counting birds

Derek Pomeroy

AWF technical handbook series 6

AFRICAN WILDLIFE FOUNDATION

COUNTING BIRDS

A guide to assessing numbers, biomass and diversity of Afrotropical birds

THE AFRICAN WILDLIFE FOUNDATION

The African Wildlife Foundation (AWF), established in 1961, works towards building the capacity of sub-Saharan African countries to manage their natural resources. AWF's current programme reflects a modern conservation agenda and includes six themes from the traditional to innovative: training and education, support to protected areas, conservation science research, critical species and habitats, policy and planning, and community conservation.

From its start, AWF has maintained a fully-staffed technical and administrative office in Nairobi. Projects are managed directly out of the Nairobi office, resulting in efficient and responsive management and enhanced opportunities for close working partnerships with African nationals and institutions.

Community conservation
AWF has pioneered the concept of community conservation through its 'Protected Areas: Neighbours as Partners' programme in East Africa. Under this programme AWF is working with wildlife management authorities to set up community-based conservation projects and to involve local people in joint responsibilities for natural resources with shared benefits.

Support to protected areas
While working extensively with communities around protected areas, AWF continues to support key protected areas by working with management authorities in this traditional sphere of activity.

Critical habitats
Establishment of the 'Critical Habitats: Costs and Benefits' programme was a recognition that not all habitats that need support are covered under protected area systems as parks and reserves. As an ongoing process, AWF assesses areas - geographical, ecological, or operational - where catalytic action would help conservation of critical habitats, especially in high priority species.

Training and education
Since its establishment training and education for conservation professionals as well as the general public has been a primary objective for AWF. AWF has worked with management authorities to train professional managers, and educational institutions, governments ministries, and NGOs to educate children and adults about natural resource conservation. AWF helped found the College of African Wildlife Management at Mweka, Tanzania and continues its support to this institution. AWF also assists in the development and production of training and educational materials.

Conservation science research
Building on traditional support to student research projects on species and ecosystem ecology, AWF is working to provide support for research on policy and management relevant issues and to link research results with the policy making process.

Policy and planning
A great deal of AWF's work involves an interactive relationship with policy-makers of different African governments, and AWF supports several projects that provide professional expertise, analyses of options, and policy implementation.

For further information about the African Wildlife Foundation and its current projects please write to AWF at P.O. Box 48177, Nairobi, Kenya or 1717 Massachusetts Ave. NW. Washington DC 20036, USA.

The AWF series of handbooks on techniques in African wildlife ecology

1. *Counting animals*. M Norton-Griffiths.
2. *Measuring the distribution of animals in relation to the environment*. D Western and J J R Grimsdell.
3. *Studying predators*. B C R Bertram.
4. *Ecological monitoring*. J J R Grimsdell.
5. *Population dynamics of large mammals*. A R E Sinclair and J J R Grimsdell.
6. *Counting birds*. D Pomeroy.
7. *Studying elephants*. (In preparation).

Series design and technical production: Ursula Shimechero and Deborah Snelson.

CONTENTS

Page

PREFACE

This manual is intended to provide an introduction to the whys and wherefores of counting birds, suitable for advanced students but with enough detail to be of use to experienced practitioners too. For this reason, a wide variety of African examples is included.

Just a small amount of experience of counting birds is usually enough to make you realise how complex it can be. Even in North America, with its apparently unlimited resources, most studies using bird count data are said to be inadequate in methodology, or to have too few samples, or to fail in other ways (Verner, 1985). If that is really true, then efforts at counting birds in Africa, where resources are usually very limited, might seem rather a waste of time! However, everything has to begin somewhere and, whilst we should certainly aim at doing 'good science', we also need to gain knowledge. Making counts, even if some of them are less than perfect, is an important first step. And our admittedly inadequate data nevertheless do generate informative patterns - as we shall see.

Despite the methodological difficulties, bird counts can be a useful and cost-effective way of monitoring changes in the environment. Because birds are sensitive environmental indicators, counts conducted in a systematic and consistent way can provide an early-warning system, allowing the 'health' of an ecosystem to be assessed. This is essential if we are to ensure that development is truly sustainable.

Many people have helped in the production of this book. I am especially grateful to Leon Bennun, Christine Dranzoa, Adrian Lewis and Neville Skinner for their comments on the manuscript. Richard Ranft, Curator of the British Library of Wildlife Sounds, kindly provided most of the information in Appendix 5.

"A little learning is a dangerous thing" wrote the English poet Alexander Pope in 1711. The only remedy to this lamentable condition would seem to be a lot of learning! So now read on ....

Goliath Heron

1. INTRODUCTION

Birds are an important component of many ecosystems, even though their biomass is usually less than that of mammals; and there are far fewer species of birds than insects. However, birds are universal, penetrating the remotest deserts, oceans and mountains on earth. They are one of the most conspicuous groups in any fauna. But although they are everywhere, they are certainly more numerous in some places than in others. The causes of such variations are, in most cases, poorly understood. Before we can even attempt to understand them, however, we need some idea of the actual numbers involved.

Birds evolved during the Jurassic Period, some 150-200 million years ago. The first mammals appeared slightly earlier, and from a different group of reptiles than the birds. As they became more successful, the ancestors of modern birds spread to all parts of the world. We can tell where some groups of birds first evolved by looking at their present distributions. For example, the Shoebill* and the Secretary Bird are both confined to Africa, so it is reasonable to suppose that they evolved here. Similarly, penguins are restricted to the southern oceans and toucans to South America. People who study patterns of distribution - biogeographers - divide the world's land areas into about six realms, one of which, the Afrotropical Realm, includes all of Africa south of the Sahara (see Figure 1). Sometimes Madagascar and southern Arabia are included too. The Ostrich is largely confined to this realm, and so are birds from several other groups, such as mousebirds, guineafowls, turacos and wood-hoopoes. But birds are the most mobile of animals and most African species have relatives in the Palearctic and other realms.

African ornithology is growing fast and had recently acquired its first textbook devoted to the subject (Maclean 1990), a most useful source of general information, especially for southern Africa.

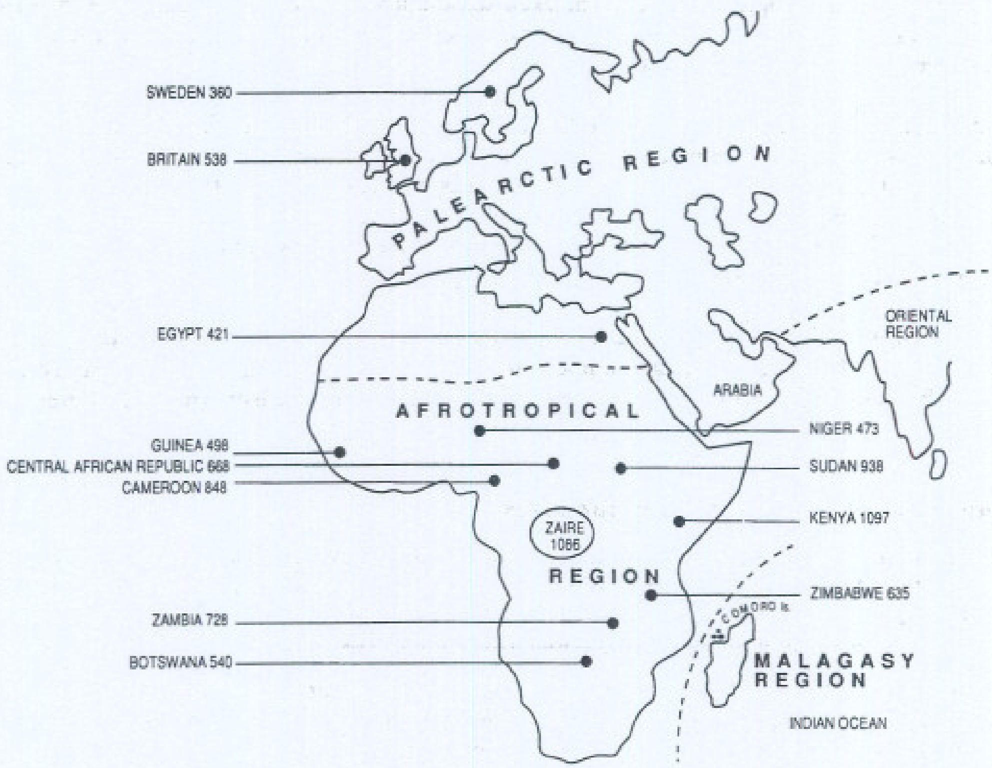


Figure 1. *The Afrotropical Region is separated from the Palearctic by arid areas and from other regions by oceans. The south-west of Arabia has a mixture of Afrotropical and Palearctic species, but the avifauna of Madagascar is quite distinct and it is usually placed, with the Comoro Islands, in a separate region. Zaire has had more species of birds recorded than any other Afrotropical country. Numbers of species shown for various countries decrease away from the equator, and are also less in drier areas. (Species totals include both breeding and migrant birds).*

* Scientific names of species are given in Appendix 9. Note, in general, names of species have an initial capital letter, e.g Shoebill, but names of groups do not, e.g stork.

2. WHY COUNT BIRDS?

The information arising from counts is useful in many ways. Here are some of them.

2.1 Birds are a key feature of African environments

Birds are the most conspicuous animals in most habitats, but just how important are they? Part of the answer to this question lies in knowing how many birds there are, since numbers are one measure of importance. We also need to know what they are doing - how much of what food they are eating, especially if they are pests; what seeds they are dispersing, what food they provide (as prey for other species) and so on. However, in this manual we shall concentrate mainly on the first part: how many birds are there?

There are two basic aspects to the numbers of birds: numbers of species and numbers of individuals. When making counts, we usually record both, but they are not necessarily related. Let us start with the numbers of species. Most of Africa lies within the tropics, and, in common with other tropical regions, supports a large number of species. For instance, there are about 840 species of breeding birds in Kenya, but only 250 in Sweden, a country of similar size (size is important because, as you might expect, larger areas usually support more species). Data for the total numbers of birds recorded in various countries appear on Figure 1.

There are several theories as to why there are more species in the tropics than at higher latitudes (Stevens, 1989). One basic cause is likely to be the greater input of solar energy in the tropics, which in turn leads to higher productivity, although in itself that might only produce more biomass, not necessarily more species. Perhaps the greater seasonality of high latitudes, especially the large seasonal changes of temperature, is also important. On the other hand, the African tropics experience marked seasonality of rainfall, particularly in the drier regions. But this seems to have less effect on the numbers of bird species, which can be as great in a semi-arid savanna as in a forest (Pomeroy & Tengecho, 1986a).

Because different places have different numbers of species and of individuals, it follows that the importance of birds in the ecosystem varies from place to place. From the birds' point of view, forests are more important than savannas. Forest bird densities are typically 30-50 birds ha^{-1} (Pomeroy, 1991) although occasionally they may exceed 70 ha^{-1} (Zimmerman, 1972). In contrast, numbers in savannas are typically only 10-20 ha^{-1}. However, the total biomass of all living things is so much greater in a forest than a savanna that, proportionately, birds contribute more to the savanna ecosystem when we use biomass as a measure.

Returning to densities, these also decrease with latitude. Average year-round densities in terrestrial habitats in Britain are only 10-20 birds ha^{-1} although numbers are higher in the breeding season. At higher latitudes still, such as northern Finland, one may find less than 5 birds ha^{-1} in the breeding season whilst the winter is completely birdless.

2.2 Making counts for conservation purposes

Some birds, like bulbuls and kites, are very common in many parts of Africa. Others, whilst less numerous, are still widespread - the Marabou, for example. But the majority of species are rare, or confined to a small area, or both. Such species are obviously of concern to conservationists, particularly if the species' numbers are thought to be below those of a minimum viable population (Soulé, 1987)

The more we change the environment, the more it becomes necessary to learn how to manage ecosystems (and not only 'natural' ones) to take account of species conservation. In extreme cases, like the Mauritius Kestrel in the early 1980s, drastic measures may be needed to remedy the situation. At one time in the early 1970s, the world population of this species was reduced to single figures (Collar & Stuart, 1985). Strenuous efforts, including captive breeding programmes, have saved it so far, and even allowed a small increase, so that by 1990 the population had reached about 25. There are probably many other cases which need action, but without accurate data on numbers, and especially on trends, we cannot make useful recommendations for management actions. These recommendations need to be soundly based, since all such interventions are expensive.

Of course, knowing the numbers of a bird is not enough; it is also necessary to understand something of its biology. Clearly there can never be large numbers of a bird like the Crowned Eagle, whose diet consists largely of forest monkeys, or the Rufous Fishing Owl, which is virtually confined to the forested banks of a few large rivers and lakes in West Africa, or the many species endemic to small oceanic islands such as the Seychelles.

It is especially important to monitor the numbers of these rare species, which could all too easily become extinct without careful management.

The need for a broad ecological knowledge applies to many situations. We are continually changing our environment and in so doing we inevitably affect the birds with which we share it. It may be, for instance, that there are as many birds in a forested area after conversion to agriculture as there were when it was forested. But if we simply count them we may fail to notice that the species have changed, and that many of the 'true' forest birds have disappeared.

2.3 Birds as environmental indicators

There is much concern in the world today about environmental changes. Many environments are threatened with degradation, through soil erosion, desertification, deforestation and pollution of all kinds. Apparently we are causing long-term climatic changes whose consequences are likely to be even more serious. Inevitably, wildlife will be affected by these changes, but how?

Of all the main wildlife groups, birds are often the easiest to observe and to count. Many studies in Europe and America have shown that counts of birds accurately reflect environmental changes. They are particularly useful for detecting unexpected changes (such as the effects of pesticides on non-target species) and for monitoring and integrating cumulative changes over long periods of time (Koskimies, 1989; Morrison, 1986). Of course, this is not the end of the process. Once a change has been detected the next step is to establish the cause, or causes. This in turn can lead to remedial actions.

One of the best known monitoring schemes, and the longest-running of its kind, is the Common Bird Census, which has run continuously in Britain since 1961 (Marchant *et al*, 1990). Amongst the underlying changes detected by this scheme have been the effects of the Sahelian droughts of the 1970s on birds such as the Whitethroat which winter in that part of Africa but migrate to Europe to breed.

An important new monitoring programme, involving more than 12 African countries, began recently. At several sites in each of these countries, a wide range of waterbird species are being counted every year in January. This is part of an international programme co-ordinated by the International Waterfowl and Wetlands Research Bureau (IWRB) (see Section 3.4). Begun in West Africa in the 1980s, the scheme was extended to eastern Africa in 1991. By the end of the century, other countries are expected to have joined, and major trends should already be apparent.

Birds are increasingly being used as key components in Environmental Impact Assessments. These are not usually published, and are therefore not readily available, but the choice of birds results partly from their being easier to work with than most other groups.

In the future, the comparative ease with which birds can be studied will make them important in assessing biodiversity (see Section 4). If, for example, only part of a forest can be protected from logging, conservationists would prefer to save the part which held the most species. Birds might then be used as indicators of biodiversity in general: when time is limited, it may be easier to rank sites on the basis of bird biodiversity than to do full-scale surveys of all the groups of plants and animals. The aim would not be simply to conserve birds, but rather to use them as a tool in setting overall conservation priorities.

2.4 Bird pests

Many birds are beneficial to man; they disperse seeds and fruits, consume numerous grasshoppers, mosquitoes and other insect pests, and make our environment more pleasant. Some species, however, damage our food supplies and a few (much less than 1%) are serious pests. Most famous in this category are the three Quelea species (Bruggers & Elliott, 1990). But whilst there is no doubt that these birds can at times do great damage, it is easy to exaggerate their effects. Other species, such as weavers and doves, are only locally important (Gichuki, 1984). However, control measures are sometimes deemed necessary and assessing their effectiveness depends upon estimating the numbers of birds, before and after the control operations.

3. METHODS OF COUNTING BIRDS

Obviously our methods of making counts will depend upon many things, such as why we are counting, the level of accuracy we hope to achieve, and the resources available to us. In addition, we have to consider the expertise of those who will be doing the work in the field. This will be less of a problem if we are only counting one or a few species, as is often the case. Where the descriptions in this book apply to all species, they can be simplified in those cases which involve only some.

Sometimes it is necessary to know the total numbers of birds in a population - which means that we have to count all of them, or at least find a way of making an accurate estimate. But it is often sufficient to know the relative numbers, which are usually much easier to assess. Even simpler is to record the presence or absence of species in an area, and to arrange them in order of abundance. Thus we can recognise four levels of counting, termed respectively:

- nominal : species' presence or absence in a particular area (eg, district, national park, lake)
- ordinal : species present, listed in order of abundance
- ratio : the relative abundance of birds in a population
- absolute : a count or estimate of actual numbers.

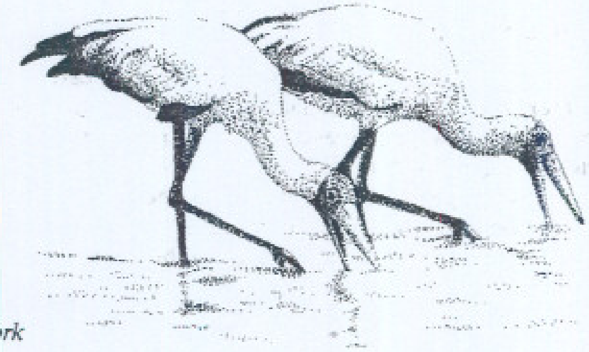
To illustrate the application of these categories, here are some examples.

A Simple species lists (nominal counts) of birds in a series of sites gives a first indication of their relative importance (Objective 1, Section 2.1).

B We might want to compare the significance of a particular group of threatened birds - such as vultures and other scavengers - in various national parks (Objective 2, Section 2.2) and the wardens of the parks would probably know which were the commonest, next commonest and so on, thus enabling ordinal lists to be made.

C Ten counts of the breeding population of Marabou storks have been made in Kampala between 1969 and 1990. During this time, Marabous have increased from less than 20 to more than 300 pairs. These absolute counts show how the birds have responded to a dramatic increase in the city's garbage: they are conspicuous environmental indicators (Objective 3, Section 2.3).

D Flocks of Quelea species can number millions and would be extremely difficult to count with any accuracy. However, what is important to farmers is to know whether they are increasing or decreasing in their fields (Objective 4, Section 2.4). Here the flocks are often much smaller and more dispersed. Regular Timed Species-counts (Section 3.1), which are one way of assessing relative abundance, would provide the answer.



Yellow-billed Stork

Time of day and time of year

When planning to make any kind of a count, we need to take account of birds' movements. Water birds, amongst others, often feed in one place and roost in another, so an evening count at the feeding place would produce very low numbers. Large birds of prey, including vultures, may not take to the wing until temperatures rise sufficiently to create thermals on which they can soar. Swallows also avoid early morning feeding, as there are few insects flying at that time. Several preliminary visits to your study sites will help you to decide the best times. In savanna, a good method is to make counts at various times of day. Even on the hottest afternoons, birds are surprisingly active, although bird-watchers may not be!

Time of year is obviously important too. Migration and breeding activities can greatly affect the numbers of birds in almost all habitats - forests were once thought to be an exception but they too provide homes for some migrants, such as cuckoos.

