TO ANALYSE RINGING RECOVERIES IN A NATIONAL ATLAS – EXAMPLES FROM THE SWEDISH PROJECT

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Preparations to produce recovery atlases showing results from extensive bird ringing activities are firmly under way in many ringing schemes. In Sweden such a project was initiated long ago and the first volume out of three will now soon be published. To standardise the presentation of results for different species has been a difficult problem to solve. The number of recoveries varies substantially between species as well as where and how they have been ringed and recovered. When selecting recoveries for subsequent analysis, it is therefore not only important to take the species' biology into account but also to consider the characteristics of ringing and recovery data. It is also important to have in mind that spatial variation in reporting rates and hunting pressures affects the geographical distribution of recoveries. Relatively few recoveries can sometimes give a good hint of a species migratory pattern. Even when many recoveries are available, sample size may become very small when the sample has to be broken down into different age categories or seasons. Another problem can be that recoveries have accumulated during almost a century. Behavioural changes may have occurred meanwhile, such as in the Canada Goose *Branta canadensis* introduced in Sweden, which seems to migrate further and further south in winter in recent years. An atlas is not just a way of presenting ringing results but may also be used in future planning of bird ringing activities.

Key words: bird ringing - Sweden - *Branta canadensis* - *Accipiter nisus* - *Anas crecca* - *Gavia stellata* - *Pandion haliaetus* - *Pernis apivorus* - *Ardea cinerea*

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INTRODUCTION

Many ringing schemes in Europe have more or less continuously carried out bird ringing during a large part of the last century. Huge numbers of birds have been ringed and many have also been reported as recovered. Thus, the archives of data concerning recovered birds held at many ringing schemes have grown very fast and currently include an extensive amount of information. During the last decades computer routines have facilitated the handling of large data sets and EURING produced in the 1960s a common code system for recovery data, which has been widely used. Much effort has been devoted at many ringing schemes during the past 20 years not only to computerise new recoveries but also to include old ones.

Analyses of recoveries from ringed birds have revealed much of the knowledge of migration routes and wintering areas of different species and populations. One major contribution to this knowledge was the atlas work started by Zink in the early 1970s treating the migratory patterns of European passerines using recoveries from a large geographical area (Zink 1973, 1975, 1981, 1985 and Zink & Bairlein 1995). It has been clear for some time that the geographical distribution of recoveries can be biased in several ways (Perdeck 1977). From the ringing schemes' point of view, the interest in producing own recovery atlases has

become more and more widespread. The Dutch ringing scheme produced a 'Migration Atlas' based on ringing recoveries from the Netherlands already 16 years ago (Speek & Speek 1984). The Belgian ringing scheme has also published a first volume (Gaviidae to Anatidae) within a national recovery atlas project (Roggeman *et al.* 1995). At the Swedish Museum of Natural History in Stockholm a national recovery atlas project was initiated in the late 1980s in collaboration with the Swedish Ornithological Society and the first volume out of three will soon be finished. The work with the first volume has been carried out together with Jan Pettersson. The aim of this paper is to provide a more detailed account of the atlas work, which might be helpful for other similar projects.

MATERIAL AND METHODS

The ringing activity in Sweden was started by the Natural History Museum in Gothenburg 1911 and two years later by the Swedish Museum of Natural History in Stockholm (Stolt 1989). Several schemes were running at the beginning of the century but from 1960 all ringing activity in Sweden has been administrated by the Museum in Stockholm, where all ringing and recovery data now are stored. Up to and including 1998 more than 8.7 million birds have been ringed in Sweden and almost 125 000 birds of 259 species have been recovered (Table 1). The number of recovered birds does not include retraps made by the ringer at the ringing site. Largest samples of recoveries are found in species with large body size, with high recovery rates, like gulls, swans, ducks and waders. The two most ringed species, the Willow Warbler *Phylloscopus trochilus* and the Pied Flycatcher *Ficedula hypoleuca*, are found further down in the list (Table 1). Since it is reasonable to include all recovered species in the atlas it is important to know how the number of recoveries differs between species. About half of the 259 species has less than 100 recoveries each and in 35 species the number of recoveries exceeds 1 000 (Table 2). A very important condition when starting an atlas project is to have the recoveries in computerised form. This was not the case in Swe-

Table 1. Species with the largest number of recoveries from Swedish bird ringing 1911-1998. The two most ringed species as well as the total for all species are also included. The numbers of recovered birds does not include retraps made by the ringer at the ringing site.

