impact on the results of a study only when the proportions of birds, ringed before and after their occurrence, are the same for each group.

The substantial difficulty in showing an exact distribution of ringed birds based on the recovery distribution is in the fact that recoveries almost never constitute random samples of ringed birds. The presented method accepts these uneven weights of recoveries, but not wholly, as it is practically impossible to divide a total destination area into small and numerous areas, which are really uniform with respect to the ringing-recovery ratio, thus to entirely fulfil requirement (6).

Also requirement (7) cannot be fully met in practice. Requirement (8) could be stated more precisely only after some experiments with the hypothetical sets containing the to-

tals of recoveries and ringings for different numbers of bird groups and destination areas and for various values of the ringing-recovery ratio.

In spite of these shortcomings, in some cases the method enables us to obtain more precise picture of the spatial distribution of ringed birds than the methods, assuming recoveries as random samples of ringed birds. However it should be stressed that the results obtained by the method presented here should not be fully accepted without checking them against other approaches, e.g. analyses of bird measurements and population trends (Busse 1981).

RESULTS OF RINGING – ADVANCED STUDIES

As it was stressed earlier, traditional imprinting of some point of view (stressing the breeding grounds) does not lead to an easy analysis. Fortunately it is also possible to carry out the analysis the other way round: from the recovery place that is an area where ringed birds have been found during winter and/or on migration (as it was explained above). Let us see the ringing pattern of the Blackcap (as shown at Figs II-22 and II-23) from this new point of view (Fig. II-37). Mapping of the breeding places of birds found at three destination areas (wintering and migration) gives breeding distributions of the individuals concerned, which have shown the differentiated migration. One can easily assume that they belong to populations exhibiting different migration urges and the apparently complicated recovery pattern becomes much simpler (Fig. II-38). Now it shows areas inhabited by populations with a single migration route (here England and France and most of Scandinavia) and those occupied by a mixture of birds, which have inherited different directions of migration. A similar migration pattern was found in the Rook (*Corvus frugilegus*), where the mixed zones of two or even four populations occur (Fig. II-39), as well as in other Corvids (Hooded Crow, *Corvus corone cornix*, and the Jackdaw, *Corvus monedula*, – Busse 1969) and in a limited analysis of the Meadow Pipit (*Anthus pratensis)* (Petryna 1976).

In recent years migration pattern of European Song Thrush (*Turdus philomelos*) has been intensively studied (Busse and Maksalon 1978, 1986 a, and b, Maksalon 1983). So, this species can be an example to demonstrate new possibilities offered by a new concept of analysis of bird ringing and catching data. Recoveries of song thrushes ringed at breeding grounds in northern, eastern and central Europe suggest a pattern of population movements shown on Figure II-32. Most of these areas are inhabited by a mixture of birds directing their migration to West Iberian Peninsula and Western France for the *W* population, East Spain and South France for the *M* population and Italy and North Africa for the *A* population. There are a few recoveries from Great Britain and the Balkan Peninsula and a problem if they are exceptions to the rule. However, this problem can be solved when a quantitative method of studying the recovery dispersal is applied to the data (see p. 169). By studying the recoveries distribution of Song Thrush migrating through different parts of the Polish Baltic coast in different waves of migration and the recovery rate of these birds, it has been found that they migrate to four winter areas (Fig. II-40) in-
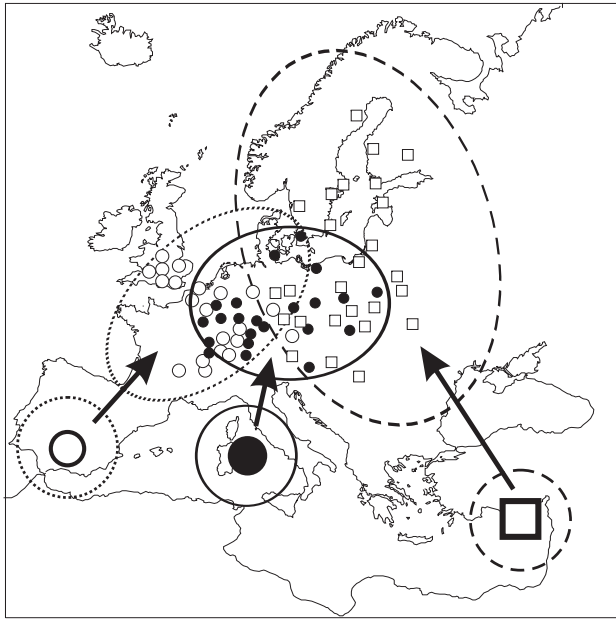
Fig. II-37. Recovery pattern of the Blackcap drawn after „looking from the south" method. Small symbols show the ringing places of birds found in the wintering quarters designated by the big symbols.
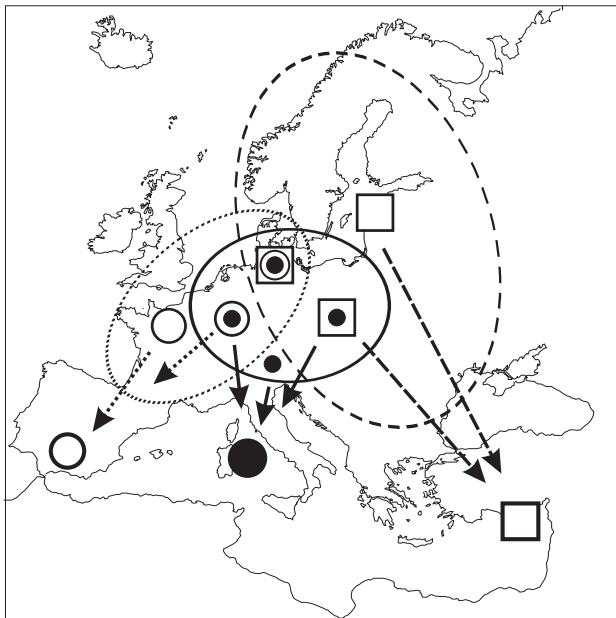
Fig. II-38. Population areas of the Blackcap from that shown in Fig. II-22 and 23. The simple symbols at the breeding grounds show areas occupied by pure populations, combined symbols show zones where there is a mixture of two or three populations.
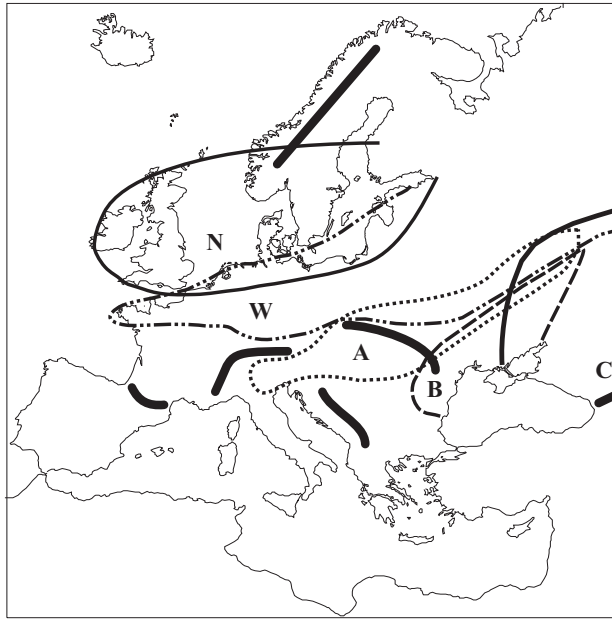
Fig. II-39. Population pattern of the Rook. Letters – symbols of different populations, lines – borders of different population areas, black stripes – main mountain ridges.
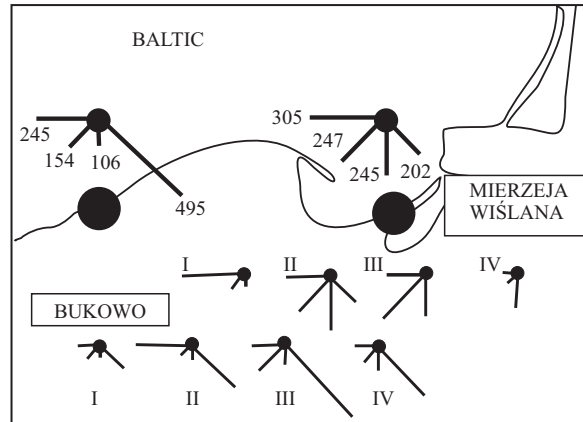
Fig. II-40. Migration pattern of the Song Thrush at two Polish Operation Baltic ringing stations Bukowo and Mierzeja Wiślana. Numbers indicate the proportion of individuals (per 1000 migrants) directing to four winter quarters (three specified at Fig. II-32 and the Balkan one). Two lower rows of sings show differentiation between subsequent waves of migrants.

stead of three suggested by the preliminary analysis (Fig. II-32). The fourth wintering area (and its corresponding breeding zone) was discovered by using the migration pattern of Song Thrush observed at the Polish Baltic coast (Maksalon 1983) and the reco-

very rates of this species ringed in different parts of the Baltic basin (Busse and Maksalon 1986 b). In addition, by re-analysing Ashmoles (1962) data from the British Isles, the final migration pattern of European populations of the Song Thrush seems to be as shown in Figure II-41. Some more detailed studies based on the analysis of the measurements of birds can solve local peculiarities of migration pattern (e.g. Fig. II-42 – Busse 1987b).
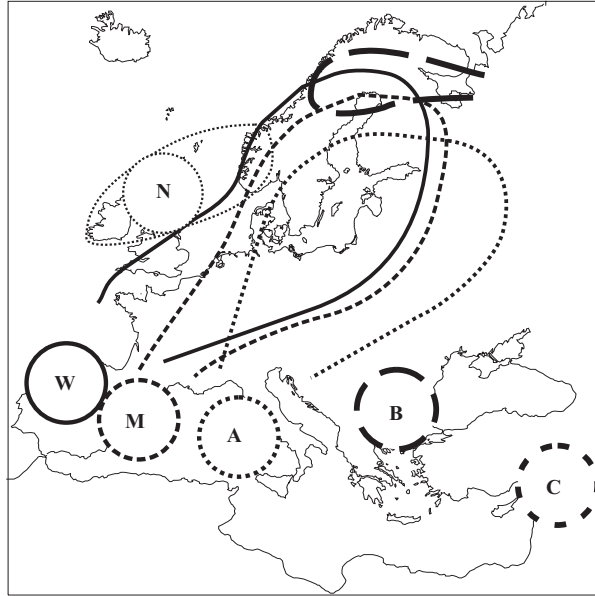
Fig. II-41. Population pattern of the Song Thrush

GENERAL PICTURE OF PASSERINE MIGRATION IN EUROPE

The results obtained by means of „looking from the south" analysis suggest that in general it is correct and can help to explain the recovery patterns of a number of passerines.

The first and basic question, when considering the idea of „looking from the south", is „why does the species winter distribution seem more important than the breeding one?" As population patterns and the inherited directions of migration of many species cannot be explained by any recent history, an answer to this question can only be found by studying the past distribution of birds. The influence of ice ages on animal and plant distribution in Europe is well known. It has been used to explain sub-specific and distribution patterns of some species of birds in various zoogeographical papers (Moreau 1955, 1972; Harrison 1982; Blondel 1997). These authors stressed the importance of the ice-free refuges during the glacial periods both for sub-specific and even for specific dif-
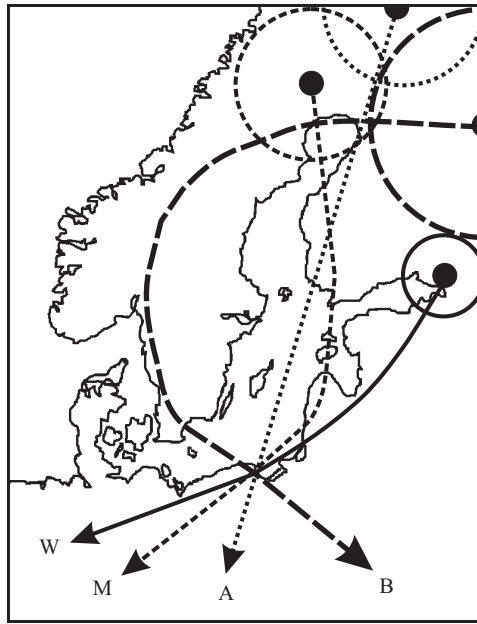
Fig. II-42. Details of migration pattern of Song Thrushes passing the Polish Operation Baltic
ringing station Hel. Areas of origin (circles with dots) and directions of migration
to four winter-quarters (specified at Fig. II-41) are shown.

ferentiation within the passerines. It is accepted that at the height of the glacial periods small and isolated populations of birds inhabited these refuges.

This situation forced genetic differentiation but in most cases it did not reach sub-specific level thus descendants and the different refugees are inseparable now by conventional systematic methods. When climate became milder, areas occupied by the different populations spread northwards and birds dispersed to new breeding grounds. Inhabitants of the newly occupied areas migrated generally to or through their earlier refuges and this instinct became fixed as an inherited direction of migration. The evolution of migration and population patterns depended on the ecology of each species (its habitat and temperature preferences) and it will depend upon the origin and numbers of individuals starting to invade the changing areas of central and northern Europe. It seems clear that the first northwards invasion routes were from the Iberian Peninsula to the British Isles and from the Balkans to Central Europe. They were isolated for a long time from each other by the tundra areas between the Alps and Scandinavia. Amelioration of the Atlantic climate was so intensive that the species, which occupied the British Isles early became resident and when they re-invaded the Continent to the East and North they migrated to winter on the British Isles and created secondary winter-quarters. Taking an overview of the passerine migration in Europe one is able to show winter quarters distributed as shown at Figure II-25. These are, of course, main winter areas and many species have secondary winter-quarters, which have been formed more recently.

The colonizing birds from the different ice-free refuges met each other in various areas of central and northern Europe. Depending on the genetic differentiation and the density of population from the different areas they could form mixed zones of a varying breadth or birds from one area could drive out the weaker population. These could create a differential migration pattern of some complexity. This explains an existence of apparently uneconomical migration routes found in several species (the Meadow Pipit – Petryna 1976, Robin – Pettersson and Lindholm 1983, Song Thrush – Busse and Maksalon 1986a).

To summarize, „looking from the south" method allows looking at migration processes with an insight gathered from the historical occupation of Europe from the different ice-free refuges (as e.g. Fig. II-43 – Busse and Maksalon 1986a). Recent spring migration is a repetition of this process whilst the autumn one forms the corollary of the basic pattern.
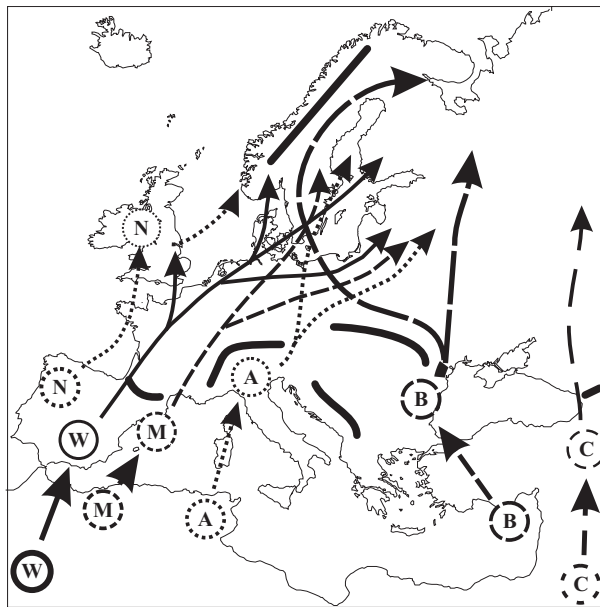
Fig. II-43. Dispersion pattern of European populations of the Song Thrush as reconstructed from recent migration patterns. Letters in thin-line circles – actual winter-quarters, letters in heavy-line circles – primary winter-quarters during the glaciation; arrows indicate directions of expansion.

RECENT EVOLUTION OF MIGRATION PATTERNS

The schematic representation of invasion patterns, as shown in Figure II-43, can be complicated by the recent evolution of migration routes. Populations are still dispersing (e.g. the Blackbird, *Turdus merula* – Spencer 1975, Carrion Crow, *Corvus c. corone* –

Cook 1975). Migration habits are changing by the shortening of a migration route and creation of the secondary winter-quarters. In this case even residency can be treated as wintering on the secondary winter-quarters, which happened to be identical with that of the breeding area. Even changes in the direction of migration can happen. This, for instance, was suggested for the Hooded Crow and Jackdaw (Busse 1969), where now different subspecies are wintering on the same areas. The most recent geographic changes can be found when one compares recovery patterns over a series of decades of our own century (Spencer 1975) while some older ones can be studied by the distribution of young and adult birds at different parts of the winter-quarters (Busse 1969). This last method assumes that young birds on their first migration follow the older customs of population and migrate longer distance than the adults do, if the process of shortening of migration took place. On the contrary, they migrate to areas closer to the breeding grounds if the migration route is extending.

The continuing evolution of migration patterns can be both of natural and human origin. Long-term climatic changes have their effect on the distribution of birds and their migratory habits as, for instance, on the distance travelled or the proportion of migrants in partially migrating species. These are certainly out of human control. However, human activity, hardly studied yet is potentially very important for at least a few species. Change in habitats, both at the breeding grounds and winter-quarters, chemical contamination of the environment and hunting activities can have pronounced influence on the density of bird populations and even on their migratory habits. The selection pressure of these factors is not known yet but very serious effects on population have been suggested by the first attempts of its evaluation (Rabøl 1978). This is clearly an important factor and is of great importance for future studies and environmental management.

CONCLUSION

Although detailed studies on bird migration patterns have been carried out for a very long time up until now our knowledge is rather poor and superficial. It is certainly not sufficient for some practical decisions on population management and bird protection that need to be taken nowadays. Even ringing which has been carried out for so many years and produced so much data that some scientists feel it should be stopped for many species, certainly has not exhausted its possibilities. One can discover much more, using new methods of data analysis of a huge file of recovery data which are now available, than it was ever possible by the mapping of ringing and recovery places – so spectacular for dilettantes but rather pointless for more demanding students of bird migration.

For a really detailed analysis of bird migration patterns one must use complicated analytical methods and a very wide ringing collaboration between researchers. The fulfilment of these dreams is something we should strive for in the future.

A FIELD STUDY OF DIRECTIONAL PREFERENCES
OF NOCTURNAL PASSERINE MIGRANTS

As night migrants travel in darkness, field studies on their directional preferences are more complicated than of diurnal migrants, which can be directly observed during a passage. In radar studies in most cases separate species cannot be precisely identified and observed migration patterns can contain various species of similar size and flight characteristics, but migrating differently as to the origin and/or destination. Other methods of direct observations of the night migration are not efficient („moon-watching") or, if they use artificial light such as a ceilometer or observations are made in strongly illuminated places (e.g. greenhouses – Svazas 1993) directionality of the passage can be much disturbed by attracting of flying birds from a wide area around. In few cases (e.g. Evans 1968, Petersen and Rabøl 1972, Rabøl 1985, Moore 1990, Ellegren and Wallin 1991) researchers used in a field a technique developed to study orientation and navigation abilities of birds – orientation cage experiments. In early Kramer's (Kramer 1949) and Sauer's (Sauer 1957) orientation experiments special cages with perches and complicated electric, then electronic counting devices were used. Most experiments were made in laboratory or quasi-laboratory conditions on caged birds and only a few studies were used in true field conditions using freshly caught birds (Evans 1968). New, simpler technique was introduced by Emlen and Emlen (1966) and then modified and commonly used in orientation experiments. Instead of complicated cages with perches and counting devices a conic cage was proposed. The bird has a little space to stay at the bottom of the cage and when it would like to escape from the cage it must jump against conic wall and consequently fall down the wall to a starting position. At the beginning of the use of this method the bottom of the cage was a wet ink-pad while wall was covered with a white paper. Footprints of the bird falling down after jumping were counted and created source data for further description of directional behaviour of the bird. Next modification – covering wall of the cage with correction paper and counting scratches of birds claws is in standard use now (e. g. Beck and Wiltschko 1981, Rabøl 1985, Hilgerloh 1989) as it avoids damaging of birds plumage by the ink from the ink-pad. This technique can be more easily used in a fieldwork and now practically all field cage experiments use Emlen's cages. The cage experiments met some criticism (e.g. Gerrard 1981) mainly because the bird is stressed by unusual situation and would like simply to escape rather than „migrate". In response to such objections birds were caged some time before experiments with intention to make the bird accustomed to a cage (Rabøl 1985, Ellengren and Wallin 1991). This caused that even birds caught at migration were disturbed in migration behaviour as they were forced to stop instead to continue normal migration. The stress reactions of individuals have not been studied yet but there were suggestions that the bird in specially stressing situation can change its directional behaviour (Busse

1992). However, despite these problems cage experiments seem to be a good tool to study directional behaviour in the field, especially when stress of the experimental birds will be reduced as much as possible. Even if Emlen's technique is improved, it is manpower expensive as counting of scratches on the correction paper is a very time consuming and tiring procedure. This disadvantage remarkably limits possibilities of using this method in most bird stations manned by amateurs (not too many amateurs would like to sit down for many hours counting hardly visible scratches on the correction paper). Now it is the method mainly for professional teams being paid for the research.

BASICS OF THE NEW TECHNIQUE

Disadvantage mentioned earlier forced people from a few Baltic bird stations to look for a method not worse as to its usefulness, but simpler – more bird and user friendly. The first idea was that the birds behave directionally in a normal cage, with a flat bottom. Thus, it is not necessary to force them to jump against sloped wall and fall down many times – this must stress the bird much more than the fact of being caged. In 1995 a new design of the experiment cage was tested and during autumn work of the stations the experiment routine was standardised.

The new cage and the experiment routine are described in the first part of this book (p. 70).

Apart from different type design of the experimental cage the new technique contains important methodological novelty in the study of night migrants directional preferences – the experiments can be carried out both at night and daytime. Daytime experiments were used for evaluation of directional preferences of diurnal migrants only (e.g. Munro, Wiltschko and Ford 1993). Observing birds at field stations during migration period suggested that at least in peak-days night migrants move directionally during daytime. Checking this impression by carrying experiments during daytime confirmed it, even to wider extent than expected (see below) – the birds behave clearly directionally. This statement changes dramatically possibilities to use the technique for field-testing of night migrants. Using this procedure of the daytime experiments allows to check much more birds than it is possible during night tests. Additionally classic night tests require handling the birds caught in the morning or during daytime in cages, which is connected with necessity to feed them and it also causes long lasting caging stress.

In the new technique practically one person can handle six birds per hour using one set of one screening wall and two-three experimental cages. This change in amount of data gives wide possibilities to study individual variation in directional preferences. That is especially important at stations situated at crossing of migration routes as it is common in the Baltic and the North Sea areas and, possibly, elsewhere.

TESTING THE TECHNIQUE

The technique was tested on several thousand birds. Some examples given here base on tests made in 1995 at the Bukowo-Kopań Operation Baltic station and some from

later studies carried out at different localities in Poland, Eastern Europe and Israel. In 1995 some experiments were made at night (about one hour after sunset) and most of them during daytime.

EVALUATION OF DATA

The main problem to solve by the means of the elaborated technique was to look at the possible differentiation inside of directional behaviour pattern of the individual, i.e. possibility of different directional choices instead of one assumed direction. This was the result of earlier suggestion that an individual bird is able to choose different directions of migration because of different inherited directional programmes (Busse 1992).