Ideally, a series of counts should be planned to cover all seasons and, within each season, to be made at different times of day. In practice this is not often possible and in that case it is important to aim for consistency. For instance, if all counts at a series of sites are made at the same time of year, and all between the times of 08.00 and 14.00, then they should all be comparable with each other.

Different kinds of counts

We can now look in some detail at the particular methods used for counting birds, ignoring for the moment the nominal and ordinal counts, which only require that, in making our lists, we cover the area thoroughly, and that we identify the birds accurately. These are topics we shall return to in Section 6 and Appendix 1.

There is an enormous literature on ways of counting birds. A useful general introduction is *Bird Count* by Dobinson (1976). Those with access to good libraries, and who may wish to pursue particular methods in greater detail, may like to refer to Verner (1985) or Ralph and Scott (1981).

Here we shall summarise the main features of those counts which give information on relative abundance (ratio counts) and then consider absolute numbers. The second category will be sub-divided into total counts and estimates, which are based on samples.

3.1 Estimating relative abundance

Estimates of relative abundance are generally easier to make, and generate far more information in less time, than absolute counts. Relative counts are quite adequate for most management decisions (see eg, Eberhardt & Simmons, 1987) and are particularly useful in situations where there is little existing information.

3.11 Timed Species-counts

This technique can be used to compare the bird faunas of a series of sites - different national parks, different habitats within a national park, different types of land use, and so on. A similar method has recently been used on a national scale to survey breeding birds in Britain and Ireland (BTO, in prep).

It is first necessary to define particular sites where the counts are to be made. The exact size of each site is not important, but around 1 km^2 is often convenient. However, the sites selected should be reasonably homogeneous and typical of the area as a whole. Thus a small swamp in an area of wooded grassland would not be included in a count of the wooded grassland.

Ideally the sites would be located randomly within the overall area, but in practice the choice is often limited by their accessibility. Having made the selection of sites, the next step is to record their basic features systematically (see Appendix 2).

A Timed Species-count (TSC) consists simply of a species list, in which all species positively identified are listed, in the order seen (or heard), within a period of one hour. (It is possible to use other times - both 40 and 90 minutes have been used - provided that the purpose is only to make comparisons within a particular study. However, comparisons between studies are more difficult when they are of different lengths, and one hour seems to be the best compromise).

Table 1. An example of a Timed Species-count (TSC). The count was made in a rather open part of Bwindi Forest, south-western Uganda, at an altitude of about 2200 m. The numbers on the left are times, in minutes.

Ruhizha	Fine, Sunny 18°C	27 July 1989	Time 0830 - 0930
		Counters TB + DEP	Serial 06

	Masked Apalis
	Chubb's Cisticola
	Ch-thr Apalis
10)	Regal Sunbird
	BH Oriole
	Luhder's Bush Shrike
	Sunbird sp - ?Bronze
20)	Black Roughwing
	YF Canary
	YW Greenbul
	Olive Pigeon
30)	Blue-hd Sunbird
	C Bulbul
40)	YRT-bird
	Ang Swallow
	WN Raven
50)	Y White-eye
	N Puffback
	White-br Crombec
	B Kite

Ch-thr = Chestnut-throated;
BH = Black-headed;
YF = Yellow-fronted;
YW = Yellow-whiskered;
Blue-hd = Blue-headed;
C = Common; Ang = Angola;
YRT-bird = Yellow-rumped Tinkerbird
WN = White-naped; N = Northern;
White-br = White-browed;
B = Black

Total - 20

Note that many species' names are abbreviated (but not the group names, eg Apalis, Cisticola), saving time in the field. (A key is provided on the right). However, the results are transcribed as soon as possible after returning to base, as in the example in Table 2. Figures on the left indicate times at 10 minute intervals. Four species were recorded in the first 10 minutes, four more by 20 minutes, and so on.

An actual example of a TSC is given in Table 1. To make the count, one moves slowly around the study site, listing any species which are anywhere within it, regardless of how far away. Species flying over are included if they are 'using' the area, for instance swallows feeding, kites looking for food or raptors displaying. At each site, a series of TSCs is made - at least 10, and preferably 15 or 20. Various methods can be used to derive indices of relative abundance from the raw data; one is described by Pomeroy and Tengecho (1986a) but a simpler one is shown in Table 2.

TSCs were used, for example, by Pomeroy and Tengecho (1986b) to study patterns of distribution in savanna areas of Kenya, and by Dranzoa (1990) to record canopy birds in Ugandan forests.

Some birds are much more conspicuous than others, and therefore tend to be over-represented in TSCs. This may not be important when the main purpose is to compare sites rather than species, as is usually the case. Nevertheless, a small modification of the method reduces this bias to some extent (J. Kalina, pers. comm.). This consists of making separate listings of (a) all species and (b) species which are less than 20 m from the observer's path. The former list, by including everything, is useful because it yields at least some data on rare species. Separate indices can be calculated from each of the two lists.

Table 2. Analysis of TSCs from Ruhizha, Bwindi Forest. Only six counts are shown, including the one in Table 1, and only for the first 18 species. The species are arranged taxonomically according to Britton (1980), the generally accepted listing for East Africa. The first column, B, gives the check-list numbers according to Britton. An F in the second column indicates that the species is a forest specialist, and therefore of greater conservation significance. Species are scored 6 if seen in the first ten minutes of a count, 5 when seen between 10 and 20 minutes and so on to 1 for the last ten minutes.

B	F		01	02	03	04	05	06	Mean
135	F	Crowned Eagle				1			0.2
138		Black Kite						1	0.2
339	F	Olive Pigeon	5	3	6	3	6	4	4.5
372		Great Blue Turaco	1	2	5	5			2.2
459		Speckled Mousebird			1				0.2
488		Cinnamon-chested Bee-eater	4	1					0.8
503	F	White-headed Wood Hoopoe	6			6			2.0
513		Black and White Casqued Hornbill					2		0.3
515		Crowned Hornbill	5						0.8
533		Grey-throated Barbet			1				0.2
548		Yellow-rumped Tinkerbird	2	1		6		3	2.0
556	F	Yellow-billed Barbet			1	1			0.3
584	F	Fine-banded Woodpecker				5			0.8
640		Black Roughwing	4	6		4	3	4	3.8
649		Black-headed Oriole	6	6	6	5	5	5	5.5
653		White-necked Raven						2	0.3
671	F	African Hill Babbler		1					0.2
676	F	Mountain Illadopsis					5		0.8

Note that the mean score for each species is here calculated on the first six TSC counts. Normally at least 15 counts are made at any one site, at various times of day and at different seasons. Even after six counts it is apparent that there are few common species and many rarer ones, including most of the forest specialists.

3.12 Mist-netting

Making TSCs is comparatively easy in 'open' habitats, but much less so where the vegetation is dense, such as forests and papyrus swamps. (To make any kind of count in a forest, one needs to be able to identify birds' calls, or at least most of them; and even so, some species rarely call outside the breeding season - see Section 3.3). In these circumstances, mist nets, which are so fine as to be almost invisible, are the best method of finding out what is there. The methods is especially useful for undergrowth birds, which live mainly at heights below about 3 m. (Please note that mist-netting can only be undertaken by those who have been properly trained; in most countries a special permit is needed. Should you wish to learn mist-netting, your local bird club or society may be able to help (see Appendix 4)).

The netting site should, so far as practicable, be 'typical' of the habitat, and to facilitate comparisons with other researchers, should be set in one of two patterns (Figure 2). In both cases the inter-net interval is 50 m. Since even small undergrowth birds usually have home ranges of at least 50 m, spacing the nets in this way ensures a good catch. A less commonly used alternative, useful for really detailed studies of small areas, is to place the nets end-to-end in a continuous line: hence ten 12 m nets produce a single 120 m net line.

It is best to open the nets as soon as it is light enough to see clearly, and to close them well before it gets dark, to allow time to remove any late catches. During the day, nets in forest areas should be checked at least once an hour; in more exposed areas, the interval should be reduced to half an hour. Well-placed nets can be viewed from a few metres away so that they can be checked without disturbing birds that might be about to be caught.

Nets should be closed immediately if there is heavy rain since birds chill rapidly when suspended in a net. It is the responsibility of mist-netters to be concerned about the birds' welfare since, apart from humanitarian considerations, reliable data can only be expected from a healthy population of birds. For this reason also, netted birds should be handled with great care, processed quickly but carefully, and released by gently throwing them away from the net in which they were caught. The processing usually includes ringing (see below), so that you can know whether a particular individual has been caught previously.

For most purposes it is convenient to set ten small-meshed nets, each of 12 m, for two or three whole days (Figure 2). After this, trapping rates decline significantly so that a move to another site is advisable, even if it is only a few hundred metres away. Catch rates for each species are usually expressed as individuals per 100-metre-net-hours; for instance, a catch of 14 birds in ten 12-metre nets, set for 12 hours on each of 2 days would be [14 x 100] /[10 x 12 x 12 x 2] or 0.49 birds per 100 mnh.

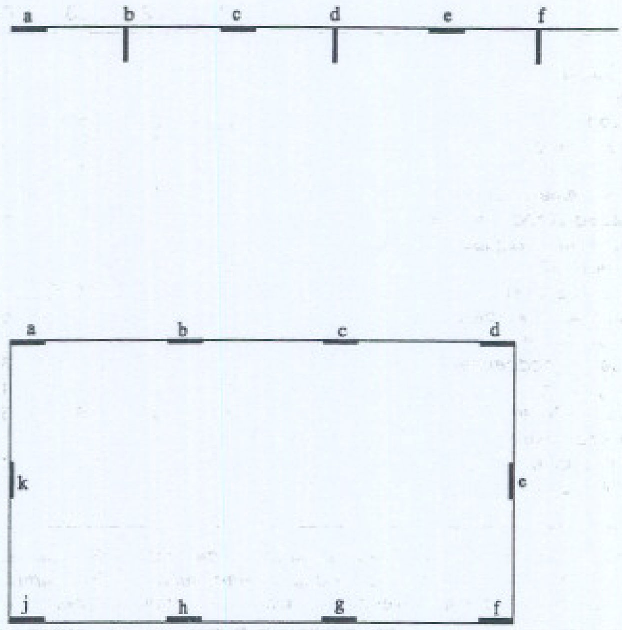


Figure 2. Mist-nets can be set along a transect (above) or as a grid (below). The latter is more effective for estimating territory sizes. 8-10 nets is about the maximum that a trained team of two can manage.

Since mist-nets are typically set with the bottom shelf close to the ground, they only catch low-flying birds. And those which are larger than about 200 g require other methods; for instance, rails in swamps or guineafowls in forests are best detected by their calls. And whilst adventurous types might contemplate netting at higher levels in forests, most canopy and mid-stratum species can be seen or heard quite easily and so they can be counted by TSCs or Point Counts (see Section 3.3).

Mist-netting has been used in many studies of African birds. Some examples are: Bekker (1988) in riverine forest in Ethiopia, Britton (1978) in Kenyan papyrus swamps, and Dowsett-Lemaire (1989) in montane forest in Malawi.

Catching birds can be useful for many reasons as well as making estimates of numbers. Birds can be ringed, weighed, measured and checked for diet, moult and parasites. Standard techniques for these studies can be found, for example, in publications of the British Trust for Ornithology (Appendix 4). Ringing, like mist-netting, is a highly skilled operation which requires a period of training by a qualified ringer. As with netting, contact your local society to find how to do this (Appendix 4 has addresses).

3.2 Absolute abundance

3.21 Total counts

A total count is one where every bird in a particular place is counted. Total counts are of several kinds:

- counts of all the birds in a restricted site, for example a wetland (eg, Roux & Jarry 1984); an airport (eg, Gwahaba, 1985); or a woodland (Vernon, 1984).
- counts of only one or a few species, often over larger areas; for instance, Macdonald and Gargett (1984) counted all the raptor nests in 620 km^2 of Zimbabwe; and various counts have been made of the flamingoes at Lake Nakuru, Kenya - sometimes up to a million of them (Vareschi, 1978).
- social and gregarious species such as Cattle Egrets can sometimes be counted when they roost. Evans *et al* (1982) did this for Sacred Ibis and Marabous, and Bennun (in press) for Grey-headed Social Weavers.

However, opportunities for making total counts are comparatively rare. More often, the area is too large, and the birds too many, or the habitat is not 'open' enough. Then we have to rely on estimates instead (see Section 3.23). We use samples to make these estimates.

3.22 Territory mapping

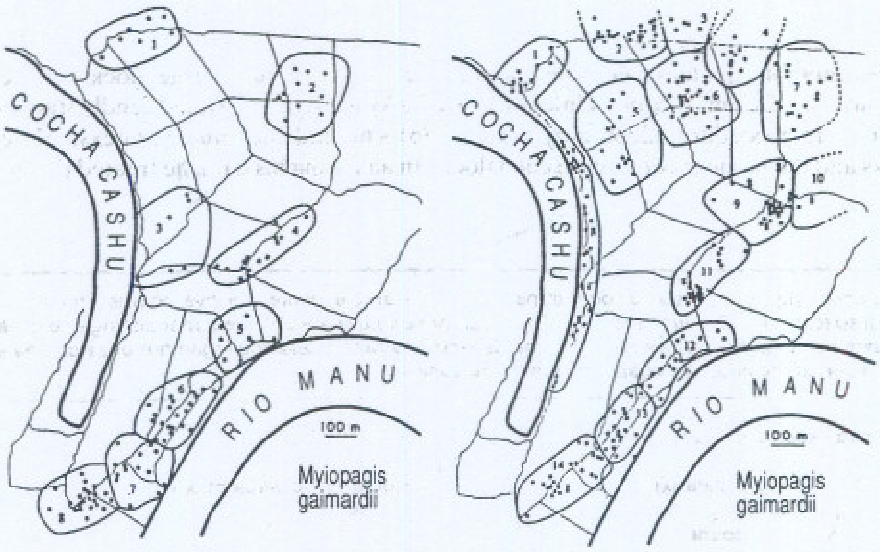


Figure 3. Spot mapping of birds in a tropical forest, in this case in Peru. The study area is bounded to the south by the Rio Manu river and to the west by Cocha Cashu lake. Thin lines are footpaths. Each map is for one species, the dots representing exact localities where the bird was singing. These observations, with sightings and other information, were used to determine territory boundaries: 1-8 for Myiopagis gaimardii and 1-14 for Myrmeciza hyperythra. (From Terborgh et al., 1990).

In Europe and north America, bird populations are often estimated by plotting the territories of all species at the beginning of the breeding season (see eg, Oelke in Ralph & Scott, 1981; Marchant *et al*, 1990). The method, also known as spot-mapping, depends heavily upon the location of singing males. This is relatively easy in temperate areas, because almost all species breed during the spring, and for a period of only a few weeks. During this time, many males spend several hours a day singing. In the tropics, however, breeding seasons are extended and vary considerably between species. The result is that there is no time of year when all species are singing and even when males do sing it is often for only a few minutes a day. Methods based upon singing males are therefore hard to apply. However, in a major study in Amazonia, Terborgh *et al* (1990) have recently shown that the method can be used successfully, even in forest (see Section 3.3 and Figure 3).

Breeding populations of raptors have been estimated by finding all the nests in a particular area (Macdonald & Gargett, 1984; Muhweezi, 1990). Many African birds are at least two years old when they first start breeding (and five or more years in the case of the larger raptors). And in co-operative breeders, only a small proportion of the birds may actually be breeding. Thus the total population of the species is much greater than that of the breeding population, possibly double the numbers actually breeding. Further, whilst some species are monogamous, a minority (notably the colonial weavers) are not; this again means that nest counts are poor predictors of the number of birds in the population although they are a useful index for comparing a species' numbers between places and years.

3.23 Samples

Whenever we make estimates of abundance based upon samples, the details of the sampling programme are of central importance. All sampling methods consist of taking a series of samples, so designed as to be properly representative of the population being studied. Having found a mean value for all the samples, this is appropriately scaled-up, according to the area covered by the samples, to give a total estimate. For instance, if each sample covered 0.5 km^2 out of a study area of 20 km^2, the sample means should be multiplied by 20/0.5 = 40, to obtain an estimate for the entire area.

If you are planning a major sampling programme, and have not taken an advanced course in ecology, it would be well worthwhile reading something about sampling theory in a standard text such as Southwood (1978) or Smith (1980).

When you are counting a number of species, the chances are that whilst most of them are uncommon, a few will be relatively numerous. Some of these may occur in flocks. Such aggregations are a nuisance, statistically speaking, because the fact that a flock is either in your count and thus contributes many birds to the total, or not, tends to create a bimodal sampling distribution. A simple and usually adequate procedure for reducing this potential source of bias is to use logarithms when calculating means, variances and deviations. An example is given in Table 3.

A few species, notably queleas and some waterbirds, come in such large flocks that even logarithmic transformations are insufficient to cope. Unless you are lucky enough to have a friendly statistician to help, it is then best to follow the procedure adopted by Lack (1986) who had such quelea flocks. He counted both the numbers of flocks and the numbers of birds in each flock. In analysing his data, he treated the queleas separately.

Table 3 Converting count data to logarithms. In this example, there are five counts, during which seven hypothetical species, A to G, were recorded. The logarithmic values are obtained after adding one to each original number, since some of the species had zero counts, and one cannot take the logarithm of zero. The extra one is subtracted again at the end. All logarithms are to the base 10.

Number of birds seen per count

Species	Raw data (x)		count			logarithmic value of (x+1)					Mean number of birds*
	1	2	3	4	5	1	2	3	4	5	
A	1	0	1	1	0	0.30	0.00	0.30	0.30	0.00	0.51
B	1	2	0	0	1	0.30	0.48	0.00	0.00	0.03	0.64
C	4	7	3	2	9	0.70	0.90	0.60	0.48	1.00	4.45
D	2	0	0	3	1	0.48	0.00	0.00	0.60	0.30	0.89
E	0	1	1	0	0	0.00	0.30	0.30	0.00	0.00	0.32
F	0	1	0	0	4	0.00	0.30	0.00	0.00	0.70	0.58
G	0	0	2	0	0	0.00	0.00	0.48	0.00	0.00	0.25
Totals	8	11	7	6	15	0.95+	1.08	0.90	0.85	1.20	7.64++

* Calculated as [antilog (mean of the 5 log.values) - 1.00]
\+ The logarithms of the [raw totals + 1.00]
++ The total of the mean values for each species, i.e (0.51 + 0.64 ..... +0.25).

Area a.

Area b.

Area c.

