THE SOUTHERN AFRICAN BIRD ATLAS PROJECT AND ITS RELEVANCE TO NATURE CONSERVATION.

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Thesis presented in fulfilment of the requirements for the degree of Master of Science at the University of Stellenbosch.

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Declaration:

I the undersigned hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree. However, the work did involve collaboration with various co-authors. The respective contributions are stated under the heading "The Papers" in the introductory chapter.

CONTENTS

SUMMARY

The objectives of this thesis are to: (a) describe the Southern African Bird Atlas Project (SABAP), document its progress and assess its success, as a contribution to the planning of future projects; (b) explore the potential of atlas data to answer questions other than those concerned with the ranges of species; (c) investigate the application of bird atlas data to some specific questions which have a bearing on the planning and practice of conservation.

The progress and organizational features of SABAP and its databank are described. It is shown that the SABAP has been a success in terms of the large volumes of accurate and up-to-date data on species' distributions and patterns of seasonality acquired. The decision to use amateur volunteers is shown to have been appropriate but not without drawbacks.

A methodological point made is that the methods of atlasing and of computerization of the data need to be planned so as to permit statistical analysis of the data. If this is done, reporting rates can provide an index of relative abundance which can, in turn, permit the application of atlas data to many questions beyond that of range extent.

The analysis of reporting rates is illuminating in the description of seasonal patterns of occurrence and therefore, of seasonal movement. This is demonstrated for long-distance migration and for local movement. The papers dealing with patterns of seasonality highlight the fact that species with extensive seasonal movements cannot be conserved within single reserves.

The growing demand for access to SABAP data is reported and the applications listed. Improvement of SABAP's relevance to the environmental consultancy user group is achieved by a method of presenting atlas data in a manner which will maximize their usefulness. The approach hinges on the ability to allocate species to habitat categories. This enables one to break down an undifferentiated species list for a grid square into a number of habitat-specific species lists.

It is proposed that atlasing could be adapted to achieve population monitoring objectives. One exercise set out to analyse changes in reporting rate through time and to correlate these with a key environmental variable, namely rainfall. The exercise is only a limited success. It is shown that, while potential to use atlas methods for

population monitoring does exist, the need to improve the standardization of methods for this purpose is crucial.

Interim results of the SABAP in the form of species distribution maps are presented as an aid to the planning of conservation action for cranes. The information for the three species is compiled to produce a map which highlights those grid squares which have the greatest diversity of cranes. It is shown that the combination of atlas information for a suite of species can yield an index of diversity which may hold greater potential for planning the location of reserves than the distribution maps of individual species alone.

Trends in bird atlasing and of the use of reporting rate as an index of relative abundance are reviewed as is the use of reporting rates as a population monitoring tool.

INTRODUCTION

There is less than general agreement about research priorities in conservation biology. Amongst the many topics which have been emphasized are autecological studies, ecosystem functioning, population genetics, global climatology and island biogeography. The realization which is now taking hold, however, is that the earth's biodiversity is rapidly diminishing and that opportunities to conserve what is left are dwindling equally rapidly. The challenge is to conserve the greatest possible diversity with the limited resources available. This has led to a need for basic information on distribution and phenology which may have been considered too elementary to merit serious study in the past. It is now being appreciated that one cannot approach the problems of effective conservation of biodiversity without knowing - in detail - what that diversity is and where it is located. Margules (1989) has explicitly stated: ". . . a knowledge of patterns of species distributions has priority over a knowledge of ecological processes in our efforts to maintain biological diversity."

Atlas projects and various other types of environmental surveys, I believe, are an expression of this realization and are part of a current trend which might be termed "neo-exploration". Here the emphasis is less on discovery of the new than on a detailed survey of known taxa and environmental variables. The information gained from these surveys is in great demand for exercises in the rational planning of resource management and nature conservation. Atlas studies, therefore, should be seen as highly relevant in a modern context, despite the fact that they are "low-tech" and often employ the input of amateurs.

The use of amateurs is an important aspect of projects like the Southern African Bird Atlas Project (SABAP). The sheer geographical scope of such a project forces one to break away from the conventional models of scientific investigation. With amateurs one is able to harness a larger workforce at lower cost to yield a bigger body of data than one could using professionals alone. However, the reliability of the data is inevitably diminished and the methods and goals one sets up must of necessity be simple and relatively unsophisticated. The question which arises then is whether or not atlasing is able to "deliver the goods" in terms of sufficient reliable information to describe accurately the current distribution patterns for all bird species in southern Africa. Extensions of the latter question are: Can the data collected in a project of simple design and uncomplicated goals be analyzed in a sophisticated manner to yield information which goes beyond the most basic presence/absence distributional pictures?

Can atlas data and analyses thereof be used to benefit nature conservation directly?

The ultimate motivation for the Southern African Bird Atlas Project was its potential to further the aims of nature conservation in general and the conservation of the subcontinent's avifauna in particular. Initially this was something of an article of faith, however, with many of its underlying assumptions remaining largely untested. The object of this thesis was firstly to describe the project itself, document its progress and assess its success, as a contribution to the planning of future projects. A second objective was to explore the potential of atlas data to answer questions other than those concerned with the ranges of species. A third objective was to investigate the application of bird atlas data to some specific questions which have a bearing on the planning and practice of conservation.

The work was prepared as papers for publication in scientific journals and conference proceedings and is presented as such. An overview of the papers follows.

THE PAPERS

The papers which comprise this thesis can be divided into three groups:

Group A: Descriptive papers dealing with the techniques of the SABAP and its progress.

Group B: Research papers which analyze atlas data in novel ways to answer specific biological questions.

Group C: Applied papers presenting atlas information in a manner which is more directly relevant to conservation-related concerns.

Each paper is briefly described below with a view to placing it in the context of this thesis. **My contribution to each paper is explicitly stated as an expansion on the declaration at the beginning of this thesis.**

Group A: Descriptive papers

Paper 1: Atlasing as a tool in conservation, with special reference to the Southern African Bird Atlas Project.
Author: J.A. Harrison
Published in 1989 in Huntley B.J. (ed.) Biotic diversity in southern Africa: concepts and conservation: 157-169. Cape Town: Oxford University Press.

(My contribution: coordinator of the SABAP and sole author of the text.)

This paper deals with the Atlasing approach to data collection and discusses the issues germane to Atlasing. It also describes and predicts the various ways in which atlas data can be analyzed to produce information which goes beyond mere statements on the range extent of species. The relevance of these analyses to conservation concerns is argued.

Paper 2: The role of large-scale data collection projects in the study of southern African birds.
Authors: L.G. Underhill, T.B. Oatley, J.A. Harrison
Published in 1991, Ostrich 62: 124-148.
(My contribution: relatively minor as co-author of the section dealing with Atlasing and input into the discussion section.)

The theme of the wide range of uses to which atlas data can be put, is continued in this paper. A review of the range of applications already attempted, is given. The potential for integrating the data for all species as part of an objective approach to the planning of a reserve network is mentioned. It is proposed that Atlasing could be adapted to achieve population monitoring objectives. The role of atlasing in the context of other large-scale projects which collect avian data, is evaluated positively.

Paper 3: The Southern African Bird Atlas Project databank: five years of growth.
Author: J.A. Harrison
Published in 1992, South African Journal of Science 88: 410-413.
(My contribution: coordination of the SABAP and sole author of the text.)

Here the progress and organizational features of SABAP and its databank are described. The growing demand for access to SABAP data is reported and the applications listed. The benefits of harnessing an amateur workforce in the service of environmental science is emphasized.

Group B: Research papers

Paper 1: Seasonal patterns of occurrence of Palaearctic migrants in southern Africa using atlas data.
Authors: L.G. Underhill, R.P. Prys-Jones, J.A. Harrison, P. Martinez
Published in 1992, Ibis 134 Suppl. 1: 99-108.

(My contribution: relatively minor, including data extraction and commenting on the text.)

An important advance in the analysis of atlas data is described here. Essentially the monthly occurrence of species is used to model the phenology of their sojourn in their non-breeding range. This technique of modelling became the basis for all subsequent analyses of seasonality.

Paper 2: Modelling reporting rates as indices of changes in relative abundance with altitude and season.
Authors: J.A. Harrison, R.A. Navarro
In press in Proceedings of the Bird Numbers Conference, Noordwijkerhout, Netherlands, 1992.
(My contribution: initiated, planned and executed the research and wrote the text. The Genstat programming and computer graphics were done by R. Navarro who also assisted in writing the text dealing with the statistical methods.)

The approach to modelling seasonality established for intercontinental migrants which leave southern Africa almost entirely in winter, was adapted here for the analysis of relatively small scale, local movements - namely altitudinal movement in Lesotho and Natal - and was found to produce useful results. This paper includes a brief review of trends in bird atlasing and of the use of reporting rate as an index of relative abundance.

Paper 3: Seasonal migration of terrestrial birds along the southern and eastern coasts of southern Africa.
Authors: A. Berruti, J.A. Harrison, R.A. Navarro
Submitted to Proceedings of the Symposium on Migration, Dispersal and Nomadism, Langebaan, South Africa, 1993.
(My contribution: assisted in the planning of the research approach and performed the data extraction, the selection of models and the initial interpretation of models, also commented on and made suggestions for the text.)

This paper extends the techniques applied in the previous paper to the analysis of littoral movements as well as altitudinal movements - with similar success.

Paper 4: Correlating relative abundance and rainfall: analyzing time-series of checklists.

Authors: R.A. Navarro, J.A. Harrison, D.G. Allan, W. Zucchini
Published in Proceedings of the Eighth Pan-African Ornithological Congress, Bujumbura, Burundi, 1992: 379-388.
(My contribution: idea, initiation and leadership of project, data extraction, first and second drafts of the paper. R. Navarro was given first authorship in recognition of his central contribution to the selection of the appropriate statistical techniques and the attendant computing. D. Allan's contribution was to the discussion and referencing of the paper and W. Zucchini was our statistical consultant.)

This project set out to analyze changes in reporting rate through time and to correlate these with a key environmental variable, namely rainfall. The exercise was fraught with difficulties - mainly owing to increasing observer competence during the early years of data collection, and was only a limited success. The paper includes a review of the use of reporting rates as a population monitoring tool (part of my contribution).

Group C: Applied papers

Paper 1: The distribution and relative abundance of cranes in South Africa as assessed by bird atlas data.
Authors: J.A. Harrison, D.G. Allan, P. Martinez
Published in the Proceedings of the First Southern African Crane Conference, Natal, 1989: 79-85.
(My contribution: initiated and carried out the research and first author; computer graphics created by P. Martinez.)

Interim results of the SABAP in the form of species distribution maps were published here as an aid to the planning of conservation action for cranes. The innovative aspect of the paper lies in the drawing together of the information for the three species and producing a map which highlights those grid squares in the eastern part of the country which have the greatest diversity of cranes based on the occurrence and relative abundance of the three species.

Paper 2: Automated annotation of species lists - an aid in environmental consultancy.
Authors: J.A. Harrison, D.G. Allan, H.J. van Hensbergen
Submitted to Ostrich, 1993.
(My contribution: Initiation and leadership of the project, first author. D. Allan assisted with designing the habitat hierarchy and commented extensively on the species

classifications and text. H. van Hensbergen was involved in the early planning stages of the project and commented on the text.)

This paper reports on the development of a method of presenting atlas data to third-party users - particularly consultants working in the area of environmental impact assessment - in a manner which will maximize their usefulness. The approach hinges on the ability to allocate species to habitat categories based on what is already known about each species' habitat requirements. This enables one to break down an undifferentiated species list for a grid square into a number of habitat-specific species lists. Although this "product" has not yet been tested in the market place, I am optimistic that it will be used and that it will improve the relevance of atlas data to environmental consultants.

The papers themselves follow this introduction.

THE PAPERS

Note that each paper has separate page numbering.

AUTOMATED ANNOTATION OF SPECIES LISTS – AN AID IN ENVIRONMENTAL CONSULTANCY.

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SUMMARY

The Southern African Bird Atlas Project (SABAP) has compiled a comprehensive distributional database for birds. This information is potentially valuable to environmental consultants, planners and managers. A computer-based routine was developed to enhance the usefulness of the information to this user group. The routine produces habitat-specific species lists and includes annotations on endemism, Red Data status and other relevant information. A hierarchical system of habitat categories and indicator and associate species statuses was designed to maximize the information which can be derived from the databank. The report was designed to facilitate prioritization and decision-making. The approach is novel in its use of a species list to generate information on habitat.

INTRODUCTION

Environmental impact assessments (EIAs) are rapidly being accepted as the instruments by which the aspirations of economic development are reconciled with the needs of environmental conservation (Robinson 1989). Such assessments should be based on sound data, but environmental data are notoriously difficult to come by in Africa (Crowe 1990; Siegfried 1989). Not only should the data be comprehensive and relevant; they must also be presented in a manner interpretable by the non-specialist. This paper presents a technique which makes a comprehensive dataset on birds in South Africa available in a form which will facilitate its use in EIAs.

Consultants engaged in preparing EIAs are frequently required to inventorize the species found in a specified area and to do this for a wide range of groups, particularly plant and vertebrate taxa. This can be a daunting, even unrealistic task for a variety of reasons. There are usually time constraints and often a lack of expertise in particular taxa. This frequently necessitates the recruitment of sub-contractors to survey the diversity and status of specific groups. Sub-contractors usually spend a day or two performing a survey of an area as a basis for a report. Owing to the typically truncated survey periods, the resultant species lists are usually incomplete. Many inconspicuous species are overlooked, as are those whose presence or conspicuousness is seasonal, e.g. ephemeral plants and migrant birds. Observers therefore usually are compelled to produce ancillary lists of species ''expected to occur'' in the study site. This is unsatisfactory. The work of consultants, at both the contractor and sub-contractor levels, could be facilitated by access to national or regional databases for the various groups.

Such databases are non-existent for most taxa but the situation for birds has recently changed dramatically. The Southern African Bird Atlas Project (SABAP) has built up a comprehensive database on bird distributions in southern Africa and especially for the Republic of South Africa (including the TBVC states) and Swaziland (Harrison 1992). The SABAP databank is fully computerized, and summary information is available for geographical areas and for species in the form of computer-generated reports. SABAP data have already been put to a wide range of uses, including the compilation of EIAs (Underhill *et al.* 1991). Without specifically marketing its data, the SABAP has experienced an increasing demand for data from environmental consultants requiring lists of birds for specified areas (Harrison 1992).

The SABAP databank has both advantages and disadvantages for the environmental consultant. The advantage of the lists which the SABAP can provide for grid squares is that they are based on recent fieldwork (mostly 1987-91) representing several visits covering different seasons (Harrison 1992). As a result of repeated visits it is possible to calculate reporting rates for species which can be used to describe their abundance in one area relative to another area (Harrison 1989). Breeding information is included and presence/absence information is given for each month. These can help to provide pointers to areas and seasons of particular sensitivity (Underhill *et al.* 1992).