The assumption that the birds' directional behaviour in the orientation cage is the result of preference of one direction of migration is the logical basis for the standard treatment of the cage pattern data. In the papers on the topic (e.g. Viehmann 1982, Helbig 1991a) numbers of directional movement signs (hoping to the perch, footprints, scratches) are treated as vectors, which are summed up altogether to find one preferred direction described by the angle (azimuth) and the vector length treated as a measure of directive tendency. Consequently, it means that all direction vectors other than the biggest one are treated as an „information noise" or a sign of a „nonsense" hopping of disoriented individual. In some cases the authors (e. g. Rabøl 1985, Helbig 1991a, 1991b) found, however, the cases of so clearly demonstrated bi-directional distribution that they used a special procedure called „doubling the angles" (Batschelet 1981) to dump this strange situations and press them into the assumed model of one direction behaviour. Following this thinking leads to unification of evaluation procedures, but simultaneously to losing some of information, which might be important in the studies on local directional preferences during passage through different field stations.

Because of the problem we would like to solve, evaluation of the raw data was done with the procedure looking for signs of inconsistencies with unimodal model of directional behaviour. In the first stage it was checked if the distribution of raw data is significantly different from the uniform circular distribution. Results of these experiments (88-96 per cent of all results) were included. After recalculation to a per cent distribution raw data were presented at the raw data graphs (see Fig. II-44, left side). Then local vectors were calculated by adding as vectors data from three sectors including local peaks in the data set, e.g. in a set:

8, **12**, 5, 1, 5, 20, **34**, 16 percent,

two local vectors taking 12 and 34 as central sectors were calculated and presented as pointers at Figure II-44. The results of the classic summing up of vectors are given at that figure (black stars) for the comparison.

Figure II-44 shows examples of different local vector patterns and Table II-7 contains distribution of these types in experiments done on different species at Bukowo-Kopań in 1995. The table demonstrates clearly that bimodal behaviour is the most common in all species. Three-modal distributions are equally frequent as unimodal ones.
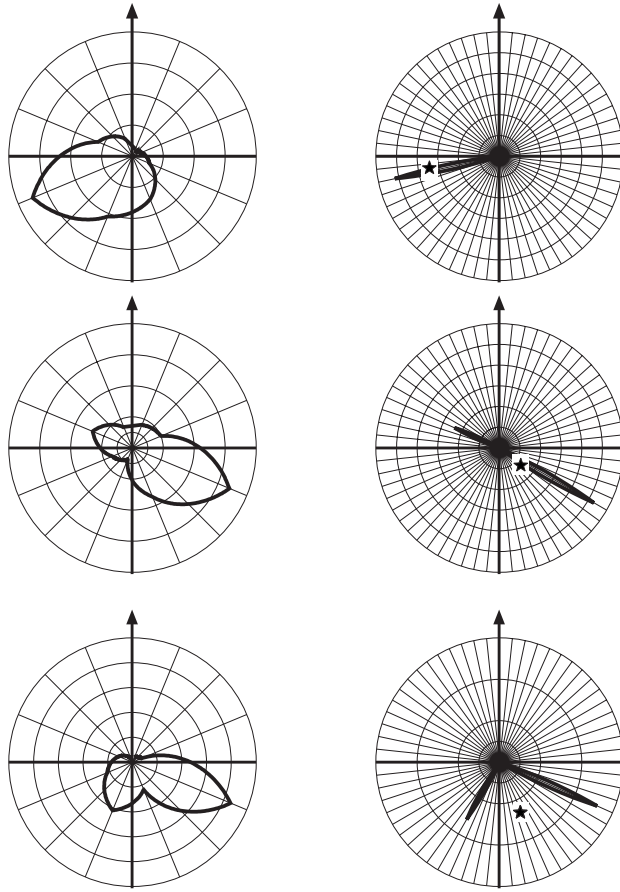
Fig. II-44. Examples of directional behaviour of tested birds. Left side – distributions of raw data, expressed in percents of all counted marks; right side – local vectors (pointers). Asteriks are explained in the text.

Table II-7. Number of local directions chosen by controlled individuals.

	Number of directions					N
	0	1	2	3	4	
E. rubecula	0	29	64	25	4	122
Ph. phoenicurus	1	8	28	9	1	47
R. regulus	0	6	10	4	0	20
S. borin	1	3	5	3	0	12
S. atricapilla	0	6	23	5	0	34
T. philomelos	0	5	15	10	0	30
Total	2	57	145	56	5	265

Detailed discussion of the methodical problems connected with evaluation of data is included in a special paper by Busse and Trocińska (1999) and only the conclusions from this work can be listed here. Both theoretical discussion and the analysis of the real data strongly suggests that:

1. The classic computing routine basing on automatic use of circular statistics procedures to evaluation of the orientation data bases on wrong biological assumption of unimodality of the bird behaviour that is not a case for many tests. Limitation *a priori* some of results by silent assumptions breaks the basics of the scientific research.

2. Classic computation procedure biases silently the results giving strong influence to side vectors that should be not included into the result vector obtained; it is, however, correct for unimodal source distributions.

3. Computing mean vectors from individual vectors is not allowed automatically as the group of studied birds can show multimodal distributions.

4. Evaluation of the orientation cage's data should allow studying both axial and multivector patterns, as they are common in the real data. The evaluation procedure proposed here allows finding any existing vector pattern. Some variants available allow concentrating on different aspects of the results.

5. Number of sectors used during collecting of the data defines accuracy of the results.

6. Interpretation of multimodal patterns is the matter for further discussion. However, some hypotheses can be given:

6.1. The most basic in the bird orientation is the axial behaviour. It allows birds to find in autumn winter-quarters and return in spring towards breeding grounds.

6.2. Direction of migration is defined independently by the season, but in special situations the bird can show reversed directional behaviour. It could be suspected that the reasons of such behaviour could be of different origin both inherited (as observed in real migration, e. g. of Blackcaps) and caused by the time of experiment (night or day), caging stress or local habitat conditions that influence bird behaviour after landing at a place. So, reversed direction does not mean „disorientation", as the axis is still correct one.

6.3. High share of individuals with two local vectors pointing at two different axes supports the suspicion that the individual that is an interpopulation hybrid can show more than one migration axis, which is expressed in the experiment as bi-vector individual pattern.

REVERSED DIRECTIONS IN THE ORIENTATION CAGE

In a high number of tests we can find that tested individuals prefer directions opposite to a normal direction of migration in the season. It is not explained yet why the reversed headings are so common at some localities (e.g. Robins at Mierzeja Wiślana, autumn – Fig. II-45) contrary to others (e.g. Robins in Central Poland – Akcja Wisła, autumn or all species in Eilat during spring migration – Trocińska *et al*. in press a). This phenomenon should be studied in the future, as it is very special feature of the results. For presentation the data the reversing backward headings is used and such distributions are called „standardised distributions".
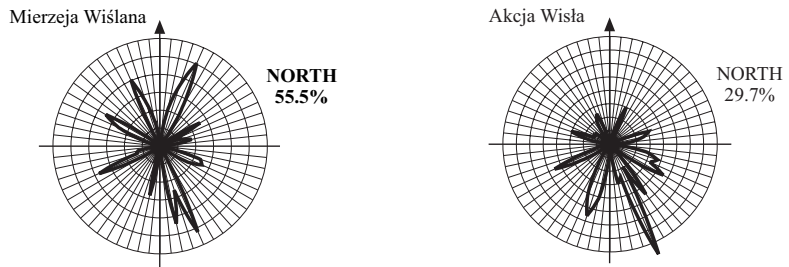
Fig. II-45. Backward headings of Robins tested in autumn 1998 at Mierzeja Wiślana (maritime location) and at Akcja Wisła (inland)

COMPARISON OF DAY AND NIGHT EXPERIMENTS

There is a very important question as to applicability of the described experimental routine to test night migrants during the daytime. As it was mentioned earlier, pilot experiments were carried out both at night and daytime. Table II-8 contains example of the comparison between day and night results in the tests of the Robin (*Erithacus rubecula*). During the day activity is significantly higher than in the night, directionality as measured by chi-square calculated deviations from the uniform distribution, seems to be higher (but not significantly at the level of 0.05) as does percentage of birds showing directionality at level $p < 0.01$. Distributions of local vector patterns are not significantly different ($p = 0.40$). Table II-9 gives some more information on the topic. In full overcast in the night both activity and directionality drop dramatically, what is not a case during daytime experiments. At days both activity and directionality are not significantly different from days with good sky visibility. This points at the next advantage of the technique – there is no need to have fine weather conditions for experiments.

Table II-8. Comparison of a day and night experiments with Robins.

	N	Activity	Chi-square	p 0.01 %	No of directions			
					1	2	3	4
Day	87	283.3	220	96.5	20.7	55.2	21.8	2.3
Night	35	166.9	174	88.6	31.4	45.7	17.1	5.7

Table II-9. Activity and level of directionality (value of chi-square) of Robins under different sky conditions

	Sky visibility	N	Activity	Chi-square
Day	good	38	284.5	242
	no	31	299.5	191
Night	good	12	247.2	248
	no	7	104.7	74

RESULTED DIRECTIONAL PATTERNS

As the examples of the resulted directional patterns obtained by means of described field technique and evaluation methods Figures II-45 and II-46 are presented. There are all local vectors of all individuals summed up. It should be mentioned that distributions obtained by summing up only the longest vectors for every individual give exactly the same picture. There can be found different patterns between species (Fig. II-46 and II-47), between seasons within the same species and the periods of migration in the same season (Fig. II-48). In the case the Song Thrush migration, the patterns found fit the hypotheses published earlier and based on ringing recoveries and measurements (Busse and Maksalon 1978, 1986a; Busse 1988).

Fig. II-46. Standardised distribution of headings for a sample of Blackcaps tested
in autumn at Bukowo-Kopań bird station

RESULTS OF ORIENTATION EXPERIMENTS AND RINGING RECOVERIES

The pilot study on directional preferences of night migrants in Eilat, Israel was made on their spring migration in 1999 (Trocińska *et al.* in press a). As a new method was applied, localisation of the study was very important. Located at the northern tip of the Gulf of Aquaba (Red Sea), at the edge of almost 2000 km of continuous desert regions of the Sahara and Sinai deserts, Eilat is the place where thousands of birds migrating from Palearctic pass on both spring and autumn migration (Yom-Tov 1984, Morgan and Shirihai 1997, Yosef 1997). Number of passerine birds caught there is much higher in spring

Fig. II-47. Standardised distribution of headings for a sample of Robins tested in autumn
at Akcja Wisła bird station

than in autumn in number of species (Yom-Tov 1984, Frumkin *et al.* 1995). On assumption birds migrating over Eilat in spring, heading to the breeding grounds, should be clearly orientated on their migration. Eilat is located on the Eastern Palearctic Flyway that is not well studied in comparison with the Western and there is a great need to study this direction of migration. The studied group was differentiated – there were species breeding all over Palearctic like the Lesser Whitethroat (*Sylvia curruca*) or Chiffchaff (*Phylloscopus collybita*), as well as species typical for the Mediterranean (e.g. Orphean Warbler (*Sylvia hortensis*), Sardinian Warbler (*Sylvia melanocephala*) (Harrison 1982, Hagemeijer and Blair 1997, Morgan and Shirihai 1997). The aim of the study in Eilat was to learn on the directional preferences of night migrants in place that was both appropriate as to a huge number of migrating birds and their assumed clear orientation to the breeding grounds.

Out of 754 tests that were analysed, 95% had shown statistically significant directionality (χ^2, 92% of the tests: $p < 0.01$; 3%: $p < 0.05$)

For the Lesser Whitethroat (*Sylvia curruca*) there is available number of ringing recoveries, so results of the tests were compared with the data on localities of the birds recovered/ringed at Eilat (Yosef 1997). Directions pointed by the vectors that birds have shown are very similar (Fig. II-49). Contrary to most European passerine species, the Lesser Whitethroat migrates from Europe in a southeasterly direction to its wintering grounds (Glutz and Bauer 1991, Hagemeijer and Blair 1997) and in spring fly to the
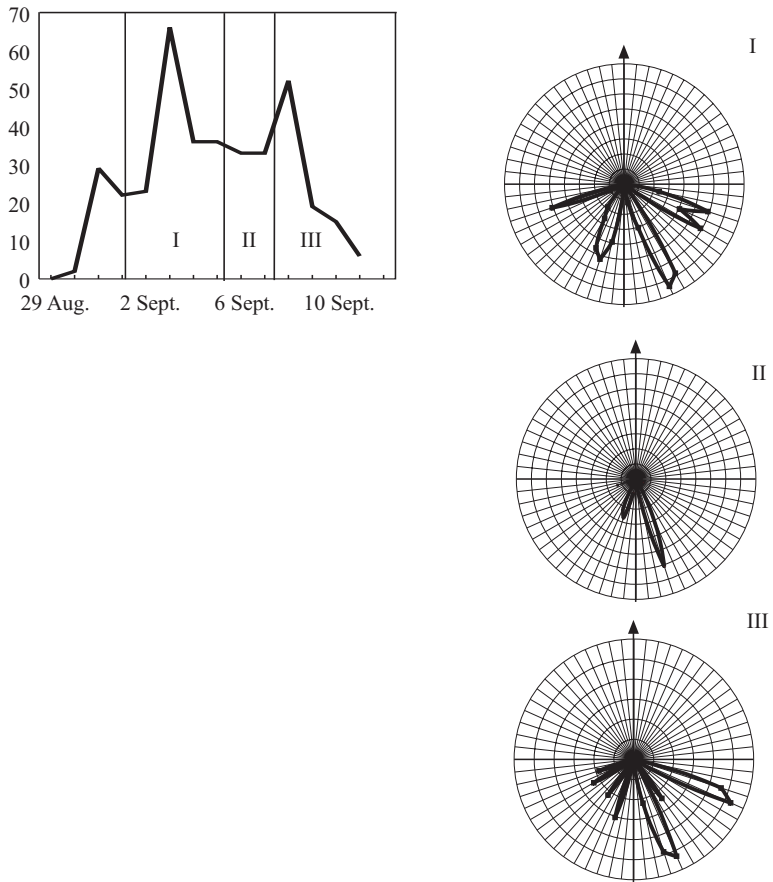
Fig. II-48. Differentiation of standardised headings of Robins tested at Bukowo-Kopań
in autumn 1998 in subsequent periods of migration (*I-III*)

northwest. According to Morgan and Shirihai (1997) the large spring passage of this species in Eilat results from the fact that the West European populations all pass through the Levant. The result of this comparison showing predominance of the western direction in the orientation cage also supports this.

LARGE SCALE STUDIES BASED ON THE METHOD

Some pilot studies using the method in large territorial scale were performed. Figures II-50 and II-51 give some ideas about differentiation of obtained patterns in various localities. They point that there is possibility to study migration patterns of night migrants on wide territories where extensive ringing is not possible.
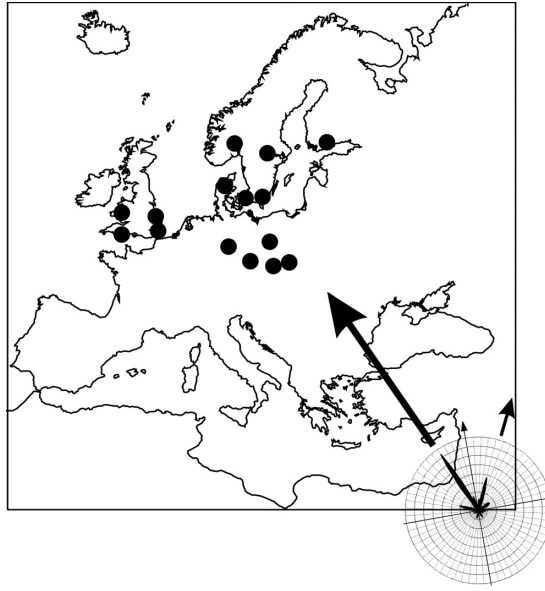
Fig. II- 49. Simplified distribution of headings of the Lesser Whitethroat (N = 218) tested in the field experiments in Eilat, Israel, spring 1999 and ringing/recovery localities of individuals recovered/ringed at Eilat (N = 15)
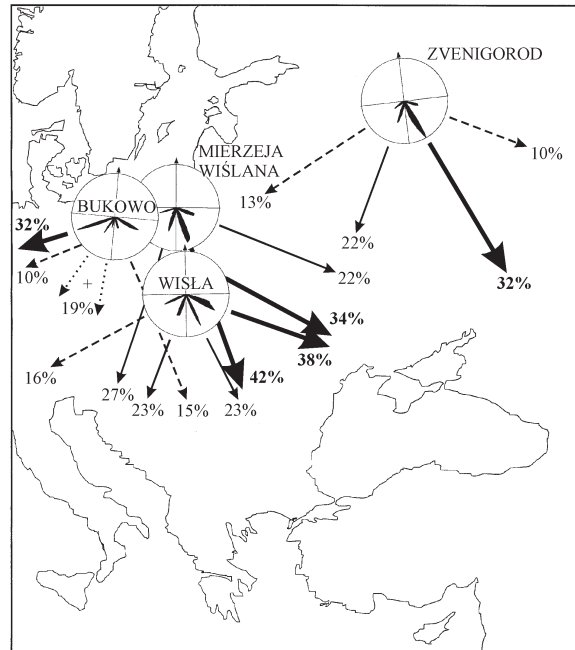
Fig. II-50. Patterns of standardised headings of Robins tested in different bird stations in September 1998.
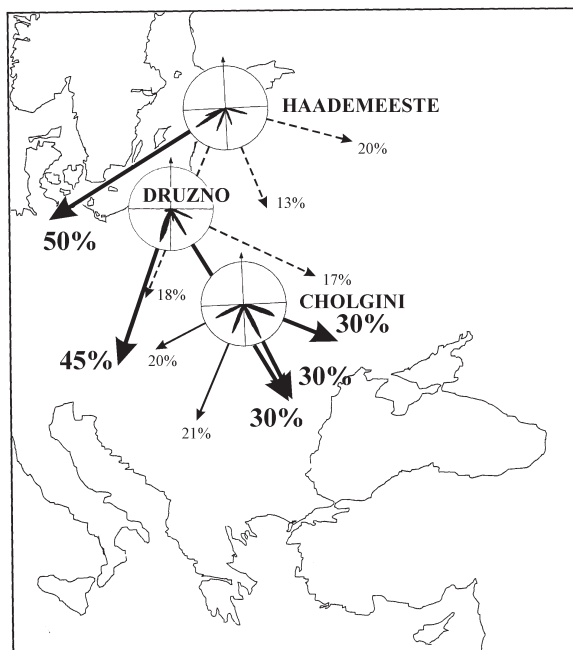
Fig. II-51. Patterns of standardised headings of Sedge Warblers tested in different bird stations.

CONCLUSIONS

1. A new method to study directional preferences of the night migrants comprises a new field technique and a special consideration to inconsistency of directional behaviour pattern of an individual bird.
2. The advantages of the field technique allow using it in real field circumstances both by professionals and amateurs:
– the equipment is simple and cheap,
– the technique is very easy to learn in a standardised form,
– the experiment routine allows collecting really big amount of data, as tests can be performed both in the night and day,
– diurnal tests in a full overcast have the same value as in good sky visibility, what is not a case in the night.
3. Analysing local vectors in a directional behaviour patterns seems to be useful in the studies on local migratory directions and population composition of migrants.

EVALUATION OF THE BIRD BODY MASS
AND THE BIRD CONDITION

Evaluation of the bird body size and the bird condition bases on three parameters measured or scored when the bird is ringed: weight, fat score and muscle score. Weighing the bird gives actual body mass in a moment of ringing, which is composed of a lean body mass, some of fat deposits and contents of the alimentary canal. The least component is very variable and depends on feeding activity just before catching and defecation that could be performed when the bird is waiting for ringing. So, it must be treated as a natural variance of body mass measurement. Two other components of the measured body mass are of different nature and they are in fact two independent parameters: lean weight – of the size of the bird and fatness – a measure of the bird condition. The lean body mass should be treated here as the mass of the body when there is no fat reserves that can be easily used as a fuel, but the individual is not going to starvation. There is still some fat in the body that can be extracted from the dried corps using extracting fluids even the individual is starved and it lost not only majority of fat but also some of proteins. The bird having no visible fat has usually clearly lower muscle scores and muscle scoring of such birds gives useful information about the bird condition.

Distinction between body mass and the bird condition is very important although usually they are not evaluated separately. Depending on the interest of a researcher there are used different assumptions: (1) „the birds are big ones because they are heavy weight" or (2) „the birds are in good condition because they have high body mass". We may comment that both assumptions could be wrong: we can caught birds that are small (low lean weight) and very fatty, so their actual weight will be high, or we can have birds with high lean body mass and very low fat reserves. These statements point that both parameters – weight and fatness should be treated separately, despite they are closely connected when measured. Fortunately, we can estimate what subsequent fat scores mean and we can standardise weight in such manner that we will be able to compare body mass not camouflaged by the fat load. The problems connected with the fat scoring are still not discussed enough and in some papers the authors assume linear relation between amount of fat and the fat score. Thus they calculate „average fat score" for the group as a mean value for scores for individuals. This could be allowed only if every score means the same difference in amount of fat deposited what is frequently not a case.

A main goal of the procedure presented below is: (1) to reach methodical correctness when comparing groups of birds as to their body size (weight as the biometrical parameter of the group), and (2) to compare bird condition not biased by the body size (amount of fat as an index of the condition of bird).

The first step is to find relation between fat scores and the actual weight of a large group of birds of the species (e.g. the Siskin, *Carduelis spinus*, – Fig. II-52). It is not surprising that the higher the fat score is the higher average weight is too. This relation gives no information on an absolute amount of fat collected by individuals scored into subsequent fat classes: we do not kill the birds and extract fat from dried corpses. However, it is not necessary to know the absolute values – we know relations between scores that is enough for our purposes. Now we can set one of the scores as a standard one (T_2 was selected as it is usually the most common on migration, at least in central Europe). Then we calculate how much less of fat have the birds scored as T_0 and T_1 and how much more of fat those scored as T_3, T_4 and so on (Fig. II-52). This figure shows also that we cannot use the same values for different species and that there is no necessarily a linear relation between fat score and amount of fat. These relations should be studied for various species, possibly for both sexes separately and for different populations. So, we should have a correction table for the species we want to work with (e.g. see Table II-10). The correction table contains values c_i describing average deviations of body mass of individuals scored as T_0, T_1, T_3, T_4 (and so on) from the average body mass of birds scored as T_2:

$$c_i = C_{Ti} - C_{T2,}$$

where: c_i – deviation for the score T_i, C_{Ti} – average weight of T_i birds, C_{T2} – average weight of T_2 scored birds.
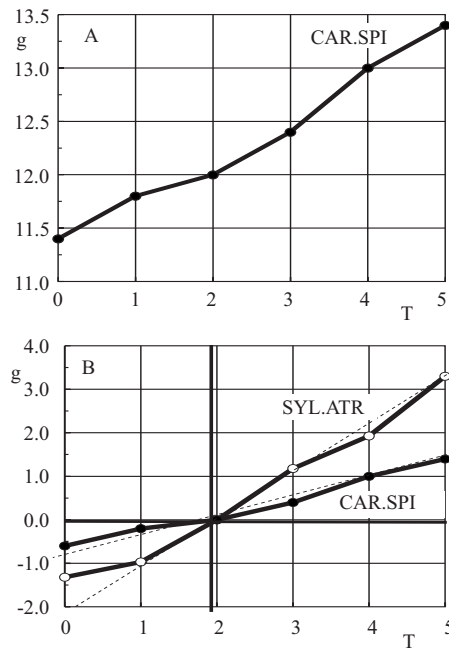

Fig. II-52. Validation of fat scores. *A* - relation between fat scores and average weight of scored birds – as an example the Siskin data ($N = 650$) are given (upper graph); *B* – deviations of average weight of scored birds from the weight of birds scored as T2 – differences between species are illustrated. CAR.SPI – the Siskin (*C. spinus*), SYL.ATR – the Blackcap (*S. atricapilla*)

Table II-10. Values of fat scores (c_i) for some species studied in spring at the Polish Baltic coast.