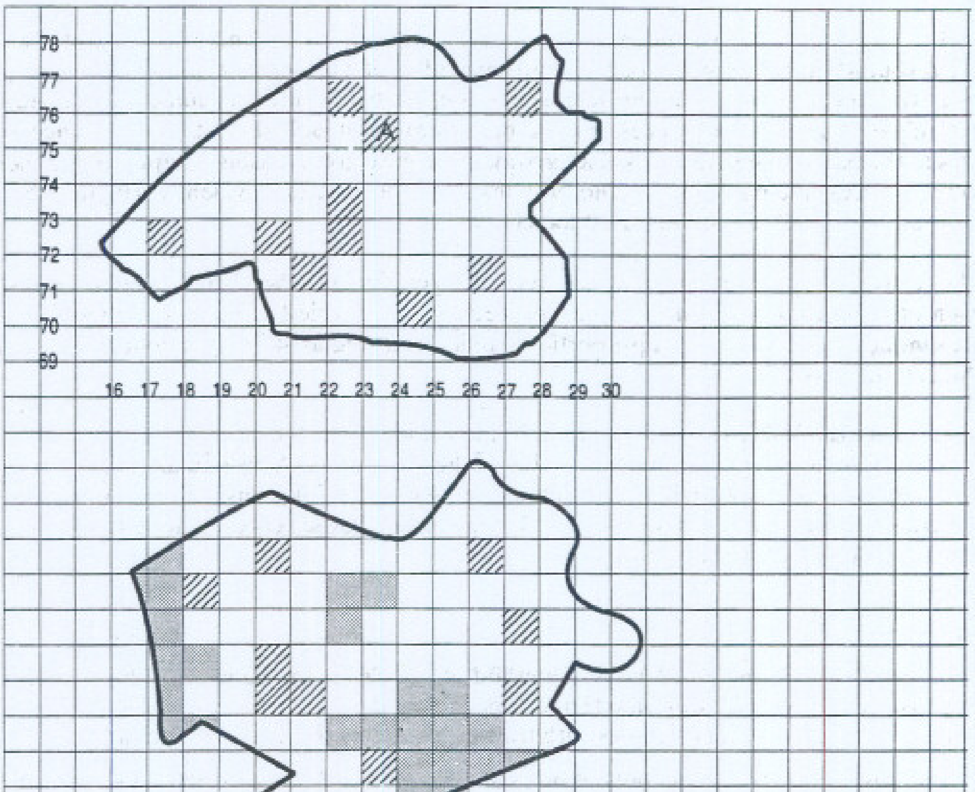


Figure 4. *Using random numbers to select study sites within a larger study area. Squares of 1 km² are used for illustration. These would be suitable for TSCs (Section 3.11) but the same principle would apply to locating transects or mist-nesting sites. Some maps are already gridded, as here, at 1 km intervals, otherwise you will first have to draw and number the grids. Area (a) is comparatively uniform and ten 1 km² sites have been selected, using a table of random numbers and the grid lines on the map to locate the south-western corner of each square. For instance, square A has the co-ordinates 2375. (Co-ordinates such as 4253 which lie outside the study area are ignored). Area (b) is also comparatively uniform but the stippled parts are inaccessible and not considered for site selection. The whole of area (c) is accessible, but a vegetation survey recognised three district zones or strata, I, II and III, covering approximately 20, 30 and 50 km² respectively. The number of sites to be sampled in each stratum is proportional to its area.*

When planning to investigate bird numbers in a large area by sampling, the siting of the samples is most important. If your whole area is more-or-less uniform, and all of it is reasonably accessible - an open grassy plain, for example - you can probably place your samples by using a table of random numbers and a gridded map (Figure 4a). But if only part of the area is accessible, perhaps because of lack of roads, then it is acceptable to restrict the samples to the parts which are accessible provided you have good reason to suppose that they are essentially similar to the inaccessible parts (aerial photographs might provide this evidence) (Figure 4b). For simplicity, part squares along boundaries are not used for sampling.

Most large areas support several different types of vegetation and these should be sampled separately. If we regard each of them as a 'stratum', then the procedure of 'stratified random sampling' is appropriate. The number of samples in each stratum is proportional to its area (Figure 4c). An example of this being used is the work of Morel (in press).

Where it is not practicable to sample randomly, then at least a serious effort must be made to ensure that the sampling point(s) are as representative as possible of the study area. A particular case where this often applies is in using transects (see below), where it is common to have very few transect lines - sometimes only one - but to make a series of counts along the same lines. To be able to choose representative sample sites, you first need to know the area quite thoroughly.

Transects

Transects are probably the most widely-used method of estimating the numbers of birds in terrestrial habitats, although the use of point counts (described later) is becoming more frequent, especially in forests. It is important to realise that there are several difficulties with transects; notably those of accuracy and effort.

Transects consist essentially of counts of birds along a strip of known width and length. A perfect transect count would record every bird present at a particular instant of time. Something close to that can be achieved with quadrats (see next Section), but not with transects, which are elongated and usually take at least a half hour to complete. This raises questions as to what birds to include in the count, which is discussed below.

Transect counts can be made in most habitats; exceptions are those with fairly continuous, dense cover in the lower layers. Hence transects are most often used in the more open habitats, such as savanna or farmland (Ayeni, 1984; Morel & Morel, 1978 ; Pomeroy & Muringo, 1984; Ulfstrand & Alerstam, 1977). Carlson (1986) used transects successfully in fairly open types of forest, whilst Kalina (1988) used them in several forest types when counting hornbills - but these birds are highly conspicuous.

To reduce bias, the transect route should if possible be chosen at random; even better would be to select a series of random routes within each habitat being sampled. However, because of the time required to set them up, it is common to use only a few transects, or even just one. Each transect is marked to ensure that the same route is followed on successive counts. A convenient way to do this is to use a small footpath or a game trail, which allows easy movement: it is essential to move quietly whilst counting.

The length of a transect depends mainly upon what is being counted, and the openness of the habitat. The width is determined primarily by the distance at which the counter can be reasonably sure of detecting all the birds to be counted. It is common practice with transect counts of large mammals, whose numbers are much lower than those of birds, to use rather wide transects - up to 500 m on either side, and sometimes also for the transects to have a variable width (see, for example, Norton-Griffiths, 1978). Transects of this type have rarely been used for birds: one exception is described by Brown (1972), who counted birds of prey along roads crossing savannas.

For small birds, which are usually relatively numerous, a transect width of 10 m on either side of the route (or 20 m in open habitats) is commonly found suitable. In this case the use of variable widths would be an unnecessary complication. The counter walks slowly along the predetermined route, recording all individuals within the transect which are ahead of him and either perched or on the ground. An assistant or two is needed to flush birds gently out of bushes (Figure 5). It is tempting to assume that any bird near the edge of a transect must be within it but you should check first! Either carry a tape measure, or practice making paces of exactly one metre so that you can be sure to measure the distance quite accurately.

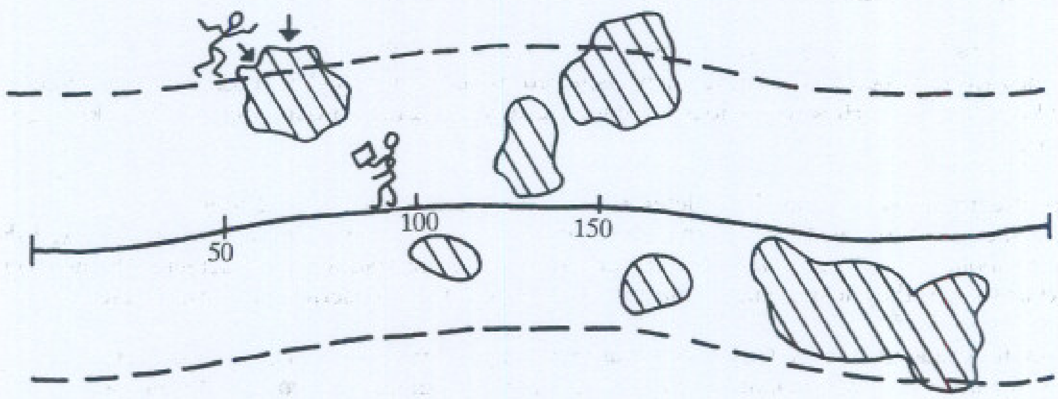


Figure 5. Counting birds along a 40 m wide transect. The assistant A is beating a bush to drive out birds towards the counter C, who himself keeps quiet.

An example of data from an actual transect count, and density calculations from it, appears in Table 4. Of course, one would not normally estimate densities from a single transect.

Table 4. An example of a transect count in western Uganda. The length of the transect is 1000 m and the width 10 m on either side of a footpath. The total area is thus [(100 x 10 x 2)/10,000] = 2.0 ha. The count is in an area of mixed cultivations including bananas, maize, beans and other crops; there are a few exotic trees, planted for fruits or as ornamentals.

Kanyawara cultivations. Fine, warm, 25°C Species	03 April 1990 Counters DEP + JA + AM Numbers	Time 1140-1240 Serial 03 Birds ha^{-1}*
Bronze Mannikin	4	2.0
Cisticola prob. Siffling	2	1.0
Scarlet-chested Sunbird	1	0.5
Variable Sunbird	1	0.5
Red-billed Firefinch	2	1.0
Red-bellied Paradise Flycatcher	1	0.5
Tawny-flanked Prinia	3	1.5
Red-faced Cisticola	4	2.0
Black-crowned Waxbill	11	5.5
White-chinned Prinia	1	0.5
Weaver sp.	1	0.5
Holub's Golden Weaver	1	0.5
White-browed Scrub Robin	1	0.5
Stonechat	1	0.5

Totals - Species 14
- Individuals 34
- Density = 17.0 birds ha^{-1}

* Densities are shown here simply to illustrate the method. In practice one would make a series of counts before estimating densities.

When making transect counts, some birds are likely to be glimpsed only fleetingly, as they fly away. It is therefore necessary to be thoroughly familiar with the birds to be counted. This will be simpler if only a few species are being studied; but often the counter is interested in the whole avifauna of a habitat, which might easily be 100 or 200 species. Considerable experience is a prerequisite in these situations.

There is no satisfactory answer as to whether to count birds which fly into the transect ahead of the observer; or those which fly away before they have been disturbed by the counters. The most important thing is to be consistent; I count them in. However, I do not count birds flying over the transect (but see the following Section, on quadrats).

Various attempts have been made to determine the accuracy of transects. Thompson (1989), counting a conspicuous species of lovebirds in a fairly open habitat, concluded that transects under-estimated the true population by about 15%. Birds of dense cover, such as thickets, can readily escape detection by slipping out of the transect as soon as they hear counters approaching. This can lead to serious under-estimates.

The main disadvantage of most transects is that they sample very small areas; a transect 500 m long by 20 m wide is only one hectare. This is minute if one is interested in estimating the populations in a national park of, say, 10,000 ha! In such a case, it would be prudent to take several transects, and extend their length to perhaps a kilometre. Alternatively, much longer transects may be used. In the Ivory Coast, Thiollay's (1974) transect was 12.5 km long and 40 m wide, a total area of 50 ha. Each approach requires a considerable investment of time, since every transect should be counted at least 10 times (and preferably 20), covering all seasons. Another disadvantage of transects is that rare species are unlikely to appear within them (although they have an annoying habit of appearing just outside, or flying over!).

Quadrats

Square quadrats, of sizes such as 50 x 50 m, enable the counter to come closer to the ideal of making an instantaneous count of a sample area. They are suitable for fairly open areas, including cultivation; the most important feature is that all four corners should be visible to the counter. A convenient system is to run a transect line through the study area, and to use random numbers to determine the position of each quadrat along it (Figure 6). Four quadrats of 50 x 50 m make an area of one hectare.

As with transects, the permanent marking of quadrats (eg, by corner posts), enables the same ones to be counted repeatedly.

The actual size of the quadrat should be determined after first making preliminary trials. In Queen Elizabeth National Park in Uganda, where bird densities are usually more than 10 birds ha^{-1}, Abe found quadrats of 50 x 50 m to be suitable (Etoori & Abe, in press). In Tsavo National Park, Kenya, with typical densities of 1 to 4 birds ha^{-1}, Lack (1986) was able to count large quadrats, about 350 x 150 m, by following a fixed route within them.

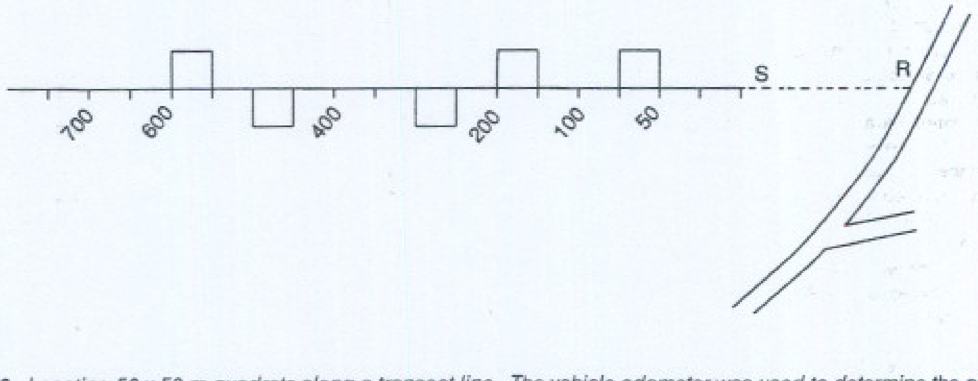


Figure 6. *Locating 50 x 50 m quadrats along a transect line. The vehicle odometer was used to determine the point R along a road. The transect direction is chosen with a table of random numbers. Then, after a set distance of say 150 m (beyond the likely effects of the road), the transect proper starts at S. Eight quadrats are demarcated at intervals determined by random numbers, the side (left or right) chosen by tossing a coin.*

As with transects, the permanent marking of quadrats (eg, by corner posts), enables the same ones to be counted repeatedly.

The actual size of the quadrat should be determined after first making preliminary trials. In Queen Elizabeth National Park in Uganda, where bird densities are usually more than 10 birds ha^{-1}, Abe found quadrats of 50 x 50 m to be suitable (Etoori & Abe, in press). In Tsavo National Park, Kenya, with typical densities of 1 to 4 birds ha^{-1}, Lack (1986) was able to count large quadrats, about 350 x 150 m, by following a fixed route within them.

To make a count in a 50 x 50 m quadrat, two or three people move through it in line, driving out any birds hidden in the vegetation, in such a way that they are seen by the recorder (Figure 7). Birds using the air space over the quadrat, such as swallows and swifts, can be counted at the moment the observer enters it to begin the count.

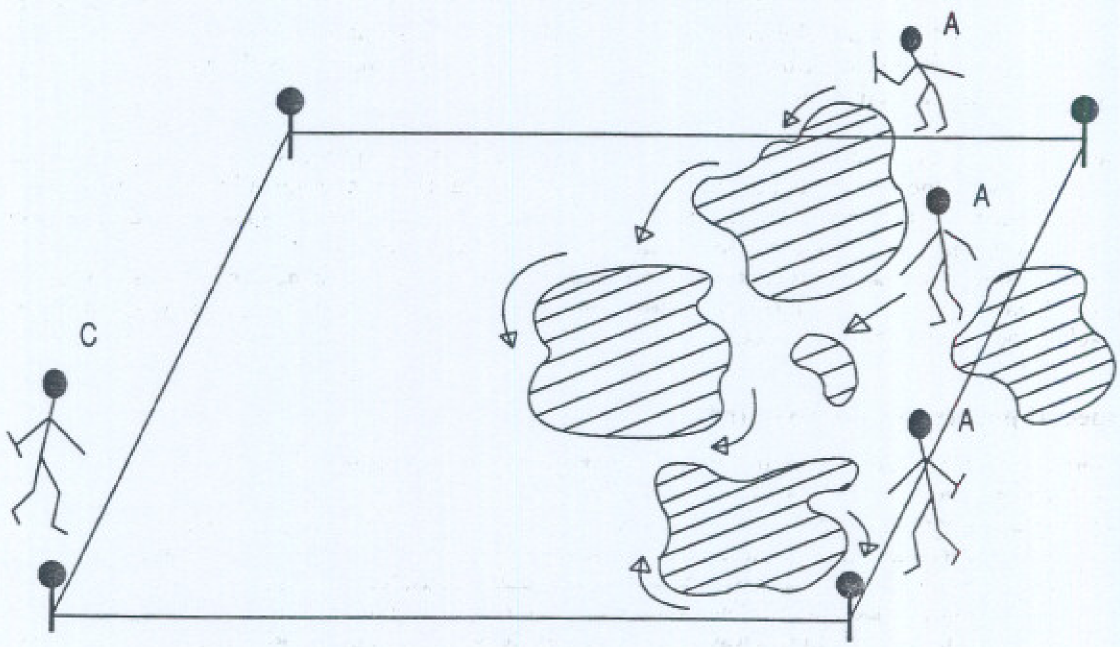


Figure 7. *Three assistants, A-A-A, driving birds from cover towards a counter C in a square quadrat. The direction of drive should be such that the sun is behind the counter's back. The corners of the quadrat are marked by easily visible posts.*

Point counts

Habitats with dense vegetation, notably forests, are the most difficult ones for bird counters. An approach which has been widely used in north America, although not as yet in Africa, is that of point counts (Ralph & Scott, 1981). At its simplest, a point count consists of standing at a particular point for a fixed time (typically 5 or 10 minutes, occasionally longer), and recording all birds seen or heard within a fixed radius (typically 10 or 20 m). After reaching the point, the counter relaxes for several minutes before starting the count, since his approach will have caused some disturbance. It is assumed that any bird present will be detected during the count; and that none slipped away as the counter was approaching his station. As a preliminary, a series of counting points are established within the habitat, and permanently marked so that they can be visited in sequence on each counting occasion. The points should be widely spread through the study area.

The radius for counting, where this is fixed, is determined by the counter's assessment of how far he can be fairly sure of detecting any birds present. If, for example, a radius of 20 m is used, then the area at each point is 1257 m^2. By visiting 10 points, the total area becomes 1.26 ha. A more accurate approach consists of having a variable radius, and of measuring the distance in the case of every bird recorded (see, for example, Raphael (1987)). The distances from the observer to the birds can be used to calculate a "basal region" (Emlen 1971, Raphael 1987) from which density estimates are derived. However, this method is only recommended for the most experienced observers , and in any case measurements of distance, even those from an observer to a fixed radius, are hard to make when the canopy is higher than about 20 m.

Mark-release-recapture methods

Many studies of bird populations involve marking and so in principle could be used as a basis for population estimates. The basic method of mark-release-recapture (MRR) is well-described in standard texts, such as Southwood (1978) and Begon *et al* (1990). If N birds are caught, ringed and released at a particular site on Day 1, and M birds are caught at the same site on Day 2, of which R are already ringed, then the ratio of M/R, multiplied by N, gives an estimate of the population, P; ie, P = M/R x N. For example, suppose that we had ringed 20 birds yesterday, and today we capture 30, of which 12 are already ringed, then our population estimate is 20 x 30/12, ie, 50 birds.

However, birds are rather mobile, and even resident species can have a large home range, so some individuals may have left the area since yesterday - and others could have moved into our area since then - both of which mean that our estimates are likely to be too high. Furthermore, there is usually no way in which we can tell how big an area our birds have come from; so it is not possible to estimate densities. But there are exceptions. For example, Dranzoa (1990) studied birds in a series of small forests near Kampala, Uganda. One of these forests was only 12 ha in extent, and since it is known that forest birds rarely leave forests, Dranzoa could assume that she was dealing with a closed population.

Where birds are captured from a limited population - such as a small forest or a swamp, surrounded by different vegetation - then a simple method of estimating the total size of the population is given by du Feu *et al* (1983). For example, if 45 birds (of all species) are caught in a 2-day ringing session, and 15 of them are recaptured during the same 2 days, then the estimated total population is 98 (Table 5). (A bird recaptured twice in the same session counts as two recaptures). A session can be any period - a morning, 2 days, a week, but one should be able to assume that no birds have moved in or out of the area during the period, which is obviously more likely to be true for shorter periods.