Species	Number of recoveries	Number ringed
1. Black-headed Gull *Larus ridibundus*	9496	162 036
2. Mute Swan *Cygnus olor*	6347	13 426
3. Mallard *Anas platyrhynchos*	5131	43 898
4. Common Gull *Larus canus*	4427	80 996
5. Herring Gull *Larus argentatus*	4330	36 402
6. Dunlin *Calidris alpina*	3876	181 771
7. Great Tit *Parus major*	3612	473 271
8. Goshawk *Accipiter gentilis*	3107	18 218
9. Starling *Sturnus vulgaris*	2597	188 320
10. Tawny Owl *Strix aluco*	2594	30 442
...		
16. Pied Flycatcher *Ficedula hypoleuca*	2101	619 421
...		
31. Willow Warbler *Phylloscopus trochilus*	1085	811 833
Total 259 species	124 499	8 776 369

Table 2. Number of species with different number of recoveries available from Swedish bird ringing 1911-1998.

Number of recoveries	Number of species
1-9	56
10-99	76
100-499	71
500-999	21
1000-4999	32
>5000	3

den and to begin with we had to input and check many thousands of old recoveries.

When preparing an atlas there are a lot of common details that have to be considered. One such question is how the species will be analysed and presented. In the Swedish project we have decided to keep the presentations relatively popular and focus on giving an overview of the recoveries available. The main text is written in Swedish but all species will have English summaries and figure legends in English as well as in Swedish. Black and white drawings produced by the artist Peter Larsson are included as illustrations for some of the species while the maps are printed in colour. We have tried to present the species in a way that make comparisons between species easy but species with larger samples are given more space, up to a maximum of six pages. The general presentation follows a standard template, starting with ringing sites of recovered birds, followed by recoveries from autumn, winter, spring and the breeding season. Some of the presentation forms are, however, not included in species with few recoveries. In species with large samples on the other hand, we have sometimes included more detailed presentations of specific analyses.

We have decided to use maps drawn in Mercator projection. In this projection, a straight line follows a constant compass bearing while the earth's surface is distorted and areas in the north are enlarged compared to areas in the south. The mapping program used is called TISS and was developed by a programmer at the museum. It has successively been modified to handle recovery data and to produce all the presentations we decided to include. To facilitate the species analyses we also have a special computer program extracting all recoveries of a given species from the large recovery database in a fixed format including only the details needed. This format include some details not stored in the main database, which are calculated by the program, such as time elapsed between ringing and recovery, speed of movement and year of life (based on age at ringing and elapsed time) as well as season (from time periods defined for each species). This program also generates some basic statistics from the selected recoveries, which can then be included directly in the species presentation.

Fixed symbols are used in the maps to indicate the four different seasons and if recoveries with uncertain finding dates are included they are shown by a fifth symbol. We have used information published in the Swedish checklist (SOF 1990) to define seasons for each species. In most maps only the finding places are shown by symbols, but in some maps ringing and finding places are connected by lines. To produce a picture of where birds are found on average we have sometimes included calculations of mean positions, shown in a separate map. The mean positions have been calculated according to Perdeck (1977) and take the roundness of the globe into account. We have not included any confidence limits of the mean positions, but we have at some occasions included statistical tests of mean positions by using a randomisation test proposed by Lokki & Saurola (1985). There are several possibilities to test whether two groups of bivariate samples deviate from each other (in a way that not should be expected by chance). Lokki & Saurola (1985) have discussed this problem and they suggested that a randomisation test could be applied rather than using the parametric Hotelling's two-sample T^2 and the non-parametric Mardia two-sample test. One advantage is that a randomisation test does not imply that the data should have any specific distribution. The first volume is based on recoveries from the period 1911-1995 and includes a total of 62 species.