		N	Values of fat scores in relation to *T2* score (in grams of fat)					
			T0	*T1*	***T2***	*T3*	*T4*	*T5*
P. ater		569	-0.33	-0.10	-	0.47	0.74	
P. caeruleus		401	-0.70	-0.34	-	0.37	1.29	
P. major	Males	1607	-1.24	-0.65	-	0.51	0.99	1.88
	Females	1675	-0.91	-0.32	-	0.53	0.9	1.65
E. rubecula		2262	-0.90	-0.43	-	0.57	1.24	
Ph. trochilus		189	-0.56	-0.14	-	0.34	0.98	
Ph. collybita		134	-0.76	-0.30	-	0.09	0.53	
R. regulus	Males	1037	-0.48	-0.31	-	0.24	0.55	
	Females	1399	-0.34	-0.23	-	0.29	0.6	
C. spinus	Males	342	-0.56	-0.22	-	0.27	0.79	1.44
	Females	323	-0.54	-0.19	-	0.43	0.95	1.74
F. coelebs	Males	1447	-1.12	-0.54	-	0.13	1.11	
	Females	1850	-0.95	-0.31	-	0.31	0.86	
F. montifringilla	Males	133	-1.42	-0.81	-	0.61	1.23	
	Females	167	-1.47	-1.17	-	0.93	1.61	

Negative values of c_i are observed for T_0 and T_1, while positive ones for other scores, but only T_2 has c_i *ex definitio* equals 0. If we have one individual weighed that shows actual weight W and fat scored as T_i, we can standardise its body mass according to the formula:

$$w = W - c_i$$

This means that standardised weight is a weight that would be if the bird would have fat score T_2. Standardised weight is higher than actual weight for birds scored as T_0 and T_1 while lower for those scored as T_3 and higher. Standardising of weight of a single individual has limited application. However, if we are dealing with the bird groups the standardisation procedure is a little bit different in computing and its practical value is much higher.

Standardisation of the average weight for group contains some steps:
1. Computation of average actual weight (W_g) and its variance (SD_W^2) for the group,
2. Computation of the mean deviation of the group fatness (t_g) that shows how much of fat (in grams) the average group member deviate from the bird scored as T_2:

$$t_g = \frac{n_i \ c_i}{N}$$

where: n_i – number of individuals scored as T_i, c_i – deviation from the correcting table, N – total number of the group members, i. e. $N = \Sigma \ n_i$,

and its variance:

$$SD_t^2 = \frac{n_i \ t_g \ c_i^{\ 2}}{N \ 1}$$

(symbols explained above).

Values t_g and SD_t are the parameters that describe average condition of the group.

3. Computation of standardised body mass (w_g) and its SD_g according to the formulas:

$$w_g = W_g - t_g,$$
$$SD_g^{\,2} = SD_W^{\,2} - SD_t^{\,2},$$
$$SD_g = SQRT\ (SD_g^{\,2}).$$

These parameters can be used for direct comparisons of the body mass between different groups of migrating birds.

Figure II-53 illustrates how large can be differences in body mass pattern when comparing subsequent waves of Robins migrating in spring at the Hel Operation Baltic station.

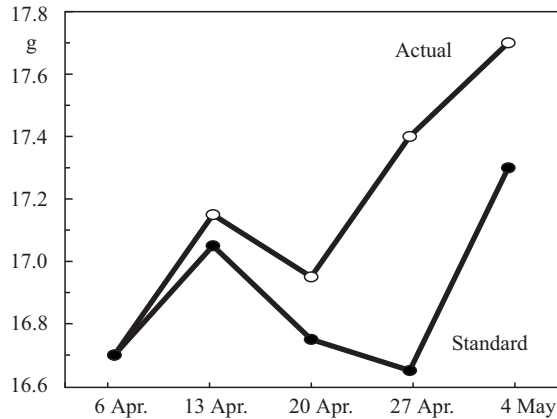Fig. II-53. Differences between standard and actual average body masses for some waves of migrating Robins at Hel bird station in spring 1963.

CONCLUSIONS

1. Standardised body mass is the only correct form of body mass parameter used in biometrical comparisons of groups of birds.

2. It is not allowed to assume that subsequent fat scores mean the same steps in amount of fat. These steps are different for various species.

EVALUATION OF THE WING-SHAPE

Wing-formula measurement of live birds is spreading through Europe since 1973, when it was recommended in proceedings of Tring conference 1970 (Sales 1973b) devoted to standardization in European ornithology. In the first papers based on wing-formula data (Williamson 1960, Scott 1962, Nitecki 1969) there were no described field methods of taking this measurement. This was done much later. In his identification guide Svensson (1970, 1975, 1984) repeated description of the method, which is not easy to use with live birds and which can discourage students from collecting wing-formula data. The other method, practiced during over thirty-five years of the Operation Baltic work (at over 800 000 of measured birds), was published in the Operation Baltic standards (Busse 1974, 1983a, 1984) and it is recommended in this manual.

Description of wing-shape by means wing-shape indices was suggested by Hołyński (1965) and broadened by Busse (1967b). The index e and l were proposed:

$$e = \Sigma p - \Sigma d$$
$$l = \Sigma p + \Sigma d,$$

where Σp – a sum of the distances from the wing tip to the tips of proximal primaries (in relation to the wing-tip), Σd – the same for distal ones. These indices were used in studies on population differentiation of migrants in number of the Operation Baltic papers (Busse 1967b, 1976, 1983b; Nitecki 1969) and elsewhere (Lövei 1983, Lövei *et al.* 1986 – index e in the form proposed by Hołyński 1965). In all cases of more rich data, there were found statistically highly significant differences in wing-shape indices calculated for various groups of migrants (migration waves and/or individuals caught at separate bird stations). These differences were found at least in the Goldcrest (*R. regulus*), Robin (*Erithacus rubecula*), *T. philomelos, F. coelebs, P. modularis. Phyll. collybita* and *P. ater.* Both indices were found useful. Depending on wing-shape of the species they can be correlated well (*F. coelebs* – $r = 0.96$, *P. modularis* – $r = 0.74$), correlated moderately (*R. regulus* – $r = 0.43$) or not correlated at all (*P. ater* – $r = 0.01$).

Fundamentally different use of the idea of wing-shape indices was proposed by Mlikovsky (1978, 1982) and, in other way, Levin (Levin *et al.* 1991).

DISCUSSION OF THE WING-SHAPE INDICES

In the first paper by Mlikovsky (1978) the methods of noting of wing-formula and its application for calculation of wing-shape indices were reviewed. New form of linear noting (formulas 5a, 5b, in this paper) was suggested there. This method is logical, but very impractical for quick measuring of wing-formula, what was checked some years ago,

when the same method was proposed by Swedish ornithologists working with some of Polish ones on field version of the Euring code. The problem of noting is, however, only the practical one for fieldworkers. The other proposal of mentioned author – the use of new indices of wing-shape (P, S) – is, from the theoretical point of view, much more important for future of these studies. Mlikovsky has written simply that e and l indices are not satisfying to him and he proposed P and S indices giving definition for them based on formulas of mathematical statistics. There were listed six formulas defining these indices and no word of argumentation why do these indices better illustrate wing-sharpness and wing-symmetry than indices used earlier. Studying of formal contents of formulas one can find that of six given ones there were mathematical mistakes in five cases, which in four cases were pointed out in the next paper by Mlikovsky (1982). Out of six presented formulas two are basic ones and next four are sub-formulas for them, so one who would like to try to understand proposed indices must incorporate these four to two main ones. The result formula is not encouraging to further trials of biological interpretation of these indices. Such trials must lead to discovery that there is a fundamental logical mistake in these indices: formulas of mathematical statistics are simply not adequate to the problem. The wing-shape is a problem of geometry and statistics has nothing to do with a single wing, which works as a geometrical unit (much more complicated then the triangle or the rectangle, but always of this character). Basing on this conclusion we can reject these indices from further discussion.

Levin *et al.* (1991) describes wing shape using two angles called wing sharpness and the sharpness of the wing tip. However, the first angle (a) can reach negative values when rounded wing (the more pointed the wing is the larger angle a is) what is rather strange situation. The second angle (b) changes its value rapidly when two longest primaries become equal.

The chronologically first index describing wing form – so called Kipps index (Kipp 1959) – is very simple one, as based on one special measurement only (Fig. II-54). This measurement is expressed in per cents of the wing-length:

$$K = k/w * 100,$$

where: K – Kipps index, k – distance from the wing tip to the first secondary, w – wing-length.

The interpretation of this index is that it is elongation of carpal part of the wing to the wing-length. Functional interpretation can be, however, more clear when the same will be presented in other form as in formulas:

$$B = 100 – K \text{ or } B = (w-k)/w * 100,$$

where: B – index of broadness of the wing in relation to the wing-length. In this form Kipps index gives important information on the width of the wing, which is not directly available from standard wing-formula measurements. One can find, however, in wing--formula measurement the distance from the wing tip to 8th primary, which is highly correlated with Kipps measurement (in interspecific comparisons correlation coefficient r reaches value 0.99 for some common passerines).
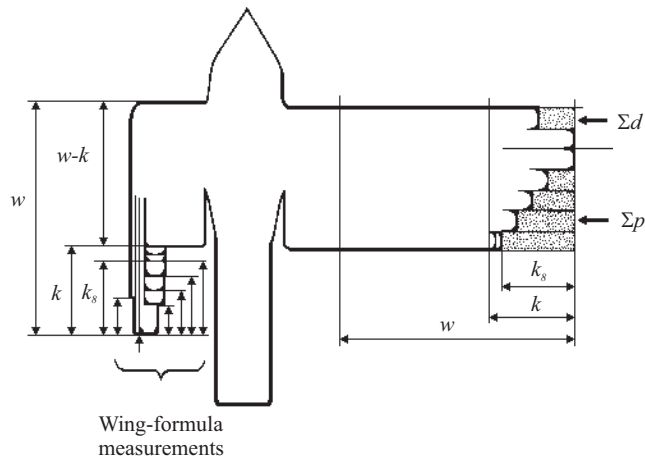
Fig. II-54. Scheme of wing measurements. w – wing-length, k – Kipps measurement, k_8 – distance from wing-tip to the tip of 8th primary (in wing-formula measurements); dotted areas: d – a sum of distance from wing-tip to the tips of distal primaries, p – the same for proximal primaries, symmetry axis of wing-tip is drawn.

Interpretation of e and l indices calculated after formulas given above as wing-tip symmetry index and wing-tip sharpness index was argued and explained in original paper by Busse (1967b). This interpretation was based more on intuition than analysis of the problem, which was very new at that time. After collecting rich data and using big samples to calculation of mean values for different species, sex/age groups and populations a deeper analysis could be done.

It is found that e and l values are usually strongly positively correlated with wing-length, which limits use of them as independent biometrics parameters. Possibility of influence of the wing-length was signalised in very first paper on this subject (Hołyński 1965) and it was accepted then by Busse (1967b), but this had not found practical application. Let us analyse carefully what represent the values of indices discussed now. Figure II-54 illustrates in simplified form the interpretation of wing-formula raw data: subsequent measurements taken in wing-formula are shown schematically as a rectangles „cut off" from the big rectangle of the open wing. They are, obviously, not of the same length as in measurement taken, but closely correlated with it. p and d used in calculation of indices are the sums of these primary rectangles at both sides of the wing tip. Now, one can imagine than the more d goes to be equal with p, the more symmetrical wing-tip is:

$$Sd \rightarrow Sp => e \rightarrow 0$$

and that if the sum of Σd and Σp grows the wing tip goes to be more pointed. This seems to confirm original interpretation of indices. Mentioned above wing-length – wing-indices correlation stresses, however, a need to find a method of, at least partial, elimination of wing-length influence on wing-indices values. Figure II-55 should help in finding the solution of this problem. There are presented in schematic form three exam-
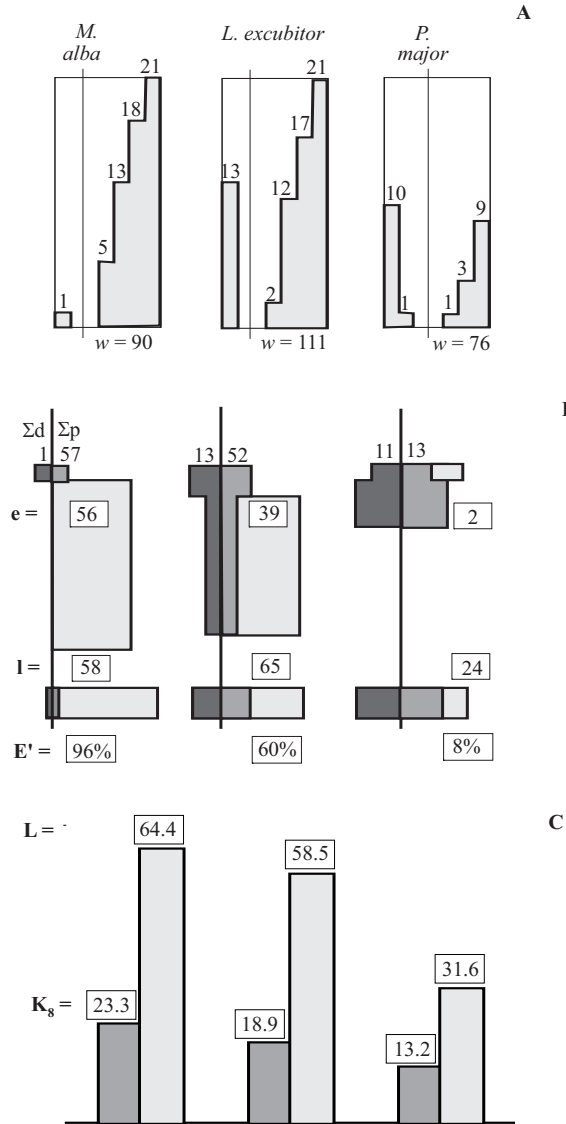
Fig. II-55. Graphical interpretation of the wing-shape indices. As examples wings typical for three species of Passerines are shown. *A* – raw data: wing-length (*w*) and wing-formula measurements; axis of the carpal part of the wing is shown as vertical line; dotted areas correspond with such at Fig. II-54. They are „cuttings-off" from the schematic wing-rectangle. *B* (above) – not standardized wing-shape indices: Σ*d* (as defined at Fig. II-54), area left of wing axis (dark crossed), Σ*p* – whole area right of the wing axis, *e* – dotted area = the rest after subtraction of crossed area (=Σ*d*) from the Σ*p* area, *l* – whole area (dark crossed + crossed + dotted) = sum of dotted areas at section *A*; (below) – standardized index of wing-asymmetry: *E'* – dotted area = *e* (as in section *B*), but expressed in per cents of whole area of the rectangle, which correspond to whole area of figures in section *B*; *C* – comparison between values of Kipps modified index (*K₈*) and these of standardized wing-sharpness index (*L*).

ples of wings of different species (A) with wing-formula raw data (measurements) and wing-lengths. Next elements of Figure II-55 (B, C) illustrate graphically algebraic operations leading from the raw data to values of *e* and *l* (B) and newly proposed *E'* (see below). In agreement with interpretation of Σd and Σp shown in Figure II-54, all operations done on wing formula data are the operations not on the wing-area (white parts in Fig. II-55A), but on the hatched area, which is the area „cut off" from the big rectangle. The size of figures situated just below raw data picture show clearly the dependence of *e* and *l* values wing-length (B): the longer wing the bigger figure representing *l* value. We can study here the problem of symmetry of the wing. *e* value is shown there as a white part of the figure: from the whole Σp value represented by right part of every figure, there is subtracted black area being situated left to wing symmetry axis and representing Σd value (this subtracted part is pointed as hatched area). In the next row (C) these *e* (white) values are expressed in relation to the whole area of the figure:

$$E' = e/l * 100.$$

So, *E* can be interpreted as „unbalanced" part of „off-cuttings" from the schematic to the rectangle carpal part of the wing. It is a kind of negative picture of the wing-shape, but nevertheless it can be used as a measure of asymmetry of this part of the wing. The *E*-index should be most correctly called: standardized wing-tip asymmetry index, when *e* – index of asymmetry (instead of „symmetry" one). As *E'* is expressed in percents of whole „cut off" area, its value should be more independent from the wing-length (both *e* and *l* areas depend on dimensions of the wing) and it is a case (see later).

Operation leading to greater independence of *l*-value from the wing-length is less clear to full interpretation. The proposed for recent use is formula for standardized wing-tip sharpness index *L* as proposed years ago (Busse 1967b):

$$L = l/w * 100.$$

The last (D) row in Figure II-55 compares information on the wing obtained by means of *L*-index and Kipps index – they show similar pattern there.

Cofta (1986) presented interesting idea of the analysis of wing-formula. He applied the correlative topography (see p. 221) for illustration of differentiation of young Willow Tits migrating through Polish Baltic coast using values Σd and Σp as direct parameters for axes instead of any secondary wing-shape index. This gave much more clear pictures, so it could be recommended when one would like to use the correlative topography for the analysis of wing-formula data.

Results of this theoretical discussion should be carefully checked on original data calculated for different species, different sex/age and population groups.

WING-SHAPE INDICES IN THE BIOMETRICAL STUDIES

Wing-shape is discussed in the literature in some different aspects. The very first analyses were done years ago by means of comparison of the wing-shape of different species (Stegman 1954, Kipp 1959). The simple methods used at that time allowed doing only very general and speculative conclusions on evolution and phylogenetic problems.

Interspecific differentiation of quantitative wing-formulas was used for systematically purposes in field identification guides (Williamson 1960, 1962, 1964; Svensson 1970, 1975, 1984) and other papers concentrated on field identification (Hołyński 1964, Mead 1977). Wing-shape indices were not used for identification purposes, but they can be used, for more advanced studies on adaptive value of different wing-shape details for ecology of species. Interspecific comparisons (taking under consideration 14 passerine species after data from Busse 1976) show higher correlation between wing-length and not standardized wing-shape indexes e and l than standardized ones E and L ($r_{we} = 0.66$, $r_{wl} = 0.88$, against $r_{wE'} = 0.45$, $r_{wL} = 0.48$). There is high correlation between e and l indices ($r_{el} = 0.91$), while correlation of E' and L indices has moderate value ($r_{E'L} = 0.60$).

Intraspecific differentiation seems to be much more interesting field for studies by means of wing-shape indices calculation. Level of variation between different groups of migrants is much higher in wing-shape indices than in wing-length and tail-length (Table II-11). Level of variation in wing-shape of Chaffinches migrating at Hel and Mierzeja Wiślana bird stations in spring is two to five times higher than in wing-length, so commonly used as the only measurement taken from birds caught at bird stations. Relationships between values of wing-length and wing-shape indices are very differentiated here: $r_{we} = 0.88$ and $r_{wl} = 0.90$ show high correlation of not standardized indices with wing-length, while $r_{wE'} = 0.13$ and $r_{wL} = 0.28$ suggest high degree of independence. Both not standardized indices are correlated very well $r_{el} = 0.96$ (the Chaffinch has clearly pointed wing), while standardized ones are poorly negatively correlated ($r_{E'L} = -0.26$). The correlation can be, however, differentiated in various species. Potential role of wing-shape indices in population differentiation studies is expressed also by higher number of statistically significant differences found in wing-shape index e and l than in comparison of wing-length values.

Table II-11. Variation of different biometrical parameters in some studied species. Coefficient of variation CV is given for n groups studied. M_{CV} – mean coefficient of variation, N – number of individuals in all groups together.

	N	n	Wing-length	Tail-length	Wing-shape indices			
					e	l	E'	L
Turdus philomelos	7454	24	0.54	1.25	-	1.78	-	1.73
Fringilla coelebs	2648	12	0.45	0.66	2.48	2.03	1.06	2.09
Parusater	4288	12	0.44	0.79	7.31	1.28	7.26	1.34
M_{CV}			(0.48)	(0.90)	(4.89)	(1.70)	(4.16)	(1.72)

Studying sex and age dimorphism one can find similar relations, that wing-shape indices are generally more variable than wing-length, tail-length and weight (Tables II-12 and II-13). There are, however, observed pronounced differences between species and between standardized and not standardized indices. Further, more detailed studies on adaptive value of various aspects of the wing-shape, as reflected by discussed indices, can clear up the picture of observed differentiation.

Table II-12. Sexual dimorphism (*D*) expressed in percent of lower value of the parameter ($D = (M_M - M_F)/M_F * 100$, as usually males are bigger). M_M – mean for males, M_F – mean for females. After data from Busse 1976.

	Age	N	Wing--length	Tail--length	Weight (stand.)*	Wing-shape indices			
						e	*l*	*E'*	*L*
R. regulus		5052	4.1	4.6	1.2	18.4	7.5	10.2	3.2
R. ignicapillus		32	3.5	4.2	-	-	4.6	-	1.3
F. hypoleuca		200	2.2	1.7	-	14.8	7.2	7.1	4.9
Ph. phoenicurus		170	2.6	0.6	-	5.1	3.9	1.1	1.3
T. merula	ad.	247	3.9	5.4	-	19.9	9.5	9.5	5.3
	imm.	432	3.1	3.1	-	8.1	6.5	1.5	3.4
P. major	ad.	1096	3.1	4.5	5.5	3.6	0.3	4.1	2.8
	imm.	1470	3.2	3.9	5.7	-	11.1	-	7.5
E. citrinella		86	5.3	3.6	5.6	6.3	3.3	2.9	2.1
F. coelebs	ad.	1038	8.1	9.5	12.2	12.4	13.3	0.7	4.7
	imm.	1712	7.7	7.7	10.2	8.3	8.1	0.2	1.3
F. montifringilla	ad.	119	7.1	8.7	4.4	-	-	-	
	imm.	258	5.8	6.1	7.3	-	-	-	
C. spinus	ad.	146	2.1	2.4	2.8	6.5	4.5	1.8	2.5
	imm.	456	3.1	3.2	3.8	6.4	6.1	0.4	3.1
P. pyrrhula		35	3.3	3.2	-	1.1	9.2	8.1	5.7
M_D			4.17	4.51	5.87	9.23	6.77	3.96	3.51

* standardised (see p. 197)

Table II-13. Age dimorphism (Δ) expressed in percent of lower value of the parameter ($\Delta = (M_A - M_I)/M_I * 100$, as usually immatures are bigger). M_A – mean for adults, M_I – mean for immatures. After data from Busse (1976).