3.3 Special problems of forest birds

Quantitative research on Afrotropical forest birds has only recently begun. Of course, forest birds are hard to see, and their innumerable calls are difficult to learn. However, some sound recordings of forest birds are commercially available (see Appendix 5). By going to the forest, listening carefully to birds' calls and songs and then playing the recordings, one can learn to recognise some species. The next step is to acquire a small portable tape recorder and microphone, and make one's own recordings. A useful technique is to record a bird and then to replay the recording immediately. This will sometimes draw a singing bird into the open, where there is a better chance of identification. In this way, you can gradually become familiar with most birds' calls. Only then is it possible to do TSCs, make transects or carry out point counts. Even so, the degree of accuracy which is possible when using these methods for forest birds has yet to be established. Amongst several pitfalls are the problems of mimicry -you may think you hear a Crowned Eagle, but in reality it's a robin chat imitating a Crowned Eagle. (You are not alone in being fooled - monkeys often make the same mistake, diving hurriedly for the undergrowth!).

Koen (1988) successfully used circular quadrats or point counts of 50 m radius (he called them spot-counts: see Section 3.23) in a montane forest in South Africa. During his counts, he moved slowly around within the quadrat to improve his chances of seeing birds hidden in the canopy. For smaller projects, point counts probably offer the best chances of estimating absolute abundance but, as with transects, will only yield adequate data for the commoner species. Birds with densities of less than 1.0 km^{-2} rarely appear in point-count data: their numbers are better assessed by TSCs.

A few studies have involved ringing birds over long periods of time and this approach leads to a better understanding of forest bird populations. Examples include Dowsett (1985), Dowsett-Lemaire (1989) and Zimmerman (1972).

The best method of all may be territory-mapping, although this has yet to be properly tested in Africa. Indeed, it is only recently that it has been effectively used in any tropical forest. However, Terborgh *et al* (1990) have shown that it can be done, using a team of very experienced field workers who learnt the songs and calls of more than 500 species before starting to map them. This extremely thorough study, using spot-mapping in combination with several other methods, provides an excellent model for all future studies of forest bird populations. The only comparable study in Africa is that of Brosset (1990) in Gabon.

Table 5 . Estimating the numbers of birds in a 'closed' population by du Feu's method. The numbers of 'new' birds are the total number of different individuals caught in a particular session. All recaptures are counted, including second and subsequent ones, of each 'new' bird. See text for an example. (From du Feu *et al*, 1983, page 225).

No. of Recaptures	Numbers of 'new' birds													
	5	10	15	20	25	30	35	40	45	50	55	60	65	70
1	4	52	115	204	317	455	619	807	1020	1259	1522	1810	2124	2462
2	9	30	63	109	167	238	321	417	525	646	780	925	1084	1255
3	7	22	45	77	117	165	222	287	360	442	532	630	737	852
4	6	19	37	61	92	129	173	222	278	340	409	483	564	651
5	6	16	32	52	72	108	143	183	229	279	334	395	460	530
6	6	15	28	46	67	93	123	157	196	238	285	336	391	450
7	6	14	26	41	60	83	109	139	172	209	250	294	341	393
8	5	13	24	38	55	75	99	125	155	187	223	262	304	350
9	5	13	23	36	51	69	91	114	141	171	203	238	276	319
10	5	12	22	33	48	65	84	106	130	157	186	218	253	289
11	5	12	21	32	45	61	79	99	121	146	173	202	234	268
12	5	12	20	30	43	58	74	93	114	137	162	189	218	249
13	5	11	19	29	41	55	71	88	108	129	152	178	205	234
14	5	11	19	28	40	53	67	84	102	122	144	168	194	221
15	5	11	19	28	38	51	65	80	98	117	137	160	184	209
16	5	11	18	27	37	49	62	77	94	112	131	152	175	199
17	5	11	18	26	36	47	60	74	90	107	126	146	168	191
18	5	11	18	26	35	46	58	72	87	103	121	140	161	183
19	5	11	17	25	34	45	57	70	84	100	117	135	155	176
20	5	11	17	25	34	44	55	68	82	97	113	131	150	170
21	5	10	17	24	33	43	54	66	79	94	110	127	145	164
22	5	10	17	24	32	42	53	64	77	91	107	123	140	159
23	5	10	17	24	32	41	52	63	75	89	104	119	136	154
24	5	10	16	23	31	41	51	62	74	87	101	116	133	150
25	5	10	16	23	31	40	50	60	72	85	99	113	129	146
26	5	10	16	23	31	39	49	59	71	83	97	111	126	142
27	5	10	16	23	30	39	48	58	69	82	94	108	123	139
28	5	10	16	23	30	38	47	57	68	80	93	106	121	136
29	5	10	16	22	30	38	47	56	67	79	91	104	118	133
30	5	10	16	22	29	37	46	56	66	77	89	102	116	130
31	5	10	16	22	29	37	45	55	65	76	88	100	114	128
32	5	10	16	22	29	37	45	54	64	75	86	99	112	125
33	5	10	16	22	29	36	44	53	63	74	85	97	110	123
34	5	10	16	22	28	36	44	53	62	73	84	96	108	121
35	5	10	16	22	28	36	44	52	62	72	83	94	106	119
36	5	10	16	22	28	35	43	52	61	71	82	93	105	117
37	5	10	16	21	28	35	43	51	60	70	80	92	103	116
38	5	10	15	21	28	35	42	51	60	69	79	90	102	114
39	5	10	15	21	28	35	42	50	59	69	79	89	101	113
40	5	10	15	21	27	34	42	50	59	68	78	88	99	111
41	5	10	15	21	27	34	42	49	58	67	77	87	98	110
42	5	10	15	21	27	34	41	49	57	67	76	86	97	108
43	5	10	15	21	27	34	41	49	57	66	75	85	96	107
44	5	10	15	21	27	34	41	48	57	65	75	85	95	106
45	5	10	15	21	27	33	40	48	56	65	74	84	94	105
46	5	10	15	21	27	33	40	48	56	64	73	83	93	104
47	5	10	15	21	27	33	40	47	55	64	73	82	92	103
48	5	10	15	21	27	33	40	47	55	63	72	81	91	102
49	5	10	15	21	27	33	40	47	55	63	72	81	91	101
50	5	10	15	21	26	33	39	47	54	62	71	80	90	100

3.4 Special problems of water birds

Most of us do not realise how great is the variety of wetland habitats, which range from mangroves to montane bogs, huge lakes to temporary pools, and many more. Africa has an amazing diversity of wetlands, many of which are in danger of disappearing before they have ever been studied.

A worldwide programme of waterbird counts is co-ordinated by the International Waterfowl and Wetlands Research Bureau (IWRB, Appendix 4). They will be pleased to give more information to anyone planning waterbird counts. Some 50 wetland sites, scattered throughout Africa, are already being counted at least once a year, typically in January, but some also in July.

Many species of waterbirds move over considerable distances. We know this because some, such as most of the waders, breed in the northern Palearctic, especially Siberia, but then spend the northern winter in Africa. Others are seen hundreds of kilometres from any known breeding site. As yet, most of these movements are poorly understood, making it difficult to interpret the results of counts.

Counts on open waters

Birds are relatively easy to see on lakes, dams and along sea shores. Provided that the area to be counted is not too big, total counts are often possible (Section 3.21). Jarvis (1984) and Meadows (1984) used this method for counting waterfowl. Counts of ducks and other large water birds are usually made with a telescope as well as binoculars (see Appendix 5). For long shorelines, or those which are inaccessible, counts can be made from boats, as was done by Kasoma (in press) studying storks and herons in Uganda, by Milstein (1984) when censusing water birds in Mozambique, and by Erikson and Sharp (1989) for Ospreys and Fish Eagles at Lake Kariba.

Rather rarely, aerial counts are made, typically by photographing the birds (Section 3.21).

Swamps

Swamp habitats vary widely; some are fairly open whilst others, notably papyrus, have dense vegetation. Here, as in forests, indirect methods are the most useful - the use of calls and mist-netting (see, for example, Britton, 1978). Swamp forests are probably amongst the most difficult of all habitats to work in: so far, they seem to have been avoided in Africa although some have been studied in tropical America.

3.5 Choosing a method

Several books are devoted to methods of counting birds. The most widely used are Koskimies and Vaisanen (1990) and Ralph and Scott (1981). However, neither is concerned with African birds. Most of the methods which are being used for counting birds in Africa have been mentioned in the previous sections. Between them they cater for a wide range of situations, but for any particular study, you will probably have to modify the method to suit your particular needs. In any case, you should always test the method thoroughly in the field before deciding whether or not to adopt it.

Table 6 provides a summary of methods. Before selecting the one which seems most appropriate for your study, take time to consider the logistic aspects; especially:

- availability and competence of field workers
- time
- equipment
- other running costs
- methods of analysis to be used.

Of these, the first is by far the most important. It is hard to exaggerate the need to 'know your birds' as thoroughly as possible before starting a field study. Most of the best research is done by people for whom birding is not only their work but also their hobby. You can easily recognise them - at every opportunity they are out with their binoculars!

Table 6. The suitability of the main study methods in relation to several categories of objectives. The entries in the table should only be treated as suggestions. (Adapted from Verner, 1985, p. 250).

OBJECTIVES	**LISTING**	**RELATIVE ABUNDANCE**		**ABSOLUTE ABUNDANCE**				**NOTES**
		TSC	Mist-netting	Total count	Transect/ quadrat	MRR	Territory mapping	
Significance of birds in whole ecosystem		**			*	*		
Conservation -								
- status of threatened species				**				Here, only the best will do
- general conservation studies	*				*	*	*	Method depends on specific objective
Birds as environmental indicators		*			*	*		
Pest status		**						
Surveying -								
- smaller areas +		**	**					Relative abundance can be indicated in atlases
- nationally	*	*						

** Probably the most cost-effective way of meeting the objective
* Generally suitable for the objective
\+ Areas in the approximate range of 10^2 - 10^5 km^2.

Second only to competence in identification is the need to be fully familiar with the methods. Verner and Milne (1989) found that prior training was one of three means of reducing variability in count data. The others were the requirement for observers to pass a performance test, and the rotation (of those who passed) between all sampling sites.

And, however experienced you are, it always pays to discuss your ideas - by correspondence if necessary - with professional colleagues.

4. DIVERSITY

The diversity of wildlife enriches our lives in many ways. Most environmental scientists consider wildlife essential to human survival. The amazing diversity of living things - the term biodiversity includes them all - is a resource of great importance.

We can consider diversity at various levels. Some places support more species than others because of a greater diversity of habitats. But some habitats contain more species than others. These differences in *species diversity* are the concern of this section.

Species diversity is an attribute of a community. We can think of a community with many species as being more diverse than one with few. Hence conservationists tend to use diversity as a measure of habitat importance. (However, it does depend upon what the species are: for example, most people would consider an area with a few rare species to be more important than one with lots of common ones, even though the latter might be more diverse).

The number of species in an area is the simplest measure of diversity; it is called species richness and often designated *S*. It provides a convenient means of comparing one area with another; thus Lake Kainji National Park in Nigeria has about 350 bird species, whereas the Parc National du Niokolo-Koba in Senegal has only 330. But such comparisons are only valid if the areas being compared are of similar size; not surprisingly, larger areas tend to support more species (Section 6). In this case, Niokolo-Koba (9100 km^2) is much larger than Lake Kainji (5300 km^2) and hence the latter has the greater species diversity.

There are many more sophisticated methods for assessing diversity; they are reviewed with great clarity in a recent book by Magurran (1988). The ecological significance of species diversity is fully discussed in most standard tests, for example, Begon *et al* (1990).

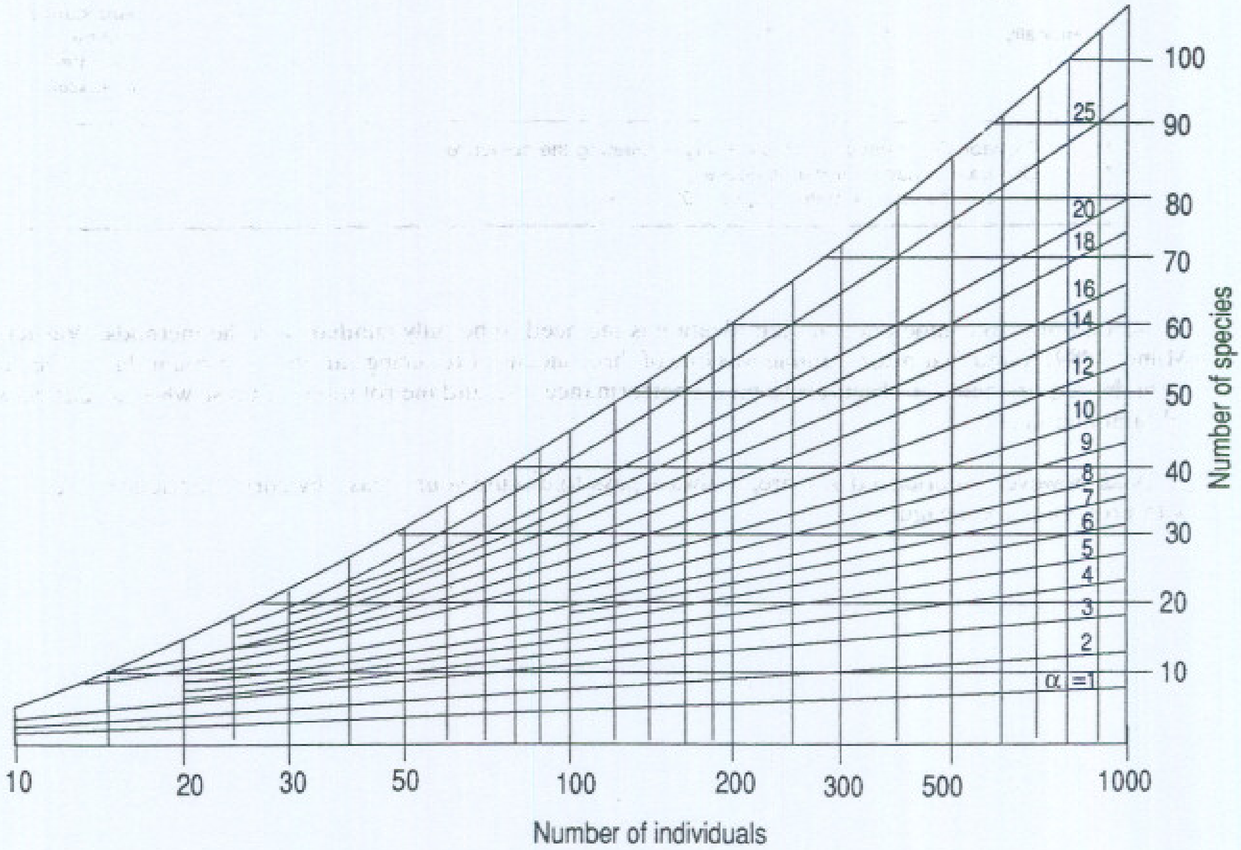


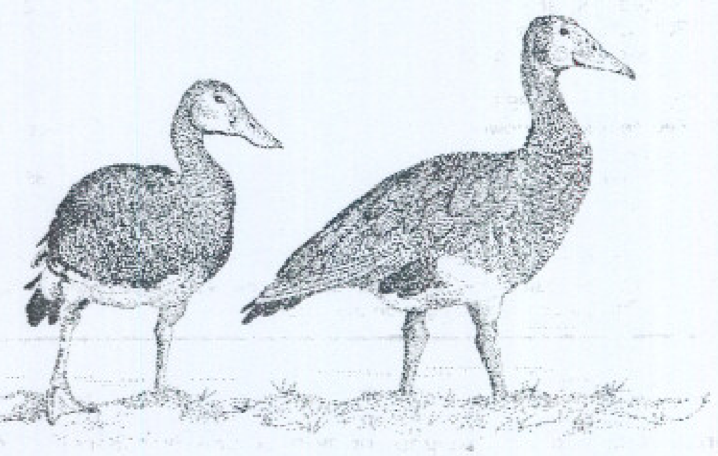
Figure 8. The log-series measure of diversity, alpha (α), can be read from this graph, based upon Lewis and Taylor (1967, page 372). For example, in a count of 120 birds there were 26 species and α = 10. For a count of 52 birds and 12 species, α = 5. It is not advisable to use the graph for counts with few individuals, say less than 20.

Undoubtedly the most widely-used method is the so-called Shannon or Shannon-Wiener index, but Magurran (1988, pp. 77-79) suggests that the less well-known index *alpha* (α) of the log-series is generally to be preferred, because it is better able to discriminate between diversities of sites which are rather similar, although not identical, and it is less affected by the size of the sample. Ideally, when using the Shannon index, samples should be of equal size.

As an index of diversity, *alpha* is fairly difficult to calculate, but for most practical purposes it can be determined with sufficient accuracy simply by reading it from a graph (Figure 8).

The Shannon index requires a simple calculation: you will find a worked example in Appendix 3.

Wherever possible, it is probably better to use S, because of its simplicity; as Verner (1985, p.251) points out, the other indices usually correlate closely with S, which requires no calculation and is easy to interpret. However, if you are comparing places of very different size, then some allowance needs to be made for that (see Section 6).



Spur-winged Geese

5. BIOMASS

Numbers of birds are not a very suitable means for comparing different species, in fact they can be quite misleading: one Ostrich, to take an extreme example, is hardly comparable with one weaver. Large birds typically have larger home ranges than small ones, so they usually occur at lower densities. Yet a bird's impact on its environment (for instance the amount of food it takes) is clearly related to its size. We can take account of this by using biomass instead of numbers when comparing species.

Table 7 gives an example of using transect data to calculate biomass of a savanna bird community in Uganda. The birds have also been arranged into guilds, which are feeding groups where both the food type and the means of capture are taken into account. (For a discussion of feeding guilds and their ecological significance, see for example Begon *et al* (1990)).

Table 7. Estimating biomass from census data, on a transect with an area of 1.06 ha. The example here is based on only five counts but that is sufficient to show the method. The data are from a wooded grassland in Lake Mburo National Park, Uganda. The area is characterised by a rather high diversity but low density of birds. Mean densities were calculated from log-transformed data, as in the example in Table 3. Two species take substantial amounts of both insects and grain and their biomass is allocated equally to both groups.

GUILD and Species	Birds counts					Weight (g)	Mean density (birds ha^{-1})	Biomass (g ha^{-1})	Guild total
	1	2	3	4	5				
FRUGIVORES									
Green Pigeon		2				240	0.23	55	
Bare-faced Go-away-bird			1			250	0.14	35	90
GRANIVORE									
Ring-necked Dove					1	125	0.14	18	106*
NECTIVORE									
Scarlet-chested Sunbird	2			1		10	0.41	4	4
INSECTIVORES									
- FLYCATCHERS									
Paradise Flycatcher	1					15	0.14	2	
Ashy Flycatcher	2					18	0.23	4	
Little Bee-eater					1	14	0.14		28
- GLEANERS									
Black Tit			1			20	0.14	3	
Grey-backed Camaroptera				1		11	0.14	2	
Trilling Cisticola			3		1	15	0.49	7	
Willow Warbler					3	9	0.30	3	15
- PROBER									
Green Wood Hoopoe				1		70	0.14	10	10
- POUNCER									
Striped Kingfisher			2			40	0.23	9	9
- GROUND SEARCHER									
White-browed Scrub Robin	1					18	0.14	3	91*
PROBER/GRANIVORES									
Red-necked Spurfowl	1				2	500	0.30	150	
Ruppell's Long-tailed Glossy Starling +	3					85	0.30	26	
TOTALS	10	2	7	3	8		3.61	333	

* Includes half of the combined value for the two Prober/Granivore species
\+ Only part of its feeding is on the ground.