The disadvantage is that the project was designed to map avian distribution over the whole subcontinent, and the geographical resolution is based on a quarter-degree (15´x15´) grid. At the latitude of South Africa each grid block is roughly 23 km by 27 km or approximately 620 km^2 in extent. Environmental consultants are typically concerned with areas very much smaller than this. As the data could have been collected anywhere within a given grid square, the list is likely to contain species not relevant to a given locality. The less representative the specific locality is of the grid square as a whole, the greater will be the incompatibility of the atlas bird list with that locality. Species lists for grid blocks will tend to be especially inconsistent with narrow or patchy habitats such as coastlines, rivers, wetlands and mountains.

The object of the work presented here was to develop a partial solution to the problem of scale by developing an automated approach to the arrangement of species lists in relation to habitat. Essentially such a procedure would provide the user with a list which is subdivided to give habitat-specific lists. As a group, birds are remarkably habitat specific (Cody 1985). It follows that the presence of a species in an area is indicative of the presence of its preferred habitat. This conclusion is especially reliable when a species is recorded regularly, as revealed by the species' reporting rate (Harrison 1989), is found breeding, or where more than one species associated with that habitat are recorded. Information on these points is obtainable from the SABAP databank. Given that the user is aware of the habitats present at the locality of interest, the habitat-specific lists should provide a good approximation of the avian communities present in the study area.

It is worth noting that the computer-based approach adopted here is the converse of the mental approach usually adopted by the environmental consultant. Typically he uses the presence of specific habitats to predict the presence of particular taxa; conversely our computer routine uses the species assemblage to ''predict'' or describe the range of habitats occurring within a specified area. (The computer-generated report can be consulted from either perspective, however.) The ability to use such an approach is a reflection of the relatively advanced state of ornithological knowledge in southern Africa in general and in particular of the pioneering work done by ornithologists such as Jack Winterbottom (1968, 1972) who meticulously documented the habitat associations of species.

An additional aim was to present the habitat-specific lists along with ancillary information relevant to conservation, in a manner which could facilitate prioritization and decision-making.

DATA AND METHODS

The automated analysis of a species list for a grid block was based on the categorization of all species according to their preferred habitat. In order to extract the maximum information for each species, a hierarchical habitat classification was adopted. Broadly defined, general habitat types were put at the first level of the hierarchy and progressively more specific, narrowly defined habitat types at the second and third levels of the hierarchy.

Table 1 gives the habitat categories and their arrangement in the hierarchy. Note that while a wide range of habitat types are catered for in the scheme, the number of general categories and their degree of subdivision was dictated by the availability of species to serve as indicators of the categories. Hence agricultural lands, for example, do not constitute a separate category as they cannot be said to have a unique avifauna; ornithologically they are derived from a variety of natural communities, dependent on the geographical location of the farmlands (Winterbottom 1972). Similarly no attempt was made to subdivide habitat types to a level of specificity, botanical or otherwise, which could not be matched by an equally specific assemblage of avian species. For example, fynbos was not subdivided into mountain and lowland fynbos, owing to the similarity between the bird faunas of these fynbos types (Winterbottom 1968).

The general habitat types were defined in such a way that the more specific types were completely subsumed. Thus any species listed at the tertiary level was also listed at the secondary level and any species listed at the secondary level was also listed at the primary level. This approach allowed all but a few of the most habitat-unspecific species to be categorized. The remainder were allocated to an "unclassified" category.

Only species which are resident in or regular visitors to the Republic of South Africa (including the TBVC states), Lesotho and Swaziland were classified. In classifying species according to habitat, only the habitat requirements normally found within the borders of these countries were considered. In this way confusion arising from different habitat requirements in different parts of a species' range was minimized. An obvious consequence of this approach is that the reports are relevant only within the geographical limits of the RSA, Lesotho and Swaziland.

Winterbottom (1972) provides the most detailed discussion of the major bird habitats in southern Africa. Earlier work by Winterbottom and Skead (1968) and Skead (1966) provides lists of bird habitats in the Cape Province south of the Orange River and the Transvaal respectively. The choice and classification of bird habitats used here is largely based on these publications. Details of the habitat of each species were extracted from Maclean (1985), supplemented by the detailed habitat comments in Tarboton *et al.* (1987) for those species that occur in the Transvaal, and from personal field experience.

Species were allocated to habitat categories according to the following rules. (Primary categories are denoted by single digit numbers, secondary categories by two digits and tertiary categories by three.)

1 MARINE: Birds of all true marine habitats including shore (coastal) and pelagic (open ocean) habitats.

1.1 PELAGIC: Birds of open ocean not usually found on the shore unless wrecked or dead.

1.2 SHORE: Birds of sandy and/or rocky coastal shores.

2 AQUATIC: Birds of all lacustrine (i.e. wetlands, e.g. marshes, vleis, lakes, pans, dams, sewage works, etc.) and lotic habitats (rivers and streams).

2.1 LOTIC: Birds of riverine and/or stream habitats characterized by flowing water.

2.1.1 OPEN WATER: Birds of open water in rivers and/or streams.

2.1.2 EXPOSED SHORE: Birds of exposed riverine shorelines lacking vegetation.

2.1.3 EMERGENT/MARGINAL VEGETATION: Birds of emergent, floating or tall marginal vegetation, e.g. reeds, rushes, sedges, etc., in or adjacent to rivers and/or streams.

2.2 LACUSTRINE: Birds of wetland habitats characterized by totally or nearly stationary water, e.g. marshes, vleis, pans, dams, sewage works, etc.

2.2.1 OPEN WATER: Birds of open water in wetlands.

2.2.2 EXPOSED SHORE: Birds of exposed wetland shorelines lacking vegetation.

2.2.3 EMERGENT/MARGINAL VEGETATION: Birds of emergent, floating or tall marginal vegetation, e.g. reeds, rushes, sedges, etc., in or adjacent to wetlands.

3 MONTANE AND ROCKY HABITATS: Birds of montane and/or exposed rocky habitats. This category is not mutually exclusive with some other general categories, so a species designated an indicator in this category may also be designated an indicator or an associate (defined below) in another category, e.g. grassland.

4 FOREST HABITATS: Birds of closed-canopy indigenous evergreen forest with typical forest understorey. Includes all species found in Afromontane/mistbelt and lowland/east coast forest. Many of these birds can also be found in alien plantations of eucalypts, pines and wattles where these occur close to natural forest.

4.1 EAST COAST FOREST: Birds of lowland sub-tropical coastal forest found along the eastern coastal plains from between Port Elizabeth and southern Transkei north to Kosi Bay.

4.2 AFROMONTANE FOREST: Birds of temperate forest found along the south coast and adjacent inland areas from Cape Town to between Port Elizabeth and the coast of southern Transkei and from there inland north to the Soutpansberg and Blouberg in the northern Transvaal.

4.3 FOREST EDGE: Birds of the rank grass, scrub and woody thickets typical of forest edges.

5 WOODLAND HABITATS: Birds of wooded habitats characterized by the presence of trees but excluding true forests. Many of these birds can also be found in stands of alien trees, parks and gardens, sometimes in otherwise treeless areas.

5.1 PLANTATIONS AND PARKLANDS: No separate provision is made for these habitats.

5.2 INDIGENOUS: Birds of indigenous woodland where indigenous trees form a more-or-less discontinuous canopy and have understoreys which are usually dominated by grass. Includes wooded habitats referred to as woodland, savannah, thornveld, bushveld, mixed woodland, etc. Birds of the relatively tall, thorny vegetation found along arid watercourses would be included here or in the Acacia tertiary category.

5.2.1 THICKET: Birds of tall woody vegetation forming dense, impenetrable tangles and lacking a clearly defined canopy and understorey.

5.2.2 ACACIA: Birds of indigenous woodlands dominated by *Acacia* spp., often termed thornveld.

5.2.3 BROADLEAVED: Birds of indigenous woodlands dominated by broadleaved trees, often termed deciduous woodland. Mopane woodlands are included here.

5.2.4 RIVERINE: Birds of tall riverine woodland typical of the banks of larger rivers in the northern parts of the country, also termed riverine forest.

6 GRASSLAND HABITATS: Birds of open grassland, including cleared areas in woodland and cultivated pastures, lawns, airfields, etc. Also includes birds using agricultural crop fields, e.g. maize, wheat, sugar cane, etc., in otherwise wooded, fynbos, Karoo or other habitats.

6.1 PASTURES AND CULTIVATED FIELDS: No separate provision is made for these habitats.

6.2 NATURAL GRASSLAND: Birds of primary natural grasslands excluding pastures, lawns, airfields, cultivated lands, etc. Range from semi-arid to moist grasslands and may include grassy patches within other habitats. Includes sweet, sour and mixed grasslands.

6.2.1 SOUR: Birds of sour (high rainfall, often montane) natural grassland.

6.2.2 SWEET: Birds of sweet (low rainfall) natural grasslands.

6.2.3 MOIST: Birds of natural grasslands which are distinctly wet to marshy in the rainy season.

7 SCRUB HABITATS: Birds of scrubby (woody shrubs) vegetation including Karoo scrub, fynbos, strandveld and the characteristic scrub of hill slopes and kloofs. Excludes the birds of the relatively tall thornbush to be found in watercourses in the Karoo and Kalahari which fall under woodland.

7.1 FYNBOS: Birds of fynbos (macchia) scrub.

7.2 KAROO: Birds of succulent and Nama Karoo scrub.

8 UNCLASSIFIED: Used for birds associated primarily with man-made habitats and species whose habitat requirements are either too general, too varied or too difficult to define.

9 EXTRALIMITAL: All southern African species either not occurring in the RSA, Lesotho or Swaziland, or occurring only as vagrants.

An important extension of this basic scheme was the additional categorization of each species as an ''indicator'' or ''associate'' of each habitat category to which it was allocated. The term ''indicator species'' has been used in a variety of contexts elsewhere but here it is given a specific definition. Indicator status implies that a species has an obligate relationship to its habitat with the corollary that it will not be found under any other main (primary level) habitat category, although it may occur in more than one secondary category of a given primary category. Associate status implies that the species is highly likely to utilize and thus be associated with a given habitat, if that habitat type is available, but that its relationship to the habitat type is facultative rather than obligate. A corollary of associate status is that a species may be listed as an associate under more than one primary habitat category. Appendix 1 lists all species as indicators or associates of the relevant habitat categories.

The computer-based routine which produces the annotated lists of species was dubbed the Habitat Annotation Routine (HAR). HAR uses a reference file to find the habitat classification of each species. Also given in this file is ancillary information on the endemism, Red Data and migratory status of each species which is used for further annotation of the output report. The reference file can be updated easily in the light of new information.

Endemism is a relative concept and must be qualified by a definition of the region to which the species is endemic. Table 2 summarizes the endemism categories used. Clancey (1986) and Maclean (1985) were the main sources of information here.

The Red Data categories and species are as given in Brooke (1984). The scheme used here differs in that the peripheral tropical species, as listed by Brooke, were placed in a separate ''marginal'' category defined as: species which are at the edge of their ranges in South Africa and are therefore rare or very restricted in a South African context but probably not so in a wider African context.

Species were categorized according to their migratory status in South Africa, as opposed to southern Africa (Maclean 1985); see Table 3.

The input to HAR is summary data (as opposed to raw fieldcard data) for quarter-degree grid squares. The data consist of counts of the number of fieldcards on which each species was recorded in each calendar month, as well as counts of breeding records, together with the total number of fieldcards collected for the grid square. This information allows for the calculation of a reporting rate for each species. The reporting rate is the proportion of cards which record a given species, expressed as a percentage (Harrison 1989). HAR calculates the reporting rate for each species and includes a species in the report only if its reporting rate falls above a cut-off point which is specified at run-time. A cut-off reporting rate is used to eliminate species which are likely to be only vagrants to an area. In the SABAP databank, species with reporting rates of less than 1.5% cannot, with few exceptions, be regarded as true members of a bird community and should be disregarded for most purposes.

The summary data are typically based on several fieldcards. The number can vary from as few as one or two for the most poorly covered grid squares to thousands of cards for those containing major urban centres. (There are 2 037 grid squares in South Africa, Lesotho and Swaziland. The mean number of fieldcards per grid square = 53.9 SD = 110.5; median = 19; mode = 7.) However, as a professional field ornithologist was employed to visit areas which were not otherwise receiving adequate attention, even those grid squares with relatively few fieldcards have reasonably comprehensive bird lists in the SABAP databank (Harrison 1992).

SABAP summary files can be generated for half-degree grid squares (30´x30´), or any unit consisting of an amalgamation of quarter-degree grid squares. The HAR routine can thus be applied to any of those units as well. Reports can be generated at short notice without any major preliminary data manipulation.

RESULTS AND DISCUSSION

The routine was designed to produce a report which would be intelligible to potential users, including non-ornithologists, and the emphasis is therefore on full documentation. The analysis of the species list for a given grid square is presented in two distinct formats. The first consists of a series of lists of species under each of the relevant habitat categories. Indicators and associates are listed separately under each heading for emphasis. Species listed low down in the habitat hierarchy are also listed at the higher levels. This introduces a degree of redundancy but allows each list to stand alone. Each list is preceded by a definition of the habitat category. The species are annotated with endemism, Red Data, breeding and migratory status information.

The second section presents the full species list in Roberts' number order (Maclean 1985) in tabular format. (See Appendix 1.) The columns of the table represent the various habitat categories and the cells contain symbols for indicators and associates. The report is concluded with a summary table in which the species richness in each habitat category is given.

All users and uses of the report would need carefully to take into account the extent of the geographical area over which the raw data were collected (usually a quarter-degree grid square) and the sample size in terms of the number of fieldcards from which the raw data were obtained. These factors affect the specificity and completeness of the report respectively.

HAR is an attempt to increase the usefulness of a very large and comprehensive dataset to particular potential user groups, namely environmental consultants, planners and managers. We feel that the design of the hierarchy, the differentiation between indicator and associate species, and the ancillary annotations not only help to present information but prioritize it in a manner which aids decision-making processes.

We can visualize the reports being used in a number of ways. The following are some possibilities:

(1) Ornithological consultants who have done a survey and are familiar with the habitat profile of their study area can use the report to supplement their findings.

(2) Consultants with little or no ornithological experience but who are familiar with the study area and its habitat composition could regard the report as a convenient survey of the avifauna and use their knowledge of the site to edit the report down to those habitat-specific lists which are relevant. The annotations in the report would assist such users in highlighting species of special significance.

(3) Planners or consultants not yet familiar with a particular site or general area could use the HAR report as a means of getting an impression of habitat and species diversity. In cases where a rapid response to a threatening development is required, the HAR report could provide an empirical basis for argument at short notice.

(4) Developers wishing to enrich avian species diversity as a means of improving the quality of a development and attracting visitors or buyers could use the report as a means of assessing the potential bird community which could be established through restoration or creation of habitats.

(5) Reports for adjacent areas could be used in a comparative manner. Researchers wishing to describe the effects of various environmental impacts could use reports for different areas to detect differences between neighbouring bird communities and use these as a point of departure for further investigation.

(6) Managers of natural areas might use the report as an aid in the design of management plans which need to take into account the full range of species and habitats.

(7) Developers with knowledge of exactly which habitats will be impacted by proposed developments at a study site, can predict the precise suite of species likely to be impacted and conversely those which are likely to be unaffected or only marginally affected.

In developing the HAR report, the Avian Demography Unit is attempting to establish a strategy whereby data are made available to the private sector at market-related rates, thus generating funds for further research.