	Age	N	Wing--length	Tail--length	Weight (stand.)*	Wing-shape indices			
						e	*l*	*E'*	*L*
T. philomelos		480	0.9	2.6	-	1.6	0.7	0.9	0.2
T. iliacus		242	0.6	0.2	-	0.4	0.7	0.2	0
T. merula	Males	303	2.2	4.1	-	10.5	4.2	6.1	2.1
	Females	376	1.3	1.7	-	0.4	1.4	1.7	0
P. major	Males	1018	0.8	1.9	0.6	-	0.2	-	0.7
	Females	1548	0.9	1.4	0.7	-	10.9	-	10.1
F. coelebs	Males	1290	2.2	2.7	1.3	4.3	7.3	2.7	4.9
	Females	1460	0.8	1.1	0.4	0.5	2.2	1.8	1.5
F. montifringilla	Males	180	1.3	2.1	0.8	-	-	-	-
	Females	197	0	0.6	2.1	-	-	-	-
C. spinus	Males	371	0.3	0.4	1.9	2.2	2.1	0.2	1.7
	Females	321	1.2	0.4	0.9	2.2	3.5	1.2	2.2
M_Δ			1.04	1.58	1.07	2.76	3.31	1.85	2.34

* standardised (see p. 197)

CONCLUSIONS

1. Wing-formula measurement is a simple and quick one, when it follows standard description as given in the Manual. Collected raw data can be base for very differentiated detailed studies on adaptive value of the wing-shape, population differentiation, sex and age dimorphism etc.

2. The simplest wing-index - Kipps index can be used in modified form as a measure of the wing-breadth.

3. Mentioned in the point 1 studies can be the most efficiently done by means of calculation of wing-shape indices – not standardized (*e* and *l*) and/or standardized ones (*E'* and *L*). Index *e* and *E'* are the measures of asymmetry of carpal part of the wing, while *l* and *L* reflect the sharpness of this part of the wing. It seems that not standardised indices reflect slightly different aspects of asymmetry and sharpness of the wing and they can be used simultaneously, but this needs further studies on different species.

4. Examples presented here show clearly that proposed standardization procedures for wing-shape indices are efficient as to making these indices independent of length of the wing.

LOCALISATION OF BREEDING ORIGIN OF MIGRANTS ACCORDING TO BIOMETRICAL DATA

Localisation of breeding origin of bird migrants using morphometry is an old idea that was a basis for the introduction of bird measurements into field routine of numerous bird ringing stations. The basic assumption was derived from a very general Bergman's rule on size differentiation in animals living at different geographic latitudes – the more to the North and East (in Eurasia) birds live the larger they are. In the bird station practice the size of birds was usually described by measuring wing-length, at some stations – 3rd primary length (Berthold and Friedrich 1979) and body mass. These are the simplest measurements. Moreover, according to the common belief that all bird size parameters are correlated with these measured ones, other proposed measurements (e.g. tail-length, wing-formula) are skipped for saving time of work with the bird. Some authors use only data collected at one bird station because of low level of collaboration between stations. This situation causes slow methodological development in evaluation of biometrical data. One of very few exceptions at the field of bird measurements is the Operation Baltic programme started in 1961 in Poland. Since its beginning we have paid a lot of attention to the bird measurements and evaluation of biometrical data. A starting set of bird measurements contained wing-length, tail-length, bill-length, tarsus length, body mass and evaluation of fat level. Pilot studies on usefulness of measurements for differentiation of bird groups as to measurements eliminated bill-length and tarsus-length in Passerines. These measurements had too high variability and too low exactness in relation to the inter-group differentiation (Szulc 1964). Since 1965 instead of them a wing-formula measurement was introduced (Hołyński 1965). On the basis of this measurement wing-shape indices were elaborated (Busse 1967b, Busse 1986b).

The enormous material already collected at the Operation Baltic stations (around 900 000 individuals measured) is still very poorly evaluated. However, methodological problems of such evaluations were studied carefully on partial data (Busse 1967b, 1968, 1972, 1976, 1983b, 1988, Busse and Kania 1970) and they gave a basis for the ideas presented here. They contain theoretically assumed models confronted with the patterns really found (Busse and Maksalon 1986b).

POPULATION MODEL IN BIOMETRICS

From the general biological knowledge it is well known that the size of an animal results from the genetic load and its phenotypic expression. The average size of birds in a group depends on genetics of the population and environment, where the group lives.

This agreed basis cannot lead, however, to the construction of one model of the morphometric structure at breeding areas.

Continental-scale evaluation of ringing data suggests clearly that population distribution of most passerine species living in Europe comprises areas from where birds migrate to separate winter-quarters and those, which can be called mixed zones (Busse 1969, 1987a, Zink 1973-1985, Busse and Maksalon 1986a). Birds living within mixed zones migrate to different winter-grounds showing wide-angle migration patterns (e.g. Blackcap – Klein *et al.* 1973, Berthold and Terrill 1988, Busse 1992). Sometimes even siblings from one nest could migrate in completely different directions (Busse 1969). This suggests that there are areas inhabited by genetically pure populations derived from the ice-age time refuges and among them areas inhabited by hybrids (Fig. II-56). This was discussed more in detail in the Chapter *„Ringing and migration patterns…"*
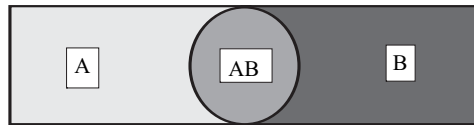

Fig. II-56. Scheme of distribution of two populations (*A* and *B*) with a mixed zone between them (*AB*).

If one looks at the problem of biometrical differentiation, the strongest suggestion from the ringing patterns leads to the morphological population model. If migrational populations with their differentiated genetic load actually exist on breeding grounds, the morphometric model could be the same: when one population of small birds neighbours with another population of big ones, hybrid zone between them will contain birds of an intermediate size. This model could be summarized as on Figure II-57. If one accepts this model of the biometrical structure on breeding grounds, he will look for statistically significant differences in the bird size between groups of birds. These groups can be defined on migration as different waves of migrants passing one station or as birds caught at different bird stations. This model of the morphometric structure was assumed at the beginning of the Operation Baltic work (Busse and Kania 1970, Busse 1972, 1976). Despite sharing common opinion on correlation of all measurements, we looked for significant differences between groups checking various measurements. We based on an assumption that differences found in these measurements would agree with each other and so, they would be a stronger confirmation when describing separate populations. The Operation Baltic has unique data collected at a few stations distributed linearly from the East to the West. Following the intensity of migration during the whole migration period the data can be divided onto a few waves of migration. Such data set should allow finding population differences if they exist. If we accept population model of biometric differentiation and a „carpet migration" pattern (parallel migration of neighbouring groups of birds) the size pattern should be as presented on Figure II-57 – we can expect clear step-like changes in measurements between groups. In this example scheme (assumed population border situated from the North to the South), by WA (Wapnica) and BU (Bukowo)
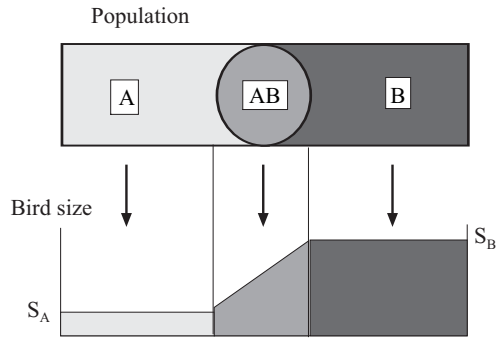
Fig. II-57. Scheme of the population model of the biometric differentiation. Above – population *A* is assumed to be composed of the smaller birds (S_A) than B (S_B); at mixed zone step change in size could be expected. Below – expected pattern of measurement values for different groups of birds migrating through different stations (WA, BU,...) in subsequent waves (*I, II*,...) when the population model is assumed; circles – basic groups, squares – totals. Further explanations in the text (p. 210).

stations migrate small birds, by MW (Mierzeja Wiślana) and NP (Nowa Pasłęka) – big birds and by HL (Hel) – intermediates. In such case summing up all birds migrating through every station is right (all individuals belong to one population, but only HL-birds are hybrids), while summing up all birds migrating through all stations in first, second etc. waves is senseless as we would mix birds from different populations. If East-West direction border between populations is assumed the picture will be rotated by 90 degrees, but the pattern will be the same. This theoretical pattern will be the basis for further checking on real data.

CLINE MODEL IN BIOMETRICS

The alternative model of the morphometric structure can be constructed when one assume (1) that the genetic load of population as to size determining genes is of secondary value in relation to actual conditions determining phenotypic effects, or (2) that the

selection pressure of actual environmental conditions is so well pronounced that genetic differences (as to the size of birds), derived from the ancestor populations were smoothed out since the time of colonisation of the central and northern Europe by these populations. In both cases the bird's size follows existing clinal changes in the environment within the breeding area. It can be suspected that different elements of the environment influence different morphometric parameters and their clines can be not parallel. The scheme illustrating this model is shown on Figure II-58.
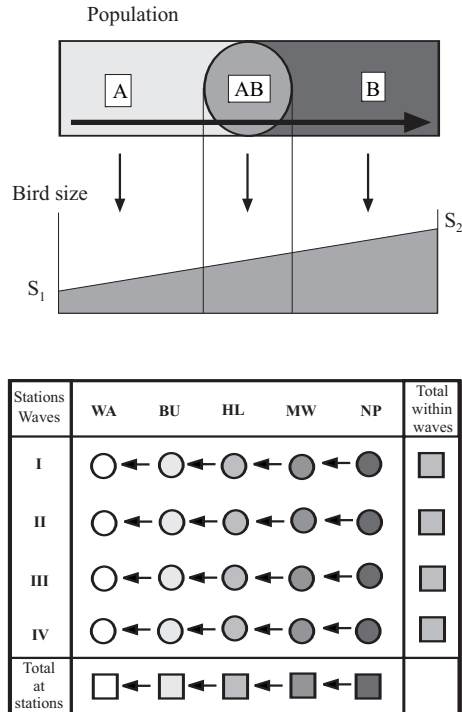

Fig. II-58. Scheme of the cline model of biometric differentiation. Above – cline variability of a measurement (from S_1 to S_2) is assumed. Below – expected pattern of measurement values for different groups of birds. Explanations as at Fig. II-57.

Apparent contradiction between existing genetic differentiation as to migration destination and lack of genetic population differentiation as to bird size can be easily explained taking into consideration biological roles of the processes regulated by these groups of genes. On one hand, the migration, with its complicated orientation mechanisms and mortal value of precise navigation must be protected by a very strong mechanisms conserving migration pattern of the population. On the other, different aspects of the bird size can be much more flexible and adaptable to the relatively quick changes in living conditions.

Accepting cline model and having biometrical data from a few stations, one can expect size pattern as illustrated on Figure II-58. In this example, for more clear picture, the cline from the West to the East is assumed as well as the migration directed simply to the South. The bird groups passing stations contain more and more large birds when we look at stations from the West to the East; wave totals are in that case equal to each other. Cline oriented in different direction change this picture adequately, but the essential character – smooth changes in measurement values will be always visible.

CHECKING THE MODELS ON REAL DATA

The basic data for checking of the models on the example of the Song Thrush were published elsewhere (Busse and Maksalon 1986b). As in the theoretical schemes presented above (Figs II-57 and II-58) data from five Operation Baltic stations were collected. The time of migration was cut onto four waves (Busse and Maksalon 1978, 1986a; Maksalon 1983). Four measurements (morphometric parameters) were taken into consideration: wing-length, tail-length, weight and wing-shape index l (Busse 1967b, 1986b). For all groups (one wave on one station is one group) average values of the parameter were calculated and statistical significance of differences (*t*-test, $p < 0.01$) was checked. The combined pattern, taking under consideration all mentioned parameters is shown on Figure II-59. Not one parameter distribution agreed with theoretical patterns expected (Figs II-57 and II-58). The pattern found, evaluated on the basis of population model, suggests 13 different groups (populations) of the Song Thrush migrating through four hundred kilometres of the southern Baltic coast. This must be treated as completely unacceptable from the point of view of population model. Thus population model must be rejected. Regular changes expected on the basis of the cline model, in parameter values, do not occur too, but that can mean that additional assumption on the „carpet migration" could be wrong. This situation does not allow confirming the cline model, but cannot be the basis for its rejection.

Figure II-59 shows some cases when statistically highly significant differences in some parameters disagree. This means that not all measured bird size parameters correlate positively and thus any single parameter is not good index of the „size" of birds. The above conclusion is confirmed by the Table II-14 that contains correlation coefficients between parameters, when group averages were taken into consideration. Some negative correlation coefficients can be found there. The most surprising is negative correlation between wing-length and weight while positive one between tail-length and weight. It is well known that within population wing-length and weight are correlated positively. Note, however, that here we cope with substantially different level - not an intra-group (we usually say „intrapopulation") morphometric relations, but inter-group („interpopulation") relations. Different groups can be characterized not only by the values of defined parameters, but their relations too. So, instead of calling one group as „small birds" in contrary to another called „big birds", we must say e.g. „short-winged and long-tailed" against „long-winged and short-tailed". This leads to a very important conclusion that
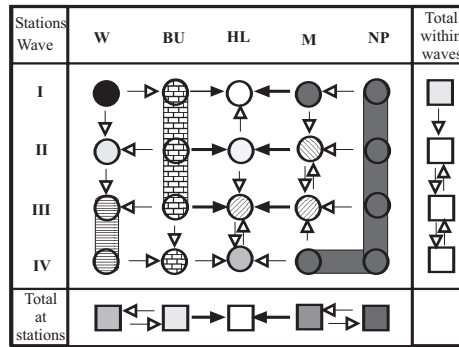
Fig. II-59. The bird size pattern found when biometrical data on Song Thrush migrants were studied and interpreted using population model. Groups of birds as at Figs II-57 and II-58. Combined results from three biometrical parameters: wing-length, tail-length and weight. Thick arrow blackhead – three parameters differ significantly at level 0.01, thin arrow blackhead – two parameters differentiated, white head arrow – one significant difference.

not one single parameter can be used as an index of the bird size, what means, further, that for characterising bird morphometry a few measurements should be taken.

Table II-14. Pearson's r correlation coefficients between parameter averages for groups of the Song Thrush ($N = 30$)

	Tail-length	Weight	l-index
Wing-length	-0.28	-0.51	0.19
Tail-length	X	0.56	-0.09
Weight		X	-0.21

HOW TO LOCALISE BIRD GROUPS BY MEASUREMENTS

If the cline model is accepted as a basis for further considerations, some possibilities to use measurements for localisation of bird groups are open. Two basic conditions must be listed. One of them is derived from geometry (despite that such a statement could be surprising here) that to localise a point at a surface one must know the co-ordinates of that point against two axes (x-axis and y-axis or latitude and longitude, if we want to fix a locality on the Earth surface). The second condition is to accept theoretical possibility (suggested earlier) that clines of different measurements (size parameters) can go in different geographical directions (this causes lack of high positive correlation of parameters studied at the level of group averages). Figure II-60 shows schematically the theoretical possibilities here. The crucial problem for localisation possibility is how to find the angle between cline axes. The relative localisation of the bird groups characterised by a set of measurements is not possible when this angle is not known. Figure II-61 illustrates how
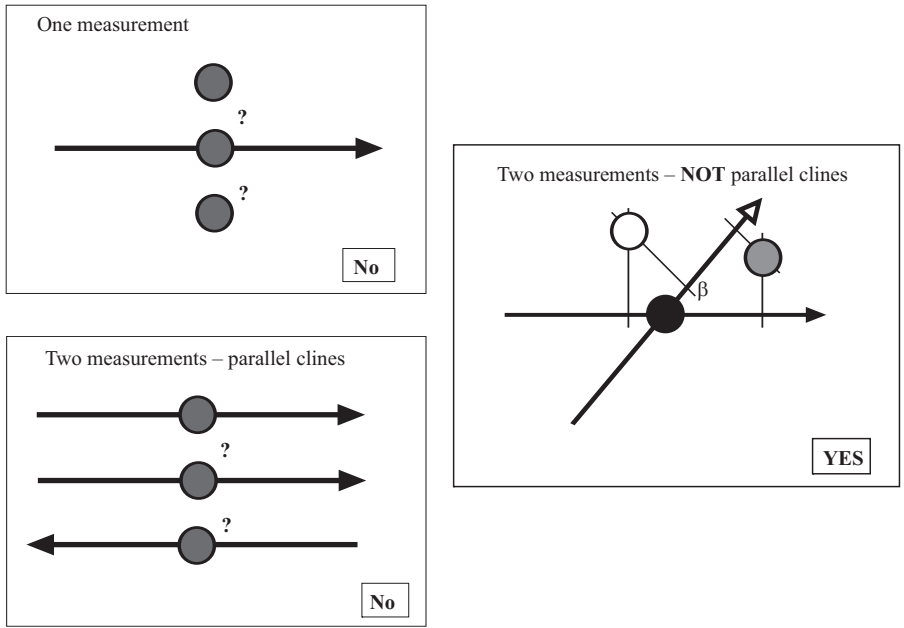
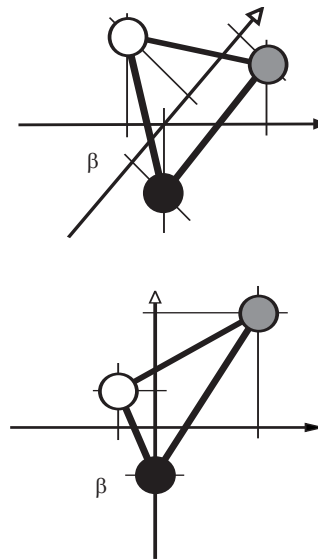Fig. II-60. Scheme of theoretical possibilities to localise bird groups basing on cline model.

Fig. II-61. Example how relative localisation of bird groups depends on values of angles (β_1, β_2) between cline axes.

much the angle between axes influences the relative localities of three groups of birds. The possibilities how to find the angle basing on measurement data were discussed in detail in paper by Busse (1988) and two consent methods were found. The most important is to understand the geometric meaning of Pearson's *r* correlation coefficient: the *r* coefficient describes numerically the angle between two regression lines of compared parameters (regression of parameter *A* against parameter *B* and parameter *B* against parameter *A*). The more the regression lines are close to each other the highest correlation is between parameters and the higher is absolute value of *r* coefficient. The angle between axes needed for our purposes is defined by the formula:

$$\beta_{xy} = arc\ sin(1\text{-}abs(r))$$

The localisation of the second axis, when one is fixed arbitrarily, depends on a sign of *r* coefficient according to a rule shown on Figure II-62. Figure II-63 illustrates the application of the above discussed idea to the real data on Song Thrush (*r* coefficients are taken from the Table II-14).
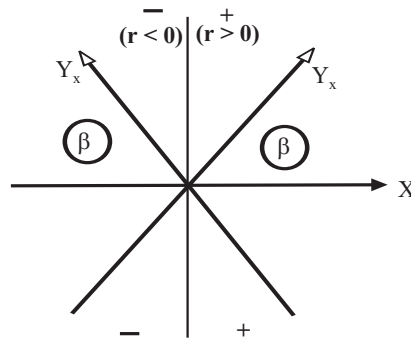

Fig. II-62. Localisation of axis Y_x according to the value of *r* coefficient.

When the angle between axes is fixed, relative localisation of the bird groups is easy to find (Fig. II-64A). Details of scaling of the axes were discussed elsewhere (cf. Busse 1988) - it was assumed that at the cross of axes there lies total averages for all birds studied and scale units are derived from the standard deviation size of every parameter.

The last step to the localisation of the bird groups in a real, geographical space needs having measurement data from two as distant as possible breeding localities within possible breeding area. This condition is derived from geometry too, as to fix the surface of relative distribution against another surface (the map of the breeding grounds) two points must be fixed. When we add to our localisation of migrating groups relative localisation of the bird groups of the known origin (the birds measured on the breeding localities prior to the migration started), the last step is necessary. It contains resizing and rotating relative distribution pattern against the real map of the breeding area. The process must be continued up to the situation, when relative positions of the groups of the known origin agree with geographical localities they really come from. The schematic example is shown on the Figure II-64B.
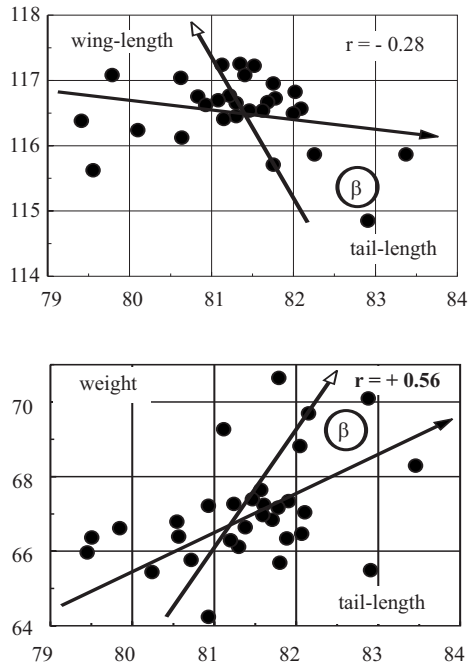
Fig. II-63. Correlation distributions of the average measurement values of migrating groups of the Song Thrush and resulted relative position of cline axes.
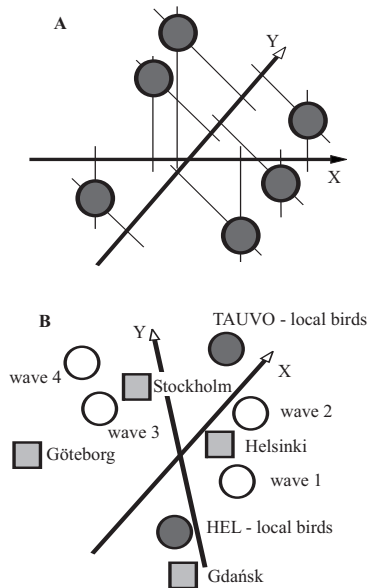
Fig. II-64. Localisation of the bird groups in a real space. *A* – Step 1 – relative localisation against cline axes; *B* – Step 2 (simplified example) – localisation on the map (land contours omitted) of four waves of migrants in relation to two localities for which local birds measurements are known (here Tauvo and Hel).

METHODICAL PROBLEMS

Making trials of the localisation of the origin of migrating groups one must be aware of limitations of the method. It bases on the sample averages having commonly known statistical uncertainties described by their standard errors (*SE*), comprising two elements: variance in the sample and the sample size. The sample size could be enlarged (and *SE* lowered) when measurements from number of years are taken into consideration (assuming repeating of the group migrations in different years what is very probably a case – see Chapter *„Modelling the seasonal dynamics…"*). However, collecting data from different years includes into a sample some additional variance. It was found that in different years the same group of birds can have, and frequently they do, significantly different values of the biometrical parameter (Busse 1976; unpublished own data from local bird population). This is caused by different feeding conditions during growth of the measured parts of the bird body (especially feathers). This influence was confirmed by feeding experiments published by Berthold (1976), although the author did not expose this conclusion from the data. Despite this additional variation, including the data from many years should be recommended: many-year averages describe inter-group relations better than one-year data, even numerous, biased much by local weather and feeding conditions in that particular year.

The second problem with representativeness of group values of the parameter is connected with internal homogeneity of the samples. At least in the central Europe, esp. at the southern Baltic coast, there were documented cases when through one station and within one period migrate birds of different origin (Busse and Maksalon 1978). The morphological differentiation within a group can be monitored by means of the method described later (correlative topography). If we found that any sample is heterogeneous, we must be aware that the localisation we found could be a fictitious one (as shown on Figure II-65A). The next methodological problem is that applying the method we find a point localisation of bird groups members which, obviously, do not origin from a small, „dot-like" area. At the moment we do not know what is the size and the shape of this area (Fig. II-65B).