Sources of data on birds' weights (or more accurately, masses) are given in Appendix 6.

6. BIRD DISTRIBUTIONS

Information on birds' distributions comes naturally from making counts. Conversely, studies whose primary interest is bird distribution sometimes provide numerical data too. In this section, I will review briefly the methods of studying distributions. They can be divided into two categories: smaller and larger. Here, 'smaller' means up to the size of a small country, say 100 000 km^2.

Important to both categories is the method of recording. Some distribution studies,including many atlas projects (Section 6.2) merely list species in certain areas, which can be quite large. However, it is much better for every record of a species to be associated with a reasonably exact location. In the past, names of villages have been widely used, but villages can be difficult to locate on maps, and it is not unusual to find two or more villages in a country, or even the same district, with identical names. Instead, records should use a grid system; either latitude and longitude (if possible, to the nearest 5) or the UTM grid (at least to the level of a 10 km square). Such data can then be entered into a GIS analysis ((UTM = Universal Transverse Mercator; GIS = Geographic Information System). These analyses are used more and more widely to relate bird distributions to such features as vegetation, soils and climate. (For an African example, see Miller *et al* 1989). However, even data on larger grids can give useful patterns when analysed in relation to climate and altitude (see, for example, Pomeroy, 1989).

Because larger areas usually support more kinds of birds than smaller ones, the size of an area has to be taken into account when comparing species numbers. Figure 9 shows a generalised species-area curve based upon data from the Afrotropical Region. Species-area curves are a basic feature of island biogeography, as described by MacArthur and Wilson (1967) and many later authors. Their importance in such fields as the design of systems of protected areas (such as national parks) is discussed by several authors in *Conservation Biology* (edited by Soule, 1988). Examples of their use for comparing different countries in Africa are given by Pomeroy and Lewis (1987) whilst Dranzoa and Pomeroy (in stet) use species-area curves in discussing the conservation of forest birds.

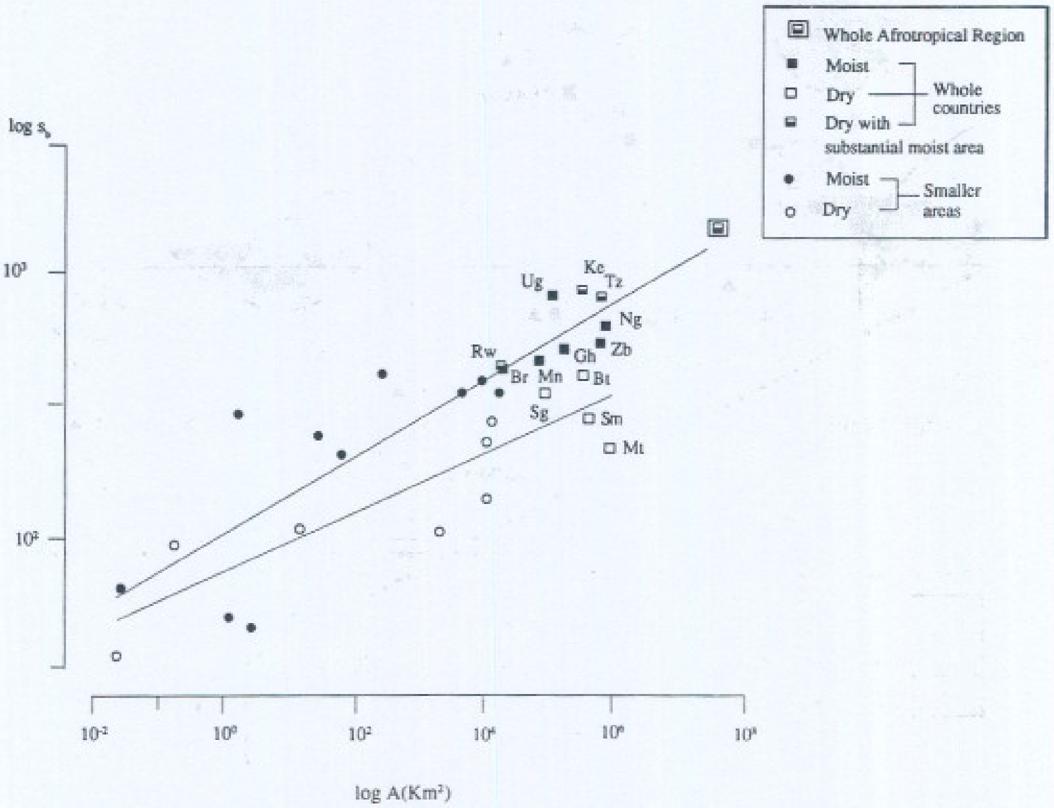


Figure 9. *Numbers of bird species recorded as breeding in various Afrotropical countries, as indicated by letters, and in some smaller areas, such as national parks. Moist countries - those with more than 800 mm of rain a year, on average - have more species than drier countries. The countries shown are Burundi (Br), Botswana (Bt), Ghana (Gh), Kenya (Ke), Malawi (Mw), Mauritania (Mt), Nigeria (Ng), Rwanda (Rw), Senegambia (Sg), Somalia (Sm), Tanzania (Tz), Uganda (Ug) and Zambia (Zb). Re-drawn from Pomeroy and Lewis (1987).*

6.1 Smaller areas

Examples of studies in this category are the distribution of pest species in an agricultural area, or the distribution of major species within a national park. Both of these examples involve a restricted number of species but some studies consider all species in a particular area.

TSCs (Section 3.1) were developed for this kind of survey. In one study in southern Kenya, 16 sites were selected within an area of about 40 000 km^2, such that they included all of the major natural habitats to be found there (Pomeroy & Tengecho, unpublished data). Although the whole area could be described broadly as 'savanna', one striking conclusion was that very few species occurred throughout the area, most having very local, patchy distributions (Figure 10). Similar results are likely elsewhere. This emphasises the need to have many sampling sites, for when they are few it is possible for a species to be missed completely, even though it might be locally abundant.

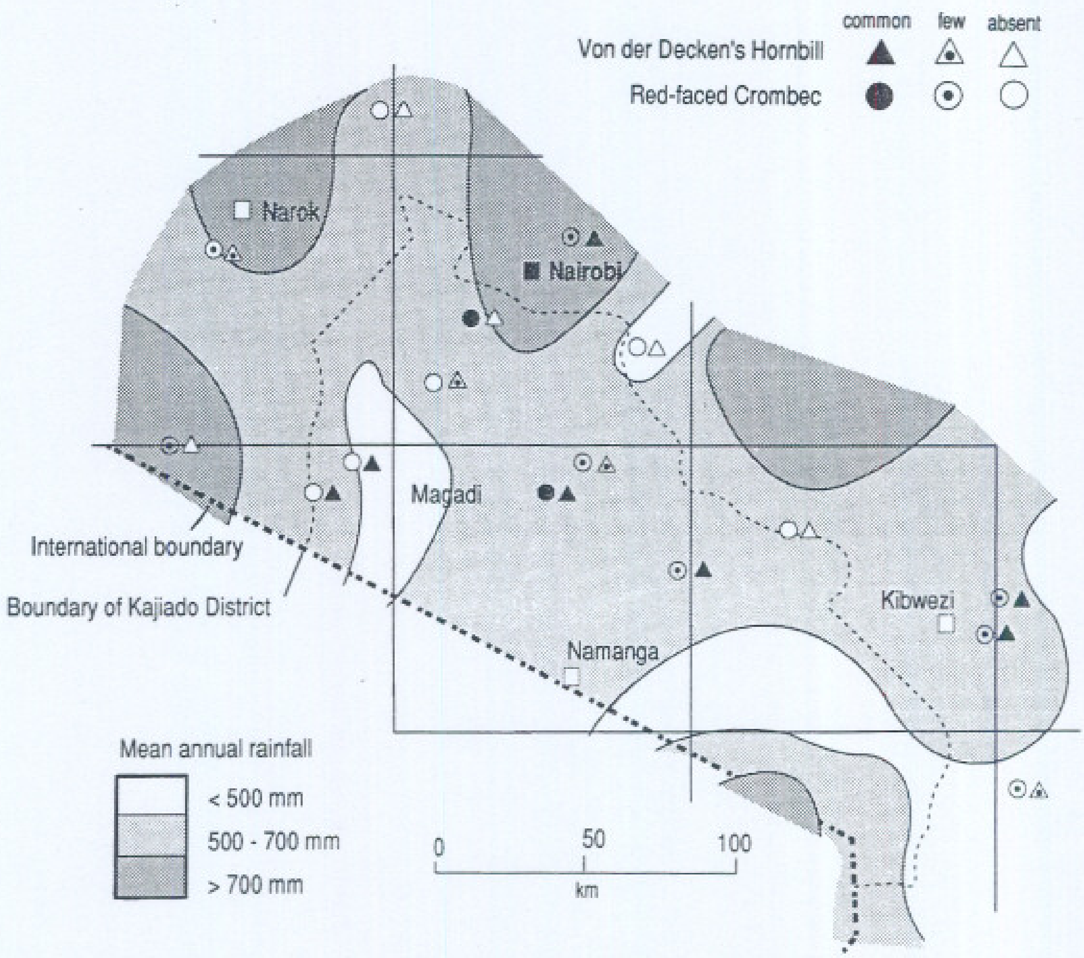


Figure 10. *Recorded distributions of two species - chosen more-or-less at random from the commoner birds of southern Kenya. The hornbill, a very conspicuous bird, was recorded from only ten of the 16 study sites. The crombec, a small warbler, was also found in only ten of the sites, but although both species require trees, the crombec was sometimes common where the hornbill was absent, and vice-versa. Such patterns are hard to explain.*

The distributions of rare species are of special concern to conservationists, who are increasingly having to advise on which of two or more areas are of most significance for conservation. Here, it is sometimes useful to give each species a weighting, high for the most endangered species and lower for those which are simply rare. A fuller discussion of this approach is given in Appendix 7.

Lists of course are never complete. 'New' species can almost always be added if one searches hard enough. It is possible to use a limited set of data to predict the number of species which would ultimately be recorded (Pomeroy & Tengecho, 1986a). However, one can only guess as to *which* the additional species would be.

6.2 Larger areas

The broad distibutions of species within a country, or even a biogeographical region, are most often represented as distribution maps. Some of these are seen in the standard textbooks, such as *The Birds of Africa* (Brown *et al*, 1982 onwards). However, what most of these maps really show is the species' range, that is, the limits of its distribution.

A more detailed approach is to map the distribution on a grid system, as in Figure 11. A series of these maps, usually one for each species (except perhaps the rarest) is called an *atlas*. Several atlases have been published for African birds, for instance Sudan (Nikolaus, 1987), Kenya (Lewis & Pomeroy, 1989) and Natal (Cyrus & Robson, 1980). By the mid 1990s, atlases, or at least atlas databases, will exist for about half of the countries in the Afrotropical Region (Skinner & Pomeroy, 1991).

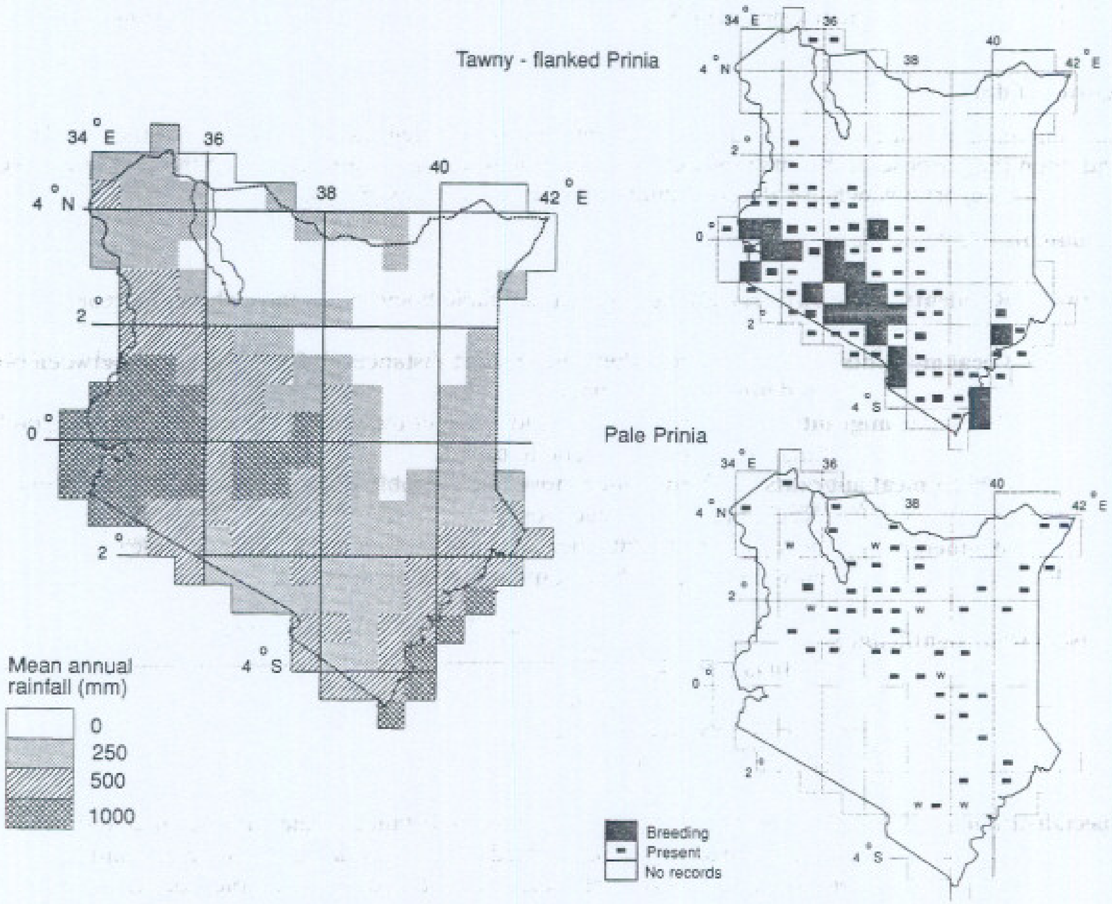


Figure 11. The distributions in Kenya of two widespread species, as shown by atlas mapping. Comparison with the rainfall map suggests that the Tawny-flanked Prinia - a species which occurs widely in Africa - is a bird of higher rainfall areas, more than 80% of the records referring to places with at least 500 mm of rain a year. In contrast, the Pale Prinia, a bird of north-eastern Africa, is largely confined to places receiving less than 500 mm a year. The lack of breeding records of the Pale Prinia is a revealing example of observer bias: there are far fewer bird watchers in dry areas! (Adapted from Lewis and Pomeroy, 1989).

7. ANALYSIS AND PRESENTATION OF DATA

It is a sad fact that many projects generate good data which never see the light of day because they were not properly analysed, or not published (and for all practical purposes, theses are not publications, since they are usually unobtainable).

For research to be worth publishing, the data need to have come from a well-planned project, they need to be properly analysed and presented, and they also need to be of sufficient quantity and quality to lead to clear conclusions. The first and last of these will normally follow from good planning. For instance, if you plan to relate bird numbers tovarious environmental variables, such as vegetation cover and diversity, as well as rainfall and temperature data, you will need multivariate analyses. This in turn will usually require you to have access to a computer with suitable programs. If you will be unable to do these analyses, it may be better to reduce the number of variables you record and to use more time for counting birds, especially since habitat variables are not easy to measure (see Appendix 2). The essential point is that all decisions should be carefully thought out first.

Analysis

Only in a few cases is it sufficient simply to present a table or a graph, with no further analysis. More often, you will want to make comparisons, identify trends, or seek other insights into the significance of your data. Luckily, there are several good textbooks to help. Two of them are specifically for ornithologists. The more useful, because it gives very clear examples, many based on counts of birds, is Fowler and Cohen (1988). The other, more advanced book is Morgan and North (1985). Several of the basic statistical books for biologists are useful too; amongst these, Clarke (1980) and Parker (1979) can be recommended, whilst Snedecor and Cochran (1967) is a valuable reference for the trickier details.

Categories of data

In analysing data, it is often useful to divide birds into different categories. The choice of these will of course depend upon the purpose of the analysis, but to enable you to compare your data with those of other people, it is best to use categories which are already familiar. Here are some examples.

1. **Taxonomic,** e.g. family, genus

2. **Status** - **Residents** - birds remaining within a definable home range throughout the year

   - **Local migrants** - birds which move short distances (a few kilometres) between breeding and non-breeding places.
   - **Palearctic migrants** - birds which spend much of the year in the Afrotropical Region but migrate to the Palearctic to breed.
   - **Afrotropical migrants** - birds which move considerable distances within the Afrotropical Region (e g, many cuckoos).
   - **Wanderers** - birds which inhabit drier areas; they often make unpredictable movements, usually in response to rain, or its lack.

3. **Conservation significance**
   - Red Data Book species
   - species of regional concern
   - species of national concern
   - species of local concern

4. **Specialisation** Two categories are of particular importance, namely forest birds and wetland birds.In each case, birds can be divided into *specialist s* and *non-specialists*. With respect to forest birds, for example, specialists are rarely if ever found away from the forest interior; non-specialists often occur in forests but are not confined to them. The former group are almost certain to become locally extinct if an area is deforested. In the same way, wetland specialists became locally extinct if a wetland is drained.

5. Feeding guilds *Commonly used categories include:*

- Herbivores
- frugivores
- granivores
- nectivores

- Carnivores
- piscivores
- birds (mainly raptors) taking other vertebrate prey
- insectivores (the term being loosely used to cover most invertebrates).

Common subdivisions here (based mainly on Thiollay (1988)) are :

- gleaners, which search eg, leaves at close range
- probers, searching bark or litter
- strikers, where the bird flies to take prey from a substrate without landing
- flycatching, orsallying, the prey being taken in flight

Table 7 (Section 5) uses a slightly different version. Substrates can be classified too, for instance by height above ground, whether trunk, twigs, leaf or flower, etc.

Presentation

If you have good data, it is important to present them well. This means careful organisation so that results are presented in a logical sequence. It also means paying attention to grammar and style. Day (1989) has useful advice on such matters.

Publication

If you feel that you have material suitable for publication in a scientific journal, your manuscript must follow closely the style of the journal of your choice. If you write to the editor, s/he will send you a copy of the 'Advice to authors'. Names and addresses of several journals which publish papers on African birds are given in Appendix 4.

It is of course necessary to refer to 'the literature' - meaning the relevant publications of other researchers. Many of us are unable to visit good libraries very often, if at all. For ornithologists, the single most useful publication is *Recent Ornithological Literature*, which comes free with *Ibis* (see Appendix 4, British Ornithologists' Union) - so persuade your librarian to subscribe. The abstracts in this publication give authors' addresses, so that you can write to them and request reprints of the articles you need.

However experienced you are, it is a good idea to have several people read and comment on your drafts. You should include somebody who has already published a number of scientific articles in recognised journals. Make sure that your final draft is free from typographical errors, that references are all present in the correct format, and that captions to tables and figures are self-explanatory (again, see Day (1989)).