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Society, Orange Free State Ornithological Society, Ornithological Association of Zimbabwe, Southern African Ornithological Society, University of Cape Town, Wildlife Society of Lesotho and Witwatersrand Bird Club.

The SABAP has been fortunate to enjoy the support of several sponsors. They are, in alphabetical order: Endangered Wildlife Trust, De Beers Chairman's Fund, Department of Environment Affairs, Distillers Corporation, Drizit South Africa, Gold Fields Foundation, Mazda Wildlife Fund, Natal Bird Club, Natural History Society of Swaziland, Southern African Nature Foundation, Southern African Ornithological Society, University of Cape Town and the Wildlife Society of Southern Africa. Several private individuals have also made generous donations.

Thousands of volunteers have spent many man-years collecting data, all at some and some at great personal expense. Scores of dedicated individuals have performed regional administrative duties, on an honorary basis. The success of the SABAP is a direct result of their inspiring efforts.

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TABLE 1

THE HIERARCHY OF HABITAT CATEGORIES

primary level	secondary level	tertiary level
1) MARINE	pelagic shore	
2) AQUATIC	lotic	open water exposed shore emergent vegetation
	lacustrine	open water exposed shore emergent vegetation
3) MONTANE & ROCKY		
4) FOREST	East coast forest Afromontane forest forest edge	
5) WOODLAND	indigenous	thicket acacia broadleaved riverine
6) GRASSLAND	natural	sour sweet moist
7) SCRUB	fynbos Karoo	
8) UNCLASSIFIED		
9) EXTRALIMITAL		

CHAPTER 10

Atlassing as a tool in conservation, with special reference to the Southern African Bird Atlas Project

J A Harrison

INTRODUCTION

A prerequisite for the conservation of biotic diversity is a description of the existing diversity of organisms and their spatial and temporal distributions and abundance. With the land available for nature conservation becoming ever more scarce, and the average size of the patches of undisturbed natural habitat becoming ever smaller, the need for accurate and relatively fine-scale distribution maps increases. There is a parallel need for more detail to support the increased rigour of ecological and biogeographical research. Gathering the amount of data required for detailed mapping has been made possible by the growing public interest in environmental issues and wildlife conservation. The technical ability to analyse large data sets has been greatly facilitated by the development of computer technology. For these and various other reasons, the concept of biological atlassing[1] has come of age and is now receiving the attention of various biological disciplines in many parts of the world.

Maps in a modern biological atlas should be distinguished from other types of distribution maps. The distributions of species have traditionally been described by drawing lines between localities at the limits of their known ranges and filling in gaps with informed guesswork. The data used in

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[1]'Atlas' has become an accepted biological term and simply refers to a collection of distribution maps for species. 'Atlassing' has come to mean the gathering of data for an atlas but does not refer to any specific methodology.

this large subjective process can be drawn from any and all time periods meaning that the hypothetical distributional picture obtained may differ dramatically from the current situation. As a quantitative and hence more objective technique, atlassing provides an accurate map of current distributions without involving guesswork or interpolation.

In the discussion which follows I attempt to provide information on the theory and practice of atlassing, particularly as it applies to birds. Readers should bear in mind that every group of organisms would impose its own peculiar set of constraints on an atlas project.

THE ELEMENTS OF THE ATLAS APPROACH TO SURVEYING

The only essential characteristic of the atlas approach to surveying is that observations are objectively and accurately linked to geographical location. Atlases can be categorized according to the degree to which they exceed this fundamental trait:

- those that record distribution regardless of temporal factors (Boshoff et al 1983);
- those that describe distributions at a particular point in time (Sharrock 1977; Bull et al 1985);
- those that document the seasonality of distributions (Cyrus and Robson 1980; Tarboton et al 1987; Earlé and Grobler 1987);
- those that measure the relative abundance of species through space and time (Blakers et al 1984); and
- those that measure the absolute abundance of species (the new atlas of breeding birds in Britain and Ireland, in progress).

Despite the fact that atlassing is currently in vogue, the objectives of an atlas project should be critically evaluated. The current state of knowledge of the group of organisms to be mapped should determine those objectives.

The Southern African Bird Atlas Project (SABAP), for example, would have difficulty in justifying its existence if it attempted only to establish the basic distributions of birds, since these are already broadly known. The SABAP has, therefore, ensured that in addition to relatively accurate distributional information, data relating to seasonality, relative abundance and breeding are also obtained (Hockey and Ferrar 1985; Harrison 1988). However, in planning an atlas project, the objectives of the project and degree of detail desired have to be weighed against the resources available to gather and process the data.

Geographic scale

The survey area is usually divided into uniform geographic units, often referred to as a 'grid', which allows for a degree of aggregation of data. The distributional picture is thus a mosaic of data sets from all the geographic units. The size and use of these geographic units should, to some extent, be determined by the nature of the biota being surveyed. Relatively large units are appropriate for animals which move about freely, birds for example, whereas a survey of more sedentary biota, or those with very specialized or restricted habitat requirements, would call for the use of smaller units or exact localities. An extreme case would be rare plants where it would be necessary to specify exact locality to allow individual plants to be located again in the future (Rebelo et al 1987; Taylor and Hopper 1984). However, it should be noted that in the absence of a grid system, it is difficult to define and monitor the coverage objectives for a project.

The size of the survey area combined with manpower limitations will also determine the degree of aggregation of data that is desirable. Thus the greater the total area and the smaller the work-force, the coarser the grid would need to be.

An 'optimism factor' should be built into the survey so that the level of geographic accuracy recorded is finer than the minimum requirements dictate. Data can always be lumped into larger geographical units if coverage of the smaller units is inadequate, but a project may be unexpectedly successful, enabling mapping on the finer scale.

Coverage in an atlas project is always patchy: certain areas have the potential to be excellently covered, whereas others will receive only minimal coverage. The potential for thorough coverage in some areas should not be wasted by adopting too coarse a grid. The procedures whereby the data are collected, processed and analysed should have built into them a degree of flexibility with regard to the scale of mapping to allow for the geographic variation in intensity of coverage.

Time scale

Unfortunately atlas projects must be given temporal boundaries because of the costs involved. By restricting atlassing to a particular period of time, the distribution patterns obtained become specific statements for that period and can be used as a basis for comparison with past or future data sets.

The atlassing period should be long enough to provide an 'average' picture which is not excessively distorted by short-term fluctuations. It should also be short enough to prevent data collected early in the project from becoming obsolete before completion of the project. At the present rate of environmental change due to human activity, the period of an atlas project should probably not exceed 10 years.

Whereas atlas data can be recorded and computerized without any date, the inclusion of a date enables both long-term trends and seasonal changes to be detected in distribution or in any ancillary data being collected, for instance breeding activity. As seasonality can have important implications for management practices, dating of data should always be seriously considered.

Dating each item of data carries with it complicating effects as does recording exact locality for each observation. Again it is desirable to employ a degree of amalgamation for the sake of simplicity and efficiency. Temporal units that have been used are, for example, seasons of three months, and calendar months (Blakers et al 1984; Cyrus and Robson 1980).

An important consideration in determining the length of time units is the multiplicative effect these units have on the sampling rate of the survey. Clearly, monthly sampling would entail three times the number of samples and three times the volume of data that would be required by quarterly (three-monthly) units. This has obvious implications for the effort required not only in data collection but also for data collation and analysis.

Scope of data gathering

The scope of atlas data can easily be expanded beyond simple presence/absence information. Provision should be made at least for breeding data. Plant specimens can be examined in detail at leisure, and plant atlases therefore have greater potential for the collection of ancillary data.

A major constraint on the choice of ancillary information is the ability to record such information in the form of simple numerical codes. Whereas the technology exists to process lengthy non-numerical data, the cost of capturing such data becomes prohibitive when dealing with large numbers of field cards.

Computerization

Not only does computerization facilitate the compilation of large quantities of data, it also allows for the emergence of more subtle information based on statistical analyses of the data. This point is expanded in the section 'What can a bird atlas show?'.

Another great advantage of computerization lies in the relative ease with which interim analyses of data can be obtained. These are invaluable as a means of providing feedback to the work-force. Regular feedback on the progress of a project is vital to sustaining motivation and directing efforts towards areas of greatest need.

Purpose-written atlas programs are preferable to commercially available packages. Ideally they should be written by someone who is closely associated with the atlas project and who will be available to maintain and modify the programs during the course of the project. All programs should be written and thoroughly tested on data from a small-scale pilot project prior to the commencement of a major atlas project.

Computerization has important implications for the design of the data reporting form. If the data submitted by observers have to be manually transposed onto coding sheets prior to computerized data capture, the work-load involved in data capture is at least doubled. It is therefore highly desirable that the data be captured directly from the observer's report form. While being 'computer compatible', the form should nevertheless be carefully designed to be 'user friendly'. The SABAP appears to have been uniquely successful in this regard (Hockey and Ferrar 1985) (Figure 10.1).

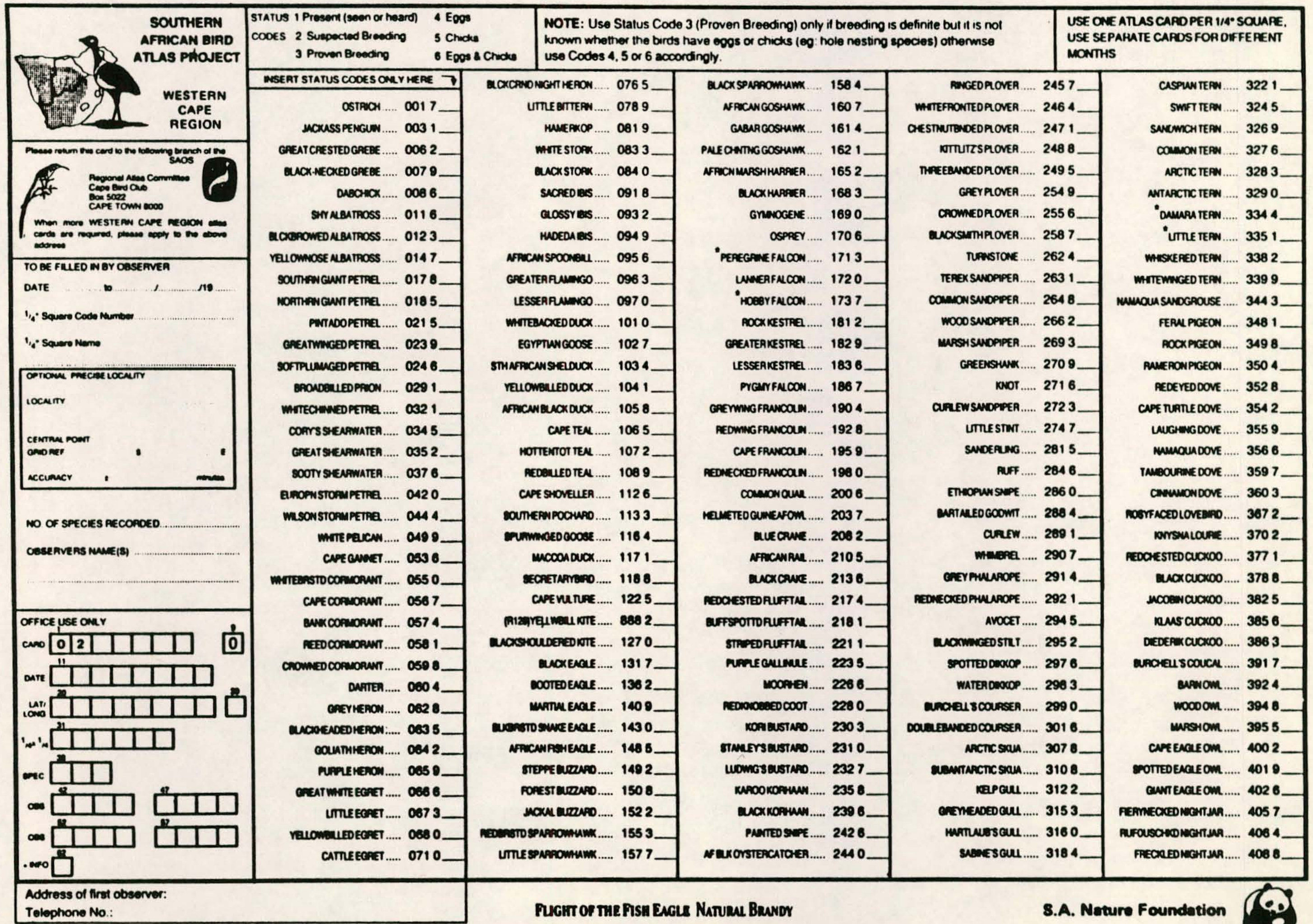
Data capture is a process that inevitably introduces errors into the data bank. This problem can be largely overcome by using a series of programmed checks for 'impossible' and inconsistent information. The 'check digit' appended to each species code is an example of such a system employed by the SABAP (Hockey and Ferrar 1985).

Choice of observers

A crucial question in the planning of an atlas project is whom to use as observers in the field. The choice is essentially between using professionals only or using volunteers drawn from the general public. The relative merits and demerits of using professionals and volunteer amateurs as observers are outlined in Table 10.1.

TABLE 10.1 Professional versus amateur observers

Professionals	Amateur volunteers
Few participants therefore little data — more time required for adequate coverage	Many participants therefore many data — less time required for adequate coverage
Data relatively reliable — vetting of data less problematic	Data relatively unreliable — vetting of data vital
More sophisticated and subtle data can be recorded	Data collection needs to be kept as simple and as undemanding as possible
Small quantities of data restrict statistical validity of analyses	Large data sets lend themselves to statistical analysis which could lead to additional and perhaps unexpected information.
Administrative functions relatively simple and small scale	Sophisticated full-time administration for recruitment of and communication with volunteers, and for coping with large volume of data
Costs relatively modest if data gathering part of normal duties — costs prohibitive if professionals are specially employed	Costs relatively great in view of greater administrative complexity and greater volume of data
Project is relatively isolated from the community at large	Wide involvement with attendant benefits for environmental education
Option of long-term or ongoing data collection is more feasible	Suited to intensive short-term data collection in the region of three to five years
More suitable for little known, esoteric biota	Will respond best to well-known – 'popular' biota



SOUTHERN AFRICAN BIRD ATLAS PROJECT

WESTERN CAPE REGION

STATUS CODES 1 Present (seen or heard) 2 Suspected Breeding 3 Proven Breeding 4 Eggs 5 Chicks 6 Eggs & Chicks

NOTE: Use Status Code 3 (Proven Breeding) only if breeding is definite but it is not known whether the birds have eggs or chicks (eg: hole nesting species) otherwise use Codes 4, 5 or 6 accordingly.

USE ONE ATLAS CARD PER 1/4° SQUARE. USE SEPARATE CARDS FOR DIFFERENT MONTHS

Please return this card to the following branch of the SAOS

Regional Atlas Committee
Cape Bird Club
Box 5022
CAPE TOWN 8000

When more WESTERN CAPE REGION atlas cards are required, please apply to the above address

TO BE FILLED IN BY OBSERVER

DATE .... to .... / .... /19 ......

1/4° Square Code Number ....

1/4° Square Name

....