Other uncertainties are connected with the routine of the application of the method. If only two measurements are used for a group's localisation all accidental deviations of the parameter averages and *r* coefficients are hidden. However, when we try to use simultaneously data of a few measurements we will meet situations as on the scheme shown on Figure II-66A. The third axis *Z* plotted against two previous ones (*X* and *Y*) shows different locations. The same is when locating a group according to three axes (Fig. II-66B). In practice, we have found examples when localisations were very close to each other as well as cases when they were very different. The last case occurs probably in situations when not homogenous bird groups are localised.

A number of such problems connected with localisation of bird groups according to biometrical data must be solved during following studies. The problems are both methodical as listed above and zoogeographic ones. Among these of the last group, is the
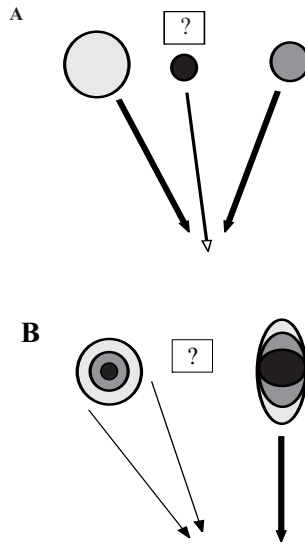
Fig. II-65. Methodical problems. *A* – uncertainty as to localisation when heterogeneous group is assumed as the homogeneous one; *B* – uncertainty as to the shape of the localised group breeding area.
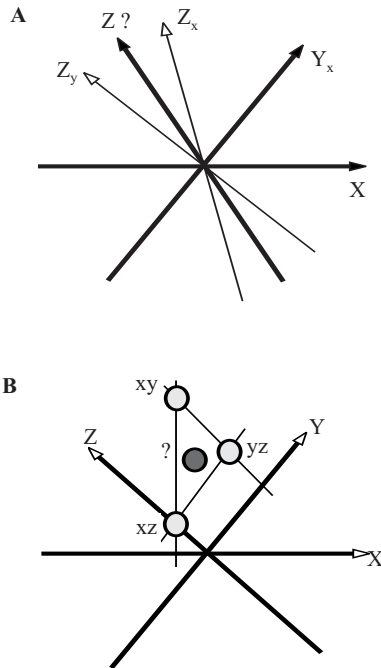

Fig. II-66. Methodical problems. A – uncertainty of estimation of angles between axes; B – uncertainty of localisation of a group in relation to a few axes.

question whether the clines found are straight over long distances (hundreds, thousands kilometres) or they can change direction within smaller areas.

CONCLUSIONS

1. After confrontation with real measurements data population model of morphometric structure at breeding grounds must be rejected.
2. No one single measurement is the right index of the bird size.
3. Single measurement data do not allow localising the bird group within the breeding area.
4. The method of bird group's localisation, based on the cline model of the morphological structure, can be applied. To localise the origin of the bird groups one must:
4.1. collect the data (at least two measured parameters needed) from number of station/wave groups and two samples of local birds,
4.2. construct cline axes pattern -
   – calculate r and $ß$ for every pair of parameters used,
   – draw axes and adjust them when more than two,
   – scale axes using average value of the parameter (all birds included) as the value of axes crossing and SD values as constant segment at every axis,
4.3. make relative distribution pattern,
4.4. rotate and resize the pattern in relation to the map according to location of groups representing local birds.
5. Have in mind the methical problems:
   – uncertainty of $ß$ angle because of r estimation error,
   – uncertainty of group localisation because of standard error in group averages,
   – uncertainty of group localisation when more than two parameters are used,
   – doubt as to the size and shape of the area pointed by the localisation found,
   – fictitious localisation when a group is heterogeneous (additional study on homogeneity is needed)
   – doubt whether the clines are constant on long distances.
6. The method could help to solve the migration pattern problems on areas where ringing is not intensive, recoveries are scarce and measuring of birds during pre-migration period is difficult.

CORRELATIVE TOPOGRAPHY – A USEFUL METHOD TO STUDY INTRA-GROUP BIOMETRICAL DIFFERENTIATION

An idea to combine results of some bird measurements in studies on biometrical differentiation of migrating birds was one of the basics of the Operation Baltic working methods. The first attempt to use correlation tables of two measurements was already published in 1968 (Busse 1968). The method of application of drawing methods originated from the geographical topography was proposed there and it was called „correlative topography". Wing-length and tail-length measurements of the Robin (*Erithacus rubecula*) migrating in spring through Hel and Mierzeja Wiślana bird stations located at the southern Baltic coast were used as an example. Although it was shown that there was well pronounced intra-group and inter-group differentiation the method was not applied in further biometrical studies (with a few exceptions – Busse and Maksalon 1986b, Cofta 1986, Meissner 1997). The main reason was that the calculations required in the analysis were very time consuming, although rather simple. Now, there is appropriate computer software (e.g. SURFER for Windows) available. This software allows not only to draw charts with isolines as it was done before, but visualises biometrical differentiation as three-dimension pictures and „slice cuts" of distributions and their relative volumes.

This chapter is a presentation of the contemporary possibilities of the method but is not a biometrical analysis of the data used as an example.

THE METHOD

The exemplary data are the wing-length and tail-length measurements of Robins caught in autumn 1997 at two bird ringing stations situated at the southern Baltic coast – Bukowo-Kopań (54°28'N, 16°25'E) and Mierzeja Wiślana (54°21'N, 19°19'E). Total number of Robins caught at Bukowo-Kopań was 873 individuals and at Mierzeja Wiślana – 1101 individuals. Biometrical data used in all examples were taken from immatures only and the numbers of measured individuals were 583 and 487 respectively. At Bukowo-Kopań station there was few ringers that measured the birds (their measurements were previously calibrated according to the Operation Baltic standards – 0.2 mm deviations allowed in averages) while at Mierzeja Wiślana station only one ringer measured all birds.

The method requires a set of measurements of two bird size parameters, as e.g. wing-length and tail-length, taken from the same individuals. These data arranged into a two-dimension array make the basic data for all next procedures. The basic plane

(*X* and *Y* co-ordinates) are measured parameters while the third dimension (*Z* axis) gives numbers of individuals that have the defined combination of measurements that are *X* and *Y* values. Such set of biometrical data is equivalent to topographical data where heights of different points located at the Earth surface describe the relief of the mountains. Then this type of data is presented on the surface as the isolines connecting points located at the same height above sea level. The analogy between geographical application and biometrical use of the method has, however, limited extent as the geographical map of the defined area is a static picture of the Earth surface relief while the biometrical „maps" are dynamic pictures depending on the group from which the data originate. Such biometrical maps for different groups show various patterns despite the *X* and *Y* values are the same. So, in biometry, the pictures obtained by the application of the method depend on the group of birds measured and they can be used for searching of intra-group differentiation.

Technically, the raw data of any studied group must be arranged as three columns in a spreadsheet file – listing *X*, *Y* and *Z* values, which describe the array. *X* and *Y* are the values of the studied biometrical parameters (e.g. wing-length and tail-length) and *Z* values are numbers of individuals representing defined combination of *X* and *Y* values. A grid values for correlation charts could be obtained by different calculation procedures used in cartography that give similar results. Here the Krigging method used as a default in SURFER software was applied.

EXAMPLE OF APPLICATION

Typical biometrical one-parameter analysis searches for differences in average values of a studied measurement between two or more groups of birds defined by e.g. time of migration, the station where they were caught or orientation experiments (Busse 1995a). Sometimes differences are statistically significant and a conclusion is that the groups in question are differentiated. Frequently, the averages are not different enough and the null-hypothesis cannot be rejected. The Robin measurements data of autumn 1997, collected at Bukowo-Kopań and Mierzeja Wiślana, could be a good example of the latter case. Nor wing-length averages (M_{bk} = 72.10 and M_{mw} = 72.31, while standard deviations SD_{bk} = 1.83 and SD_{mw} = 1.84 and numbers of individuals N_{bk} = 583, N_{mw} = 487) nor tail-length did not differ significantly (tail-length averages nearly identical, while SD_{bk} = 2.63 and SD_{mw} = 2.09). Nevertheless, one should remember the basic limitations of the statistical way of thinking: (1) the possibility to show statistically significant differentiation depends very much on a number of measurements in the samples, and (2) groups which are not homogenous should not be defined as statistically not differentiated even their parameter's average values are the same. In the discussed example, there is suspicion of heterogeneity of at least tail-length measurement because of distribution of this parameter (Fig. II-67) and statistically significant (*F*-test, $p < 0.05$) difference in the tail-length variance. So, one of principles when studying biometrical differentiation is the knowledge whether the groups in question are uniform or not.
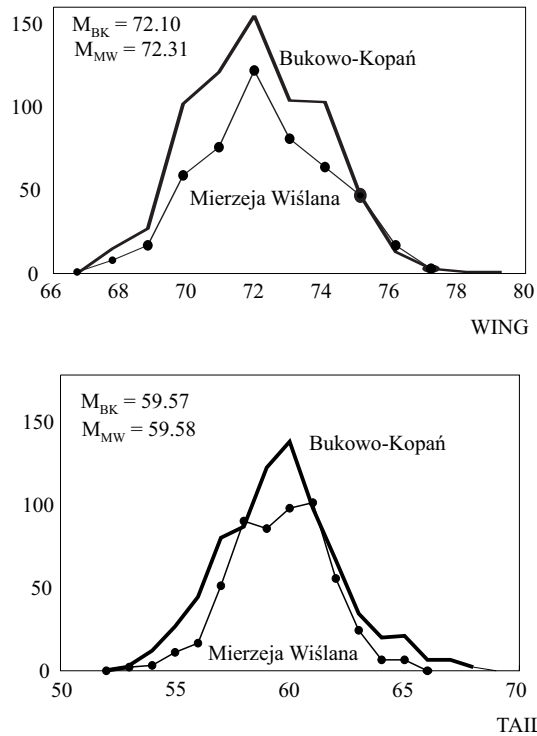
Fig. II-67. Distributions of wing- and tail-length measurements of immature Robins caught in autumn 1997 at Bukowo-Kopań and Mierzeja Wiślana ringing stations. Average values (M_{bk} and M_{mw}) are given for both measurements.

Let's try to make the correlative topography analysis starting from the general data set – all Robin measurements taken at both ringing stations. Performing procedure for all data one obtains a picture shown at Figure II-68. In a central part of the chart there is rather regular concentration of isolines representing a „central mountain" and some rather chaotic lines around, being the result of some exceptional deviations in measurements included into calculations. At least some of them were reading mistakes of measurements and miswriting the data during recording. These lines should be removed, as they represent usually nothing more than „information noise". Removing of some „lowland" isolines is possible within the options available in the SURFER programme. After this „cleaning procedure" the main „mountain" could be shown in two aspects – the plane isolines map and three-dimensional graph giving better picture of the group composition (Fig. II-69). The second aspect is useful for those who have some problems with three-dimensional interpretation of the isolines' map. This, very general picture, confirms a common belief that wing-length and tail-length are positively correlated (this is generally true for the Robin, but it is not always the case – Busse 1988). At the same time this distribution seems to be contradictory to data showing that there is sexual dimorphism in both wing- and tail-length (e.g. Glutz von Blotzheim 1988, Svensson
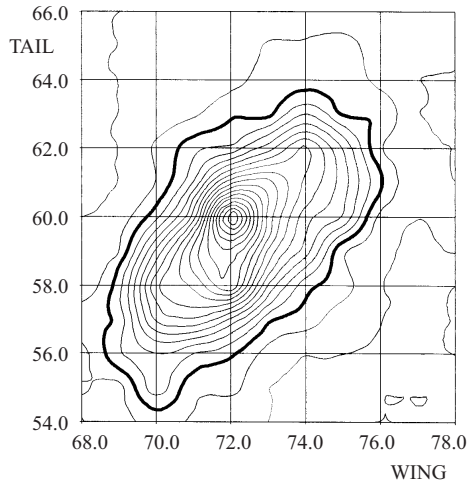
Fig. II-68. Correlation chart (wing-length/tail-length) for all young Robins (*imm.*) caught in autumn 1997 at Bukowo-Kopań and Mierzeja Wiślana. Isolines below the thick one are removed from the next Figures.
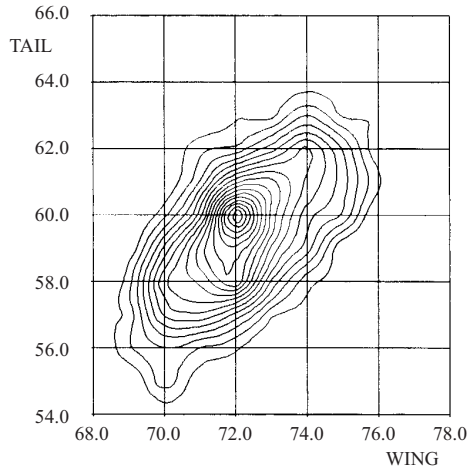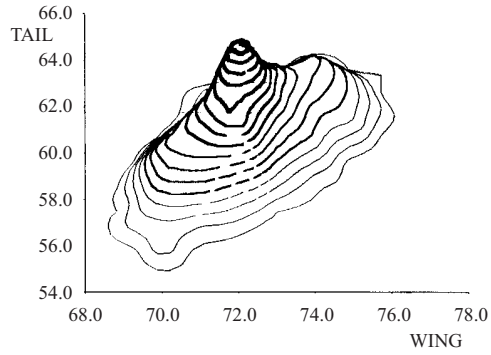
Fig. II-69. „Cleaned" correlation chart and three-dimension picture for the total sample presented at Figure II-68.

1992). If there is a sexual dimorphism in measurements, this distribution must contain at least two groups of birds where males belonging to the group of smaller birds are just of size of females originated from the bigger-sized birds. Possibility that the size structure is even more complicated should not be excluded.

Next steps of the analysis confirm the last statement of the previous paragraph – when we use correlative topography procedure to the samples of the Robin measurements collected at both ringing stations separately, the pictures (Fig. II-70) show clear differentiation of Robins migrating through Bukowo-Kopań and Mierzeja Wiślana. The „mountains" we obtained are of a very different „relief" and the highest peaks are situated in various locations. At Bukowo-Kopań there is one very compact peak at co-ordinates 72.00 (wing) and 60.00 (tail) while the highest peak at Mierzeja Wiślana is at 72.00-58.00. When one consider supplementary information about seasonal migration patterns at both stations in 1997 (Fig. II-71) the biometrical differentiation shown above

Fig. II-70. Correlation charts and their three-dimension presentations for Bukowo-Kopań and Mierzeja Wiślana separately.

Fig. II-71. Migration dynamics of Robins passing Bukowo-Kopań and Mierzeja Wiślana, autumn 1997.
Arrows below the *X* axis show division of the migration into three periods. At Mierzeja Wiślana
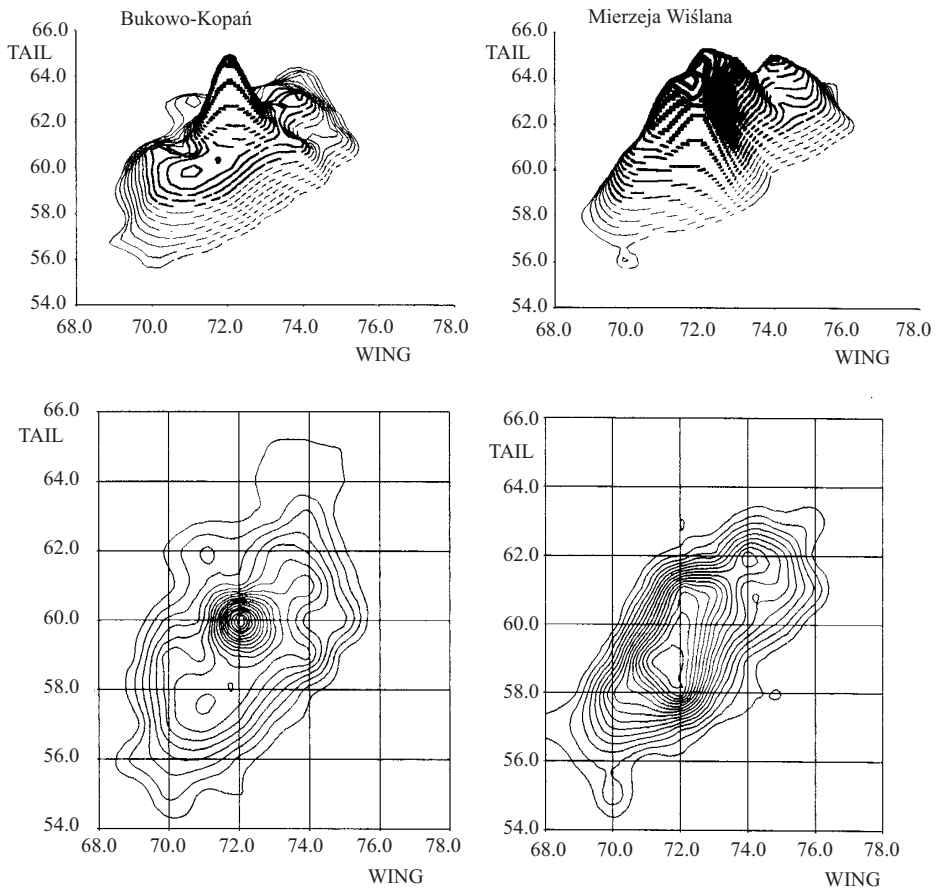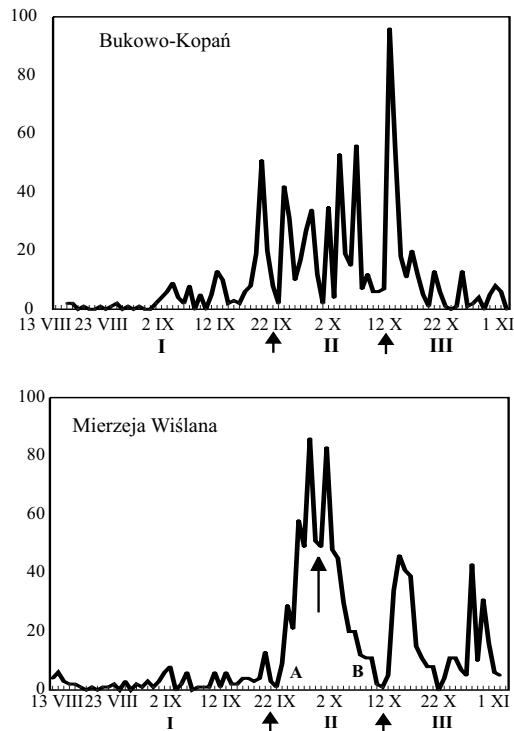a subdivision of the second period is pointed by the arrow on the graph.

is not too surprising as the migration pattern suggests that different populations of Robins do pass these two stations. For more detail analysis the biometrical structure of migrating Robin populations, the season was divided into three periods of migration as shown at the Figure II-71. This is a very rough division of Robins into few groups used in this exemplary analysis and is not equivalent to a real wave division, similar to those used in other biometrical analyses (e.g. Busse 1972, Busse and Maksalon 1978, Maksalon 1983) or analyses of seasonal migration dynamics (Busse 1996, Remisiewicz and Baumanis 1996, Kopiec 1997). Figures II-72 and II-73 show how well pronounced the differences in wing/tail distributions are if more compact groups of migrants are analysed. Out of six analysed groups of birds only group II at Mierzeja Wiślana is similar to the general distribution at this station. However, this group divided into two parts according to the migration dynamics (two-days of lower intensity of migration between two distinct peaks – Fig. II-71) shows that even neighbouring peaks of migration could be differentiated very much (Fig. II-74). In this case it is interesting that the first, pronounced peak of migration in the season is more uniform than the following one. The pictures presented above visualise the complexity of the biometrical patterns observed if more detailed analyses are performed. This should convince that a great care is necessary when any assumptions as to uniformity of biometrical data are made.
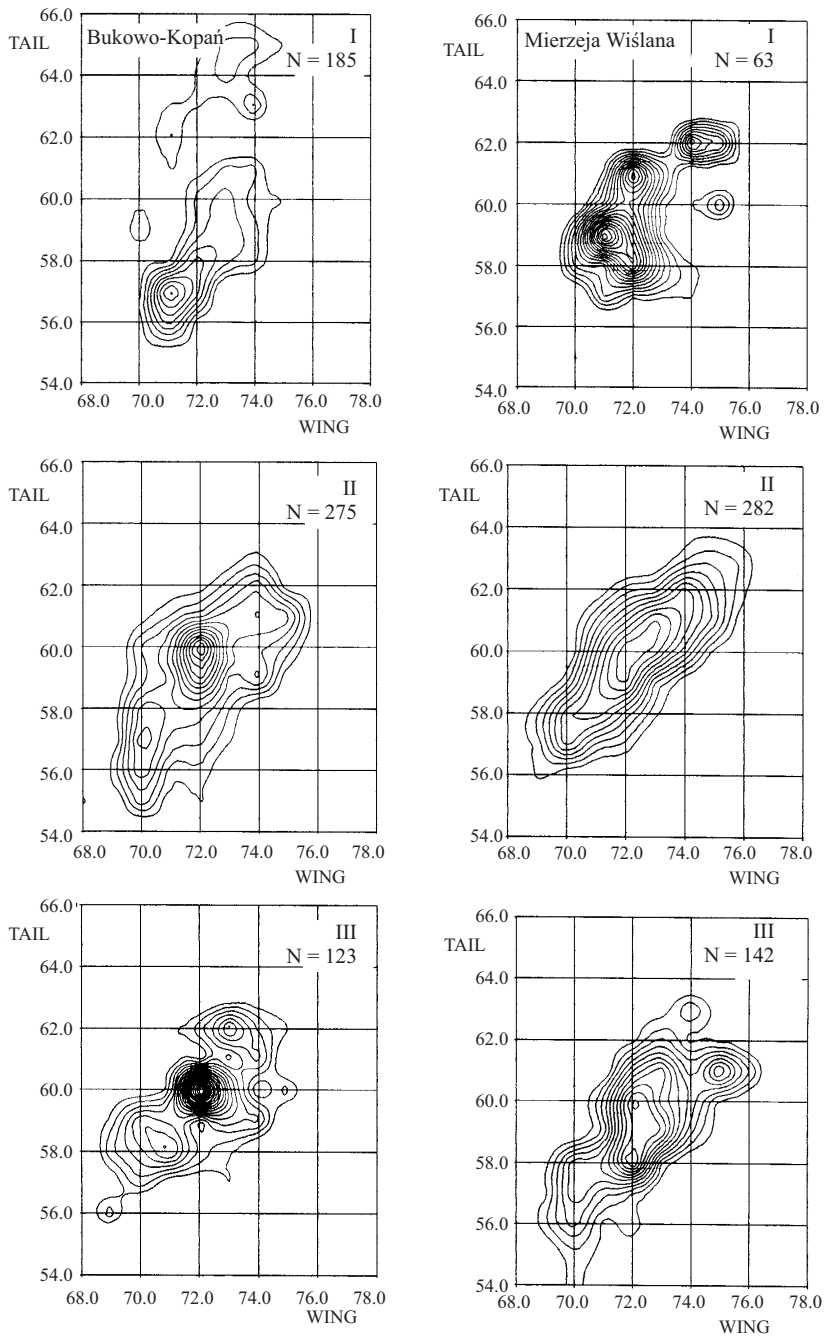
Fig. II-72. Correlation charts for three periods of migration (according to division shown at Fig. II-71). Number of individuals measured is given as *N*.