Despite working very hard to prepare a good manuscript, you will probably be asked to make some revisions before it is published. Worse, the editor may reject your paper completely! This sometimes happens toeven the most experienced authors. Take careful note of the editor's comments, revise your paper along the lines required by a different journal, and submit it there.

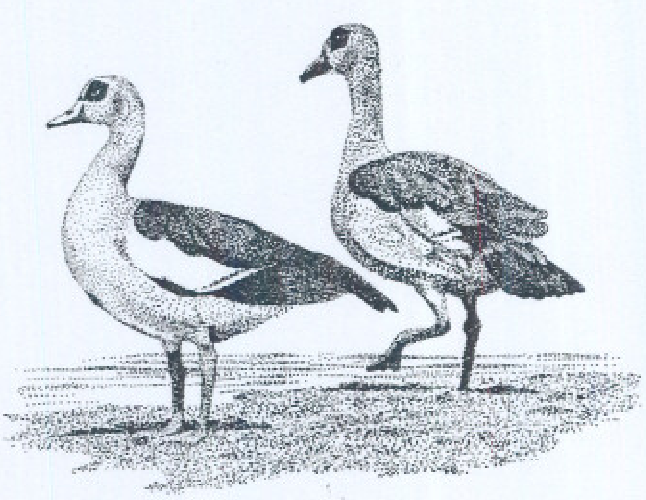
8. A FINAL WORD

Counting birds is often hard work, requiring one to go to remote and difficult places, to be up before dawn and generally to be rather anti-social for days or even weeks at a time. However, it can also be fun and the dedicated researcher finds that the work brings its own rewards. There can be much satisfaction in making new discoveries, properly documenting needed information, and contributing to a worthwhile enterprise - conservation, for example.

It is always good to share the results of your labours with others. When you publish a paper, send reprints to people you think will find them useful and interesting. In return, most authors will be willing to send reprints to you, especially if asked by letter.

Should your project have interest to conservationists, you can keep in touch with international activities through the International Council for Bird Preservation (ICBP) (their address is in Appendix 4): they have representatives in most parts of Africa. In addition, ICBP co-ordinates a number of specialist groups, for instance on bustards, on cranes, on flamingoes and on storks, ibises and spoonbills.

Sharing information and ideas is vital to research. African ornithologists get together to do this every four years, the next Pan African Ornithological Congress (PAOC) being due in October 1992. There is a standing committee, the PAOCC, whose Chairman can give information about future congresses. His address is given in Appendix 4. Finding the funds to attend a PAOC is not always easy, but the effort is very worthwhile.



Egyptian Geese

APPENDIX 1 : IDENTIFICATION

Identification is probably the most challenging aspect of field work with birds. It can be difficult, which is why it is not at the beginning of the book - we did not want to put you off! For, whilst Africa is fortunate in having such a diversity of birds, it has to be admitted that some of them are quite hard to identify, especially in the field. But it can be done, and gradually the number of competent observers is increasing.

If you are intending to work with species which are likely to be difficult, such as weavers or waders or forest birds, it really is important to have a preliminary period of field work in which you get to know them well, before starting serious counting. This preliminary period is necessary for other reasons too - becoming familiar with all the habitats within the study area, learning important aspects of the vegetation, trying out different methods of counting, developing draft recording forms, and so on.

Some studies, even though intending to cover all species, can be simplified by grouping the more difficult ones, eg, *Ploceus* spp, sunbird spp. Only in biodiversity studies does this seriously reduce the value of the data, and it can help you a great deal when getting started. Furthermore, even the most competent observers still need these categories for birds that are not well seen. One or two examples are included in Tables 1 and 4.

It is very difficult to teach oneself to identify birds; by far the best way of starting is to spend as much time as possible in the field with somebody who is more experienced. Some local natural history societies arrange regular field trips. When you reach the point of being fairly sure of the family of all the birds you see, and the genus of most of them, then you can begin to teach yourself the species, because you now know enough to be able to use the identification books effectively. These are the most important tool for identification. Remember that in most species there are two or more plumages; males can differ from females, and both from young birds. And it is surprising how many people think that young birds, even after leaving the nest, are smaller than the adults! - although this is true in the nidifugous species (such as cranes, guineafowls and plovers).

Whenever you see a bird which you cannot immediately identify, the most important first step is to write a description of the chief features, and to indicate the distribution of colours - and such things as long tail feathers or a curved beak - on a sketch as in Figure 12a. Such field notes are often invaluable to refer to later. If you feel inadequate as an artist, simply make a few copies of Figure 12b and carry them on your clipboard whenever you go to the field. Then you just have to add the key points of the particular bird you are describing.

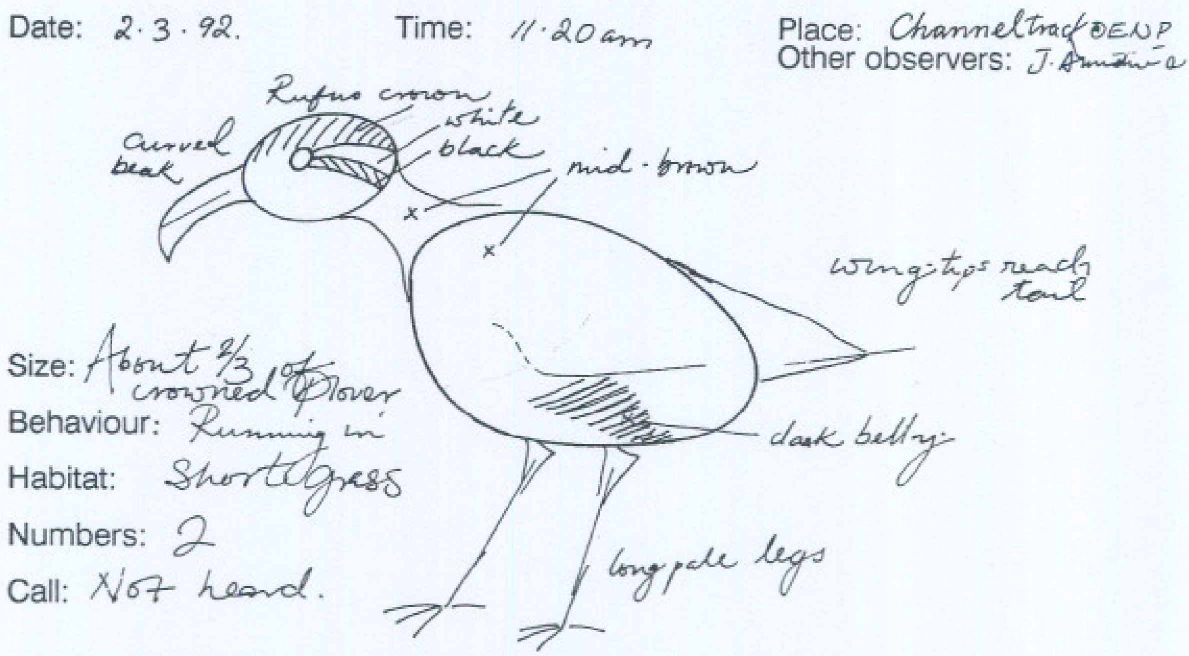
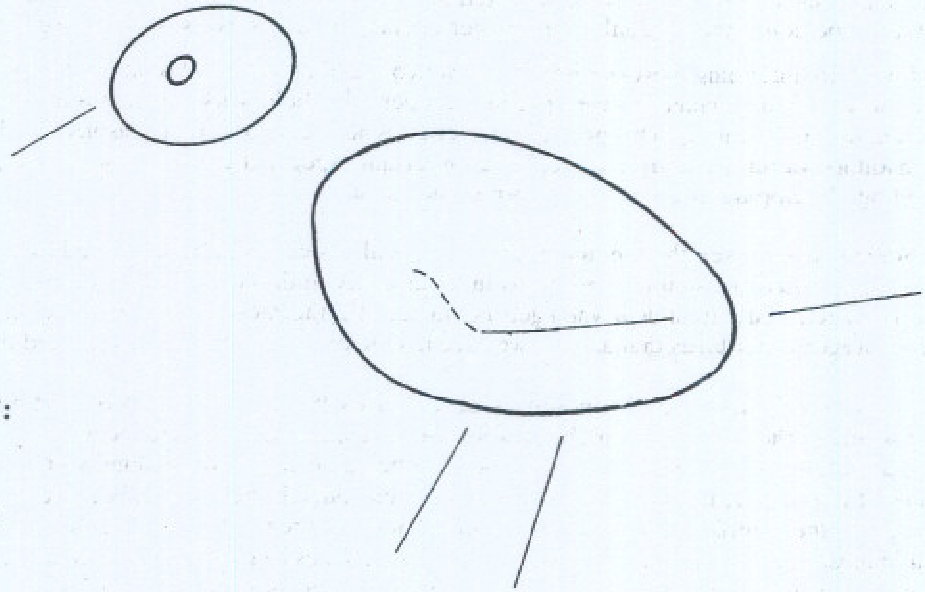


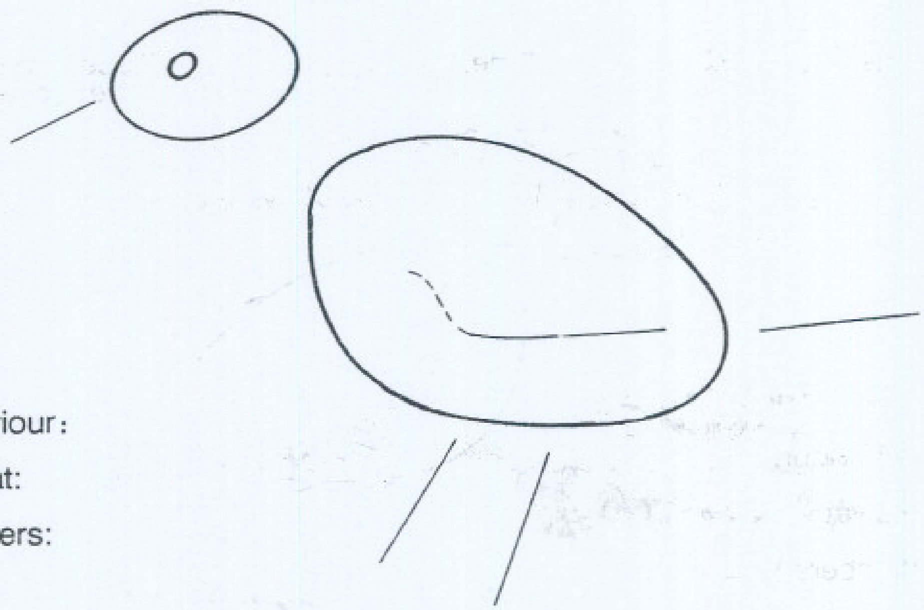
***Figure 12a**. An example of a field sketch. The bird here turned out to be Temminck's Courser (which is widely distributed in Africa).*

Date: Time: Place:
Other observers:



Size:
Behaviour:
Habitat:
Numbers:
Call:

Date: Time: Place:
Other observers:



Size:
Behaviour:
Habitat:
Numbers:
Call:

***Figure 12b**. Field sketch outlines.*

Whether or not you use the outlines in Figure 12, you should also record the bird's size, which is best done by comparison with a nearby individual of a known species. Other things which often assist the identification process are the bird's behaviour, calls and habitat. Try to be as precise as possible in recording them.

Books

Field Guides

A few books cover all of the birds of Africa, but others are primarily regional. All of the African Field Guides belong to the latter category and the most appropriate for each region are to be found in Appendix 8. Pictures in Field Guides are always the first place to look, but beware! Invariably, some of the pictures are better than others and the less good ones can be very misleading. Even when there is a picture resembling 'your' bird, it is essential to check the text too. The majority of Field Guides only illustrate some of the birds. The text will at least *mention* any which are not described, and you may need to check the descriptions of those too.

It is especially important to check on the distribution of an unfamiliar species. For instance, if you are in southern Nigeria and the text says 'semi-arid areas of north-eastern Africa', you have either found something really unusual or you have made a mistake. Sadly, the latter is much more likely! If there is a national check-list for your country, that too can be useful in helping to decide what is possible.

Because most African Field Guides concentrate on the more common species, it is helpful to have both the local guide and one intended for the Palearctic Region: descriptions of Palearctic migrants are brief or missing in many regional guides. Appendix 8 includes some suggestions.

Reference books

Field Guides can - and should - be carried in the field. When, after consulting one, you are still unhappy about an identification, the major reference books are likely to resolve the problem. They are expensive, but they are also an essential back-up to any project involving more than just a few species. As well as describing birds in considerably greater detail than the field guides, these books contain much more information on such topics as distribution, breeding, other aspects of behaviour, and food. The best of them summarise everything that is known about a species, and give you further references should you need to know even more.

The Birds of Africa (see Appendix 8 for details) is fast becoming the major reference book for the Afrotropical region. It will eventually consist of six or seven volumes, and is an essential reference for major research libraries. Other important books are also listed in Appendix 8.

Skins

As books become more and better, the need to refer to specimens in museums has decreased. Nevertheless, it can often be useful to look at skins, especially of 'difficult' species, such as cisticolas and greenbuls. Further, reference collections remain essential for taxonomic studies. There are particularly large collections of skins of Afrotropical birds in the museums in Pretoria, Bulawayo and Nairobi; and also in London (the Natural History Museum), Chicago (Field Museum) and Brussels.

Sounds

The more readily-available sound recordings of African birds are listed in Appendix 5. These are particularly useful for forest birds.

Records of unusual birds

There are plenty of opportunities for adding to the knowledge of African birds. So if you see a species which is new for your area, or in unusual numbers, or doing something especially interesting, your record should be sent to a suitable journal (see Appendix 4). If your record is of something rare for your area, then the editor will expect you to include a copy of your field notes, together with the names of any other experienced observers who also saw it and the features which make you feel sure of your identification. In this way, the risk of including records which are less than certain is avoided. Most journals have a panel of experts to help the editor to assess new records.

APPENDIX 2 : ENVIRONMENTAL VARIABLES AND SITE DESCRIPTIONS

Almost all studies on the numbers and distributions of birds require some additional information: for example, aspects of the weather and the vegetation. This calls for just as careful planning as the counting itself. To be useful, it also has to be done well. Block *et al* (1987) found striking differences between observers recording a variety of habitat characteristics, such as vegetation, despite their having been trained. So it is probably better to measure rather than estimate such things as percentage cover; even then, a large number of data points is needed.

Weather

Most people record the more obvious features of the weather in their field notes. But if you ask them why, their answers are usually rather vague! So before starting field work on any project, consider which aspects of the weather are likely to be the most important. For instance, vultures are much more likely to be seen soaring on a hot, sunny day than a cool, cloudy one. So in this case a simple measure of cloud cover (eg , 0 = no cloud,10 = complete cloud cover) would be appropriate. But remember that the more data you collect, the more time it will take to analyse them. On the other hand, it is not helpful to realise, towards the end of a project, that you should have recorded the temperature and cloud cover from the beginning, but had forgotten to do so.

Give careful consideration to how you are going to use your data when planning the methods to be used. Do you need daily rainfall, or will monthly totals suffice? Winds can be important to migrants but instead of buying expensive anemometers, it will usually be sufficient to record wind strength on a 5-point scale (0 = no wind . . . 5 = gale), together with an indication of direction (N, NE, E . .). Temperature and day length are not always important to birds; but when they are, simple measurements are often all that are needed.

Other environmental variables

These depend very much upon the project you are doing; if your study area is subject to such things as floods, over-grazing, fire and human disturbance, then consider whether or not it is relevant to record them, and on what scale.

Site descriptions

Studies of Afrotropical birds provide little guidance on the best ways of making site descriptions. Obviously one needs to record the geographical locations of study sites, preferably on a map, and their size. Altitude, mean annual rainfall and its seasonality should be noted. It is useful to indicate the natural vegetation of the area, perhaps mentioning the commonest ('dominant') or most characteristic plant species, particularly trees, and the extent to which the natural vegetation has been changed by fire, cultivation or other human activities. When visiting several sites, the recording of key features can be standardised by designing a simple form.

The selection of habitat variables to be measured is more difficult. The purpose of measurement is usually to enable testing of correlations between bird numbers, or species composition, and habitat variables. But most of these variables are difficult to measure accurately and the most significant differences can sometimes be those between observers! (eg, Block *et al*, 1987). For example Maurer (1986) found very few correlations between bird numbers and a whole series of site variables in a grassland study.

Nevertheless, a few variables have been found useful. In eastern Africa, bird numbers in natural vegetation are closely correlated to rainfall and to the amount of woody vegetation - trees and shrubs (Pomeroy, 1991). In this case, woody vegetation was recorded in four layers, by height : 0-1, 1-3, 3-8 and >8 m. In each layer, the % cover of woody plants (irrespective of species) was estimated by eye, following a simple procedure. At each site, at least five points were selected at random. At each point, the % cover of woody vegetation within a circle of radius 10 m was estimated for each layer by imaginarily dividing the circle into four equal segments, with the observer at the centre. These were each scored out of 25 and then totalled. It is fairly easy to see whether a shrub, for example, extends over a fifth or a half or whatever of the segment (cover is taken to extend to the tips of the shoots in any particular layer, as shown in Figure 13).

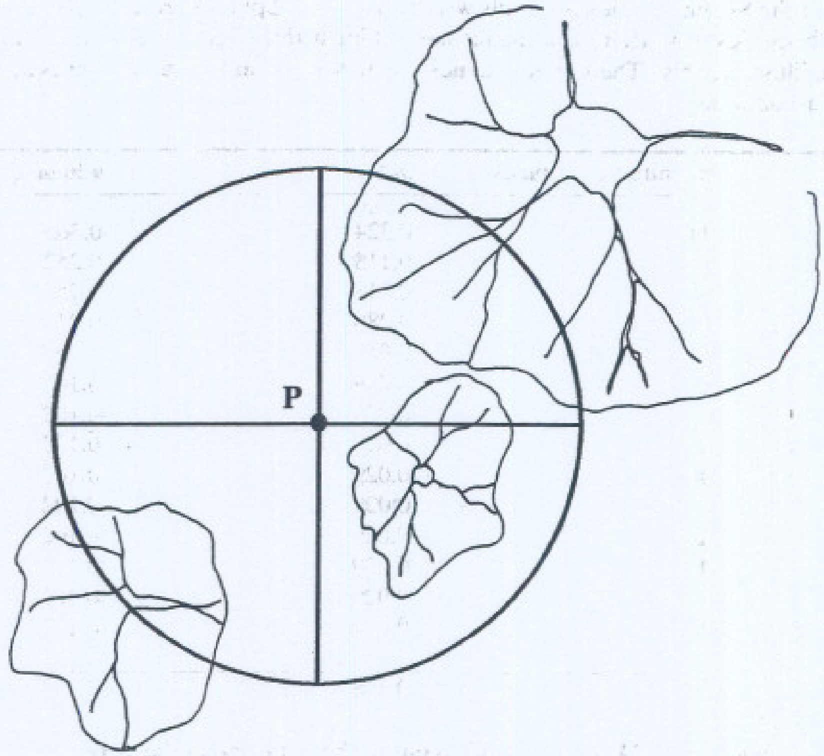


Figure 13. *Estimating % cover of woody vegetation. One of a series of random points in the habitat is P, where the observer stands. In one particular layer, say 1-3 m, there are three bushes, as shown, within a 10 m radius. By eye, the observer estimates the % cover in each of four imaginary quadrats, each out of 25, as 15, 10, 10 and 0 respectively (clockwise from top right). He therefore estimates the cover for point P as 35% (actually it is 36%).*

Heights are easily estimated by standing an assistant at a convenient place. If he is 170 cm tall, then 1 m is waist height, 3 m is just less than twice his height and 8 m is nearly 5 times his height. The total woody vegetation is the sum of the four layers. Since each could theoretically have 100% cover, the maximum possible score is 400 but even in a forest scores rarely exceed 250.