OPTIONAL PRECISE LOCALITY

LOCALITY

CENTRAL POINT GRID REF S E

ACCURACY ± minutes

NO OF SPECIES RECORDED ....

OBSERVERS NAME(S) ....

....

OFFICE USE ONLY

CARD 0 2 0

DATE

LAT/LONG

1/4° 1/4

SPEC

OBS

OBS

• INFO

INSERT STATUS CODES ONLY HERE		BLCKCRND NIGHT HERON	076 5	BLACK SPARROWHAWK	158 4	RINGED PLOVER	245 7	CASPIAN TERN	322 1
OSTRICH	001 7	LITTLE BITTERN	078 9	AFRICAN GOSHAWK	160 7	WHITEFRONTED PLOVER	246 4	SWIFT TERN	324 5
JACKASS PENGUIN	003 1	HAMERKOP	081 9	GABAR GOSHAWK	161 4	CHESTNUTBNDED PLOVER	247 1	SANDWICH TERN	326 9
GREAT CRESTED GREBE	006 2	WHITE STORK	083 3	PALE CHNTNG GOSHAWK	162 1	KITTLITZ'S PLOVER	248 8	COMMON TERN	327 6
BLACK-NECKED GREBE	007 9	BLACK STORK	084 0	AFRICN MARSH HARRIER	165 2	THREEBANDED PLOVER	249 5	ARCTIC TERN	328 3
DABCHICK	008 6	SACRED IBIS	091 8	BLACK HARRIER	168 3	GREY PLOVER	254 9	ANTARCTIC TERN	329 0
SHY ALBATROSS	011 6	GLOSSY IBIS	093 2	GYMNOGENE	169 0	CROWNED PLOVER	255 6	*DAMARA TERN	334 4
BLCKBROWED ALBATROSS	012 3	HADEDA IBIS	094 9	OSPREY	170 6	BLACKSMITH PLOVER	258 7	*LITTLE TERN	335 1
YELLOWNOSE ALBATROSS	014 7	AFRICAN SPOONBILL	095 6	*PEREGRINE FALCON	171 3	TURNSTONE	262 4	WHISKERED TERN	338 2
SOUTHRN GIANT PETREL	017 8	GREATER FLAMINGO	096 3	LANNER FALCON	172 0	TEREK SANDPIPER	263 1	WHITEWINGED TERN	339 9
NORTHRN GIANT PETREL	018 5	LESSER FLAMINGO	097 0	*HOBBY FALCON	173 7	COMMON SANDPIPER	264 8	NAMAQUA SANDGROUSE	344 3
PINTADO PETREL	021 5	WHITEBACKED DUCK	101 0	ROCK KESTREL	181 2	WOOD SANDPIPER	266 2	FERAL PIGEON	348 1
GREATWINGED PETREL	023 9	EGYPTIAN GOOSE	102 7	GREATER KESTREL	182 9	MARSH SANDPIPER	269 3	ROCK PIGEON	349 8
SOFTPLUMAGED PETREL	024 6	STH AFRICAN SHELDUCK	103 4	LESSER KESTREL	183 6	GREENSHANK	270 9	RAMERON PIGEON	350 4
BROADBILLED PRION	029 1	YELLOWBILLED DUCK	104 1	PYGMY FALCON	186 7	KNOT	271 6	REDEYED DOVE	352 8
WHITECHINNED PETREL	032 1	AFRICAN BLACK DUCK	105 8	GREYWING FRANCOLIN	190 4	CURLEW SANDPIPER	272 3	CAPE TURTLE DOVE	354 2
CORY'S SHEARWATER	034 5	CAPE TEAL	106 5	REDWING FRANCOLIN	192 8	LITTLE STINT	274 7	LAUGHING DOVE	355 9
GREAT SHEARWATER	035 2	HOTTENTOT TEAL	107 2	CAPE FRANCOLIN	195 9	SANDERLING	281 5	NAMAQUA DOVE	356 6
SOOTY SHEARWATER	037 6	REDBILLED TEAL	108 9	REDNECKED FRANCOLIN	198 0	RUFF	284 6	TAMBOURINE DOVE	359 7
EUROPN STORM PETREL	042 0	CAPE SHOVELLER	112 6	COMMON QUAIL	200 6	ETHIOPIAN SNIPE	286 0	CINNAMON DOVE	360 3
WILSON STORM PETREL	044 4	SOUTHERN POCHARD	113 3	HELMETED GUINEAFOWL	203 7	BARTAILED GODWIT	288 4	ROSYFACED LOVEBIRD	367 2
WHITE PELICAN	049 9	SPURWINGED GOOSE	116 4	BLUE CRANE	208 2	CURLEW	289 1	KNYSNA LOURIE	370 2
CAPE GANNET	053 6	MACCOA DUCK	117 1	AFRICAN RAIL	210 5	WHIMBREL	290 7	REDCHESTED CUCKOO	377 1
WHITEBRSTD CORMORANT	055 0	SECRETARYBIRD	118 8	BLACK CRAKE	213 6	GREY PHALAROPE	291 4	BLACK CUCKOO	378 8
CAPE CORMORANT	056 7	CAPE VULTURE	122 5	REDCHESTED FLUFFTAIL	217 4	REDNECKED PHALAROPE	292 1	JACOBIN CUCKOO	382 5
BANK CORMORANT	057 4	(R128)YELLWBILL KITE	888 2	BUFFSPOTTD FLUFFTAIL	218 1	AVOCET	294 5	KLAAS' CUCKOO	385 6
REED CORMORANT	058 1	BLACKSHOULDERED KITE	127 0	STRIPED FLUFFTAIL	221 1	BLACKWINGED STILT	295 2	DIEDERIK CUCKOO	386 3
CROWNED CORMORANT	059 8	BLACK EAGLE	131 7	PURPLE GALLINULE	223 5	SPOTTED DIKKOP	297 6	BURCHELL'S COUCAL	391 7
DARTER	060 4	BOOTED EAGLE	136 2	MOORHEN	226 6	WATER DIKKOP	298 3	BARN OWL	392 4
GREY HERON	062 8	MARTIAL EAGLE	140 9	REDKNOBBED COOT	228 0	BURCHELL'S COURSER	299 0	WOOD OWL	394 8
BLACKHEADED HERON	063 5	BLKBRSTD SNAKE EAGLE	143 0	KORI BUSTARD	230 3	DOUBLEBANDED COURSER	301 6	MARSH OWL	395 5
GOLIATH HERON	064 2	AFRICAN FISH EAGLE	148 5	STANLEY'S BUSTARD	231 0	ARCTIC SKUA	307 8	CAPE EAGLE OWL	400 2
PURPLE HERON	065 9	STEPPE BUZZARD	149 2	LUDWIG'S BUSTARD	232 7	SUBANTARCTIC SKUA	310 8	SPOTTED EAGLE OWL	401 9
GREAT WHITE EGRET	066 6	FOREST BUZZARD	150 8	KAROO KORHAAN	235 8	KELP GULL	312 2	GIANT EAGLE OWL	402 6
LITTLE EGRET	067 3	JACKAL BUZZARD	152 2	BLACK KORHAAN	239 6	GREYHEADED GULL	315 3	FIERYNECKED NIGHTJAR	405 7
YELLOWBILLED EGRET	068 0	REDBRSTD SPARROWHAWK	155 3	PAINTED SNIPE	242 6	HARTLAUB'S GULL	316 0	RUFOUSCHKD NIGHTJAR	406 4
CATTLE EGRET	071 0	LITTLE SPARROWHAWK	157 7	AF BLK OYSTERCATCHER	244 0	SABINE'S GULL	318 4	FRECKLED NIGHTJAR	408 8

Address of first observer:
Telephone No.:

FLIGHT OF THE FISH EAGLE NATURAL BRANDY

S.A. Nature Foundation

FIGURE 10.1 An example of a field card used by the SABAP. Note the minimum of coding required (bottom left-hand corner) before actual data capture, which is carried out directly from the field card. The fourth digit in the species code is a computer check digit.

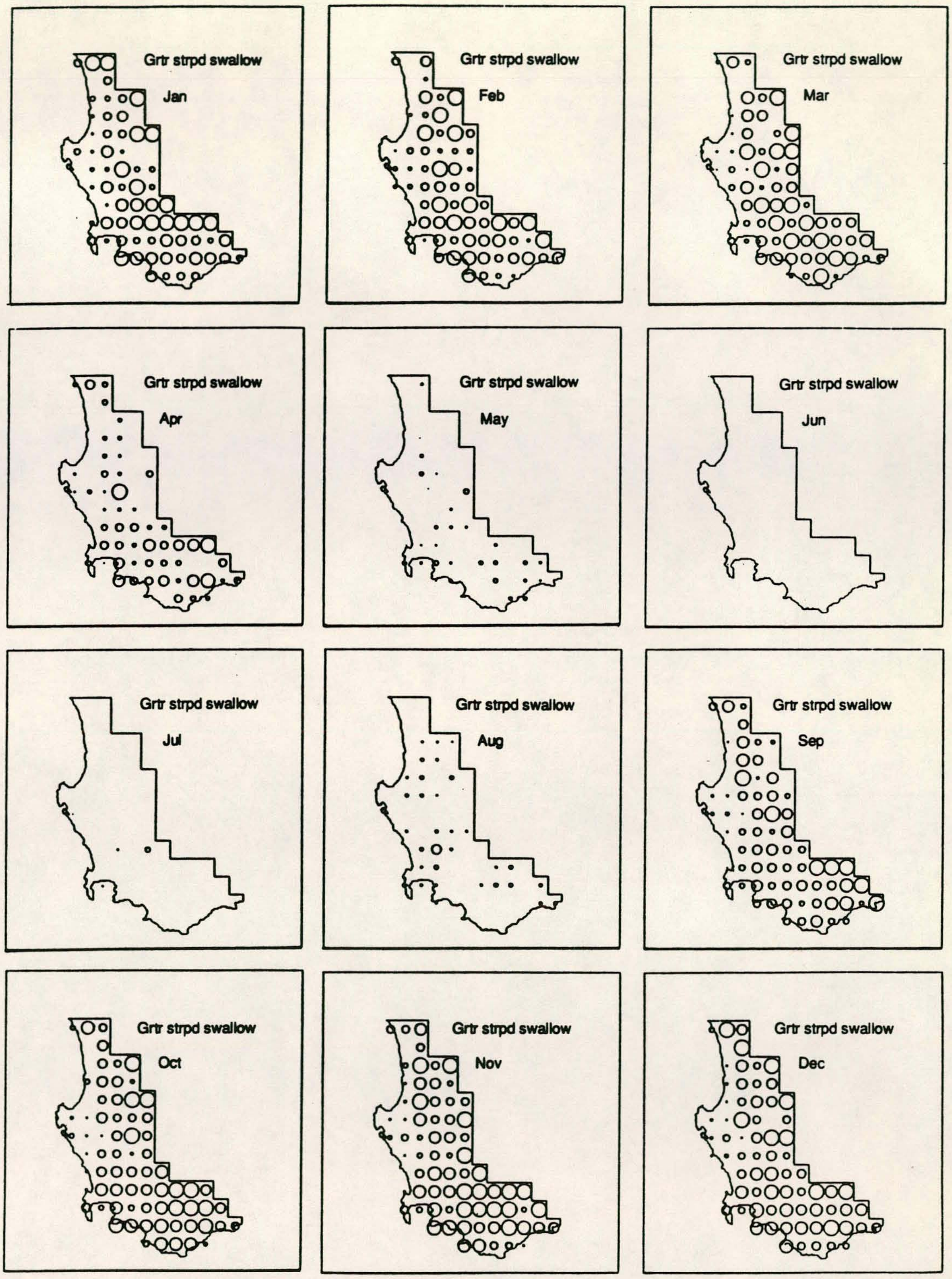


FIGURE 10.2 Monthly distribution maps for the greater striped swallow, an intra-African migrant, in the south-western Cape. Note the relatively brief period of absence from May to August. (The diameter of the circle is proportional to the reporting rate for each quarter-degree square.)

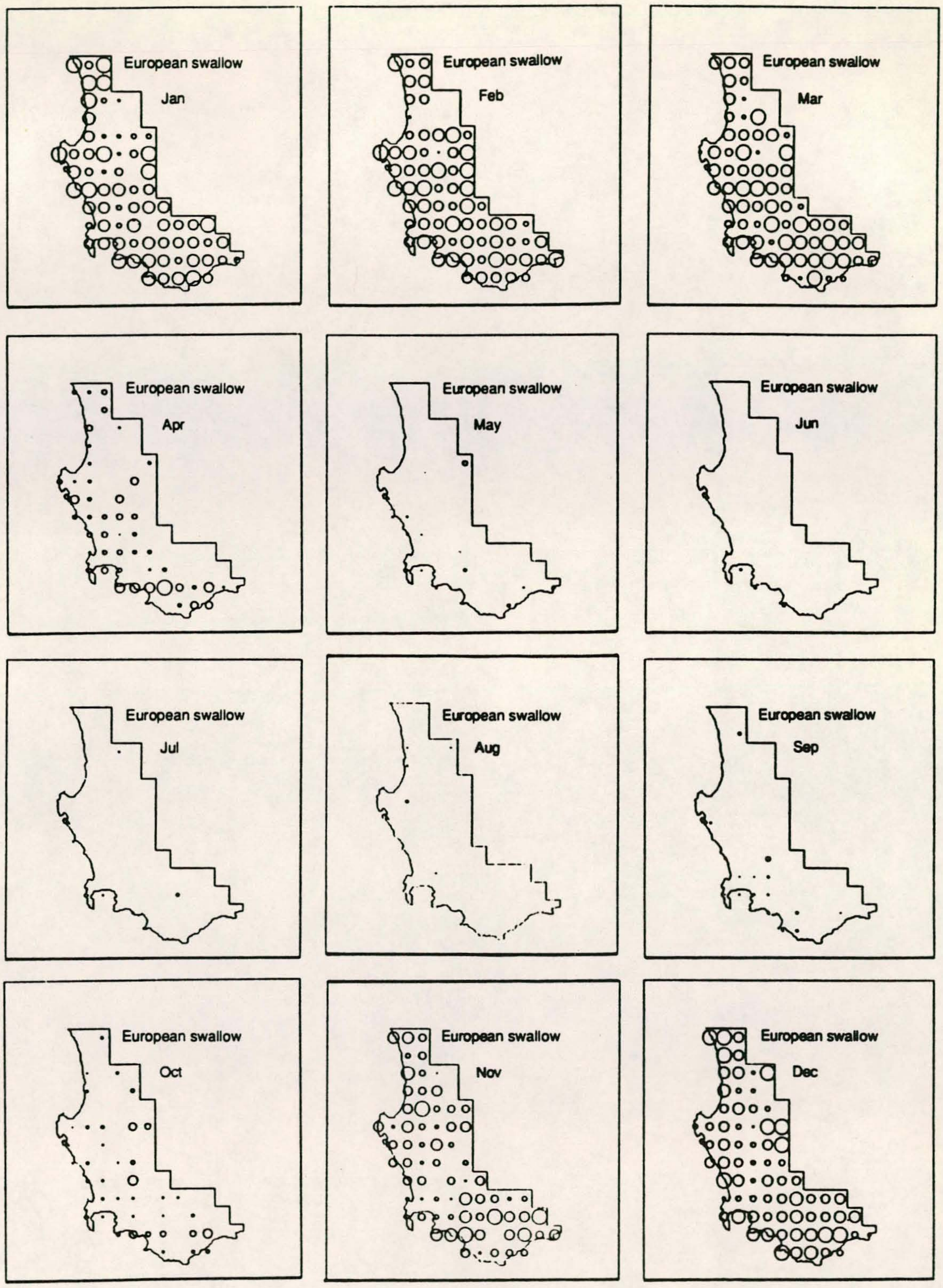


FIGURE 10.3 Monthly distribution maps for the European swallow, a palaearctic migrant, in the south-western Cape. Note the relatively long period of absence from April to October.