Bukowo-Kopań   I   Mierzeja Wiślana   I
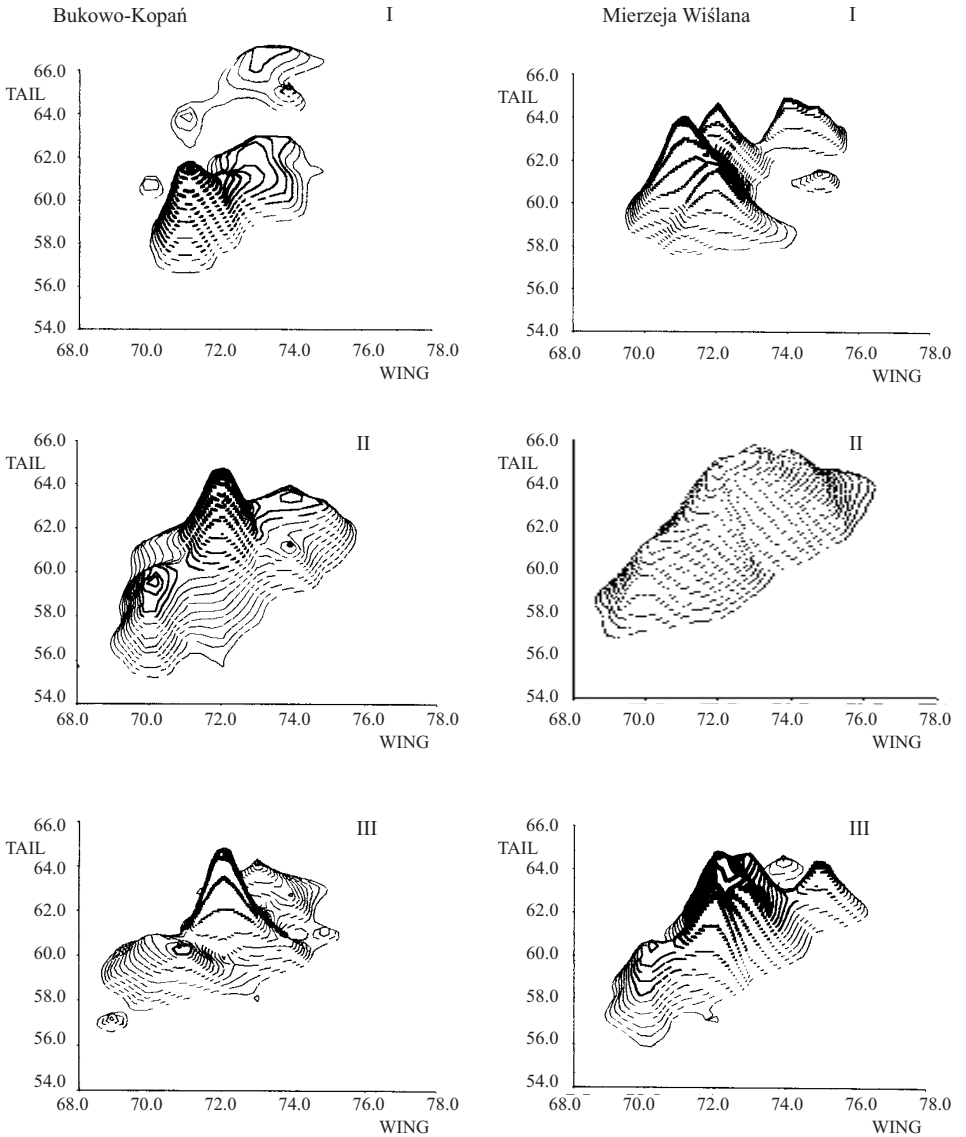
Fig. II-73. Three-dimension presentation of the correlation charts shown at Figure II-72.

Apart from this very general conclusion the method offers some possibilities to de-
scribe observed patterns more precisely. The software allows localising local peaks of
every group distribution (giving their *X* and *Y* co-ordinates and relative height), to define
„volume" and surface of the „mountains" above defined level (Table II-15, Fig. II-75). If
one would like to compare different groups (both at one station and these at different sta-
tions) the original, raw distributions should be recalculated to the same number level,
e.g. to one thousand of measured birds or to per cent shares. Then resulting distributions

Mierzeja Wiślana
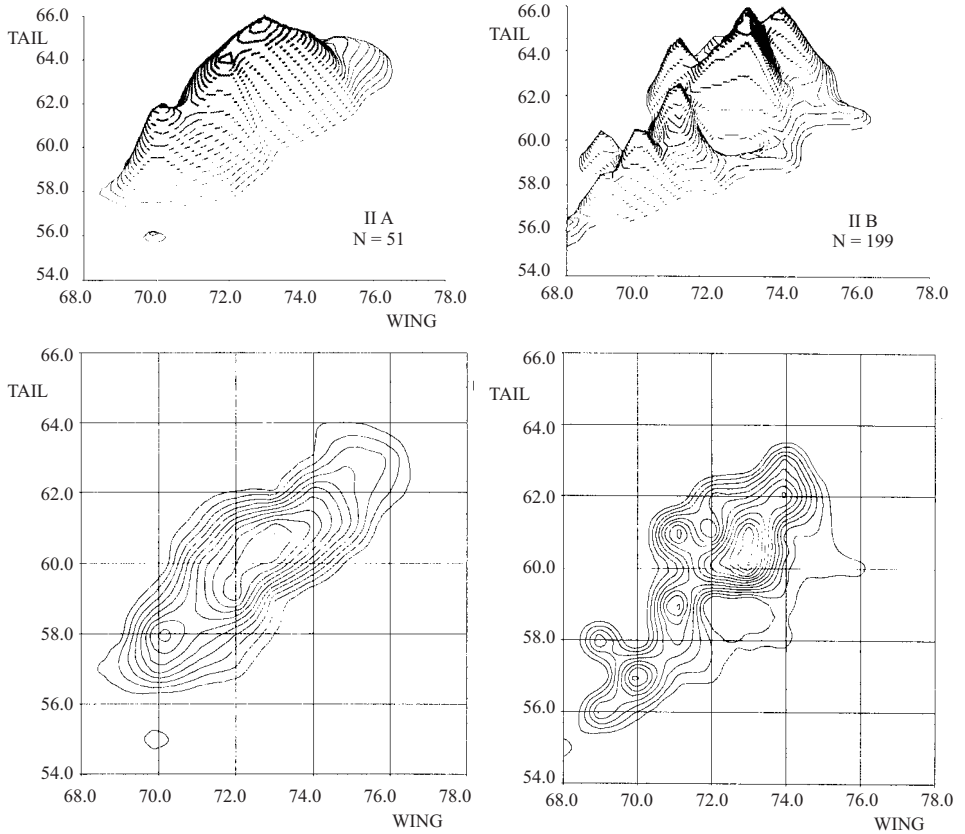
Fig. II-74. Correlation charts and their three-dimension presentations for two subsamples (*A* and *B*, according to division shown at Fig. II-71) of the period *II* at Mierzeja Wiślana.

must have the same value of the basic isoline (at Figure II-75 all distributions were recalculated to one thousand and the basic isolines are equal to 25). The studied distributions can be described by number of peaks and their height, e.g. Bukowo-Kopań I (BK I) group and Mierzeja Wiślana II (MW II) group have only one low peak suggesting about small concentration of measurements. At the same time these two groups are much differentiated as to a total number of birds which measurements fall within the central concentration of the distribution (very small value of „volume" index for BK I and much higher for MW II). Other groups have three peaks each but their heights show large variation as well as their volumes. Surface index seems to illustrate how much differentiated is the relief of distribution „mountains" but it should be interpreted in relation to the volume index. More exact evaluation of these parameters will be possible after more detail analyses of distribution patterns.

Table II-15. Characteristics of wing-length/tail-length distributions of Robins caught at Bukowo-Kopań and Mierzeja Wiślana stations in subsequent waves of migration. Peak's height as well as wave's volume and surface are given in relative values. Main distribution peak within the wave is given in bold.

Wave	Peak		Wing	Tail	Peak		Wing	Tail	Peak
		Bukowo - Kopań				**Mierzeja Wiślana**			
I	A		**71.00**	**57.06**	**55.9**				
	B						**71.00**	**58.89**	**103.0**
	C						72.00	60.94	76.0
	D						74.00	61.96	60.3
Volume		50.1				288.1			
Surface		140.2				638.5			
II	A		70.00	57.06	38.7				
	B		**72.00**	**59.91**	**76.7**		**72.00**	**59.91**	**59.4**
	C		74.00	60.93	35.5				
Volume		141.1				228.1			
Surface		329.5				373.8			
III	A		71.00	58.08	47.4				
	B						**72.00**	**58.08**	**67.7**
	C		**72.00**	**59.91**	**119.2**		72.00	59.91	61.5
	D		73.00	61.96	47.5				
	E						75.00	60.94	46.3
Volume		163.7				198.7			
Surface		465.0				394.4			

Another method of analysis of distribution patterns is using the slicing procedure, which allows drawing vertical profiles of the „mountains" cut along defined lines. The lines could be arbitrary selected but slicing through the highest peaks of studied distributions could be recommended. The profile shape depends on the line of cutting – for the same distribution various profiles can differ to a large extent (Fig. II-76). Despite of this unpleasant property, drawing profiles could be a useful method when comparisons between some groups are required (Fig. II-77). Contrary to three-dimensional distributions, linear profiles could be easily tested for statistical significance of their differentiation.

Correlative topography analysis should be performed especially if one wants to localise the breeding origin of migrants using the biometrical data (see Chapter **„*Localisation of the breeding origin…*"**).
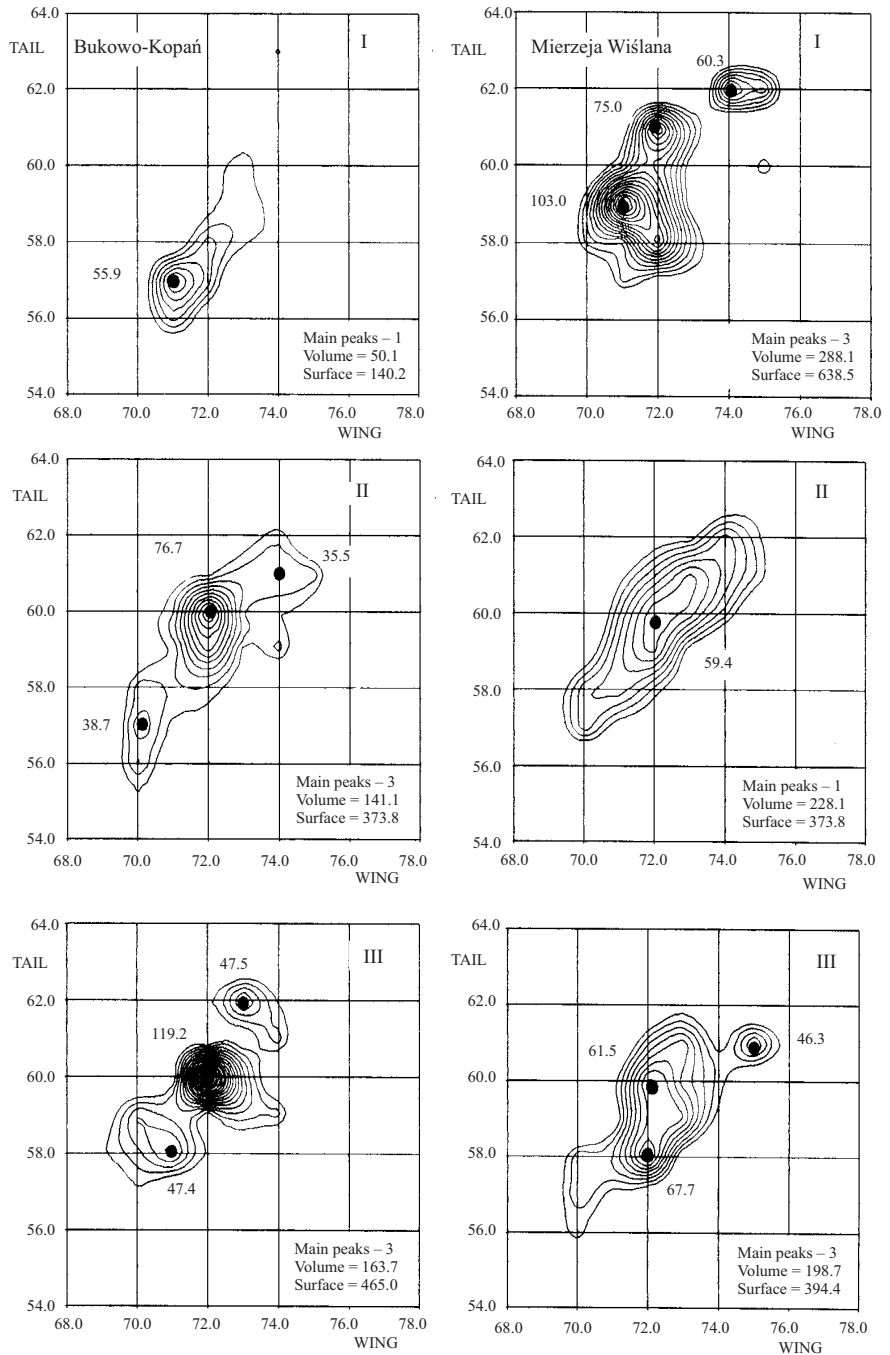
Fig. II-75. Standardised correlation charts for three periods at Bukowo-Kopań and Mierzeja Wiślana (common basic level - value 25 of isolinie). Numbers describe heights of observed peaks. Number of peaks, volume and surface indices are listed for every chart.
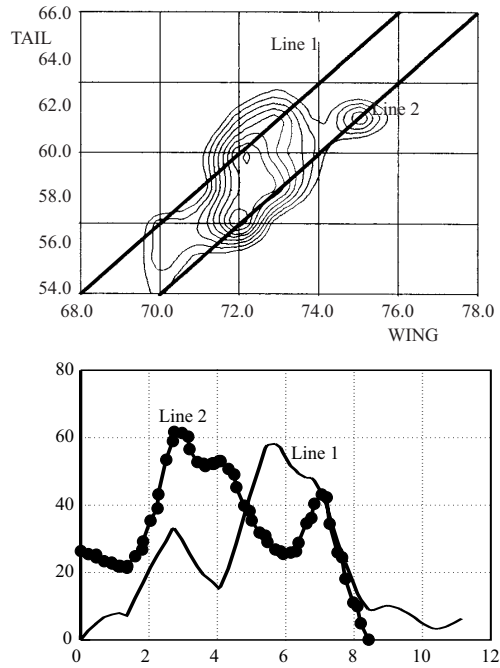
Fig. II-76. Exemplary presentation of distribution by slicing method. Results for one correlation chart cut along two lines are shown.
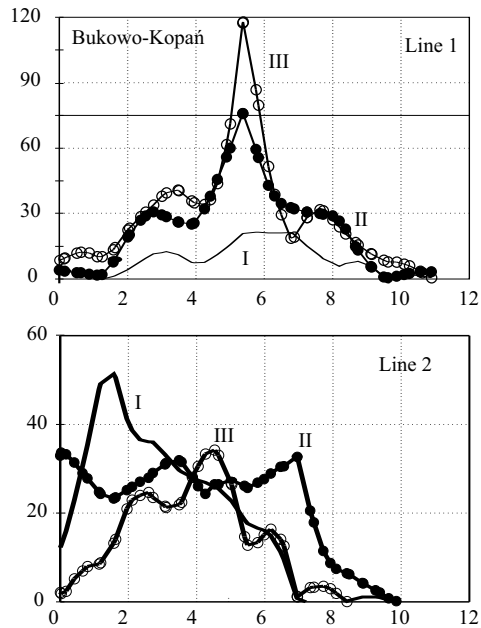
Fig. II-77. Distributions obtained by slicing the correlation charts for three periods at Bukowo-Kopań.

CONCLUSIONS

1. The method gives opportunity to study internal biometrical differentiation of groups of birds defined by means of seasonal migration pattern analysis, collected at different ringing stations or selected using other methods of bird migration studies.
2. The method should be developed by comparison of its results with the data collected by ringing and orientation experiments. The combined picture could allow solving the problem of mixing of different populations on migration or show at least partial isolation of groups that originate from various breeding grounds.
3. The method can help in general orientation in size of intra-group differentiation and aware against unsound assumptions as to homogeneity of studied samples. It seems that it is very risky to assume *a priori* that any group of measured birds is homogenous enough to accept without any cautions a null hypothesis when the group is compared with other ones.

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STUDIES OF LONG-TERM POPULATION DYNAMICS BASED ON RINGING DATA

Ringing data can be a source of information on population dynamics. They are: ringing recoveries that can be used to evaluate survival rates – a very important parameter of population dynamics – and ringing totals that can be used to describe long-term population trends and analyse yearly fluctuations of bird numbers. Most papers presented at the EURING/MEG Technical Meetings have been devoted to survival analyses, while long-term population dynamics studies based on ringing data are dispersed elsewhere. This separation is a very unfortunate phenomenon, as the results of these studies are supplementary and should be discussed together. In survival studies different assumptions are adopted and they determine the results in many cases. These should be, however, related to real data on long-term dynamics of population. It is possible that an apparently correct assumption induces results, which do not fit to a real population at all. This is a reason for the present discussion of methodical problems in the evaluation of population dynamics based on ringing data. These problems are different when one evaluates national and station/local ringing totals.

NATIONAL RINGING TOTALS

This kind of data has been used in monitoring evaluations a few times. Although authors have found some reasonable results, it should be stressed that such totals may be very biased, especially when they contain both pulli and full-grown birds. The most obvious source of bias – a variable number of ringers – could be, theoretically, corrected by recalculation of a number of ringed birds per ringer. Nevertheless one should keep in mind that not only the number of ringers, but also their ringing preferences, as well as the popular ringing programmes and general ringing politics of the scheme, could influence ringing of certain species very much. An implicit assumption of equal interest of ringers in ringing of different bird groups or species may be wrong, so the presentation of species data as a percentage of the total ringing seems to be doubtful. Additionally, apart from the conscious activity of ringers, long-term changes in the standard of living and social development of a country play an important role in the ringing activity by changing an amount of free time and money spent on ringing when it is a hobby. It can be concluded that national ringing totals should be avoided as a source of monitoring data or, at least, treated with extreme caution.

STATION RINGING DATA

When a study is based on this kind of ringing data, problem of biases control seems to be simpler than in the case of the national ringing totals, but still numerous biases

could still be expected. They are of a very different origin: they depend on a locality of a station in relation to migration pattern of a species, methods of data collection and evaluation.

If we focus on monitoring problems, one can imagine an ideal ringing station: (1) located inside a large area covered by homogenous and stable habitat, where broad front migration occurs, and (2) having highly standardised methods of data collection. A typical European bird ringing station is, however, generally far from this ideal model.

Localisation of the station

The location of the station is rarely ideal: most stations are situated in the places where concentration of migrants is expected – on islands, at the seacoast or on mountain passes. Such places allow catching more birds, but the number of migrants that occur there is more sensitive to random fluctuations due to weather conditions. These fluctuations differ much: the largest are on islands (e.g. Heligoland – Germany, Ottenby – Sweden, Christianso – Denmark), smaller at the sea coast, where migrants land after over-sea flight (e.g. Dutch coast, Hel Peninsula – Poland) and on mountain passes (e.g. Col de Bretolet – Switzerland); the smallest weather influences can be expected at those coastal sites which are guiding lines for diurnal migrants (e.g. Rybatchy – Russia, Mierzeja Wiślana – Poland). It should be stressed here that some inland stations are ecological equivalents of island stations (e.g. an isolated lake for reed birds) with all the consequences of that type. Generally, the type of a station must be taken into consideration in monitoring data interpretation. This is because weather fluctuations cause part of a year-to-year number variation. However, these fluctuations will not change long-term trends.

An important requirement of the location of the station in homogenous and stable habitat is very rarely fulfilled. Homogeneity of habitat allows us to assume equal capture efficiency of all nets used at the station, which is helpful when, due to organisation of the station work, the number of nets is not exactly stable. Nets located in mixed habitat are not of equal capture value – it will vary for different species, so recalculation of catching results per one net or per standard length of nets is always biased and, moreover, biased to different extent for various species. The second habitat parameter – its stability – would be fulfilled only at a station located in habitat at a climax stage. This is practically never a case, as such habitats are unsuitable for catching birds. At most ringing stations, habitat is in the succession stage: reedbeds become dryer and more bushy, while bushes and young forest plantations grow up and become more dense. It is clear that such processes lead to changes in habitat suitability for birds, which can cause substantial bias in the long-term trend estimation. The problem is solved at the stations in two different ways: (1) artificial standardisation of plant cover at the station area (e.g. MRI Program – Berthold and Schlenker 1975), or (2) moving of a catching area inside a bigger area of a similar habitat according to succession (e.g. Operation Baltic stations – Busse and Kania 1970). Both solutions have their own advantages and disadvantages. The first method is applicable in special conditions, when the habitat can be easily managed, e.g. „catching gardens" at a few stations (e.g. Heligoland, Ottenby) or willow shrubs at bor-

ders of lakes. However, this method of management of the station area does not eliminate habitat bias – the bias can extend further as an area around the station may strongly alter changing its attraction for birds, which could concentrate at the places out of the station area or *vice versa*. This bias is, in practice, incalculable. The second solution – adaptation of the catching area and location of nets according to habitat succession reduces „habitat bias", but its effectiveness depends on local conditions and the experience of the station staff. The best results are at the stations situated at clear guiding lines of migration when experienced staff carefully chooses new catching places according to local traditions of migrants. However, also in that case, the bias is incalculable too.

Methods of data collection

The most important elements of the field methods are as follows:
1. sufficiently long, standard and continuous period of work,
2. standard number and quality of catching devices,
3. numerous enough and qualified staff.

Requirements listed here will be clear and obvious, when we take a look at Figure II-78, where an example of the seasonal migration dynamics of a typical migrant, the Robin, is presented. A two-month long period of work is necessary to cover the time of migration of the species in any particular year. A two and a half month period of work is therefore sufficient for such species. When more species, and usually this is the case, are studied simultaneously this period would be insufficient, as a number of species would migrate earlier or later than the Robin mentioned and their data would be biased because of migration time. E.g. a few such species can be found, when the period of autumn work of the station is limited to August 17th-October 31st. If the work of the station is carried out every year throughout the standard period the data are directly comparable. In practice there are, however, some deviations from the standard time – for different reasons
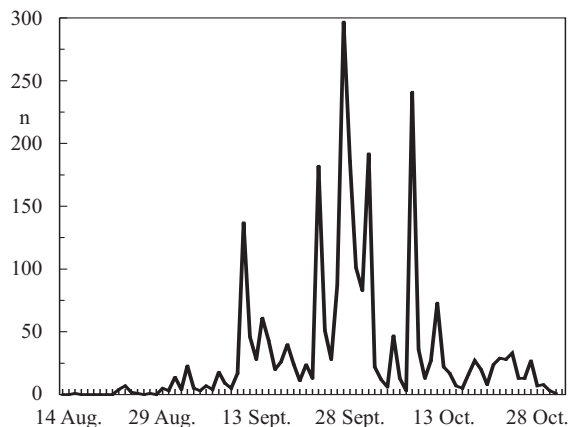
Fig. II-78. Seasonal migration dynamics of the Robin (*E. rubecula*) at Bukowo station (Poland) autumn 1981

the station starts to work later or is closed earlier. In such cases the final data are not directly comparable to other years and it is necessary to make an extrapolation of bird numbers to the standard time. This can be done on the basis of an average cumulative curve of migration of the species (Busse 1973).