In non-natural habitats, bird numbers tend to be affected differently, being fewer in habitats with high scores for woody vegetation (eg, a *Eucalyptus* plantation) and high in mixed farming areas with only a few trees. Sadly, whilst cultivations often have many birds, species are relatively few and the diversity is consequently low.

The amount of woody vegetation in each layer can also be used to calculate Foliage Height Diversity (FHD - see Appendix 3).

In aquatic habitats, other variables are important. The International Waterfowl and Wetlands Research Bureau (Appendix 4) are developing a system for classifying African wetlands, which should be available by 1992.

Key wetland factors include the size of the area or its main parts; the extent of open water, floating vegetation, rooted vegetation and exposed mud or sand; the depth, if less than about 10 m, the salinity or alkalinity, if the water is not fresh; exposure to wind; and breeding sites, such as rocky islands, steep banks or tall trees near the water's edge. In wetlands, as on land, the extent and nature of human disturbance can be important.

APPENDIX 3 : CALCULATION OF DIVERSITY INDICES

The most widely used diversity index for birds is that of Shannon (which was independently derived by Wiener and can therefore be called the Shannon-Wiener index. The term Shannon-Weaver is incorrect; see Magurran, 1988).

The formula for the Shannon index is usually written as $H' = -\Sigma pi \ln pi$, H' being the index. The proportion of birds in the *i* th species is written *pi*; *ln* means natural logarithms and Σ means the sum of. We can use the data in Table 4 to illustrate this. The species' names are no longer important; the birds are now arranged from the most to the least abundant.

	n = number of birds	*pi**	*pi* ln *pi*
	11	0.324	-0.365
	4	0.118	-0.252
	4	0.118	-0.252
	3	0.088	-0.213
	2	0.059	-0.167
	2	0.059	-0.167
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
	1	0.029	-0.102
Totals	34	0.998	-2.232

**pi* for the first species = 11/34 = 0.324, and so on, so the total should be 1.000.

Since *pi* ln *pi* = -2.232, then $H' = 2.232$. This is a fairly typical figure, most values lying between 1 and 3. The corresponding log series value (Section 4, Figure 8) is = 9.

The Shannon index can also be used to calculate Foliage Height Diversity (FHD). For data based upon four layers (Appendix 2), we might for example have:

Height (m)	%cover of woody vegetation	*pi*	*pi* ln *pi*
0-1	25	0.152	-0.287
1-3	50	0.303	-0.362
3-8	70	0.424	-0.364
>8	20	0.121	-0.255
Totals	165	1.000	-1.268

Hence $H' = 1.268$. MacArthur and MacArthur (1961), using only three layers (approximately 0 - 0.7, 0,7 - 8 and >8 m) found FHD values mainly around or below 1.0, which correlated well with bird species diversity. Many subsequent researchers have followed their methods.

Of course, diversity estimates are normally based upon series of counts, not single ones as used here for illustration.

APPENDIX 4 : ORGANISATIONS

The addresses here include organisations which may be consulted for assistance on particular problems (A), those which publish journals (J), in which case the address is that of the editor, and those which organise local activities, such as field trips. The names of all but a few indicate their geographical coverage. Addresses of organisations handling sound recordings are given in Appendix 5.

J British Ornithologists' Union, publishes *Ibis* which covers all of Africa and elsewhere. Editor: Dr P J Jones, Dept of Forestry and Natural Resources, The King's Buildings, Edinburgh EH9 3JU, Scotland.

J *Bird Census News*, worldwide. Editor: Rob G Bijlsma, c/o SOVON, Postbox 81, 6573 ZH Beek, Holland.

J *Tauraco*, a journal of Afrotropical ornithology. Editor: R J Dowsett, Rue de Bois de Breux 194, B-4020 Jupille-Liege, Belgium. This is a comparatively new journal; write to the editor before sending a manuscript.

A African bird atlases: Dr Neville Skinner, 60 Gunton Drive, Lowestoft, Suffolk NR32 4QB, England.

A ICBP (International Council for Bird Preservation) 32 Cambridge Road, Girton, Cambridge CB3 OPJ, England.

A IWRB (International Waterfowl and Wetlands Research Bureau) for information on waterbird counts: Slimbridge, Gloucester GL2 7BX, England.

A BTO (British Trust for Ornithology) for advice and publications relating to catching and ringing birds: The Nunnery, Nunnery Place, Thetford, Norfolk IP24 2PU, England.

J West African Ornithological Society. Editor of *Malimbus*: Dr H Q P Crick, c/o BTO (see above).

J East African Natural History Society. Editor of *Scopus*: G C Backhurst, P O Box 24702, Nairobi, Kenya.

Zambian Ornithological Society. Chairman: D R Aspinall, P O Box 33944, Lusaka, Zambia.

J Ornithological Association of Zimbabwe: Editor of *Honey-guide*: M P S Irwin, 3 Whitecairns Avenue, Hillside, Bulawayo, Zimbabwe. Namibia Bird Club. Secretary P O Box 67, Windhoek 9000, Namibia.

J Botswana Bird Club. Editor of *Babbler*: Mrs W Borello, P O Box 71, Gabarone, Botswana.

J South African Ornithological Society. Editor of *Ostrich*: Dr A J F K Craig, Dept of Zoology, Rhodes University, Grahamstown 6140, South Africa.

J Ornithological Society of the Middle East: the area covered includes Libya, Egypt, Sudan and Ethiopia: Editor of *Sandgrouse*: c/o RSPB, The Lodge, Sandy, Beds SG19 2DL, England.

Pan African Ornithological Congress Committee: Chair, Professor L Short, Department of Ornithology, National Museum, P O Box 40658, Nairobi, Kenya.

APPENDIX 5 : FIELD EQUIPMENT

Binoculars and telescopes

Serious birdwatchers always own their own binoculars - borrowing somebody else's or having to make do with an institutional pair leaves much to be desired. So it is worth making every effort to acquire your own, or at least to have exclusive use of a particular pair. Having acquired them, you should treat your binoculars with a great deal of respect, keeping them dry and away from dust, dirt and grease. Severe knocks are bad for them too, sometimes causing a displaced prism - noticeable as a 'double image' - which can cause severe eye strain, greatly reduces their use and is costly to repair.

Choice of models

Binoculars with a magnification of 8, 9 or 10 times are the most widely-used. Modern binoculars almost invariably have relatively large object lenses (the "40" in "8 x 40" for example is the object lens diameter in millimetres). This allows through a good amount of light and gives a wide field of view. Since many people wear spectacles, binoculars usually have rubber eyecaps to keep the binocular and spectacle lenses apart.

There is not a great deal to choose between binoculars with a magnification of 8 or 10: the higher power is most useful in open areas, such as savannas and lakes, whereas the rather wider field of view of most x8 binoculars is an advantage in confined habitats such as woodlands and forests.

The major factor, of course, is price. Many professionals use Zeiss 10 x 40 B roof-prism binoculars which are robust and optically superb. But they cost around $800. These and some cheaper models are encased in rubber, which reduces the risks of damage from accidental knocks. There are many smaller binoculars, especially in the 8x40 range, and most of the better-known makes such as Optolyth, Swift, Kowa and Minolta are good value for money at prices which are usually around $100 to $200.

Much smaller binoculars, popularly known as "mini-bins", are very convenient for slipping into a pocket but they are much less robust than "standard" binoculars. In a catalogue they can easily be detected by the small size of the object lens - 8 x 20 and 10 x 25 are typical varieties. Although often good optically, they are not really suitable for extensive field work.

Telescopes are only needed in special situations, usually in open areas where birds can be seen from a considerable distance. Counts of waterbirds on lakes and estuaries are instances of where a telescope is almost essential. A telescope also allows you to see such details as food items being brought to a far-off nest, or feather patterns in raptors soaring in the distance.

Modern telescopes, such as the Bausch and Lomb Elite, have object lenses of 50-60 mm and a variable (zoom) magnification (typically x 15 to x 60). Their weight, bulk and high magnification make the use of a tripod essential: the combination of tripod and telescope is likely to cost $500 to $800.

Using binoculars and telescopes

Seeing the bird through binoculars takes experience but is quickly learnt. Lining-up a telescope can be done quite well by looking along the tube with the naked eye. Provided that the telescope is mounted on a good tripod with pan-and-tilt head it will stay where you put it whilst you look through. Always take care to adjust binoculars carefully if you want to get the clearest picture. The centre hinge allows you to adjust for the distance between your eyes; there is an individual focus for one eyepiece because some people have one eye with slightly long or short-sight. These two adjustments need checking only occasionally whereas the centre forcus needs continual use.

The best protection for binoculars is always to have the strap around your neck: then they cannot drop in the mud and knocking is much less likely. When in a vehicle, especially on rough roads, always give your binoculars (or telescopes or cameras) a comfortable ride, for instance by keeping them on your lap or at least on a seat secured against falling if the vehicle brakes sharply.

Care of optical equipment

Binoculars and telescopes, like cameras, should always be kept away from damp and dirty places when not in use. I keep mine in an air-tight wooden box with a jar of silica gel which is changed whenever necessary. The same box is used for storing photographic films. Lockable cupboards can often be adapted for the purpose.

If you take good care of your equipment in the field it will rarely require cleaning. Occasionally however the lenses especially will have to be cleaned. Scratching a lens reduces the sharpness of what you see so it is very important to start by removing any grit or other scratchy particles very carefully with, for example, the corner of a clean handkerchief or a lens brush. After that, unused lens tissues clean the lenses well, aided by first breathing gently onto them. If you do not have lens tissues, use good quality toilet paper. Only if there is any grease, for instance on eyepieces from your eyelashes, should a very small drop of alcohol be added to the tissue

Repairing optical equipment requires skill and the proper tools. Always seek advice from reliable dealers as to who is competent to undertake even minor repairs. Major repairs can cost more than the equipment is worth but will never be necessary if you are always careful.

Sound records and recording

There are several ways of learning bird calls. The most obvious, and really the best, is to identify a bird by seeing it clearly whilst it is actually calling (for simplicity, 'calls' include song and even non-vocal sounds which birds make when communicating to each other). But very frequently the bird can be heard but not seen. Here, learning from a more experienced observer is very useful.

Learning is greatly helped by using a portable machine to record calls as they are heard. The recordings can be used in several ways. Replaying them several times impresses the calls upon the memory and playing them to an expert may enable him to identity the birds for you. Alternatively, you can compare your recordings with commercially-available records or cassettes (see below). Finally, playing back a recording immediately after making it sometimes draws the bird out into the open, presumably thinking that a rival has come, and this enables you to see it.

All field recordings which you may want to keep should include, in voice, such reference information as a serial number, the date, place, habitat and so forth. Alternatively, simply speak the serial number and record everything else in a permanent notebook.

Portable recorders

There are several things to bear in mind when selecting a portable tape recorder for use in the field. The most important are:

- the volume control should be manual, not automatic
- there should be a good case with a shoulder strap for easy carrying
- the controls should be readily accessible when the recorder is slung from the shoulder
- there should be a socket for connecting a good microphone (built-in mikes are not very suitable)
- a built-in loudspeaker is needed for field use
- dolby and other noise reduction systems are not recommended for bird calls
- the machine should not be heavy and batteries should be of a type that is readily available.

Models which meet these criteria and produce good results in the field include the Sony Professional Walkman WM-D6C. Slightly better results may be achieved with the more expensive Sony TC-D5 PROII or Marantz CP 430.

Commercial recordings

There are numerous sound recordings of African birds but not many are available commercially. A useful list of those which can be obtained is given in Volume 3 of the *Birds of Africa* (1988, edited by C H Fry, S Keith and E K Urban) - pages 587-589. The list indicates the types of calls included, whether they are tapes or record discs, and addresses which you can write to for further information, including purchase. Of particular note are the following:

Keith, G S and Gunn, WWH (1971) *Birds of the African rain forests.* American Museum of Natural History, Central Park West, New York 10024-5192, New York, USA; 95 species, mostly East African.

Chappius, C. (1985). *Les oiseaux de l'Ouest Africain,* disc ALAUDA 13. Societe d'Etudes Ornithologiques, 46 rue d'Ulm, 75230 Paris, France.

Gillard, L. (1985). *Southern African bird calls*. More than 500 species. Gillard Bird Cassettes, P O Box 72059, Parkview 2122, Johannesburg, South Africa.

Two organisations are willing to give advice to those who are seriously into the subject of bird calls. These are:

- The Percy Fitzpatrick Bird Communication Library, Bird Dept, Transvaal Museum, Paul Kruger Street, P O Box 413, Pretoria 0001, South Africa; and

- British Library of Wildlife Sounds, National Sound Archive, 29 Exhibition Road, London SW7 2AS, England

APPENDIX 6 : DATA ON BIRD WEIGHTS

To calculate biomass, you need information on bird weights (strictly speaking, mass) as well as density, as seen in the example in Table 7. Few bird books give birds' weights so it is necessary to know where to look for them. A major source is the *Birds of Africa* (Brown *et al*, 1980 on) which does give weights, as well as detailed measurements, for all species: however, by 1992 only the first 3 volumes, covering the non-passerines, had been published.

Many papers contain data on bird weights, but this literature is highly scattered. Amongst the more accessible papers are those by Greig-Smith and Davidson (1977), Moreau (1944) and Pierce (1984).

Most museums with bird collections have data on weights, either on the labels attached to the skins, or in a card index. Some are prepared to send this information to enquirers, as are the organisers of some ringing schemes.

Finally, weights can be estimated, although this should be considered as a last resort. But if you need the weight of species A, which is a similar size and shape to species B, whose weight you know, you can use B's weight as an approximation. Bear in mind that weight, when compared to a linear measurement such as length, l, increases in proportion to l^3.

Data on weights need to be interpreted carefully, since an individual bird's weight is not constant, and there can be big differences between individuals; in some species there are pronounced sexual differences too.

APPENDIX 7 : USING BIRD DATA IN ASSESSING SITES FOR CONSERVATION PURPOSES

Conservation biologists are frequently asked to advise on the importance of conservation sites. This is a demanding task and needs very careful thought. Many conservation values are very difficult to assess; how does one put a figure on amenity and aesthetic attributes? However, conservationists have begun to devise ways of putting an economic value on threatened ecosystems, arguing for example that a forest is worth more in its intact state than if it were harvested or put to other uses (Peters, 1989).

Birds are often useful in this context, especially for comparing one site with another. Categories to be considered when doing this include:-

1. Numbers of species, organised under some or all of the following headings

   - total number of species (S, Section 4)
   - overall species diversity (α, Section 4);
   - numbers of Red Data Book species (Collar & Stuart, 1985);
   - numbers of national endemic species;-numbers of local endemics, sometimes taken as species with global distributions of less than 50 000 km^2;
   - other species of particular importance, such as forest or wetland specialists (Section 7);
   - migrants, since these species involve international obligations.

Wherever possible, the population sizes of these species should be considered. Minimum viable populations (Soulē 1987) are hard to determine but are usually likely to comprise several hundred individuals, at least. So, do all of the important species at the site in question have populations of that size, either at the site or as a 'metapopulation' - a single genetic unit but spread over several sites, between which individuals occasionally move (Olivieri *et al*, 1990).

The numbers of species in various categories can be taken as they are, or subjected to some sort of weighting. This has been done, for example, for African primates, first by Oates (1986) and later by Lee *et al* (1988). More recently, the idea has been applied to African birds by Collar and Stuart (1988). They based their weightings on the *Red Data Book* categories, ranging from 5 for Endangered through 3 for Rare to 1 for Near-threatened. Another approach would be to score species inversely in proportion to their Africa-wide distributions, or their national distributions, or both. This, however, would still leave problems - some species of rare birds, especially large ones, have very wide distributions: the Shoebill and Pel's Fishing Owl are examples.

2. Some conservation areas have important tourist value, actual or potential. This is always attractive to planners.

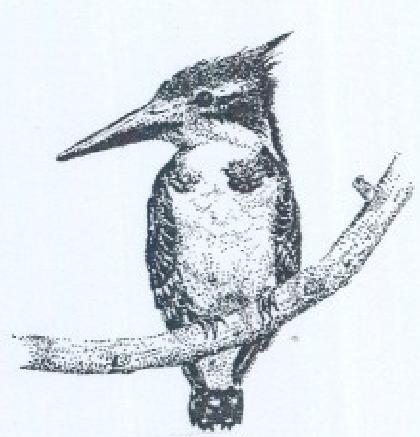
3. Economically useful birds deserve special mention. Various species of storks are major predators of locusts and other grasshoppers. Scavengers such as the Marabou and Hooded and Egyptian Vultures remove harmful wastes. Breeding sites of these species and others therefore need to be conserved.

APPENDIX 8: REFERENCE BOOKS

Recommended books for bird identification in the field (F) and for more detailed descriptions and reference (R).

	Author*	Parts of Africa covered	Notes
R	Brown *et al* (1980 on)	all	Only 3 volumes so far published (1992)
R	Maclean (1988)	southern	
R	Mackworth-Praed and Grant (1957, 1960)	eastern and north -eastern	
R	Mackworth-Praed and Grant (1962, 1963)	southern	
R	Mackworth-Praed and Grant (1970, 1973)	central and western	
R	Bannerman (1930-1951)	western	Hard to obtain
R	Bannerman (1953)	central and western	Shorter version of above
R/F	Hayman *et al* (1986)	all	Valuable for waders
R/F	Porter *et al* (1981)	all	Valuable for raptors
F	Benson *et al* (1973)	south-central	
F	Newman (1990)	southern	
F	Serle *et al* (1977)	western	
F	Williams and Arlott (1980)	eastern	
F	Heinzel *et al* (1985)	all	This Palearctic guide is a good supplement to the regional ones

*See References for full details.



Pied Kingfisher

APPENDIX 9 : SCIENTIFIC NAMES OF SPECIES MENTIONED IN THE TEXT

For non-passerines, names are as in *Birds of Africa* (1982-1988) and for passerines as in Britton (1980). The order follows those works.