Because of the large geographic scale of most atlas projects there is, in practice, often no alternative to using volunteer amateurs to collect data. As can be seen from Table 10.1, this has important implications for the organization of an atlas project and it also determines many of the strengths and weaknesses of the atlas approach.

When is an atlas project indicated?

Although atlassing may appear to be the answer wherever baseline distributional data are required, there are certain fundamental limitations in the applicability of this approach.

Any group within which there are many unknown or inadequately described species will not lend itself to atlassing. Furthermore, there should be convenient and readily available field guides for the group to facilitate identification in the field.

If it is decided to use volunteer assistance with field work one is further restricted to those organisms that are relatively accessible and appealing to members of the public. In this regard birds are ideal but reptiles, for example, are not. A large, well-organized amateur organization can assist greatly with the recruitment and organization of volunteers. In the case of the SABAP, the Southern African Ornithological Society (SAOS) has played a pivotal role (Harrison 1987).

The scale and ambitiousness of a project obviously holds immense implications for the cost of the project, the most important factor being staffing. If the project is big enough to require the employment of special staff, a great increase in expense can be expected.

ATLASSING AND LONG-TERM MONITORING

Atlas projects generally attempt to cover a large geographic area with the help of a large volunteer amateur work-force. Such projects are usually relatively short-term and intensive with well-defined goals, so that costs can be kept down, fund raising motivated, and volunteers kept enthusiastic. Atlas projects *per se* are thus not equivalent to long-term monitoring; they attempt rather to provide baseline information. However, there are ways in which atlassing can contribute significantly towards long-term monitoring.

First, atlassing methods of data collection can be used for monitoring relatively small areas, particularly where a professional work-force is permanently available, as in forestry and nature conservation agencies.

As atlas projects span several years, trends can often be detected within the period (Underhill and Hockey 1988). These observations can provide the motivation for further, more specialized monitoring subsequent to the atlas project.

Objective methods make repeatability a feature of atlas projects. By repeating a project at intervals, the data series becomes the equivalent of 'pulsed' monitoring. For very large areas this type of monitoring may be more effective than continuous, low-intensity monitoring.

An atlas project such as the SABAP is, among other things, an ambitious public relations exercise. The possibility exists that sufficient dedicated volunteers will be recruited during the course of the project to allow data gathering to continue on a less intense but more structured basis after the initial atlassing period. Other options for long-term monitoring, namely ongoing data collection versus periodic repetition of atlas projects, should be investigated before the end of the SABAP's data -gathering period in 1991. The feasibility of a continuous monitoring attempt will depend largely on continuity of administration, which is envisaged in the form of a Bird Populations Data Unit (Ledger 1985 a, b; Prys-Jones 1984).

WHAT CAN A BIRD ATLAS SHOW?

The *raison d'être* of an atlas project is to describe distributions and this it can certainly do well if the desired standards of coverage are attained.

Beyond distribution *per se*, date-specific atlas data provide pictures of seasonal distributions for resident species, and times of arrival and departure for migratory species. This type of information enhances the potential for correlating atlas data with other environmental variables thus elucidating ecological mechanisms. See, for example, a comparison of seasonality of the greater striped swallow (an intra-African migrant) and the European swallow (a Palaearctic migrant) in the south-western Cape (Hockey et al in prep) (Figures 10.2 and 10.3).

This potential is greater still if breeding records have been included in the atlas data bank. Animals, particularly birds, often range well beyond their breeding grounds. Comparison of breeding and non-breeding distributions and pinpointing the timing of breeding can give further insight into ecological relationships and into the conservation priorities for species.

With regard to breeding it should be noted that where breeding activity is cryptic, as it is in many avian species, breeding records tend to be incidental and subsidiary to basic presence/absence information. This weakness can be overcome by the introduction of a formal search methodology, but this is not always practicable when using a semi-skilled work-force of amateur volunteers.

Although this is not one of the primary aims of an atlas project, it may be possible to detect changes from year to year. Such changes may be due to temporary exceptional circumstances such as droughts or floods, or they may be part of a cyclical pattern or ongoing trend. Despite the relatively short period of an atlas project, irruptions and range expansions and contractions can often be detected. Trends such as these can be further elucidated by reference to historical data (Blakers et al 1984). The hadeda ibis, for example, showed a marked westward expansion during the course of the Cape Bird Club's atlas project (Macdonald et al 1986; Hockey et al in prep) (Figure 10.4).

An important dimension of population variability is population size. Most atlas projects have not attempted to census species in order to avoid complicating atlassing techniques to a prohibitive degree. Nevertheless, an index of relative abundance can be obtained from the reporting rate (Blakers et al 1984). The diversity, ubiquity and conspicuousness of birds in particular make this type of analysis possible.

The technique depends on multiple sampling of the same geographic area, and calculating the proportion of field cards on which a particular species is recorded. For a given species, a difference in reporting rate between two areas is taken to indicate a difference in abundance.

It is important to appreciate that the calculation of the reporting rate assumes unbiased reporting of all species seen. It also assumes a reasonable minimum effort in the preparation of each field card. The field card is the basic sample unit and should list as many species as possible. All the data must be captured (computerized) in field card units in spite of the apparent redundancy of many of the data. The reporting and/or computerization of only certain 'special' species would make the calculation of reporting rates statistically meaningless.

Spatial variations in abundance of a species can indicate the 'core' range of the species as opposed to peripheral extensions of its range. Comparison of reporting rates for different species can be undertaken but only with great circumspection, since reporting rate is a function of conspicuousness and identifiability as much as it is a function of abundance. Where species are very similar and equally conspicuous, comparisons can be made, however. These are particularly interesting where the species are sympatric over parts of their ranges or where their ranges abut.

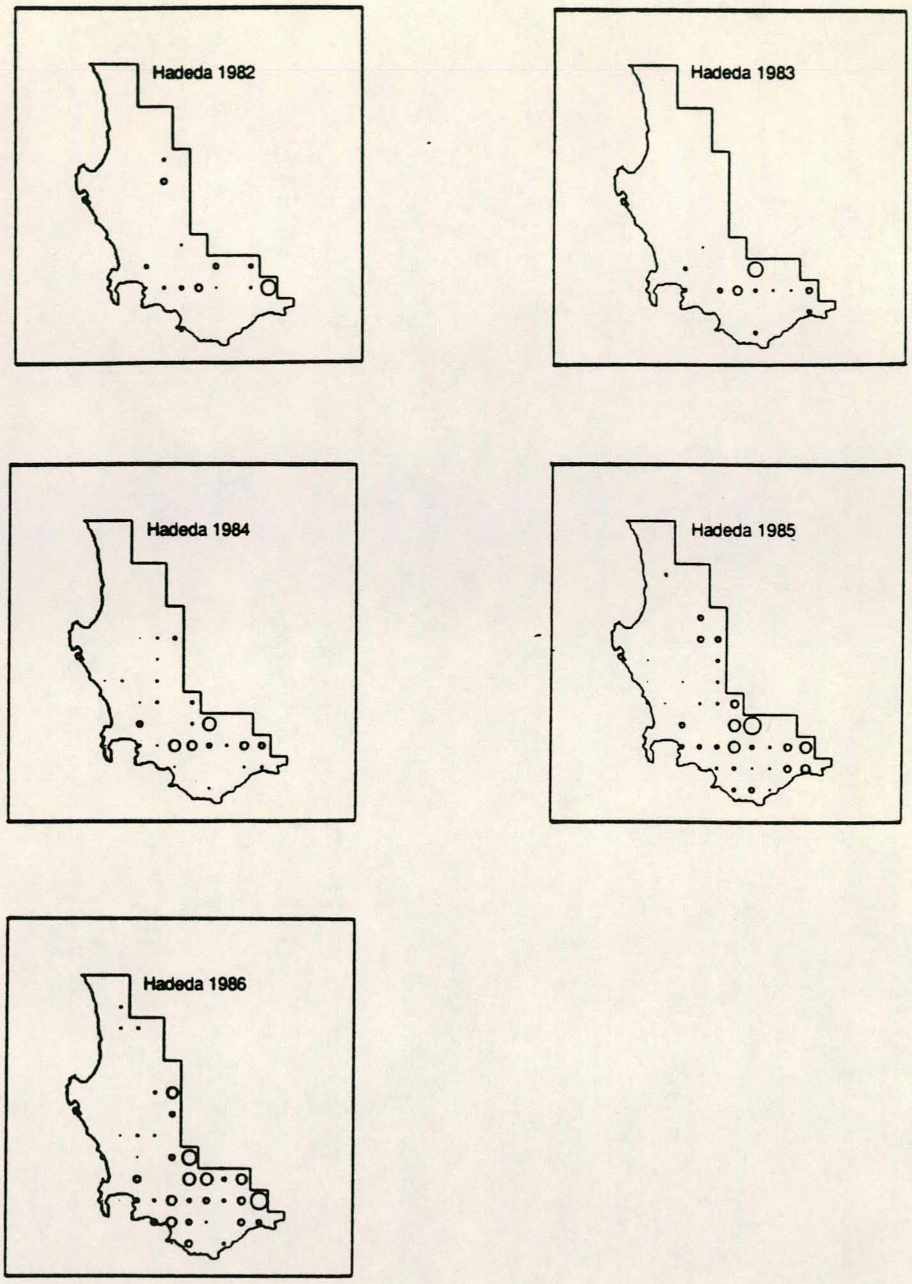


FIGURE 10.4 Annual distribution maps for the hadeda ibis from 1982 to 1986. The diameter of the circles is proportional to the reporting rate in the respective quarter-degree squares. The increasing number of squares in which the species was seen, together with an increased reporting rate in some of those squares, strongly suggests rapid expansion of the species' range into the region.

The replacement of one species by another in space invites analysis of habitat preferences and of the mechanisms maintaining allopatry or permitting sympatry.

It should be emphasized that far subtler insight into these issues can be gained from analyses of relative abundance than from absolute presence/absence patterns alone. The pied and black crows of the south-western Cape are a good case in point. Based on presence/absence data alone the two species appear sympatric in the south-western Cape, but when data are presented in terms of relative abundance, the distributions are found to be almost allopatric (Hockey 1987) (Figure 10.5).

Relative abundance over time can indicate temporal fluctuations in population size. Again these fluctuations can be related to environmental variables. For example, the irruptions of blackheaded canaries in the south-western Cape in 1982 and 1984 were probably the result of the severe drought conditions prevailing in their normal range in the northern Cape (Underhill and Hockey 1988).

A further example of the use of reporting rates concerns the fluctuations in population size indicated for certain species of migratory waders (Summers and Underhill 1987). These cyclical fluctuations were first detected using the recapture rate of ringed birds at Langebaan. The fluctuations were correlated with cycles of predation pressure, mainly by Arctic foxes, in their northern hemisphere breeding grounds. These cycles were in turn linked to the demographic cycle of lemming. Reporting rates in the south-western Cape provided independent corroboration of cyclical fluctuations in wader population sizes. The reporting rates for waders not subject to the same predation pressures showed no comparable fluctuations (Underhill and Hockey 1988).

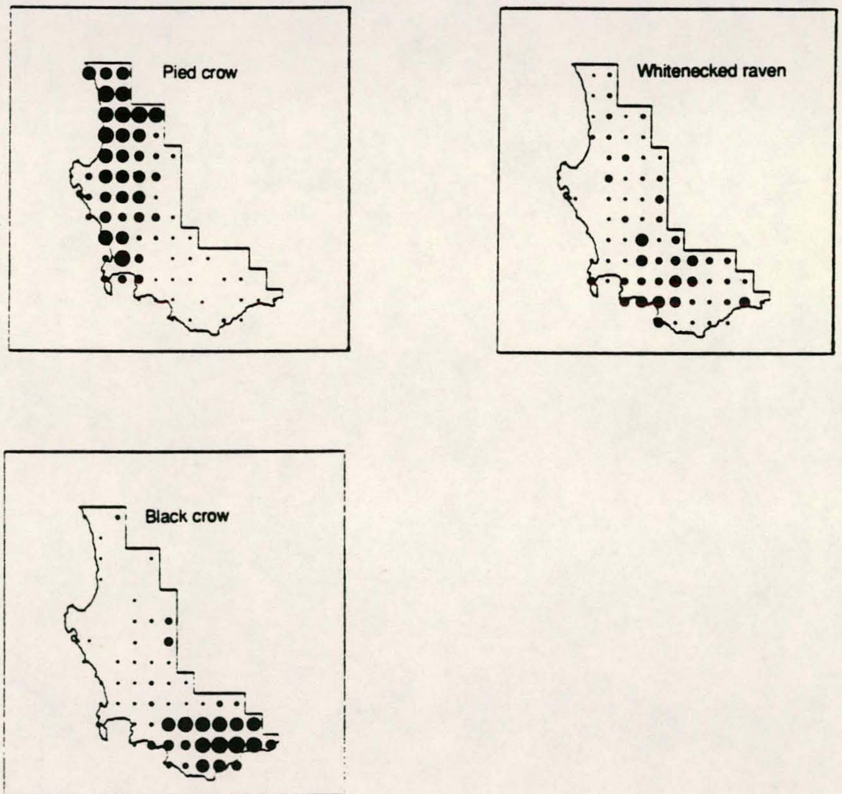


FIGURE 10.5 The distributions of pied crow, black crow and whitenecked raven in the south-western Cape. Whereas absolute presence/absence patterns suggest sympatry, relative abundance of the black crow and pied crow, as indicated by the reporting rates (circle diameters), suggest that these two species tend towards allopatry in the region. The whitenecked raven appears to favour the more mountainous parts.

The above examples should demonstrate that an atlas project can go well beyond the drawing of basic distribution maps provided that appropriate data have been collected and the necessary analytical programs are available.

THE BENEFITS OF A BIRD ATLAS TO CONSERVATION

Research required by nature conservation agencies can be categorized, in ascending order of complexity, as follows:

1) cataloguing of species within and outside conservation areas;
2) description of the distribution and status of threatened species;
3) evaluation of potential sites for nature reserves on the basis of features such as diversity and the extent of endemism;
4) monitoring of the status of species, particularly exploited species, and species that may be used as 'indicators' of more general biological conditions (eg the encroachment of alien vegetation) (Macdonald 1986);
5) determining appropriate management strategies for conservation areas, depending on management objectives (ie for diversity or for particular species); and
6) development of theory relating to the size, distribution and biological viability of nature reserves.