SOME EXAMPLES FROM THE PRESENTATIONS AND DISCUSSION

Most of the species presentations start with a map showing where the recovered birds have been ringed in Sweden (Fig. 1). In order to show the representativeness of ringed birds it would have been preferable to plot the locations of all ringed birds, but in Sweden this information is not available in computerised form. It is, however, reasonable to believe that the ringing sites of birds recovered give a picture of where ringing activity has been carried out. A common pattern is that most of the birds are ringed in the southern part. In the Sparrowhawk *Accipiter nisus*, for example, about 90% of the recoveries are from birds ringed in the south, with concentrations at the two large bird observatories Ottenby and Falsterbo. The distance from south to north in Sweden is about 1500 km, and the migratory habit in birds from the northern part can very well differ from the habit of birds from the southern part. It is therefore important to be aware of how the ringing sites of the recovered birds are distributed. In the Sparrowhawk about 50% of the recoveries are from birds ringed as nestlings while a large part of the rest comprises birds ringed on migration. Recoveries from birds ringed on migration might be treated separately in order to find out the area from which migrants come. This can be important since one of the aims of an atlas can be to find out the migratory pattern of populations breeding within the area of focus. If the sample size of birds ringed at their birthplaces and found during the first autumn migration is large enough we show the circular statistics of directions following Batschelet (1981), and mean directions as well as concentrations (r) are given (Fig 1). In some cases information is shown separately for birds from the southern and northern part, respectively. Birds from the northern part are often more concentrated in their migratory direction than birds from the southern part (e.g. Sparrowhawk) which might be because they often migrate a longer distance.

A special box contains recovery statistics, where the reader can find some standard information for each species, including number ringed, number recovered, proportion recovered, oldest individuals, longest movement and, if data are available, autumn migration speed, as can be seen in the Teal *Anas crecca* (Table 3). We have decided to calculate the recovery proportion on number of individual birds recovered, which might differ from the total number of recoveries if birds are reported more than once. The autumn migration speed has been calculated as the arithmetic mean from recoveries of birds ringed and recovered within the same autumn. Before doing the calculations we have also applied the criteria listed by Hildén & Saurola (1982) to select appropriate subsets of recoveries by excluding recoveries with inaccuracies, short movements and those moving

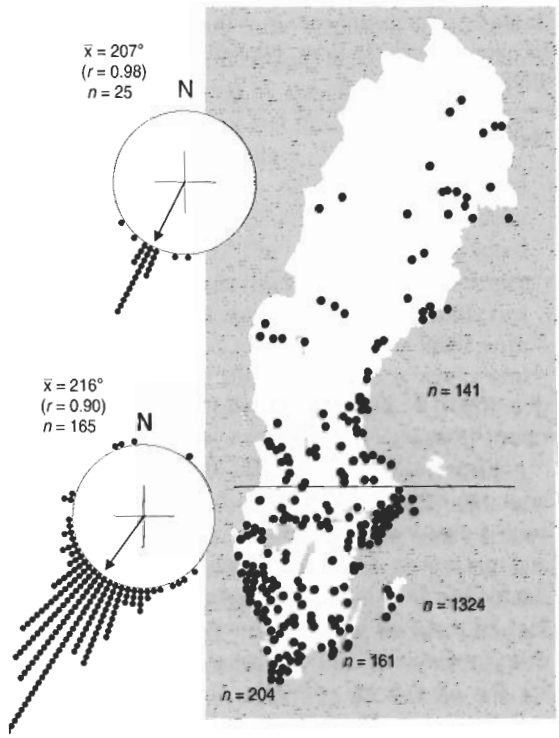

Fig. 1. Ringing sites for recovered Sparrowhawks *Accipiter nisus* and migratory directions during first autumn (August-November) of birds ringed as nestlings in different parts of Sweden and found at a distance of at least 100 km.