Ostrich	*Struthio camelus*
Cattle Egret	*Bubulcus ibis*
Marabou	*Leptoptilos crumeniferus*
Shoebill	*Balaeniceps rex*
Sacred Ibis	*Threskiornis aethiopica*
Osprey	*Pandion haliaetus*
Black Kite	*Milvus migrans*
African Fish Eagle	*Haliaeetus vocifer*
Egyptian Vulture	*Neophron percnopterus*
Hooded Vulture	*N. monachus*
Crowned Eagle	*Stephanoaetus coronatus*
Secretary Bird	*Sagittarius serpentarius*
Mauritius Kestrel	*Falco punctatus*
Red-necked Spurfowl	*Francolinus afer*
Temminck's Courser	*Cursorius temminckii*
Olive Pigeon	*Columba arquatrix*
Ring-necked Dove	*Streptopelia capicola*
Green Pigeon	*Treron australis*
Great Blue Turaco	*Corythaeola cristata*
Bare-faced Go-away-bird	*Corythaixoides leucogaster*
Pel's Fishing-Owl	*Scotopelia peli*
Rufous Fishing-Owl	*S. ussheri*
Speckled Mousebird	*Colius striatus*
Striped Kingfisher	*Halcyon chelicuti*
Cinnamon-chested Bee-eater	*Merops oreobates*
Little Bee-eater	*M. pusillus*
White-headed Wood Hoopoe	*Phoeniculus bollei*
Green Wood Hoopoe	*P. purpureus*
Crowned Hornbill	*Tockus alboterminatus*
Von der Decken's Hornbill	*T. deckeni*
Black-and-white Casqued Hornbill	*Ceratogymna subcylindricus*
Grey-throated Barbet	*Gymnobucco bonapartei*
Yellow-rumped Tinkerbird	*Pogonolius bilineatus*
Yellow-billed Barbet	*Trachyphonus purpuratus*
Fine-banded Woodpecker	*Campethera tullbergi*
Eurasian Swallow	*Hirundo rustica*
Black Roughwing	*Psalidoprocne pristoptera*
Black-headed Oriole	*Oriolus larvatus*
White-necked Raven	*Corvus albicollis*
Black Tit	*Parus leucomelas*
African Hill Babbler	*Alcippe abyssinica*
Mountain Illadopsis	*Trichastoma pyrrhopterum*
Yellow-whiskered Greenbul	*Andropadus latirostris*
Common Bulbul	*Pycnonotus barbatus*
White-browed Scrub Robin	*Cercotrichas leucophrys*
Stonechat	*Saxicola torquata*
Masked Apalis	*Apalis binotata*
Chestnut-throated Apalis	*A. porphyrolaema*
Grey-backed Camaroptera	*Camaroptera brachyura*
Siffling Cisticola	*Cisticola brachyptera*
Chubb's Cisticola	*C. chubbi*
Red-faced Cisticola	*C. erythrops*

Trilling	*C. woosnami*
Willow Warbler	*Phylloscopus trochilus*
White-chinned Prinia	*Prinia leucopogon*
Tawny-flanked Prinia	*P. subflava*
Pale Prinia	*P. somalica*
Whitethroat	*Sylvia communis*
White-browed Crombec	*Sylvietta leucophrys*
Red-faced Crombec	*S. whytii*
Ashy Flycatcher	*Muscicapa caerulescens*
Red-bellied Paradise Flycatcher	*Terpsiphone rufiventer*
Paradise Flycatcher	*T. viridis*
Yellow White-eye	*Motacilla flava*
Northern Puffback	*Dryoscopus gambensis*
Lühder's Bush Shrike	*Laniarius luehderi*
Rüppell's Long-tailed Glossy Starling	*Lamprotornis purpuropterus*
Blue-headed Sunbird	*Nectarinia alinae*
Bronze Sunbird	*N. kilimensis*
Regal Sunbird	*N. regia*
Scarlet-chested Sunbird	*N. venusta*
Yellow White-eye	*Zosterops senegalensis*
Holub's Golden Weaver	*Ploceus xanthops*
Grey-headed Social Weaver	*Pseudonigrita arnaudi*
Black-crowned Waxbill	*Estrilda nonnula*
Red-billed Firefinch	*Lagonosticta senegala*
Bronze Mannikin	*Lonchura cucullata*
Yellow-fronted Canary	*Serinus mozambicus*

REFERENCES

Ayeni, J S O. 1984. The biology and utilisation of helmeted guineafowl (*Numida meleagris galeata* Pallas). I. The habitat and distribution of guineafowl in the Kainji Lake Basin area, Nigeria. *African Journal of Ecology*, 22, 1-6.

Bannerman, D A. 1930-1951. *The birds of tropical West Africa*, volumes 1 - 8. Crown Agents, London.

Bannerman, D A 1953. *The birds of west and equatorial Africa*, volumes 1 - 2. Oliver and Boyd, Edinburgh.

Begon, M, Harper, J L and Townsend, C R. 1990. *Ecology: individuals, populations and communities* (2nd ed). Blackwell Scientific Publications, Oxford.

Bekker, C D. 1988. Patterns in bird populations along the Omo River in Ethiopia. *African Journal of Ecology*, 26, 1-10.

Bennun,L.(1989) Communal breeding in the Grey-headed Social Weaver *(Pseudonigrita arnaudi)*. D Phil thesis, OxfordUniversity.

Bennun, L. (in press). Movements, mortality and mating patterns of Grey-headed Social Weavers. *Proceedings of the seventh Pan-African Ornithological Congress.*

Benson, C W, Brooke, R K, Dowsett, R J and Irwin, M P S. 1973 (2nd ed.). *The birds of Zambia.* Collins, London.

Block, W M, With, K A and Morrison, M L. 1987. On measuring bird habitat: influence of observer variability and sample size. *The Condor,* 89, 241-251.

Britton, P L. 1978. Seasonality, density and diversity of birds of a papyrus swamp in western Kenya. *Ibis*, 120, 450-466.

Britton, P L. 1980 (ed.). *Birds of East Africa: their habitat, status and distribution.* East Africa Natural History Society, Nairobi, Kenya.

Brosset, A. 1990. A long term study of the rain forest birds in M'Passa (Gabon). In A Keast (ed). *Biogeography and ecology of forest birds*. SPB Academic, The Hague, Holland.

Brown, L H. 1972. *African birds of prey*. Collins, London.

Brown, L H. and others (1982 onwards). *Birds of Africa.* Academic Press, London. Volume 1 (1982) edited by Brown, L H, Urban, E K and Newman, K. Volume 2 (1986) edited by Urban, E K, Fry, C H and Keith, S. Volume 3 (1988) edited by Fry, C H, Keith, S and Urban, E K.

Bruggers, R L and Elliott, C C M (eds) 1990. *Quelea quelea: Africa's bird pest.* Oxford University Press, Oxford.

Carlson, A. 1986. A comparison of birds inhabiting pine plantation and indigenous forest patches in a tropical mountain area. *Biological Conservation,* 35, 195-204.

Clarke, G M. 1980 (2nd ed). *Statistics and experimental design*. Edward Arnold, London.

Collar, N J and Stuart, S N. 1985. *Threatened birds of Africa and related islands*. ICBP/IUCN, Cambridge, England.

Cyrus, D and Robson, N. 1980. *Bird atlas of Natal*. University of Natal Press, Pietermaritzburg, South Africa.

Day, R A. 1989. *How to write and publish a scientific paper.* Cambridge University Press, Cambridge, England.

Dobinson, H M. 1976. *Bird count*. Penguin, London.

Dowsett, R J. 1985. Site-fidelity and survival rates of some montane forest birds in Malawi, South-central Africa. *Biotropica,* 17, 145 - 154.

Dowsett-Lamaire, F. 1989. Ecological and biogeographical aspects of forest bird communities in Malawi. *Scopus*, 13, 1 - 80.

Dranzoa, C. 1990. Survival of forest birds in formerly forested areas around Kampala. Unpubl. M Sc thesis, Makerere University, Kampala.

Dranzoa, C and Pomeroy, D E. (in press). *Tropical birds need large forests.*

du Feu, C, Hounsome, M and Spence, I. 1983. A single-session mark/recapture method of population estimation. *Ringing and migration,* 4, 211 - 226.

Eberhardt, L L and Simmons, M A. 1987. Calibrating population indices by double sampling. *Journal of Wildlife Management,* 51, 665-675.

Emlen, J T. 1971. Population densities of birds derived from transect counts. *Auk,* 88, 323 - 342.

Erikson, M O G and Sharp, C. 1989. Density and distribution of the African Fish Eagle and the Osprey at Lake Kariba. *Honeyguide*, 35, 54 - 62.

Etoori, D K and Abe, E. (in press). Environmental impact of human activity on bird distribution in a savanna. *Proceedings of the seventh Pan-African Ornithological Congress.*

Evans, S M, Cantrell, M.A and Cran, A. 1982. Patterns of arrival and dispersal from a mixed communal roost of Sacred Ibises and Marabou Storks. *Ostrich*, 53, 230 - 234.

Fowler, J and Cohen, L. 1988. Statistics for ornithologists. *BTO Guide 22.* British Trust for Ornithology, Thetford, England.

Gichuki, N N. 1984. The pest status of some granivorous birds in eastern Machakos District, Kenya. *Proceedings of the fifth Pan-African Ornithological Congress*, 371 - 386.

Greig-Smith, P W and Davidson, N C 1977. Weights of West African savanna birds. *Bulletin of the British Ornithologists' Club*, 97, 96 - 100.

Gwahaba, J J. 1985. Presence of birds at Entebbe airport, Uganda. *African Journal of Ecology,* 23, 1-10.

Hayman, P, Marchant, J and Prater, A. 1986. *Shorebirds: an identification guide to the waders of the world*. Croom Helm, Beckenham, England.

Heinzel, H, Fitter, R and Parslow, J. 1985. *The birds of Britain and Europe.* Collins, London.

Jarvis, M J F. 1984. Distribution and abundance of water-fowl (*Anatidae*) in Zimbabwe. *Proceedings of the fifth Pan-African Ornithological Congress,* 395 - 412.

Kalina, J. 1988. Ecology and behaviour of the Black and white Casqued Hornbill, *Bycanistes subcylindricus subquadratus* in Kibale Forest, Uganda. Ph D thesis, Michigan State University.

Kasoma, P M B. (in press). Distribution and abundance of Ciconiiform wading birds around Mweya, Queen Elizabeth National Park, Uganda. *Proceedings of the seventh Pan-African Ornithological Congress.*

Koen, J H. 1988. Stratal distribution and resource partitioning of birds in the Knysna Forest, South Africa. *African Journal of Ecology,* 26, 229-238.

Koskimies, P. 1989. Birds as a tool in environmental monitoring. *Annales Zoologici Fennici,* 26, 153 - 166.

Koskimies, P and Vaisanen, R A. 1990. *Monitoring bird populations*. Zoological Museum, Finnish Museum of Natural History, University of Helsinki, Finland.

Lack, P C. 1986. The structure and seasonal dynamics of the bird community in Tsavo East National Park, Kenya. *Ostrich*, 58, 9 - 23.

Lee, P C, Thornback, J and Bennett, E L. 1988. *Threatened primates of Africa - the IUCN Red Data Book*. IUCN, Gland, Switzerland.

Lewis, A D and Pomeroy, D E. 1989. *A bird atlas of Kenya*. Balkema, Rotterdam, Holland.

Lewis, T and Taylor, L R. 1976. *Introduction to experimental ecology*. Academic Press, London.

MacArthur, R H and MacArthur, J W. 1961. On bird species diversity. *Ecology*, 42, 594 - 598.

MacArthur, R H and Wilson, E O. 1967. *The theory of island biogeography*. Princeton, University Press, New Jersey.

Macdonald, I A W and Gargett, V. 1984. Raptor density and diversity in the Matopos, Zimbabwe. *Proceedings of the fifth Pan-African Ornithological Congress*, 287 - 308.

Mackworth-Praed, C W and Grant, C H B. 1957, 1960. *Birds of eastern and north eastern Africa*, volumes 1-2. Longman, London.

Mackworth-Praed, C W and Grant, C H B 1962, 1963. *Birds of the southern third of Africa*, volumes 1-2. Longman, London.

Mackworth-Praed, C W and Grant, C H B. 1970, 1973. *Birds of west central and western Africa*, volumes 1-2. Longman, London.

Maclean, G L. 1988. *Roberts' Birds of South Africa*. (5th ed). New Holland Publishers.

Maclean, G L. 1990. *Ornithology for Africa*. University of Natal Press. Pietermaritzburg, South Africa.

Magurran, A E. 1988. *Ecological diversity and its measurement*. Croom Helm, London.

Marchant, J H, Hudson, R, Carter, S P, and Whittington, P. 1990. *Population trends in British breeding birds*. BTO, Tring, England.

Maurer, B A. 1986. Predicting habitat quality for grassland birds using density-habitat correlations. *Journal of Wildlife Management*, 50, 556-566.

Meadows, B S. 1984. Numbers and seasonality of filter-feeding ducks in Kenya. *Proceedings of the fifth Pan-African Ornithological Congress*, 441 - 459.

Miller, R I, Stuart, S N and Howell, K H. 1989. The methodology for analyzing rare species distribution patterns utilizing GIS technology: the rare birds of Tanzania. *Landscape Ecology*, 2, 173 - 189.

Milstein, P. le S. 1984. A waterfowl survey of southern Mozambique, with conservation implications. *Proceedings of the fifth International Ornithological Congress*, 639 - 664.

Moreau, R E. 1944. Some weights of African birds and of wintering Palearctic birds. *Ibis*, 86, 16 - 29.

Morel, G J. (in press). The riverine forests of *Acacia nilotica* in Senegal and their importance for Palearctic birds. *Proceedings of the seventh Pan-African Ornithological Congress*.

Morel, G J and Morel M Y. 1978. Recherches écologiques sur une savane sahélienne du Ferlo septentrional, Sénégal. Etude d'une communauté avienne. *Cah ORSTOM*, series Biol. 13, 3 - 34.

Morgan, B J T and North, P M (eds) 1985. *Statistics in ornithology*. Springer-Verlag, Berlin.

Morrison, M L. 1986. *Bird populations as indicators of environmental change*. Current Ornithology 3, 429-451.

Muhweezi, A. 1990. The ecology of raptors in around the Impenentrable Forest, south-western Uganda. M Sc thesis, Makerere University.

Newman, K. 1990. *Newman's birds of southern Africa*. Southern Book Publishers, Cape Town.

Nikolaus, G. 1987. Distribution atlas of Sudan's birds with notes on habitat and status. *Bonner zoologische Monographien* No. 25.

Norton-Griffiths, M. 1978. *Counting animals*. African Wildlife Leadership Foundation, Nairobi.

Oates, J F. 1986. *Action plan for African primate conservation*:1986-90. IUCN, Gland, Switzerland.

Olivieri, I, Couvet, D and Gouyon, P-H. 1990. The genetics of transient populations: research at the metapopulation level. *Trends in ecology and evolution*, 5, 207 - 210.

Parker, R E. 1979. (2nd ed.). *Introductory statistics for biology*. Edward Arnold, London.

Peters, C.M. 1989. Valuation of an Amazonian rain forest. *Nature*, 339, 655 - 656.

Pierce, M A. 1984. Weights of birds from Balmoral, Zambia. *Bulletin of the British Ornithologists' Club*, 104, 84-85.

Pomeroy, D E. 1989. Using East African bird atlas data for ecological studies. *Annales Zoologici Fennica* 26, 309 - 314.

Pomeroy, D E. 1991. Land bird populations in East Africa. *In* F I B Kayanja and E Edroma (eds). *African wildlife: research and management*, 134 - 140. ICSU Press, Paris.

Pomeroy, D E and Lewis, A D. 1987. Bird species richness in tropical Africa: some comparisons. *Biological Conservation*, 40, 11 - 28.

Pomeroy, D E and Muringo, C. 1984. Studies of birds in a semi-arid area of Kenya. I. The use of transects to assess the effects of bush-clearance on bird populations. *Proceedings of the fifth Pan-African Ornithological Congress,* 179-199.

Pomeroy, D E and Tengecho, B. 1986a. Studies of birds in a semi-arid area of Kenya. III. The use of 'Timed Species-counts' for studying regional avifaunas. *Journal of Tropical Ecology*, 2, 231-247.

Pomeroy, D E and Tengecho, B. 1986b. A method of analysing bird distributions. *African Journal of Ecology*, 24, 243-253.

Porter, R F, Nielson, BP and Christensen, S. 1981. *Flight identification of European raptors*. Poyser, Calton, England.

Ralph, C J and Scott, J M (eds). 1981. Estimating numbers of terrestrial birds. *Cooper Ornithological Society: Studies in Avian Biology 6.*

Raphael, M G. 1987. Estimating relative abundance of forest birds: simple versus adjusted counts. *Wilson Bulletin,* 99, 125 - 131.

Roux, F and Jarry, G. 1984. Numbers, composition and distribution of populations of *Anatidae* wintering in West Africa. *Wildfowl*, 35, 48 - 60.

Serle, W and Morel, G J. 1977. *A field guide to the birds of West Africa*. Collins, London.

Skinner, N and Pomeroy, D E. 1991. *Bird atlases and censuses in Africa. Bird Census News*, 4, (1): 5-12.

Smith, R L. 1980. *Ecology and field biology* (3rd ed). Harper and Row, New York.

Snedecor, G W and Cochran, W G. 1967. *Statistical methods*. (6th ed.). Iowa State University Press, Ames, Iowa.

Soulē, M. 1987 (ed). *Viable populations*. Cambridge University Press, Cambridge, England.

Soulē, M. 1988 (ed.). *Conservation biology*. Sinauer Associates, Sunderland, Massachusetts.

Southwood, T R E. 1978. *Ecological methods* (2nd ed). Chapman and Hall, London.

Stevens, G C. 1989. The latitudinal gradient in geographical range: how so many species coexist in the tropics. *American Naturalist*, 133, 240 - 256.

Terborgh, J, Robinson, S K, Parker, T A, Munn, C A and Pierpont, N. 1990. Structure and organization of an Amazonian forest bird community. *Ecological Monographs*, 60, 213 - 238.

Thiollay, J M. 1974. Le peuplement avien de la savane de Lamto. Pages 39 - 68 in *Analyse d'un ēcosystemē tropical humide: la savane de Lamto (Côte d'Ivoire)*. IV Les vertēbrēs. ORSTOM, Paris.

Thiollay, J M. 1988. Comparative foraging success of insectivorous birds in tropical and temperate forests: ecological implications. *Oikos*, 53, 17 - 30.

Thompson, J J. 1989. A comparison of some avian census techniques in a population of lovebirds at Lake Naivasha, Kenya. *African Journal of Ecology*, 27, 157-166.

Ulfstrand, S and Alerstam, T. 1977. Bird communities of *Brachystegia* and *Acacia* woodlands in Zambia. *Journal fur Ornithologie*, 118, 156 - 174.

Vareschi, E. 1978. The ecology of Lake Nakuru (Kenya). I. Abundance and feeding of the Lesser Flamingo. *Oecologia* (Berlin), 32, 11 - 35.

Verner, J. 1985. Assessment of counting techniques. Pages 247-302 in *Current Ornithology*, 2 (ed, R F Johnston). Plenum.

Verner, J and Milne, K A. 1989. Coping with sources of variability when monitoring population trends. *Annales Zoologici Fennici*, 26, 191 - 199.

Vernon, C J. 1984. Population dynamics of birds in a *Brachystegia* woodland. *Proceedings of the fifth Pan-African Ornithological Congress*, 201 - 216.

Williams, J G and Arlott, N. 1980. *A field guide to the birds of East Africa*. Collins, London.

Zimmerman, D A. 1972. The avifauna of the Kakamega Forest, western Kenya, including a bird population study. *Bulletin of the American Museum of Natural History*, 149, 255 - 340.

INDEX