It is clear that the SABAP or any other atlas project will make a significant direct contribution to categories (1) and (2). Categories (3), (4) and (5) would also benefit greatly from the use of atlas data as part of broader data-gathering exercises.

Surveys of conservation areas usually result in the publication of 'check-lists' which frequently lack any reference to the status of individual species. Thus the inclusion of a species on a check-list does not necessarily mean that the species is being conserved in that area. It may be merely an occasional vagrant to the area or it may be on the decline. The quantification of relative abundance achieved by the SABAP means that a crude but useful measure of the status of species is obtained. Changes in relative abundance through space and time provide information relevant to conservation. Underhill and Hockey (1988) have developed a statistical technique with the potential to detect significant change in relative abundance.

Indications from the computerized south-western Cape Bird Atlas data are that several species will emerge as useful indicator species which will provide a key to the evaluation of habitat type and quality (P A R Hockey pers comm). This has a direct bearing on categories (4) and (5), in as much as atlas data will provide baseline information against which future changes may be measured.

The effective conservation of biotic diversity will entail the identification of centres of species diversity and of endemism. Evidence that centres of diversity and endemism tend to be congruent (Crowe and Crowe 1982) suggests that conservation could be especially advanced by identifying and setting aside land in such centres. Although atlas information is usually presented in the form of distribution maps for individual species, there is no obstacle to using geographic units as the focus of analysis. In this way species lists for localities can be compiled and compared in order to identify areas of particular species richness.

Given the necessary computer program, we could use our present knowledge of the composition of bird communities to map particular types of habitat. The computer would locate those areas in which a particular assemblage of species occurs, thus helping to pinpoint patches of habitat. The validity of this approach could be tested using habitat such as forest, and then the approach expanded to other habitats whose distribution is less easily detected by other standard techniques. This could be 'fine-tuned' to select those geographic units containing patches that are not yet degraded and are therefore potential candidates for conservation action. Conversely, the technique could be used to indicate areas of known habitat which are being degraded and therefore require further monitoring action.

Category (5) is important to professional conservationists, since it relates directly to the achievement of their aims and the execution of their duties. If the value of atlas data to categories (1) to (4) is demonstrated, it is reasonable to assume that they will be used to contribute towards the drawing up of management plans for the conservation of birds and, concomitantly, of biotic diversity.

Category (6) concerns the scientific basis for conservation action. Most studies of this nature would need to refer to a distributional data base as a foundation for the development of theory. As the SABAP promises to produce the most comprehensive and detailed distributional data base for a whole group of organisms yet available in southern Africa, it may prove essential to the development of this type of advanced theory in South Africa.

ACKNOWLEDGEMENTS

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THE ROLE OF LARGE-SCALE DATA COLLECTION PROJECTS IN THE STUDY OF SOUTHERN AFRICAN BIRDS

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SUMMARY

UNDERHILL, L.G., OATLEY, T.B. & HARRISON, J.A. 1991. The role of large-scale data collection projects in the study of southern African birds. *Ostrich* 62: 124–148.

The major ornithological data collections in southern Africa (checklists, migration enquiry, atlas projects, censuses, bird ringing and recoveries, biometric data, nest record cards, moult cards and beached birds) are described. For each project, current volumes of data are tabulated. The Southern African Bird Atlas Project database contained 5,0 million records in December 1990. 1,25 million birds of 810 species had been ringed with South African Bird Ringing Unit rings by June 1989, resulting in 22 000 recoveries. There were more than 100 recoveries for 27 species. The nest record card scheme of the Southern African Ornithological Society had 117 000 cards on file in February 1990, representing 696 species, with more than 1 000 cards for 18 species. There were 4 040 cards of 380 species in the moult record scheme. African Seabird Group beach patrols had found 10 057 seabirds by the end of 1985. A selection of published applications for each data set is given. The potential of the data sets for further analyses is considered, especially in relation to key demographic characteristics such as abundance, productivity and survival. It is recommended that volunteer participation projects should concentrate on monitoring and that indices for change in the demographic characteristics be developed. Most of the projects could be incorporated into an Avian Demography Unit.

INTRODUCTION

Birds are generally abundant and are relatively easy to find, identify, count, catch, mark and measure. They also interest many people and are therefore ideal for large scale data collections. These collections range from simple checklists of occurrence to detailed inventories of information such as mensural data, diet, longevity, movement, and reproductive output.

This paper reviews some of the major collections of bird data in southern Africa, particularly those that have been extensive in space or time, or which have enjoyed a substantial amateur input, largely from members of the Southern African Ornithological Society (SAOS).

In the first sections of the paper, we describe each project and its resulting dataset, tabulate the volume of records, note the medium of storage and comment on the accessibility of the data. We provide a selection of examples of past and present usage, and suggest future analyses and applications.

Two recent conferences have focused on the importance of long-term studies in ecology (Likens 1989) and ornithology (Dunnet 1991). Both concluded that carefully designed long-term studies are essential components both of effective conservation management and research into population processes. In the Discussion, we therefore evaluate these projects from a conservation and research viewpoint, and provide recommendations for projects which should receive priority in the future.

CHECKLISTS

Description and applications

The need for lists of birds in local areas in southern Africa is not as acute in 1991 as it was in the mid 1950s when Winterbottom (1956) could table only 39 local areas in the subcontinent for which published lists were available. To meet this need, Winterbottom established the *South African Avifauna Series* in 1961 (Winterbottom 1966). By 1972, when the series was discontinued, 90 titles had been published from widely scattered localities in southern Africa, with poor coverage of the arid west of the subcontinent (Table 1, Fig. 1). The role of this series was taken over by *Southern Birds*, and 16 titles have been published to date (Table 2, Fig. 1).

However, the need for bird lists has not been exhausted. Even in 1988, Siegfried (1989) could obtain lists, partial or complete, published or unpublished, for only 213 out of 582 publicly owned nature reserves in southern Africa.

Many of the bird clubs affiliated to the SAOS had field card schemes prior to the commencement of atlas projects (see below). For example, the field card scheme in the southwestern Cape held 8 000 cards, now filed at the South African Bird Ringing Unit (SAFRING). They were collected from the early 1950s to 1981, when they were superceded by the southwestern Cape atlas project (Hockey *et al.* 1989). Several of the titles in the *South African Avifauna Series* were compiled, at least partially, from these field cards.

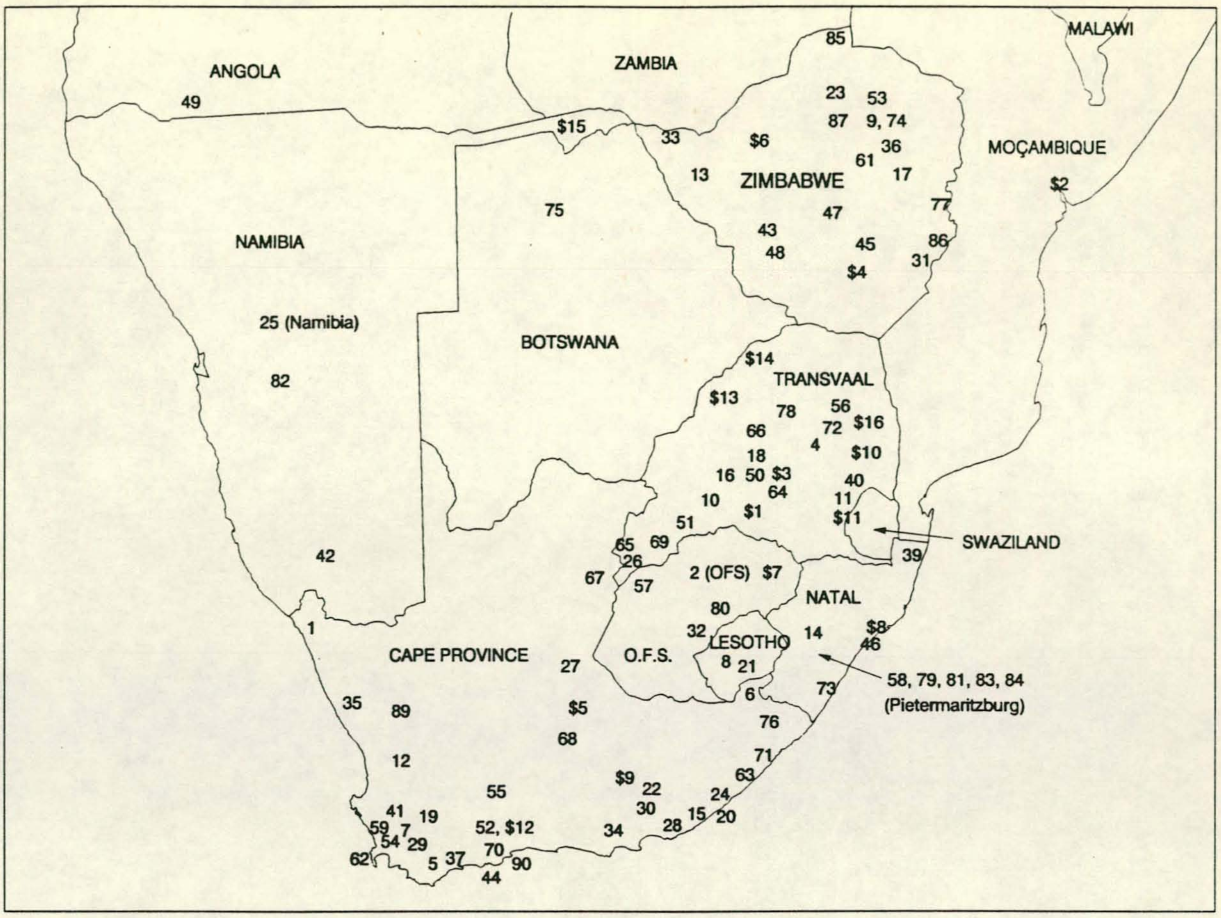

FIGURE 1

Localities at which bird lists were compiled for the *Southern African Avifauna Series* (numbered from 1 to 90, Table 1) and *Southern Birds* (numbered S1 to S15, Table 2).

Future

The field cards collected from all areas could, in conjuction with the recent atlases, form the basis of an historical atlas to demonstrate range contraction or expansion since c 1950. The chief difficulty is that these field cards were not collected on the quarter-degree-grid system now regarded as standard, but a large proportion of the cards can be allocated to a quarter-degree-grid square. Apart from areas less than a quarter-degree-grid square, the role of fieldcards and checklists has, to a large measure, been taken over by the atlas projects.

MIGRATION ENQUIRY

This project which commenced in 1950 and terminated in 1975 on the death of the organiser, aimed to describe the phenology of migration in southern Africa. Observers submitted records they considered "interesting", mostly records of early arrivals and late departures. Two reports were published, the first in two parts, the second (which describes itself as the third) in three parts (Broekhuysen 1955/1956, 1971/1974). The original data appear to have been lost. A similar project commenced in Namibia in 1986 (Brown 1986).

In spite of the self-censoring of observations by the recorders, Broekhuysen provided a good overview of migration in southern Africa. For several species, his reports still provide the main published information on the phenology of migration. The role of this project is largely fulfilled by the atlas projects (see below).

ATLAS PROJECTS

Description

The first major bird atlas project published in South Africa was conducted from 1970 to 1979 in Natal (Cyrus & Robson 1980). Subsequently, five regional atlases have been produced (Table 3). The aim of a bird atlas is to produce detailed distribution maps over a specified time period using a grid system appropriate to the area. These maps may also display an index of relative abundance (Hockey *et al.* 1989), as opposed to simple presence/absence data (Boshoff *et al.* 1983), show breeding distributions (Sharrock 1976), or be limited to a particular season of the year (Lack 1986).

In 1983, at a workshop to discuss the feasiblity

TABLE 1
LOCALITIES FOR WHICH BIRD LISTS ARE PROVIDED BY THE *SOUTH AFRICAN AVIFAUNA SERIES*. NUMBER IN SERIES (FIRST COLUMN) IS USED AS PLOTTING SYMBOL IN FIG. 1. IN THE LOCALITIES BELOW, THE WORD "DISTRICT" REFERS TO THE MAGISTERIAL DISTRICT. JMW = J.M. WINTERBOTTOM

No.	Locality (or topic)	Year	No. of species	Authors
1	Little Namaqualand	1967	221	JMW M. Courtenay-Latimer
2	Orange Free State	1961	423	A. van der Plaat
3	Habitats in Cape Province	1968		JMW C.J. Skead
4	Mineral Range farm and Loskop Dam, Groblersdal	1962	305	P. le S. Milstein
5	Swellendam District	1962	235	JMW
6	Swartberg District	1962	165	J.B. Shephard
7	Worcester District	1962	198	JMW
8	Lesotho	1963	221	C. Jacot-Guillarmod
9	Harare	1963	420	R.K. Brooke
10	Klerksdorp area	1963	63	W. Bartie
11	Carolina District	1963	231	J. de V. Little
12	Clanwilliam District	1967	193	JMW
13	Wankie National Park	1963	346	E. Davison
14	Weenen County	1964	269	O. West, F.B. Wright & G. Symons
15	King William's Town District	1964	362	C.J. Skead
16	Florida North	1964	107	A. Morley
17	Peterhouse-Springvale area	1964	242	M.L. Snell
18	Pretoria City	1964	322	M.B. Markus
19	Verkeerdevlei, Touwsrivier	1964	97	JMW
20	East London area	1964	376	M. Courtinay-Latimer
21	Lesotho (ms J.P. Murray)	1964	65	JMW
22	Fort Beaufort and Adelaide	1964	303	J.S. Taylor
23	West Sinoia District	1964	211	R.K. Brooke & W.R. Tarboton
24	Kobonqaba, Transkei	1965	201	E.O. Pike
25	Namibia	1965	523	JMW
26	Bloemhof District	1965	248	D.M. Skead
27	Hopetown District	1965	172	JMW
28	Saltvlei, Bathurst	1965	228	E. Morse Jones
29	Robertson District	1965	173	JMW
30	Albany (Grahamstown) District	1965	362	C.J. Skead
31	Central Sabi Valley	1965	278	R.K. Brooke & K.E. Cackett
32	Kirklington farm, Gumtree	1965	171	A.D. Boddam-Whetham
33	Victoria Falls National Park	1966	345	R.A.C. Jensen
34	Amanzi district, Uitenhage	1966	346	C.K. Niven & P.N.F. Niven
35	Vanrhynsdorp District	1966	175	JMW
36	Marandellas area	1966	159	S.G. Lees
37	Riversdale District	1966	169	JMW
38	Habitats in Transvaal	1966		D.M. Skead
39	Ndumu Game Reserve	1966	374	A.C. Pooley & J.E.W. Dixon
40	Barberton District	1966	263	D.A. Hughes
41	Ceres District	1966	169	JMW
42	Ai-Ais, Fish River	1966	64	G.J. Broekhuysen, M.J. Broekhuysen, JMW & M.G. Winterbottom
43	Acacia Savannah, Harare	1967	371	C.J. Vernon
44	Mossel Bay District	1967	225	T.J.R. von Etzdorf & JMW
45	Fort Victoria area	1967	256	R.M. Harwin
46	Twinstreams farm, Mtunzini	1967	232	I.F. Garland
47	Gwelo District	1967	329	R.M. Harwin
48	Matopos	1967	226	C.J. Vernon
49	Northern Ovamboland, central Kunene valley	1967	180	W.R. Tarboton
50	Tonquani garden, Bryanston	1967	197	R.A. Reed
51	Potchefstroom	1967	325	H.D. Brandt & A. Malherbe
52	Prince Albert District	1967	180	JMW
53	Glendale, Zimbabwe	1967	302	R.G. Arkell & R.K. Brooke
54	Jonkershoek, Stellenbosch	1968	163	W.R. Siegfried
55	Beaufort West District	1968	207	W.F. Quinton & JMW
56	Hans Merensky Nature Reserve	1968	190	R.B. Payne
57	Hoopstad District	1968	188	D.M. Skead, H.D. Brandt & H.K. Morgan
58	Winterskloof, Natal	1968	183	T.B. Oatley & N.R. Pinnell
59	Tulbagh District	1968	164	JMW
60	Additions to previous lists nos 2, 5, 7, 12, 29 and 52	1968		JMW
61	Marandellas District	1968	337	P.J. Ginn
62	Cape of Good Hope Nature Reserve	1969	142	E. Middlemiss
63	Qolora River mouth area	1969	116	C.K. Cooke & P. Cooke
64	Benoni	1969	158	W.R. Dean
65	Schweizer Reneke District	1969	153	D.M. Skead
66	Warmbaths, Transvaal	1969	333	H.P. Mendelsohn & J.M. Mendelsohn
67	Christiana District	1970	131	D.M. Skead
68	Richmond District	1970	155	JMW
69	Wolmaransstad District	1970	152	D.M. Skead
70	George District	1970	267	W.R. Siegfried, C.J. Skead & JMW
71	Port St. Johns	1970	321	D. McCulloch, C.J. Skead & JMW
72	Loskop Dam	1970	259	M. Baker
73	Durban	1971	448	W.J. Lawson
74	Additions to Harare list (no. 9)	1971	68	R.K. Brooke & R.P. Borrett
75	Moremi Wildlife Reserve	1971	245	W. Fraser
76	Kokstad	1971	244	C. Belcher
77	Chimanimani Mountains	1971	154	C.J. Hodgson
78	Mosdene Nature Reserve, Naboomspruit	1971	336	W.R. Tarboton
79	Bisley Valley, Pietermaritzburg	1972	182	C.J. Vernon