Table 3. Recovery statistics from the ringing of Teals *Anas crecca* in Sweden 1911-1995.

Number ringed	4344
Number of birds recovered	773
Recovery proportion	17.8%
Total number of recoveries	774
Recoveries from juveniles ringed at their place of birth	51
Found abroad	731 (94%)
Oldest bird	9 yr 51 d
Second oldest	8 yr 321 d
Longest distance	3672 km
Most southerly recovery	Morocco 33°16'N
Autumn migration speed	44.9 km d^{-1} (n = 67)
Maximum speeds	226 km d^{-1} (679 km)
	208 km d^{-1} (1671 km)

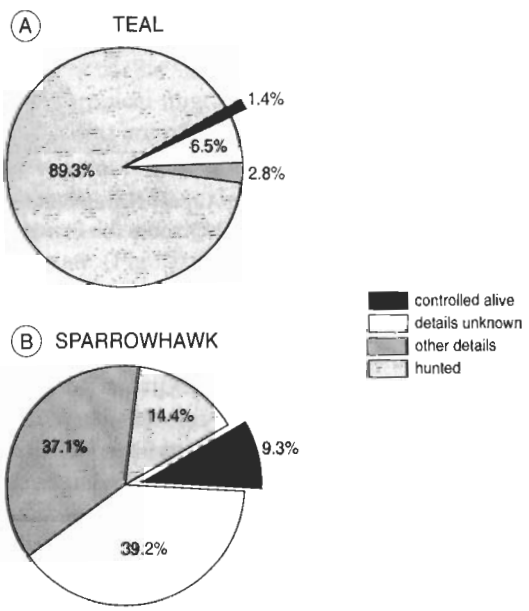

Fig. 2. Swedish recoveries of A) Teals *Anas crecca* (n = 774) and B) Sparrowhawks *Accipiter nisus* (n = 1465) by finding circumstances.

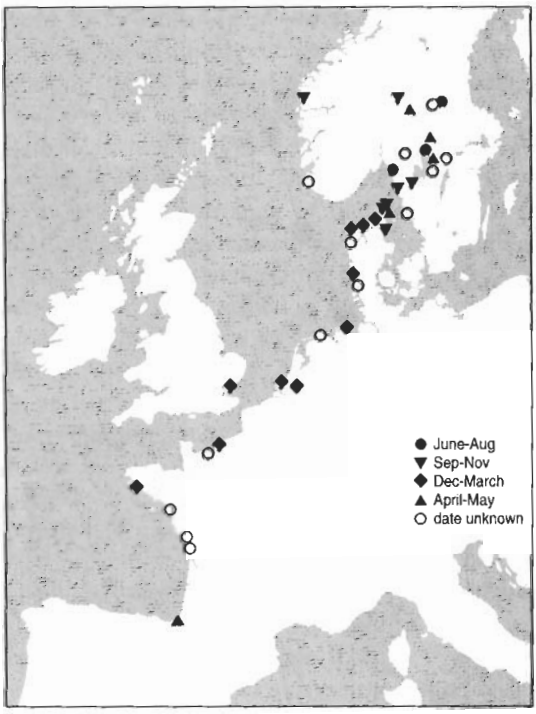

Fig. 3. Recoveries of Red-throated Divers *Gavia stellata* ringed in Sweden (n = 40).

north of an W-E axis. The overall speed integrates both periods of flying and periods at stopover sites. To show how ringed birds of a species have been recovered we have used the code system for finding circumstances introduced by EURING. We have separated all recoveries into four main groups of circumstances in a circular diagram, making it easy for the reader to compare between species (Fig. 2). The four groups are 'hunted', 'controlled alive' (most often by another ringer), other known details ('other details') and 'details unknown'. Included in the group 'details unknown' are birds found dead without any indication of cause of death as well as those where no details at all are available. It is important to bear in mind that these four groups of finding circumstances do not reflect the causes of death, since a bird hunted or collided with human structures is more likely to be recovered than a bird dying somewhere in the wild.