In an example diagram (Figure II-79) it can be seen that, due to differences in migration time and intensity, variation around the average curve is rather large, especially in the central part of the migration time, so the extrapolation is allowed only for a few marginal five-day periods. An example of the results of such extrapolation is given in Table II-16 and in Figure II-80.
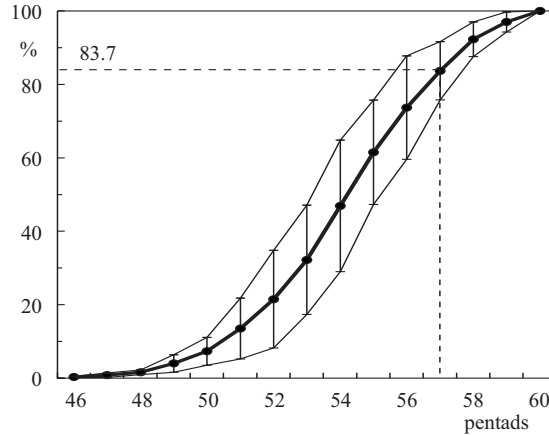
Fig. II-79. Average cumulative curve of migration of the Robin (*E. rubecula*) at Bukowo (1971-1982). E. g. in pentad 57 (8-12 Oct.) 83.7% of birds of the yearly total already passed the station. Vertical lines – *SD*.
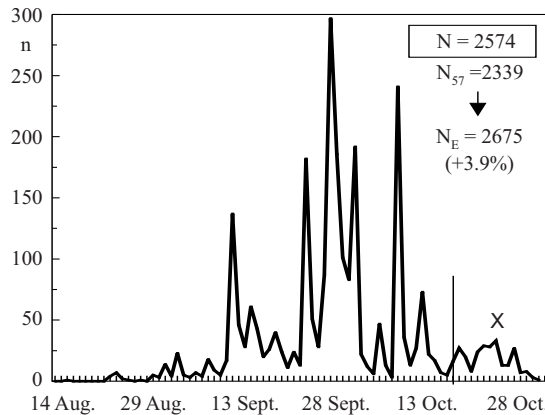
Fig. II-80. Example of the results of extrapolation when data from the last three five-day periods are „unknown" (X). *N* - real number of birds caught till the end of work (60th pentad), N_{57} – number of birds caught by the end of 57th pentad (vertical line), N_E – estimated number of birds for the end of the 60th five-period. Extrapolation based on Figure II-79.

Table II-16. Results of extrapolation of the number of Robins (*E. rubecula*) at Bukowo station, when data from the last three five-day periods are treated as „unknown". Extrapolation based on Figure II-79. N_{57} – number of birds caught by the end of 57th five-day period, NE – estimated number of birds for the end of work (60th five-day period), N – real number of birds caught till the end of 60th five-day period, Δ – NE-N difference in percent.

Year	N_{57}	$NE \pm SD$	N	$D\%$
1971	1054	1259 ± 83	1149	+9.6
1972	1079	1310 ± 87	1158	+13.1
1973	1100	1314 ± 87	120	+8.9
1974	-	-	-	-
1975	788	941 ± 76	887	+6.1
1976	535	639 ± 42	690	-7.4
1977	596	712 ± 47	781	-8.8
1978	478	571 ± 38	682	-16.3
1979	481	575 ± 76	555	+3.6
1980	517	618 ± 82	653	-5.3
1981	2339	2674 ± 177	2574	+3.9
1982	852	1018 ± 67	1100	-7.4

Consideration presented as above is based on an assumption of continuous work of the station – the work is carried out each day throughout the whole standard period. Figure II-78 shows clearly that any sampling (e.g. one day of catching per week, or five or ten day periods etc.) cannot give reasonable data for monitoring purposes – accidental and incalculable deviations would be much too big. The same is true if any uncontrolled gap occurs within the period of work – analysis of Robin migration at Bukowo station (1971-1982) shows that a single peak day of migration contains on average 14.4% of birds caught in a particular year (sometimes as much as 28%). Many researchers at different bird stations made similar observations. Some of them concluded that peak day values were accidental (depending on the weather) and that they should be damped mathematically before calculation of indices of true population size. However, study on daily fluctuations of the Robin migration at Bukowo station (above) suggested that this conclusion was doubtful and should be further checked. It was found that years with a high total of birds also showed a high variance in daily catches ($r = 0.98$, the same for variance calculated with and without peak days), so these peak catches are a natural consequence of high variance connected with high population level. Another test of the latter hypothesis is presented in Figures II-81 and II-82. The cumulative curves of birds caught in separate years were constructed as follows: out of forty days of the main period of migration a day with the smallest catch was found, then next smallest catch was added the to that number of birds and so on to the highest peak day. The curves never cross each other, which means that the distribution of days with low and moderate catches, as well as the highest ones, is determined by the total number of migrants. The average curve (Fig. II-82) can be used for extrapolation of the total number of birds when for a few peak days the number of birds cannot be fixed (Fig. II-83), e. g. when too small or in-
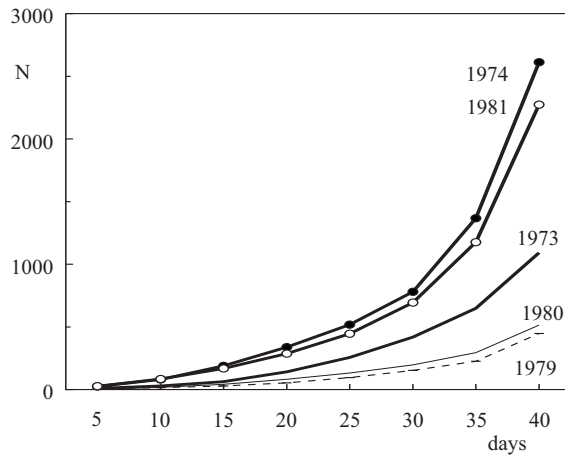
Fig. II-81. Cumulative curves of catches in the main period of migration of the Robin (*E. rubecula*)
at Bukowo station. Explanation in the text.
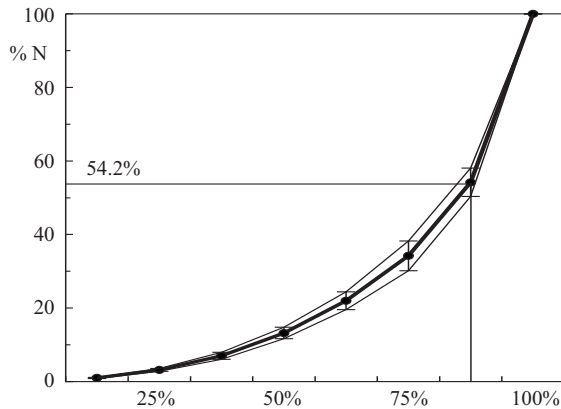
Fig. II-82. Average cumulative curve calculated from data presented in Figure II-81. Vertical lines – ±*SD*.
Forty days period is treated as 100%. E. g. if catching results are not known for five peak days (see Fig.
II-83) in the rest of days of the main migration period 54.2% of the yearly total of birds had passed.

experienced staff closed some nets from the standard set. The bias caused by the estima-
tion is surprisingly low: the coefficient of variation is only about 7%, when estimation is
based on thirty-five out of forty catching days.

Extrapolation of numbers of caught birds, when the number of nets varies between
days or seasons, is in common use e.g. Busse (1973) recalculated the yearly catches per
net of standard length, using the average number of nets that worked in a season (gener-
ally a stable number of nets was in use and they were open continuously), while Rabøl
and Lyngs (1988) recalculated the every day catches per total length of nets used on
a particular day (a different number of nets operated on different days and they were
open during varying parts of a day). However, everybody must bear in mind that such re-
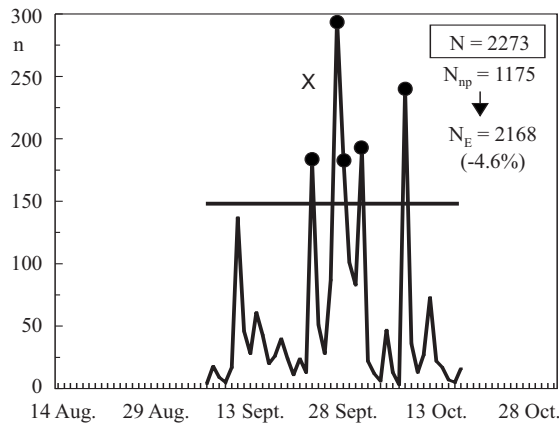
Fig. II-83. Example of the results of extrapolation when data from five peak-days (o) are „unknown".
N – real number of birds caught, N_p – number of birds caught in non-peak days, N_E – estimated
number of birds. Extrapolation based on Figure II-82.

calculations may generate biases, which could be substantial and difficult to estimate. Frequent changes in the number of nets and their placement are especially dangerous – they can lead to gross disturbances of the migration dynamics curve and enlarge biases of other extrapolations. Because of this, sampling with a fixed number of nets and continuous catching is strongly recommended. Different diurnal activity pattern of migrants during low, moderate and peak migration days makes continuous catching important, though in some conditions (e. g. in hot climate) it cannot be observed.

Evaluation of the station ringing data

Yearly (seasonal) station ringing totals corrected, as discussed above, can be presented as raw data curves, where data are plotted against the years of the study. The other method of data presentation is a plot of percentage indices of population size, calculated from the raw data in relation to a datum level. When curves from different stations or populations are expected to be compared the latter method is recommended, especially when a mean population level is accepted as a basis for calculations.

The raw data curves based on station ringing totals usually show pronounced year-to-year fluctuations (Fig. II-84). The fluctuations are a matter for discussion. Whilst Svensson (1978) considered that migration counts show higher fluctuations than breeding bird censuses, because of weather and methodological factors introducing accidental deviations, Busse (1990) has shown that natural population processes can explain most of the variation and only a small part is due to chance. Autumn migration data curves are clearly likely to differ from population estimates during the breeding season since migrant birds will include large number of 1-year birds. Thus such curves not only trace the breeding population curves, but also have an additional (and variable) influence of the productivity attained by the species during the breeding season.

More general trends in population dynamics can be shown as curves based on raw data but smoothed by means of a moving average calculated according to different formulae. From population dynamics studies point of view it is important to know whether the yearly fluctuations deform long-term population trends. Examination of some tens of smoothed curves drawn from migrating Passerines data leads to the conclusion that in most cases even big year-to-year fluctuations do not alter the general shape of the smoothed curve (an example is shown in Figure II-84). So, the conclusion is similar to that about the value of peak day catches for yearly number indices – usually even the most extreme values are based on a real size of the population studied.
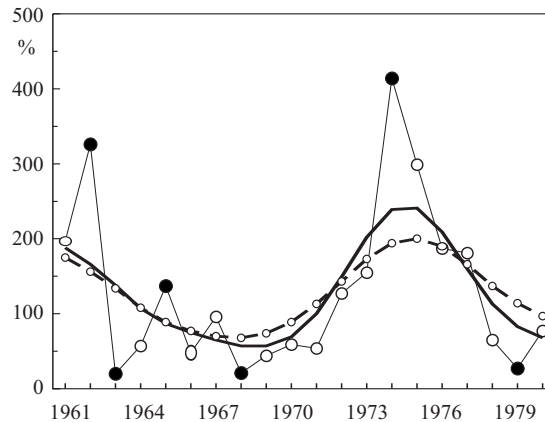
Fig. II-84. Presentation of the station ringing data: the Goldcrest (*R. regulus*), Mierzeja Wiślana station: thin line and large circles – raw data curve, thick line – smoothed curve, all years included, broken line – smoothed curve, extreme yearly totals (black dots) excluded.

In population dynamics studies a year-to-year variation level is an interesting parameter, which can be analysed as a special measure of population processes. Different bird species show different levels of variation, spring-time fluctuations are different from the autumn ones and variation at one station can be different from fluctuations of the same species at another station. When this problem is studied one meets a methodical problem with the calculation of the measure of variation. Standard deviation (*SD*) and coefficient of variation (*CV*) are not enough good measures here as they depend not only on year-to-year variation but also on a long-term trend of population size. Both parameters of the long-term trend – a shape of the curve and a mean size of population – influence the value of these indices. Busse and Cofta (1986) proposed the calculation of another index of variation – the coefficient of oscillations (*CO*), based on the idea that variation should be expressed as a measure of deviations from the smoothed curve of a long-term population dynamics. After further studies the *CO* formula does not seem to be ideal and now, in current studies, a similar index of variation, called a coefficient of fluctuations is in use:

$$CF = \frac{1}{M} \sqrt{\frac{(X_{oy} - X_y)^2}{N}} \cdot 100\%,$$

where M – mean value of population size index for all studied years, X_y – the value of a population size index for year „y", X_{oy} – local value of moving average for the year „y", and N – number of years in the sample. Comparison of CV and CF values for the same data is presented in Figure II-85. It can be easily seen there that CF values better describe the size of the variation.
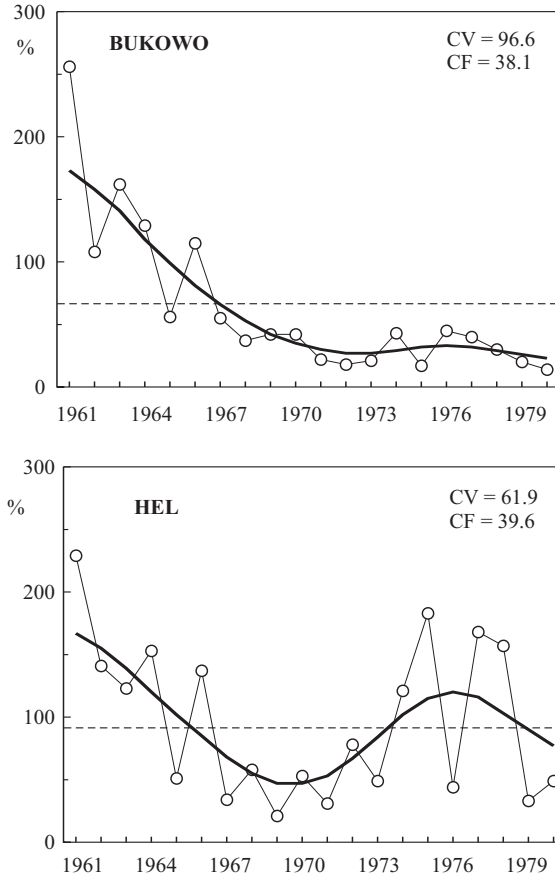
Fig. II-85. Two measures of variation (CV - coefficient of variation, CF - coefficient of fluctuations) calculated for the Blackbird (*T. merula*) – data from Bukowo and Hel stations: thin line – raw data curve, thick line – smoothed curves, broken line – mean population level for the station.

Although the study of population level year-to-year variation is important, most researchers are primarily interested in the description of the long-term population trends and they use regression analysis as the main method. Different variants of calculations are used which usually give similar results, with differences in robustness only.

E.g. Berthold *et al.* (1986) have used the same data in five variants of calculations (Spearman rank correlation coefficient, linear regression, log-linear regression, log-linear robust regression and log-linear maximum likelihood estimation) and they obtained practically the same effects (out of 104 comparison only six, and not statistically significant values, disagreed with the others).

   Although regression analysis seems to be an adequate statistical method for the problem of the long-term population trend studies, it must be stressed that population dynamics is much more complicated than the simple linear or log-linear trends that is a case when that method is used. Figure II-86 gives an example in which the regression lines do not describe the differences between dynamics of the Goldcrest populations migrating through two bird-ringing stations sufficiently. This is very typical example as most population dynamics studies, carried out over a sufficiently long time, show that wave-like, or cyclic population dynamics patterns, predominate among studied species of birds. This very common phenomenon induces caution in the interpretation of the results of regression analyses based on the short-term studies. In population dynamics studies even ten years data seem to represent too small sample for general conclusions on the welfare of the species. Local, short-term trends can be drastically different from a really long-term trend, as illustrated in Figure II-87. The twenty-eight year trend shown there as a „real long-term trend" should be, however, treated with caution too, as bird population cycles as long as fifty years were reported (Machalska *et al.* 1967).
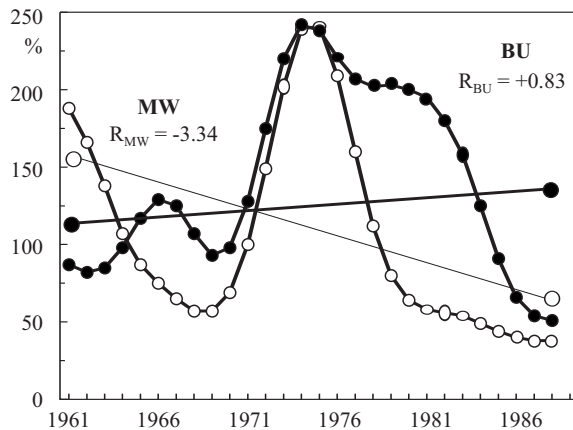
Fig. II-86. Population trends of the Goldcrest (*R. regulus*) migrating through Bukowo (black dots, BU) and Mierzeja Wiślana (open circles, MW) stations. Regression coefficients are given.

Interpretation of the results

   It could be generally agreed, that station ringing data collected and evaluated with all the cautions discussed above give sufficiently good information about the real number dynamics of migrants passing through the station. However, there is further methodical
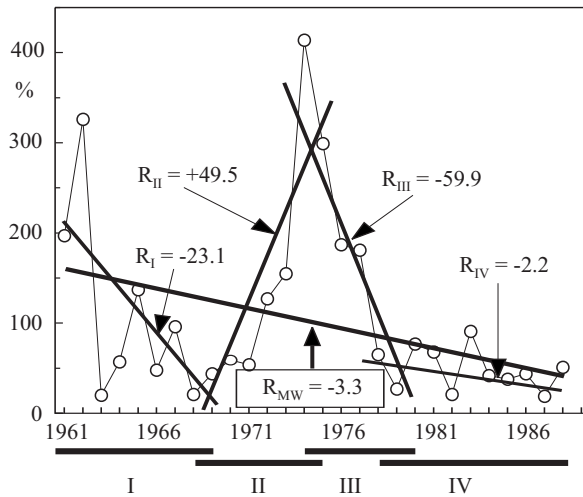
Fig. II-87. Comparison of local, few year trends, calculated for four periods (*I-IV*) and long-term trend of population of the Goldcrest (*R. regulus*) migrating through Mierzeja Wiślana station: thin line and open circles – raw data, thick lines – local trends for different periods, very thick line – long term trend (MW).

problem: „which population is represented by a studied group of migrants?" The problem is important, as looking for causes of the year-to-year variation in population level and interpretation of an overall population dynamics requires defining the breeding and wintering areas of the population studied. In some cases it is possible to find them by ringing recoveries analysis alone, in other more complex bird migration studies must be included (see Chapter *„Ringing and migration patterns…"*). It should be stressed here that apparently natural assumptions on native areas of migrants taken as a basis for correlation analyses are frequently doubtful, and result in poor correlations between ringing station data and breeding bird censuses. Migration patterns of various species are very different and hardly any inter-species extrapolations can be accepted. There are examples which show that quite different birds migrate through stations situated relatively close to each other – Busse (1972) for the Redstarts migrating through Mierzeja Wiślana and Nowa Pasłęka, Operation Baltic stations, Maksalon (1983) for Song Thrushes passing Ottenby and Falsterbo stations. The case of the Song Thrush is especially apposite as it was shown that migrants at the Polish Baltic coast stations differ both in the origin and destination of migration and, moreover, the numerical composition of these migrants is not the same at the stations (Busse and Maksalon 1978, Maksalon 1983). This is a situation when it is impossible to assign described numerical dynamics to any defined area. There is, however, another example, where the numerical dynamics of successive waves of migrants is clearly differentiated as successive waves come from the separate breeding grounds (the Meadow Pipit – Petryna 1976).

These few examples suggest that interpretation of the results of population dynamics studies, based on ringing station data, is very difficult if the migration pattern of the species is not well described.

POOLING THE DATA

A few papers evaluating migration counts monitoring data collected simultaneously at dozen or so bird-ringing stations situated within northern and central Europe were published. They contain data on several species from different passerines families (shrikes, *Laniidae*, warblers, *Sylviidae*, and thrushes, *Turdidae*). This new level of monitoring studies (in contrary to evaluation of population trends at separate stations: Busse 1973, 1994, Berthold *et al.* 1986, Lindholm *et al.* 1983, Busse and Cofta 1986, Baumanis and Rute 1986, Hjort and Lindholm 1978, Payevsky 1990, Svensson 1978, Pettersson and Hedenstrm 1986) brought results, which must be interpreted within more general than local population dynamics model.

Comparisons of the same species data from different stations show clear differentiation in the long-term trends and annual fluctuations. Sometimes stations can be grouped into clusters where population dynamics/fluctuations are similar, but different from other groups. Trend patterns can be difficult to explain when a background bird migration pattern is not studied sufficiently. This is especially clear within northern and central Europe, where populations are differentiated as to direction of migration – some birds of the same species and from the same breeding area can migrate to such distant winterquarters as Spain and Balkan Peninsula. In some species (e.g. the Blackcap) results suggest that birds migrating SW and SE show different population number dynamics. Could this phenomenon lead to shifts in population distribution in northern and central Europe? Similarities between population trends/fluctuations of some species were observed (do they come from the same areas?) and various patterns in closely related species were found (do they come from different areas or do they react differently to the same ecological conditions?). In species where periods of high and low population levels can be distinguished, levels of an annual variation are usually differentiated too – they are higher in periods of raised level of the population number. Which population level is „normal" for the area? Should we alert bird conservationists and a wide audience every time we found a negative trend? Such questions can be asked when the data come from a wide area and from many bird stations.

A special problem of analysis arises when one tries to generalise trends observed at different bird stations and answer the question: how does the number status of the studied species develop at a wide area being under migration monitoring control? What is the general trend? What is the size of the fluctuations? Answers to such questions require the integration of counts obtained at different bird stations to provide regional totals.

It is well known that the numbers of individuals of the same species caught yearly at the bird stations vary greatly. Numbers vary not only from year to year, but, what is the most important, the averages at various stations are also different. Differences in averages can be assumed to be a result of (1) various trapping efficiencies at the bird stations, (2) various numbers of individuals passing the stations (i.e. different average intensities of migration) or (3) both. When the first assumption is true general population totals should be calculated as un-weighed averages from the station data values (the influence of every station trend/fluctuation value on the total is the same independently of the

number of individuals caught). When the second assumption is true – the totals must be averaged by weighing for the number of individuals caught at the particular station (trends at the stations with higher ringing totals influence total trend/fluctuation value more than the others). When both assumptions are true simultaneously (third case) the best estimation of the trend will be after reduction of influence of the first factor (catching efficiency). This can be partially reached by relating the number of individuals of the particular species caught at the bird station to the total number of birds caught there by means of the same catching devices and having similar habitat preferences. The species shares within the bird station totals can define a kind of validation of the station as to its value for migration of the species. Trends at the bird stations with the share of the species higher than the total average can be assumed as more valid for the general population trend than those at the stations, where the species is scarce.

A comparison of different methods of pooling count data is discussed in the present chapter.