TABLE 1 (CONT.)

80	Franshoek farm, Ficksburg	1972	155	A.D. Boddam-Whetham
81	Scottsville, Pietermaritzburg	1972	93	C.J. Vernon
82	Valencia ranch, Namibia	1972	136	A.C. Kemp & M.I. Kemp
83	Pietermaritzburg	1972	338	C.J. Vernon
84	Peattie's Lake, Pietermaritzburg	1972	71	G. Bennett & H.T. Laycock
85	Kariba-Zumbo, Zambesi valley	1972	381	J. Cooper
86	Buzi farm, Chipinga	1972	218	J.A. Scott
87	Kashwayo	1972	279	G.W. Parnell
88	Mopane habitat	1972		JMW
89	Calvinia District	1972	168	JMW
90a	Knysna valley	1972	83	E.O. Pike

of a southern African bird populations database, it was agreed that a bird atlas project for southern Africa was feasible and had the potential to generate enthusiasm and mass participation by volunteers (Prŷs-Jones 1984a). In the following year, a workshop was held under the auspices of the Council for Scientific and Industrial Research to develop proposals for a bird atlas on a subcontinental scale (Hockey & Ferrar 1985). These proposals came to fruition and the Southern African Bird Atlas Project (SABAP) appointed JAH as Atlas Coordinator in 1986 (Harrison 1987).

SABAP employs a quarter-degree-grid system (except in Botswana, where a half-degree-grid system had already been adopted), resulting in 3 863 quarter-degree-grid squares (plus 229 half-degree-grid squares for Botswana) in southern Africa. The earliest published distribution maps on the quarter-degree-grid scale appear to be for the three southern African crows (Winterbottom 1975). Observers submit a field card for each quarter-degree-grid square visited in a calendar month. The subcontinent is divided into 14 regions for fieldwork and administrative purposes (Table 4), and the project has a Regional Atlas Committee in each region. Most of the fieldwork costs have been borne by the observers themselves, but atlasing in remote areas has been supported by subsidized fieldtrips and through the employment of a full-time field ornithologist from April 1990.

The atlas of the birds of the southwestern Cape (Hockey *et al.* 1989) was the first in southern African to use computers, the data processing for earlier atlases having been done manually. The computer programs developed for this atlas were modified and extended for SABAP. Data capture for SABAP is done manually; a check-digit system is employed to provide a large measure of protection against key-punch errors. Extensive data verification systems operate at the regional level to check for possible misidentification and other errors. Besides distribution data, breeding information is collected in six categories (suspected breeding, proved breeding, nest with eggs, unfledged young, nests with both eggs and young, dependent fledglings).

The period of intensive data collection for SABAP is from 1987 to 1991. Where appropriate, data sets from regional atlases have been subsumed into SABAP. The SABAP computer system contains details of all species recorded on each field card. This enables the computation of reporting rates (the percentage of field cards for a region that record a particular species). Although reporting rates are not linearly related to absolute abundance, experience suggests that the relationship is monotonic: if the reporting rate is low the species is relatively rare, if high, it is relatively abundant. Reporting rates were developed by Linsdale (1928), and their first use in southern Africa was by Vernon (1967). The atlas of the birds of the state of Wisconsin, U.S.A., also made use of reporting rates (Temple & Temple 1986). Caveats to the use of reporting rates were discussed by Underhill *et al.* (in press b).

By December 1990, there were 5,0 million records in the SABAP database, with at least one

TABLE 2
LOCALITIES FOR WHICH BIRD LISTS ARE PROVIDED BY *SOUTHERN BIRDS* SERIES

No.	Locality	Year	No. of species	Authors
1	Suikerbosrand Nature Reserve	1975	210	D.H. Day
2	Lower Zambesi	1976	322	D.B. Hanmer
3	Melville Koppies Nature Reserve	1977	134	L.J. Bunning
4	Zimbabwe Ruins area	1977	301	C.J. Vernon
5	De Aar District	1978	178	J.A. Kieser & G.A. Kieser
6	Sengwa Wildlife Research Area	1979	269	N.H.G. Jacobsen
7	Seekoeivlei, Memel	1979	110	O.B. Kok & Z.N. Roos
8	Lake St Lucia	1980	331	A. Berruti
9	Cradock District	1982	324	J. Collett
10	Mataffin	1983	340	D.G. Hall
11	KaNgwane (Mswati District)	1983	309	P.C. Lawson & J.A. Edmonds
12	Remhoogte farm, Prince Albert	1984	155	J.M. Winterbottom & M.G. Winterbottom
13	Lapalala Wilderness, Waterberg	1986	262	I.H. Davidson
14	Upper Limpopo River valley	1987	357	D.H. Day
15	Eastern Caprivi	1988	390	J.H. Koen
16	Lydenburg area	1990	276	D. de Swart

TABLE 3
REGIONAL ATLASES PUBLISHED IN SOUTHERN AFRICA

Region	Temporal coverage	Reference
Natal	1970–1980	Cyrus & Robson 1980
Raptor atlas of the Cape	1700–1979	Boshoff *et al.* 1983
Transvaal	1960–1986	Kemp *et al.* 1985; Tarboton *et al.* 1987
Orange Free State	1983–1986	Earlé & Grobler 1987
Southwestern Cape	1982–1986	Hockey *et al.* 1989
Lesotho	1986–1989	Osborne & Tigar 1990

field card from 90% of the quarter-degree-grid squares (Table 4). Because data processing lags several months behind fieldwork, Table 4 shows the extent of the atlas database about three-quarters of the way through the fieldwork. Feedback to participants is through *SABAP News* which provides information on progress, priorities for the forthcoming period, and guides to the identification of the more difficult species groups. Ten issues of *SABAP News* were produced during the first four years of fieldwork.

Applications

Although data from atlasing projects have only recently become available, they have already been used for a variety of purposes:

a. Distribution: Craig (1985) utilized atlas data to supplement other data sources (he lists museum specimens, nest record cards and the *South African Avifauna Series*) to plot the distribution of the Pied Starling *Spreo bicolor*. SABAP data were used by Harrison *et al.* (in press) to show the distribution of the three southern African crane species. Their maps used reporting rates to indicate where each species was concentrated and where it occurred more infrequently. This information was used to highlight areas where all three species might effectively be conserved.
b. Phenology: Summers *et al.* (1987b), Summers *et al.* (1989) and Underhill *et al.* (in press b) used atlas reporting rates to infer arrival and departure months of Sanderlings *Calidris alba*, Turnstones *Arenaria interpres* and Willow Warblers *Phylloscopus trochilus*, respectively. Harrison (1989) showed that Greater Striped Swallows *Hirundo cucullata* arrive in the southwestern Cape mainly during September whereas European Swallows *Hirundo rustica* do not arrive in bulk until November. A Fourier model for migration phenology which introduced the concepts of mid-arrival and mid-departure dates showed that the rate of arrival of several species of Palearctic migrants was slower than the rate of departure (Underhill *et al.* in press b). In all the above papers, the summarization of data was by months. However, a large proportion of the fieldcards submitted to SAPAB refer to observations made on one day. This information is included in the computer database, making it possible to examine migration phenology on a finer timescale than monthly.
c. Movement: Cyrus (1989) used atlas data to deduce that the Cape Robin *Cossypha caffra* is a winter visitor to the coastal plain of Zululand. Similarly, Underhill (1990) showed that European Bee-eaters *Merops apiaster* move from the coastal lowlands to the mountains after breeding in the southwestern Cape.
d. Historic changes in distribution: Macdonald *et al.* (1986) plotted the range expansion of the Hadeda Ibis *Bostrychia hagadash* in southern Africa, and Harrison (1989) presented year-by-year maps that displayed the dramatic expansion of this species in the southwestern Cape Province over the period 1982 to 1986.

TABLE 4
SUMMARY OF DATA CAPTURED BY DECEMBER 1990 BY THE SOUTHERN AFRICAN BIRD ATLAS PROJECT (SABAP)

Atlas region	No. of QDGS[1]	No. of QDGS covered	No. of field-cards	Starting year	No. of records	No. of species	No. of breeding species
Namibia	1241	1072	15790	1975	402046	669	403
Western Cape	423	408	18106	1983	837102	469	294
Eastern Cape	294	289	12752	1985	591499	500	351
Swaziland	35	35	1679	1986	98836	481	186
Natal	198	192	11074	1987	572224	601	411
Lesotho	63	57	707	1987	16298	238	98
Orange Free State	185	183	5960	1983	244847	446	262
Northern Cape	382	372	4655	1987	164826	437	266
Southern Transvaal	121	121	11372	1987	509095	534	322
Northern Transvaal	144	139	7088	1987	374986	500	334
Northeastern Transvaal	79	79	3690	1987	227350	548	348
Transvaal Lowveld	96	96	5092	1987	266533	539	372
Zimbabwe	602	441	14636	1961	655140	681	419
Totals	3863	3484	112601		4960782		

[1]quarter-degree-grid squares
[2]half-degree-grid squares, as used by the Botswana atlas

e. Changes in bird distribution and abundance in relation to explanatory variables: Macdonald (1984, 1986) showed that the range expansion of the Pied Barbet *Tricholaema leucomelas* into the southwestern Cape Province was associated with the introduction of alien acacias. Du Plessis (1989) compared atlas reporting rates during drought and wet periods in the Orange Free State, and discussed the species with the largest increases and decreases in reporting rate after the floods.
f. Environmental impact assessments: Atlas data provide assessors with a comprehensive list of birds which are known to occur in the relevant quarter-degree-grid square, and have been used for assessing the potential impacts of dams, mines, a nuclear power station, and recreational and residential developments on the environment (D.G. Allan in litt.; C.J. Brown in litt.).
g. Land-use planning: Brown (1990) used atlas data to justify the conservation of an area in the Caprivi Strip, Namibia.

Future

The full range of applications of the atlas database has not yet been exploited. The SABAP database may either be used to describe species distributions, or, in inverted form, be used to provide lists of birds (and reporting rates) for geographical areas. For the first time, the atlas project presents the opportunity to realize Winterbottom's desire for lists for all parts of southern Africa. The fieldwork protocol enables the calculation of reporting rates, and the quarter-degree-grid and monthly time frame provide spatial and temporal information at a standardized scale.

Such lists may prove invaluable, for example, to authors wishing to contribute to the *Southern Birds* series; the editors of this series may wish to consider encouraging contributions based on the quarter-degree-grid squares. Currently, Whitelaw *et al.* (in prep.) are producing a systematic list of the birds of the West Coast National Park based on the atlas lists for two quarter-degree-grid squares. Bird clubs and conservation education bodies may wish to use the data to produce checklists of the commoner species in an area.

The atlas data will be of immeasurable assistance to conservation managers. An integrated analysis of all the distribution maps may be used to determine a network of conservation areas which will conserve a full representation of the avifauna of southern Africa. Such analyses will provide an objective, rather than *ad hoc*, basis for motivating for an area to be added to the nature reserve system in southern Africa. Up-to-date distribution maps will be invaluable in assessing the conservation status of species listed in the red data book for birds (Brooke 1984) and for updating this publication.

On a more theoretical level, comparison of atlas distribution data with environmental variables may be used for developing and testing biogeographical theories for the southern African subcontinent in the same way as the Christmas Bird Count Atlas data have been used for North American birds (Root 1988). Biogeography was the motivation for much of Winterbottom's passion for lists (Crowe 1985), and was one of the major themes on which he published (especially Winterbottom (1972a), see also Brooke & Underhill (1985)). The development of geographic information systems (GIS) will facilitate many avenues of biogeographical enquiry; for example, an overlay analysis of digitized maps containing atlas distribution and environmental data will investigate and identify spatial correspondence (Shaw & Atkinson 1990). Another approach to establishing relationships between bird distributions and environmental variables is via generalized linear models (McCullagh & Nelder 1989), as pioneered by Osborne & Tigar (1990) in the atlas of Lesotho birds.

Atlas maps may be smoothed using geostatistical methods (Clark 1979); Verlander (1990) demonstrated the potential of one such method, known as kriging, on SABAP data.

To date, the breeding component of the information in the database has not been utilized. Applications include mapping of breeding distribution, and graphical displays of breeding phenology.

There is demonstrated potential for atlas data to assist in monitoring changes in distribution, as noted above for the Hadeda Ibis and Pied Barbet. The range expansions earlier this century of, for example, the Cattle Egret *Bubulcus ibis* (Siegfried 1965a), European Starling *Sturnus vulgaris* (Winterbottom & Liversidge 1954), Indian Myna *Acridotheres tristis* (Calder 1953) and House Sparrow *Passer domesticus* (Winterbottom 1961; Niethammer 1971) are poorly documented. Many of these authors mentioned the difficulty of reconstructing the timing of the spread of the species they were considering. Contractions of distributions are even more difficult to document, as last observations of a species in a region are seldom reported in the same way that first observations are. Regular atlasing is probably the simplest and most effective technique for simultaneously monitoring range expansions and contractions in all species. Atlas data, if in sufficient volume, are also capable of monitoring relative abundance, as shown by du Plessis (1989). Underhill & Hockey (1988) developed statistical methodology for an index of relative abundance based on atlas data. Incorporating the data from the fieldcard projects into the atlas database would enable us to examine the direction and pace of change over the past few decades and to place future change in context. This has been done successfully in the U.S.A. (Temple & Temple 1984).