In species with a small number of recoveries a

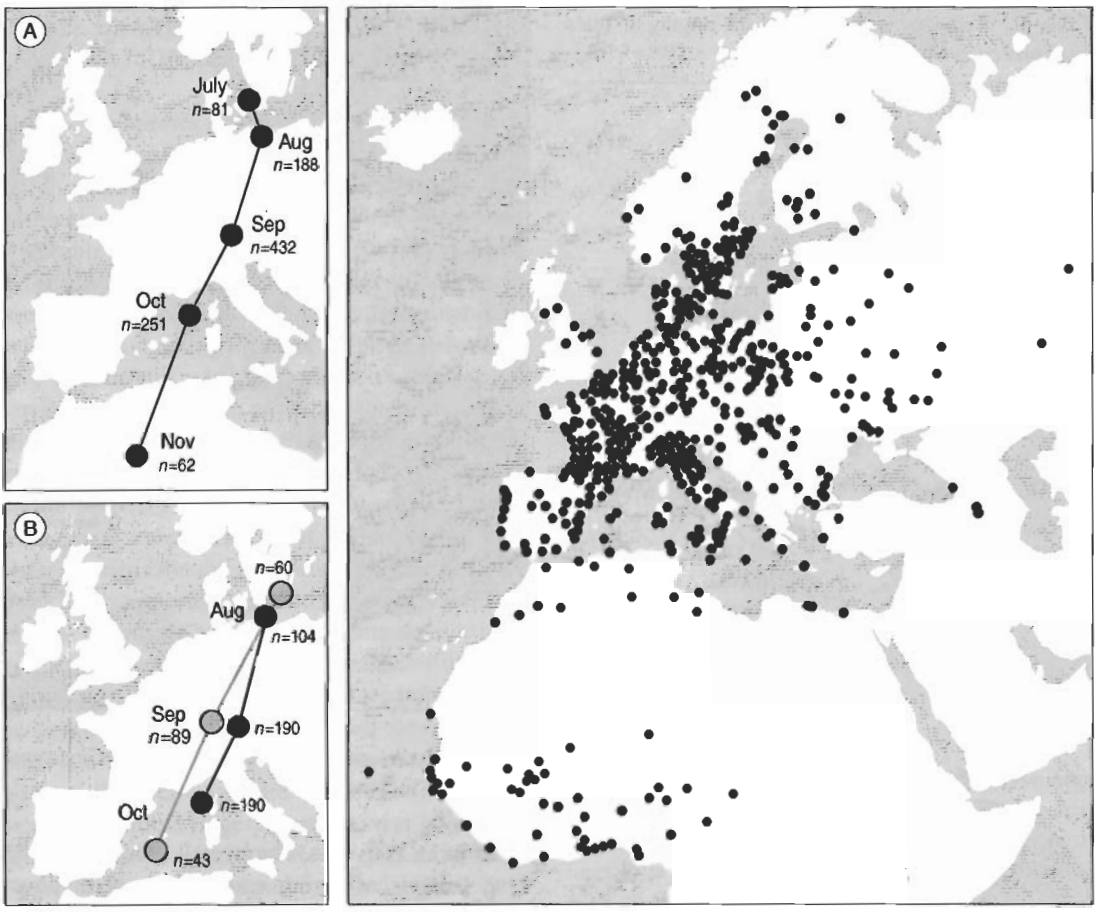

Fig. 4. Recoveries of Ospreys *Pandion haliaetus* ringed in Sweden and recovered during August-November (n = 933), A) monthly mean positions for July-Nov and B) monthly mean positions for August-October for first-year (black) and adult birds (grey).