The data used as an example are extracted from some papers where migration count data (results of catching) were given (Busse and Marowa 1993, Busse 1995b, Busse *et al.* 1995). In these papers the trends and annual variations for the years 1961-1990 were analysed for ten species: the Red-backed Shrike (*Lanius collurio*), Great Grey Shrike (*L. excubitor*), Willow Warbler (*Phylloscopus trochilus*), Wood Warbler (*Phyll. sibilatrix*), Chiffchaff (*Phyll. collybita*), Garden Warbler (*Sylvia borin*), Blackcap (*S. atricapilla*), Whitethroat (*S. communis*), Lesser Whitethroat (*S. curruca*), and Barred Warbler (*S. nisoria*). Present discussion includes a group of eight species being long-distance migrants (the Great Grey Shrike excluded) and sufficiently numerous (Table II-17 – more than 100 individuals per season at six stations; the Barred Warbler was twice less numerous and hence excluded).

Table II-17. Average number of individuals of the studied species caught per year at different bird stations.

	Mierzeja Wiślana	Hel	Bukowo	Helgoland	Ottenby	Rybatchy	Total
L. collurio	12.2	3.1	5.5	2.5	206.1	3.1	232.3
S. atricapilla	122.1	47.1	101.5	464.8	61.5	26.8	823.7
S. borin	83.9	38.1	58.5	572.1	118.1	52.6	923.1
S. curruca	27.2	16.6	20.4	4.6	177.4	58.8	305.1
S. communis	13.3	1.6	6.9	62.1	124.6	17.3	225.8
P. trochilus	395.3	159.2	178.4	315.6	756.6	685.4	2490.5
P. collybita	50.8	17.6	35.5	37.8	42.4	34.8	218.9
P. sibilatrix	6.8	1.3	2.6	1.9	47.9	45.1	105.5
Total	711.6	284.6	409.3	1461.4	1534.6	923.9	

Source papers contain the data from 9-15 bird stations depending on availability of station data and their compatibility with other data sets. The raw data are listed in the re-
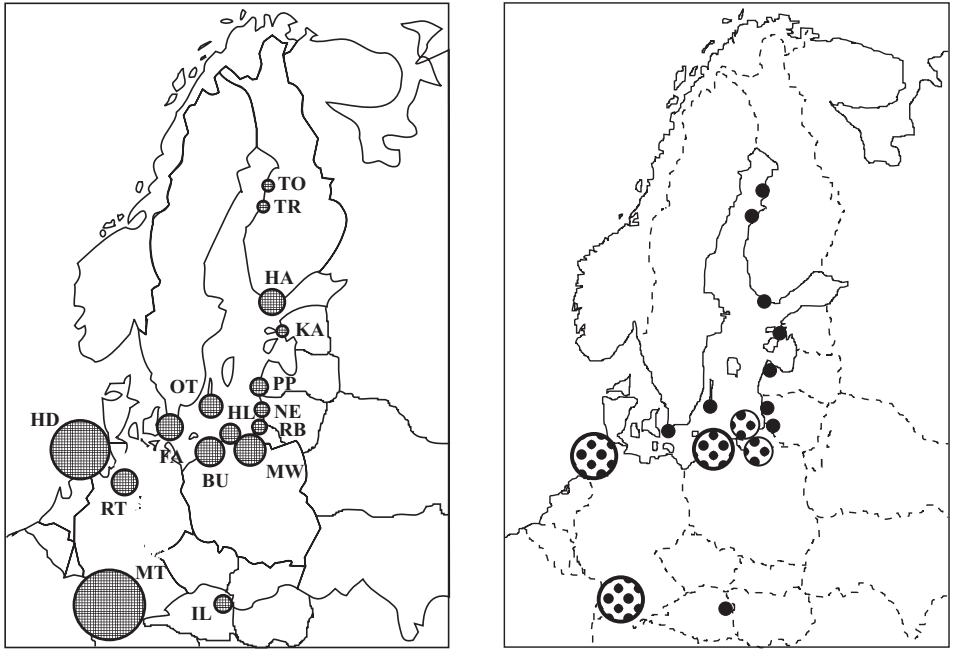
Fig. II-88. Numbers of individuals of the Blackcap caught yearly at the bird stations (left) and validation of the stations for this species (right). Left picture: areas of circles are proportional to annual average numbers of Blackcaps caught; right picture: heavy circles – station value index more than 150, circles – station index 100-150, dots – station index less than 100.
Stations: BU - Bukowo/Kopań, FA – Falsterbo, HO – Hanko, HD – Helgoland, HL – Hel, IL – Illmitz, KA – Kabli, MT – Mettnau, MW – Mierzeja Wislana, NE – Neringa, OT – Ottenby, PP – Pape, RT – Reit, TO – Tauvo, TR – Tankar.

ferences along with their working periods and special comments as to the compatibility of the data. In this chapter data from those six stations, which had the longest working periods are used (see Fig. II-88): Mierzeja Wiślana (54°21'N, 19°19'E), Hel (54°46'N, 18°28E), Bukowo/Kopań (54°21'N, 16°17'E/54°28'N, 16°25'E), Helgoland (54°00'N, 8°00'E), Ottenby (56°12'N, 16°24'E), Rybatchy (55°09'N, 20°52'E). At Mierzeja Wiślana, Hel and Bukowo the birds were mist-netted, at Ottenby they were caught by mist-netting and trapping in a heligoland type trap, while Helgoland and Rybatchy data were based on heligoland traps (they were of quite different size and construction). Four bird stations (Mierzeja Wiślana, Hel, Bukowo and Rybatchy) are situated within linearly formed coastal woodland habitats, where migrants can move during daytime. Two bird stations (Helgoland and Ottenby) are on the islands. These variations in the catching methods and the station location could have an important impact on the evaluation of the trapping efficiencies at the stations.

Two statistics are used to describe population variations: long-term trends expressed as a linear regression coefficient, R and annual variation in the number of the birds caught at the station expressed as a coefficient of fluctuation, CF (see above in the chapter).

All numbers describing population levels (abscissa at figures) and *R* values are percents of the average number of individuals of the species caught per year at the particular station in years 1974-1983. This period was selected, as it was a common period of work of most of the stations analysed in the source papers. Calculations in those papers included in the first step, recalculation of bird numbers into percents of the standard average number level (1974-1983) and then calculations of *R* and *CF* values (cf. Table II-19 – station data). As the present text is devoted to the methodical considerations, next steps of calculations performed here are explained below.

Let us assume that the true broad front of migration should result in more or less even distribution of the species during migration. When such an assumption is valid for all studied species then the stations' share of the species should be the same at different stations. The value should be equal to the total species share within a mass of migrants as estimated from all count data pooled together. However, data collected show that it is not a case (Table II-18). Species included are differentiated very much as to their share in the totals for the stations. The most pronounced differences are for the Wood Warbler (at Helgoland 0.1% while at Rybatchy 4.9%) and the Red-backed Shrike (Helgoland – 0.2% and Ottenby – 13.4%). This suggests that some bird stations are located in stopover sites more important to the species than the others. Such areas are distributed according to the migration pattern of the particular species, which is frequently poorly known. Thus different stations have various „values" for a description of both migration pattern and population trends. The stations with the species shares higher than average are more important for the species than those with shares lower than the total average. Values of the station indices (Table II-19) are calculated as the ratio of the station percent in relation to average for all stations together. For example: Willow Warbler has 55.6% share at Mierzeja Wislana and total value for this species is 46.8 % (Table II-18), so (55.6/46.8)*100 = 119 (Table II-19). Figure II-88 shows exemplary station value patterns for the Blackcap based on numbers of individuals caught and value indices calculated for 15 stations as it was prepared for more detailed study. The most important (in discussed meaning) stations are not necessarily those with the highest numbers of individuals caught (note e. g. high value of Bukowo station). Within the group of the studied species the most differentiated are station indices for the Red-backed Shrike, the most stable that for the Willow Warbler. For the Red-backed Shrike, Whitethroat and Lesser Whitethroat the most important station is Ottenby, for the Blackcap and Garden Warbler – Helgoland, for the Willow Warbler and Wood Warbler – Rybatchy, while for the Chiffchaff – Polish stations Bukowo, Mierzeja Wiślana and Hel.

Comparison of average levels of station value indices at some stations shows that only Ottenby has clearly higher average value index for the studied species than other stations, which are rather even as to this respect. Ottenby has a very high value for studying the Red-backed Shrike, Lesser Whitethroat, Whitethroat and Wood Warbler, while the migration of the Blackcap and Garden Warbler is insignificant there. Mierzeja Wiślana and Hel are most important for the Chiffchaff, Bukowo for the Chiffchaff and Blackcap, Helgoland for the Blackcap and Garden Warbler and Rybatchy for the Wood and Willow Warblers.

Table II-18. Share of the species at the station in relation to the total number of individuals of the studied group (as a percentage).

	Mierzeja Wiślana	Hel	Bukowo	Helgoland	Ottenby	Rybatchy	Total
L. collurio	1.7	1.1	1.3	0.2	13.4	0.3	4.4
S. atricapilla	17.2	16.5	24.8	31.8	4.1	2.9	15.5
S. borin	11.8	13.4	14.3	39.1	7.7	5.7	17.3
S. curruca	3.8	5.8	5.1	0.3	11.6	6.4	5.7
S. communis	1.9	0.6	1.7	4.2	8.1	1.9	4.2
P. trochilus	55.6	56.1	43.6	21.6	49.3	74.2	46.8
P. collybita	7.1	6.2	8.7	2.6	2.8	3.8	4.1
P. sibilatrix	1.1	0.5	0.6	0.1	3.1	4.9	2.1

Table II-19. Relative value indices of the station for the species within the studied group. Percent values of the species station share (station data from Table II-17) in relation to the „Total".

	Mierzeja Wiślana	Hel	Bukowo	Helgoland	Ottenby	Rybatchy	Variation (*SD*)
L. collurio	39	25	30	5	305	7	106
S. atricapilla	111	106	160	205	26	19	67
S. borin	68	77	83	226	45	33	64
S. curruca	67	102	88	5	204	112	59
S. communis	45	14	40	100	193	45	60
P. trochilus	119	120	93	46	105	159	34
P. collybita	173	151	212	63	68	93	56
P. sibilatrix	50	25	30	5	155	245	86
Average	84	78	92	82	138	89	
SD	43	48	61	83	89	76	

The problem of station evaluation becomes important when one would like to combine results from many stations to get more general indices (e. g. regression coefficients and fluctuation coefficients), which describe population trends across wide breeding areas.

There are four possible procedures, which have different pros and contras. This is discussed below, based on an example of the Table II-20, where station data are fictitious, but a sector right and down of the table contains real values of T_{sum}, T_{avg}, T_n and T_{st} for the Red-backed Shrike.

1. Un-weighed average – every station is assumed to have the same significance for the population studied (broad front migration assumed). This procedure is the simplest, but stations where the number of individuals is very low have relatively high influence on the pooled value of the parameter. Two pooling procedures are possible:

1.1. T_{sum} – summing up the stations data and then calculating total values of the population parameters (regression coefficient and CF value).

Calculation procedure:

A. PC_{sum} for every year is an average of PC_a, PC_b, etc., e.g. (for first row): $(227 + 105) / 2 = 166$

Note that this procedure is the simplest, but the stations where the number of individuals is very low have relatively high influence on the pooled value of the parameter: here behind PC_a value is 360 individuals against only 15 for PC_b value, which are averaged into PC_{sum} value;

B. T_{sum} values for R and CF are calculated as for one station (cf. p. 243).

1.2. T_{avg} – averaging parameter values calculated for single station into pooled population value.

T_{avg} values are the averages for R and CF values for the stations (b_a, b_b ..., CF_a, CF_b ...); e. g.:

$R_{arg} = (b_a + b_b) / 2; CF_{arg} = (CF_a + CF_b) / 2$

2. Weighed average – the stations are assumed to be of unequal value for describing total population parameters. Two procedures were used:

2.1. T_n – weighing for the number of individuals of every species caught at the station (N-weighing).

Calculation procedure:

A. PC_n for every year:

$PC_n = ((PC_a * M_a) + (PC_b * M_b) + ...)) / M_a + M_b + ...$

e. g.:

$PCN_1 = ((227*158.4)+(105*14.2)) / (158.4+14.2) = 217$

B. T_n values are calculated as for one station.

This can lead to overemphasising of the stations with the highest numbers of birds caught because of a very high efficiency of the catching methods (here 217 is much closer to 227 than to 105).

2.2. T_{st} – weighing for the station value indices („St-weighing") should theoretically be the best method as relating species data to the total catching results. Calculation procedure is much as in „N-weighing" but instead of M_x there are used ST_x values (station validation indices). However, one must be aware that when the particular station is extremely valuable for one or two species, the station validation for others can be negatively biased.

Tables II-21 and II-22 contain results obtained by means of application of different pooling procedures for the same raw station data. The general pattern of results for both population parameters clearly shows that different procedures lead to pooled values, which are highly variable. Weighed and un-weighed values of regression coefficient are

especially different. In some papers (Busse 1995b, Busse and Marova 1993, Busse *et al.* 1995), where un-weighed calculation procedure was used pooled regression coefficients were clearly negative (see Table II-21 – ,,*sum*" procedure) for all species and thus the conclusion was rather pessimistic as to welfare of the studied species. This is especially clear in the Whitethroat and Red-backed Shrike. Application of the weighing procedures leads to much more optimistic general conclusions. Weighed procedures applied to the Wood Warbler even give a statistically significant positive trend instead of a significant negative trend. Figure II-89 shows how big can be the influence of the pooling procedure on the presentation of total population dynamics. For the Lesser Whitethroat the influence is relatively low that is visible both within the course of population dynamics curve and regression coefficient values. The Red-backed Shrike and Wood Warbler are examples of high dependence of dynamics curve and regression coefficient on calculation procedures.

Table II-20. Example of the calculation procedures (explanation in the text p. 250)

Years	Station a		Station b		Total (%)			
	N_a	PC_a (%)	N_b	PC_b (%)	PC_{sum}	PC_{avg}	PC_n	PC_{st}
1	360	227	15	105	166		217	205
2	20	13	5	35	24		12	17
3	220	139	24	169	154		127	144
4	92	58	11	77	68		63	61
...								
30	100	63	36	253	158		58	98
$SumN$	4752		426					
M_x	158.4		14.2					
ST_x	180		40					
R_x		-2.46		-8.17	-6.91	-5.31	-1.23	-2.85
CF_x		27.1		120.1	7.95	73.55	2.36	3.48
	a	b	T_{sum}	T_{avg}	T_n	T_{st}		

N_a, N_b – number of individuals; $SumN$ – total number;
M_x – station ,,x" yearly average; ST_x – station ,,x" validation index;
R_x – correlation coefficient for the station (or total in the right sector of the table)
CF_x – fluctuation coefficient for the station or total;
T_{sum} – calculation procedure 1.1. in the text,
T_{avg} – calculation procedure 1.2,
T_n – calculation procedure 2.1,
T_{st} – calculation procedure 2.2.

Pooled regression coefficients obtained by means of weighing procedures seem to be independent of the numbers of individuals caught per species at all stations (Table II-20). Results of un-weighed procedures seem to be, to some extent (but $p > 0.05$), positively correlated with numbers of birds caught. Does it mean that most common birds are more resistant against changes in environment?

Table II-21. Comparison of weighed and un-weighted regression coefficients for the species calculated according to different procedures: Un-weighed – T_{sum} (procedure 1.1 in the text), T_{avg} (procedure 1.2) Weighed – T_n (procedure 2.1), T_{st} (procedure 2.2).

	N per year	Un-weighed		Weighed	
		T_{sum}	T_{avg}	T_n	T_{st}
L. collurio	232.3	-6.91**	-5.31	-1.23**	-2.85**
S. atricapilla	823.7	-1.97**	-1.72	-0.19~	-2.38**
S. borin	923.1	-2.94**	-2.36	-1.46**	-2.52**
S. curruca	305.1	-4.45**	-3.89	-2.79**	-3.96**
S. communis	225.8	-8.76**	-9.33	-2.96**	-4.81**
P. trochilus	2490.5	-1.91**	-1.92	-0.78**	-2.57**
P. collybita	218.9	-2.45**	-2.63	-1.83**	-3.38**
P. sibilatrix	105.5	-3.21**	-3.34	+3.71**	+0.48~
Average		-4.07	-3.81	-0.94	-2.75
r with number		0.48~	0.46~	-0.02~	0.03~

Statistical significance: ** – $p < 0.01$, * – $p < 0.05$, ~ – n.s.

Table II-22. Comparison of weighed and un-weighed *CF* coefficients for the species calculated according to different procedures: Un-weighed – T_{sum} (procedure 1.1 in the text), T_{avg} (procedure 1.2) Weighed – T_n (procedure 2.1), T_{st} (procedure 2.2)

	N per year	Un-weighed		Weighed	
		T_{sum}	T_{avg}	T_n	T_{st}
L. collurio	232.3	7.95	73.55	2.36	3.48
S. atricapilla	823.7	2.55	9.11	3.36	2.35
S. borin	923.1	5.28	15.71	3.48	3.69
S. curruca	305.1	4.03	20.46	6.01	4.66
S. communis	225.8	13.95	67.78	9.91	7.05
P. trochilus	2490.5	4.91	16.37	4.11	4.81
P. collybita	218.9	5.09	17.32	5.46	6.38
P. sibilatrix	105.5	9.58	60.23	9.63	8.66
Average		6.69	35.07	5.54	5.14
r with number		-0.39~	-0.50~	-0.40~	-0.33~

Statistical significance: ** – $p < 0.01$, * – $p < 0.05$, ~ – n.s.

The influence of the pooling procedure on the results of estimating annual fluctuations within the general population is less clear. The only one exception is un-weighed averaging procedure (Table II-21). Despite calculation of *CF* values is very similar to estimation of the variance (cf. formula at p. 243), which is an additive measure, averaging station *CF* values (to T_{avg}) has a very different effect than another un-weighed procedure (T_{sum}). As it gives pooled *CF* values several times higher than other procedures it cannot be accepted. Second, un-weighed procedure gives a little higher average *CF* value than weighed procedures, but within different species there are various value patterns. All
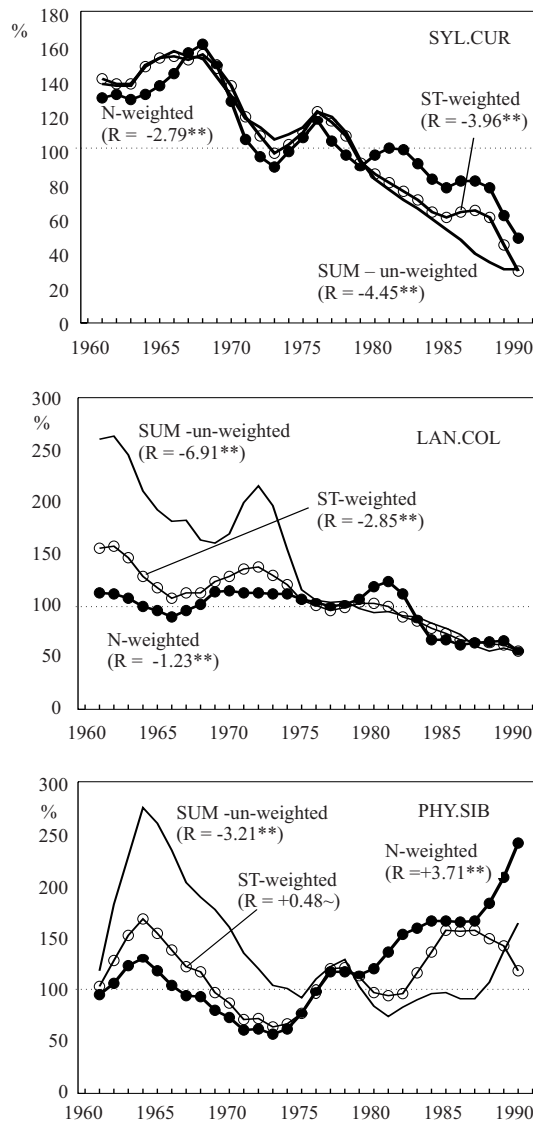
Fig. II-89. Examples of population dynamics patterns described by means of different calculation procedures. Un-weighed: SUM-procedure 1.1 in the text; weighed: N-procedure 2.1, ST-procedure 2.2. SYL.CUR – Lesser Whitethroat (*S. curruca*), LAN.COL – Red-backed Shrike (*L. collurio*), PHY.SIB – Wood Warbler (*Ph. sibilatrix*).

pooled *CF* values, independently from the procedure used, seem to be negatively correlated with the numbers of individuals caught per species, but the correlation coefficients do not reach significance level of $p = 0.05$. CF coefficient values seem to be more species than number dependent. Svensson (1978) presented similar finding on variation within migration counts, but very general patterns for passerines and raptors were studied. It seems that the problem needs further detailed studies on many species.

CONCLUSIONS

1. Station ringing data can be used for monitoring purposes if:
1.1. period of work is sufficiently long within a season, standard and continuous,
1.2. a number and quality of catching devices are standardised,
1.3. the staff is qualified and numerous enough.
2. Some incompleteness in data and standardisation of work can be eliminated using extrapolation method without large biases.
3. Migration count monitoring must be a really long-time project if more general conclusions are planned.
4. The method of pooling monitoring data collected at several stations influences the results greatly.
5. For regression coefficients weighed averages give always more positive (or less negative) values, which can change conclusions derived from the monitoring data. It seems that the results from the stations where the species is more numerous are more representative of the overall population trend than those from other the stations.
6. The influence of the pooling procedure on annual fluctuation measure, *CF* is less clear and the *CF* seems to be more species dependent.
7. Further studies on effects of pooling procedures are needed.

APPENDIX II

NUMBERS OF PENTADS IN FULL YEAR SYSTEM

Pentad	Days	Pentad	Days	Pentad	Days
1	1-5 Jan.	26	6-10 May	51	8-12 Sept.
2	6-10 Jan.	27	11-15 May	52	13-17 Sept.
3	11-15 Jan.	28	16-20 May	53	18-22 Sept.
4	16-20 Jan.	29	21-25 May	54	23-27 Sept.
5	21-25 Jan.	30	26-30 May	55	28 Sept. - 2 Oct.
6	26-30 Jan.	31	31 May - 4 Jun.	56	3-7 Oct.
7	31 Jan. - 4 Feb.	32	5-9 Jun.	57	8-12 Oct.
8	5-9 Feb.	33	10-14 Jun.	58	13-17 Oct.
9	10-14 Feb.	34	15-19 Jun.	59	18-22 Oct.
10	15-19 Feb.	35	20-24 Jun.	60	23-27 Oct.
11	20-24 Feb.	36	25-29 Jun.	61	28 Oct. - 1 Nov.
12	25 Feb. - 1 Mar. (!)	37	30 Jun. - 4 Jul.	62	2-6 Nov.
13	2-6 Mar.	38	5-9 Jul.	63	7-11 Nov.
14	7-11 Mar.	39	10-14 Jul.	64	12-16 Nov.
15	12-16 Mar.	40	15-19 Jul.	65	17-21 Nov.
16	17-21 Mar.	41	20-24 Jul.	66	22-26 Nov.
17	22-26 Mar.	42	25-29 Jul.	67	27 Nov. - 1 Dec.
18	27-31 Mar.	43	30 Jul. - 3 Aug.	68	2-6 Dec.
19	1-5 Apr.	44	4-8 Aug.	69	7-11 Dec.
20	6-10 Apr.	45	9-13 Aug.	70	12-16 Dec.
21	11-15 Apr.	46	14-18 Aug.	71	17-21 Dec.
22	16-20 Apr.	47	19-23 Aug.	72	22-26 Dec.
23	21-25 Apr.	48	24-28 Aug.	73	27-31 Dec.
24	26-30 Apr.	49	29 Aug. - 2 Sept.		
25	1-5 May	50	3-7 Sept.		

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