single page is generally used and all recoveries are included in one map, with symbols to differentiate classes. In some cases even a small sample can give a clear hint of the migratory pattern. In the Red-throated Diver *Gavia stellata* we can see that the European coast is followed south in winter (Fig. 3). When larger samples are available more detailed presentations are included for each season. In the Osprey *Pandion haliaetus*, which is a species with a large sample of recoveries, several maps are included to show the autumn migration (Fig. 4). The migration route passes both the Mediterranean Sea and the Sahara on a broad-front to the main wintering sites for North European Ospreys in tropical West Africa (Österlöf 1977; Saurola 1994). The monthly mean positions show the average progress of the movement south. In a separate map mean positions of first-year birds are compared with those of adult birds, indicating that adult Ospreys on average move south faster than first-year birds. Unknown spatial and temporal variation in reporting rate can make comparisons between species difficult, but comparisons of subgroups of a species having similar reporting pattern can be more valid and also show interesting biological differences.

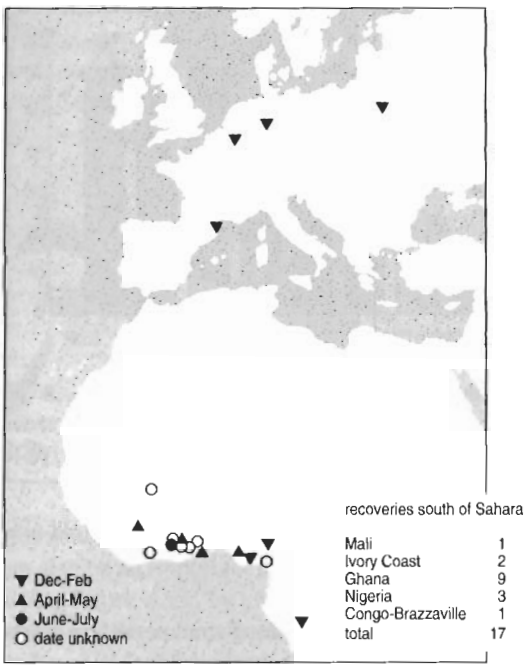

Fig. 5. Honey Buzzards *Pernis apivorus* ringed in Sweden recovered south of Sahara in Africa and outside Africa during the period December-March (n = 21).

In tropical migrants recoveries from the wintering area are often few or in some species completely lacking. For the Honey Buzzard *Pernis apivorus* we have 17 Swedish recoveries from tropical Africa, eight of them with uncertain finding date (Fig. 5). All of them are shown in the winter map with symbols to differentiate finding dates and a small table showing their distribution in the countries of Africa. Many of the Swedish-ringed Honey Buzzards have been found in Ghana. Even in species known to be tropical migrants it often happens that some birds are reported as accurately found during winter in Europe. Some of them may be unhealthy first-year birds that have not been able to migrate successfully. Among the Swedish Honey Buzzards found in Europe during winter, two are first-year birds. It is however, important to keep in mind that even if a few individuals stay in Europe the chance of receiving a report from these is much higher than from those wintering in Africa. Uncertainty of finding date can be a problem when using recoveries to analyse temporal patterns. The EURING code system makes it easy to select recoveries with accurate finding date and those with a smaller margin of uncertainty. The proportion of recoveries with an uncertainty of finding date larger than a month can sometimes be considerable, shown by some examples from Sweden; Sparrowhawk 8.9% (from a total n = 1465), Common Buzzard *Buteo buteo* 12.5% (n = 1862) and Grey Heron *Ardea cinerea* 13.6% (n = 2214). It is an important task for personnel at ringing schemes to keep this proportion as low as possible in new recoveries, for example by always asking for supplementary details if the first report fails to include any information on finding date.

Variation in the biology of different species should be considered when planning the presentations. For species where first breeding is delayed by several years, for example, it can be interesting to use the recoveries to analyse the behaviour of birds during these early years. Ospreys do not start breeding until about three years of age (Cramp & Simmons 1981) and it is known from Swedish recoveries that many Ospreys stay in West Africa during the summer as one year olds (Österlöf 1977). This phenomenon is shown in a series of maps of summer recoveries of birds of different ages (Fig. 6). A large proportion of one year old birds is reported in West Africa. When two years old, many go back to Europe but they are spread over a large area (one bird was even found in Iceland) and only 25% are found in Sweden. As three years old, when many start breeding, a large proportion (63%) is found in Sweden and the proportion is similar for older birds (72%). In all age classes there are, however, single birds reported from West Africa during the breeding season. For many species, the sample size can get very small when selections are made by age and/or season. This can be seen, for example, in the Osprey where the recoveries from the second summer (May-August) consist of only 29, while the total sample is close to 2000.

The recoveries included in an atlas presenta-

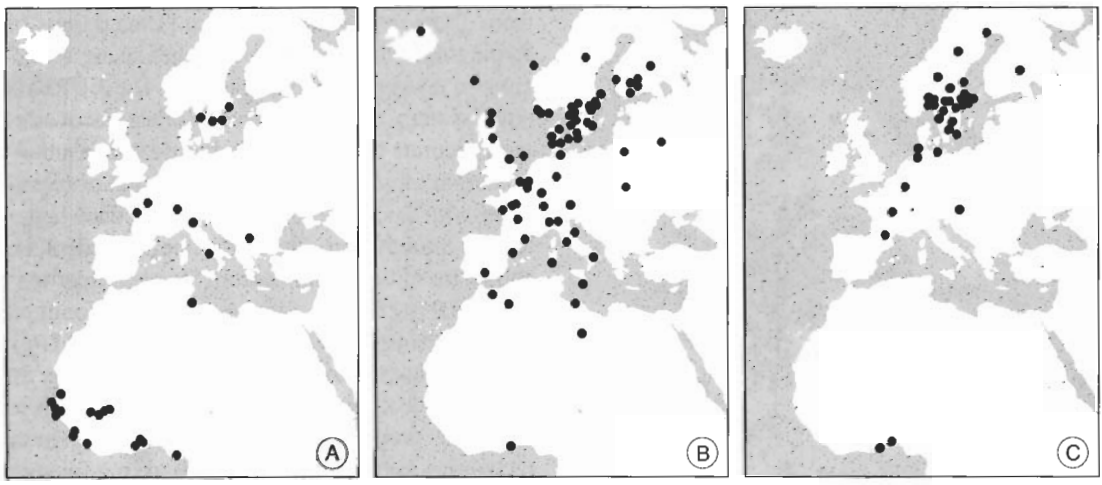

Fig. 6. Ospreys *Pandion haliaetus* of different ages recovered during the period May-July; A) one year old (n = 29), B) two years old (n = 76) and C) three years old (n = 40).

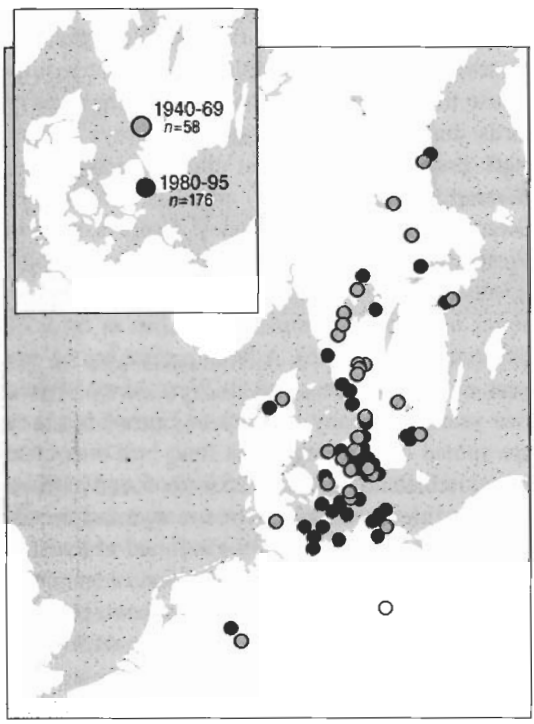

Fig. 7. Recoveries of Canada Geese *Branta canadensis* ringed in Sweden and found during December-February in 1940-69 (grey) and in 1980-95 (black). Randomisation test following Lokki & Saurola (1984) for two sample locations (10 000 runs, $P < 0.001$).

tion can be from a very long time period, in some cases from almost a century, and changes that affect the recoveries can have occurred, biological as well as cultural. In a number of species, recent behavioural changes altering the migratory habits have been found (cf. Sutherland 1998). The Canada Goose *Branta canadensis*, introduced in Sweden around 1930, was originally resident during the winter (Fabricius 1983). According to the distribution of winter recoveries from two different time periods, the Canada Goose has moved its wintering area more to the south in recent years (Fig. 7). The difference between the two means is, however, only about 150 km. Among other factors that may have changed during the period under consideration is the habit of hunting birds. For example, the proportion of recoveries of Herons ringed in Sweden and reported as hunted has decreased markedly during the last 50 years (Fig. 8). This is likely to affect the geographical distribution of the recoveries and it has been taken into consideration in our analyses.

The production of a recovery atlas can be an important way for a ringing scheme to summarise and present the results from its work. The presentations included here give an overview of the types of available data and might stimulate scien-

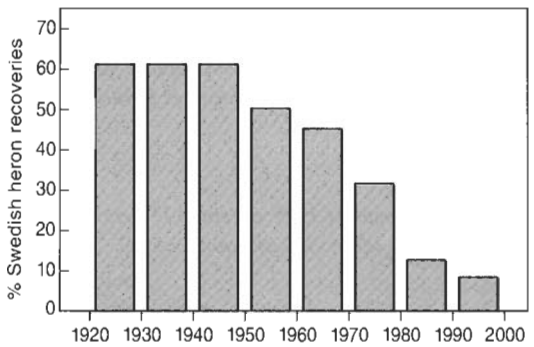

Fig. 8. Proportion of Swedish Heron *Ardea cinerea* recoveries reported as hunted during 10-years periods 1920-1995 (n = 2214, χ^2 = 206.0, df = 7, $P < 0.001$).

tific analyses to be carried out. A recovery atlas can also be an important tool for a ringing scheme to plan future work, by identifying gaps and hence improving the collection of long-term data, that is representative of both the species composition and the geographical distribution of the ringing activity within the area considered.

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SAMENVATTING

De laatste jaren wordt er veel tijd gestoken in de productie van atlassen waarin de resultaten van vele jaren ringwerk worden samengevat. Het is niet eenvoudig om een wijze van presentatie te vinden waarbij de meeste soorten goed tot hun recht kunnen komen. Van sommige soorten zijn enorme aantallen terugmeldingen bekend, terwijl het materiaal van andere soorten beperkt is. De ene soort is ook veel kwetsbaarder voor jacht dan andere en de ringterugmeldingen kunnen daardoor danig worden beïnvloed. In deze bijdrage worden enkele voorbeelden gepresenteerd uit een Zweedse driedelige atlas, waarvan het eerste deel binnenkort zal verschijnen. Een bezwaar van dergelijke

nationale atlassen is, dat veel van de geringde vogels ook in het land van productie geringd zijn (in dit geval in Zweden). Samengestelde kaarten waarop de trekwegen van een soort vanuit verschillende landen tegelijkertijd worden afgebeeld, zijn uiteraard van veel grotere betekenis en geven beter inzicht in de trekbewegingen van soorten. Helaas zijn dergelijke internationale gegevens in elk geval in Zweden niet in computerbestanden beschikbaar. Voorbeelden worden gegeven van de Canadese Gans *Branta canadensis*, Wintertaling *Anas crecca*, Roodkeelduiker *Gavia stellata*, Blauwe Reiger *Ardea cinerea*, Sperwer *Accipiter nisus*, Visarend *Pandion haliaetus* en Wespendief *Pernis apivorus* (CJC).

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