To achieve this monitoring role, the atlas would either need to be repeated at regular (decadal) intervals or need to become an ongoing project. The former option is less attractive because it would require the setting up of the organisational infrastructure from scratch each time and no monitoring would take place in the periods between atlases. For the atlas to be manageable as an ongoing project, several structural changes would need to be implemented. Data entry should be through an optical mark reader, bypassing the need for manual input. Continuous atlasing, as for SABAP, would not be sustainable. For logistic reasons, fieldwork would need to be on a reduced scale; one possibility is two short periods of atlasing activity per year, one in summer and one in winter. The existing SABAP database, together with the historic data from the fieldcards, should be used to determine what level of effort would be required to ensure that changes in distribution and relative abundance are detected.

CENSUS DATA

Description and applications

We consider censusing in relation to three loosely defined groups of birds — waterbirds, seabirds and terrestrial birds. We use the term waterbirds to embrace all species that are associated mainly with inland waters, estuaries and the coastline. It thus includes waders, ducks, geese, flamingos, pelicans, egrets, kingfishers, etc. Seabirds refers to all pelagic species: penguins, albatrosses, petrels, shearwaters, etc. We refer to the remaining groups of species as terrestrial birds, including aerial foragers. Waterbirds, because of their restricted habitat, and seabirds, because they breed mainly colonially on islands, are relatively easy to census. In contrast, the censusing of terrestrial birds, particularly in erratic environments, is fraught with difficulties (Recher 1988; Fraser 1990). We therefore consider these groups separately.

Waterbirds

The African Wildfowl Enquiry (AWE) began in 1954 (Anon 1954). Its objective was to conduct "a comprehensive investigation into the ducks and geese in Africa in the southern hemisphere." A large network of field observers undertook regular surveys of wetlands used by wildfowl, submitting their counts on a specially designed card. Many thousands of these cards are stored at SAFRING, but it is not known if this collection is complete. A numbered series of at least 10 papers was produced by AWE: those that we have been able to trace (and other papers attributed to AWE) are listed in Table 5. In addition, an issue of *Bokmakierie* (vol. 11(2) (1959)) was devoted to wildfowl and the work of AWE. The AWE went into a steady decline in its activities during the late 1960s: this can probably be ascribed to difficulties in processing the amassed data and to a lack of feedback to the observers.

Between 1952 and 1966, the Cape Bird Club undertook regular surveys of the major vleis and other wetlands on the Cape Peninsula and Cape Flats (Winterbottom 1960; Blaker & Winterbottom 1968); photocopies of the individual survey sheets are at SAFRING. More recently, the Cape Bird Club has undertaken monthly surveys at some of these localities, but no results have been published, probably daunted by data processing problems. Datasheets are held by the various survey organisers. A comparison of the 1952–66 and the recent data sets would enable us to quantify the impact of wetland destruction on waterfowl and waders in this region.

In 1972, the Western Cape Wader Study Group (Underhill 1979) initiated surveys to census waterbirds at Langebaan Lagoon (Pringle & Cooper 1975; Summers 1977). Since 1975, Langebaan Lagoon has been surveyed bi-annually, in midsummer and midwinter, (Robertson 1981; Underhill 1987b), the 33rd survey being undertaken in winter 1991. Besides these regular surveys, a series of midsummer expeditions were made by members of the group to all sections of the southern African coastline except southern Namibia and Transkei, so that at least one count of waders and other waterbirds has been made at most coastal wetlands, offshore islands and along the shoreline (Table 6). The detailed counts from all these surveys have been computerized and archived as Underhill & Cooper (1984a, b, c) and Underhill (1991). The total number of birds counted during these coastal surveys was 1,7 million: summarized results for waders (Charadrii) were given in Summers *et al.* (1987a, Table 2).

Further examples of long-running counts of waders and other waterbirds are monthly surveys at the Swartkops estuary (Martin & Baird 1987), on the Skeleton Coast (Tarr & Tarr 1987), at the Wilderness Lakes (Boshoff *et al.* 1991) and at Cape Recife (Spearpoint *et al.* 1988), and twice yearly surveys at Walvis Bay Lagoon, in variable months (A.J. Williams in litt.).

Information on numbers of birds at wetlands may be used to measure their relative importance (for example, Summers *et al.* 1987a) and to pro-

TABLE 5
PUBLICATIONS OF THE AFRICAN WILDFOWL ENQUIRY

No.	Contents	Reference
—	wildfowl parasites	Paterson 1957
—	breeding season of Cape Shoveller *Spatula capensis*	Middlemiss 1957
1	Southern Pochard *Netta erythroophthalma*	Middlemiss 1958
2	Yellowbilled Duck *Anas undulata*	Rowan 1963
3	Cape Shoveller *A. smithii*	Siegfried 1965b
4	Cape Teal *A. capensis*	Winterbottom 1974
7	young of Cape Shoveller *Spatula capensis*	Winterbottom 1959
8	key to ducks and geese	Wheeler & Winterbottom 1959
9	Lombard Nature Reserve	Winterbottom & van der Merwe 1960
10	Witwatersrand	Winterbottom 1964b

Note: we were unable to locate publications 5 and 6.

TABLE 6
COASTAL SURVEYS FOR WATERBIRDS IN SOUTHERN AFRICA (FIG. 1). SURVEYS, EXCEPT OF THE TRANSKEI (OCTOBER), WERE CARRIED OUT IN MIDSUMMER (NOVEMBER–JANUARY). COVERAGE REFERS TO PERCENTAGE OF SHORELINE SURVEYED

Section	Coverage	Year	Reference
Kunene to Cape Cross, northern Namibia	100%	1981	Ryan *et al.* 1984
Cape Cross to Sandwich Harbour, central Nambia	100%	1976/77	Underhill & Whitelaw 1977; Whitelaw *et al.* 1978
Lüderitz Bay, and offshore islands, southern Namibia		1981 1978	Hockey 1982 Cooper *et al.* 1980
Orange to Olifants Rivers, northern Cape	40%	1980	Ryan & Cooper 1985
Olifants River to Mossel Bay, southwestern and southern Cape	99,5%	1975/76 and 1980/81	Summers *et al.* 1976, 1977; Ryan *et al.* 1988
Mossel Bay to Kei River, southern and eastern Cape	82%	1978/79	Underhill *et al.* 1980
Transkei	50%	1980	Underhill & Cooper 1984b, c
Natal	99%	1980	Ryan *et al.* 1986

vide quantitatively-based conservation proposals (for example, Cooper *et al.* 1976). Regular surveys provide opportunities for monitoring bird numbers and the rate of disappearance of wetlands.

Seabirds

Censuses of seabirds are mainly carried out at breeding colonies on offshore islands by scientists of organisations represented on the Island Research Liaison Committee (IRLC) — National Parks Board, Directorate of Nature Conservation of the Cape Provincial Administration and Sea Fisheries Research Institute. These organisations are responsible for administration of the islands and various acts of parliament relating to the marine environment. A series of papers containing estimates of the numbers of breeding pairs of all breeding seabirds except Greyheaded Gull *Larus cirrocephalus*, Caspian Tern *Hydroprogne caspia* and Damara Tern *Sterna balaenarum* has been published (Table 7). The IRLC aims to conduct censuses of most breeding seabirds at five-yearly intervals: some colonies will be monitored more frequently (R.J.M. Crawford in litt.).

Terrestrial birds

Surveys of terrestrial birds usually rely on sampling techniques. These may be extrapolated to give an estimate of the total population size. Frequently, interest focuses on relative differences in density between years, seasons or localities. Such surveys have been carried out on a large scale in the United States and Canada (Robbins *et al.* 1986) and in Britain (Marchant *et al.* 1990). In southern Africa, with exceptions, terrestrial birds have been counted in small areas, using methodology developed for the northern temperate regions, possibly adapted for local conditions.

Boddam-Whetham (1965) stratified his farm Kirklington (28 50 S 27 42 E), Orange Free State, into habitat types and undertook transect counts in each, employing a team of six to eight "schoolchildren who had recently served their time as cattle-herds and were consequently well acquainted with the veld birds." The observers were spaced at intervals of 22–45 m, with Boddam-Whetham acting as "pacer, recorder and overseer." He arrived at an estimated average density of 10,6 birds/ha in summer and 4,7 birds/ha in autumn. This methodology is clearly suitable for open habitat in southern Africa and could be more widely used.

In addition to doing transect counts, Tarboton (1980) used territory mapping (Enemar 1959; International Bird Census Committee 1970; Marchant 1983; Marchant *et al.* 1990) to plot the positions of singing birds, territory interactions and

TABLE 7
RESULTS OF SEABIRD CENSUSES IN SOUTHERN AFRICA

Species	Breeding pairs	Reference
Jackass Penguin *Spheniscus demersus*	28 506[1]	Crawford *et al.* 1990
Cape Gannet *Morus capensis*	80 153	Crawford *et al.* 1983
White-breasted Cormorant *Phalacrocorax carbo*	2 524[2]	Brooke *et al.* 1982
Cape Cormorant *Ph. capensis*	277 032	Cooper *et al.* 1982
Bank Cormorant *Ph. neglectus*	9 022	Cooper 1981
Crowned Cormorant *Ph. coronatus*	2 662	Crawford *et al.* 1982b
Kelp Gull *Larus dominicanus*	11 199	Crawford *et al.* 1982a
Hartlaub's Gull *L. hartlaubii*	13 253	Williams *et al.* 1990
Swift Tern *Sterna bergii*	4 660	Cooper *et al.* 1990
Antarctic Tern *S. vittata*	13 500[3]	Brooke *et al.* 1988
Roseate Tern *S. dougallii*	134	Randall *et al.* 1991
White Pelican *Pelecanus onocrotalus*	333[2]	Cooper 1980; Crawford *et al.* 1981

[1] West of Cape Agulhas; in addition, there are there are c 52 000 penguins in Algoa Bay (Crawford *et al.* 1990).
[2] Coastal populations only; species also breeds inland.
[3] Estimated size of non-breeding population on southern African coasts in winter.

nest-sites on an aerial photograph, undertaking six to ten surveys per month in *Acacia* and *Burkea* woodland. The results of the surveys were combined to determine territories and hence to estimate breeding densities of birds in the two types of woodland.

The point count method (Hutto *et al.* 1986) was used by Fraser (1989) to estimate bird densities before and after a planned fire in mountain fynbos in the southwestern Cape. This method forms the basis of a large-scale mass participation bird counting project initiated in Australia in 1989 (Ambrose 1989).

Thirty-two gardens in southern Africa were surveyed during the Garden Bird Counts (Winterbottom 1971a, b, 1972b). The analyses were based on averages of counts of birds in each third of a month.

Roadside counts of conspicuous birds have been used to describe relative abundance between areas, seasons, years and species; for example, Siegfried (1968) analysed raptor counts made during 330 000 km of roadside surveys in the Cape Province, and Allan (in press) counted Blue Cranes *Anthropoides paradiseus* along fixed routes at quarterly intervals and compared his results with those of Siegfried (1985). A raptor road count project commenced in Namibia in 1977; by 1984 there were 67 participants and surveys covered 180 000 km (Brown & Biggs 1984). The Namibian raptor count project is unique in southern Africa as the only project for terrestrial birds which enables comparisons over time to be made. Moreover, it is currently the only voluntary participation censusing project in southern Africa.

The SAOS undertook a national census of White Storks *Ciconia ciconia* during the summer of 1984/85 (Allan 1984). A large volume of sighting, road count and aerial census data were collected by c 3 000 participants, but only the results of a National Stork Counting Weekend were published (Allan 1985a, b, 1989). A similar national census of cranes was undertaken by the SAOS during 1985/86 (Holtshausen & Ledger 1985).

Future

We discuss here whether the censusing methods described above can become large-scale, long-term projects with clear research and conservation objectives. To this end, census work in the future should focus on two areas: obtaining estimates of total population sizes, and on producing indices of changes in population size at some convenient scale such as annual, quinquennial or decadal. For waterbirds, an index devised by Ogilvie (1967) has been used by the National Wildfowl Counts of the Wildfowl and Wetlands Trust since 1960/61 and by the Birds of Estuaries Enquiry of the British Trust for Ornithology (BTO) since 1970/71 (e.g. Salmon *et al.* 1989). For terrestrial birds, such indices were pioneered by the Common Birds Census of the BTO (Taylor 1965).

Seabirds and waterbirds

Surveys of breeding colonies of seabirds should be continued in the systematic manner which is the policy of IRLC. Indices of abundance should be computed because these have more impact than changes in population sizes. For example, the Jackass Penguin *Spheniscus demersus* population declined from 237 000 to 104 000 birds between 1956 and 1978 (Crawford & Shelton 1981); the extent of the decrease is more apparent from the statement that the Jackass Penguin population index fell from 100 to 44 over the period.

Southern African waterbirds have adapted to the irregular climatic fluctuations in the region by nomadism, and as a result, they require extensive systems of wetlands for their survival. Wetland loss in southern Africa has been rapid (Zaloumis & Milstein 1975; Milstein 1985). The time is therefore opportune to resurrect the African Wildfowl Enquiry as a comprehensive investigation into the status of waterbirds and as a monitoring operation on a scale large enough to provide annual indices of population size (Underhill 1989b). This could be done in collaboration with International Waterfowl and Wetlands Research Bureau (IWRB) which is currently expanding its wetland surveys beyond Europe to Asia and Africa (Pirot 1989).

Terrestrial birds

Most census procedures were developed in the north temperate zones where the variability of environmental factors, particularly rainfall, is far lower than in southern Africa. Similar erratic conditions prevail in Australia: Recher's (1988) review of methods for censusing terrestrial birds there summarizes experience of great relevance to southern African researchers. Recher describes sources of bias associated with these conditions over and above those encountered in the north temperate latitudes.

Tarboton (1980) demonstrated that the territory mapping method could be modified for southern African conditions. However, the method is extremely demanding in terms of fieldwork skills and time, and a national monitoring project based on this procedure is probably too ambitious to implement at the present time.

In order to obtain estimates of total population size, a recently developed censusing method could be adapted for southern African circumstances. Partridge (1988) described a sampling method to estimate the population sizes of breeding waders in Northern Ireland. One "tetrad" (a square 2 km × 2 km) was randomly chosen from each 10 km grid square, and surveyed for breeding waders (Fig. 2). A similar method, using point counts at randomly chosen stations was adopted by the atlas project in Lombardy, Italy (Massa & Fedrigo 1989). The random selection of survey sites has the advantage that it enables confidence limits to be placed on the estimates of population size. Besides the transect count method used by Boddam-Whetham (1965) and Tarboton (1980), we recommend that the random sampling method used by Partridge be considered by projects which seek to estimate population sizes of species of terrestrial birds which are dispersed thinly over large areas.

Frequently, however, measures of relative, rather than absolute, abundance are sufficient for

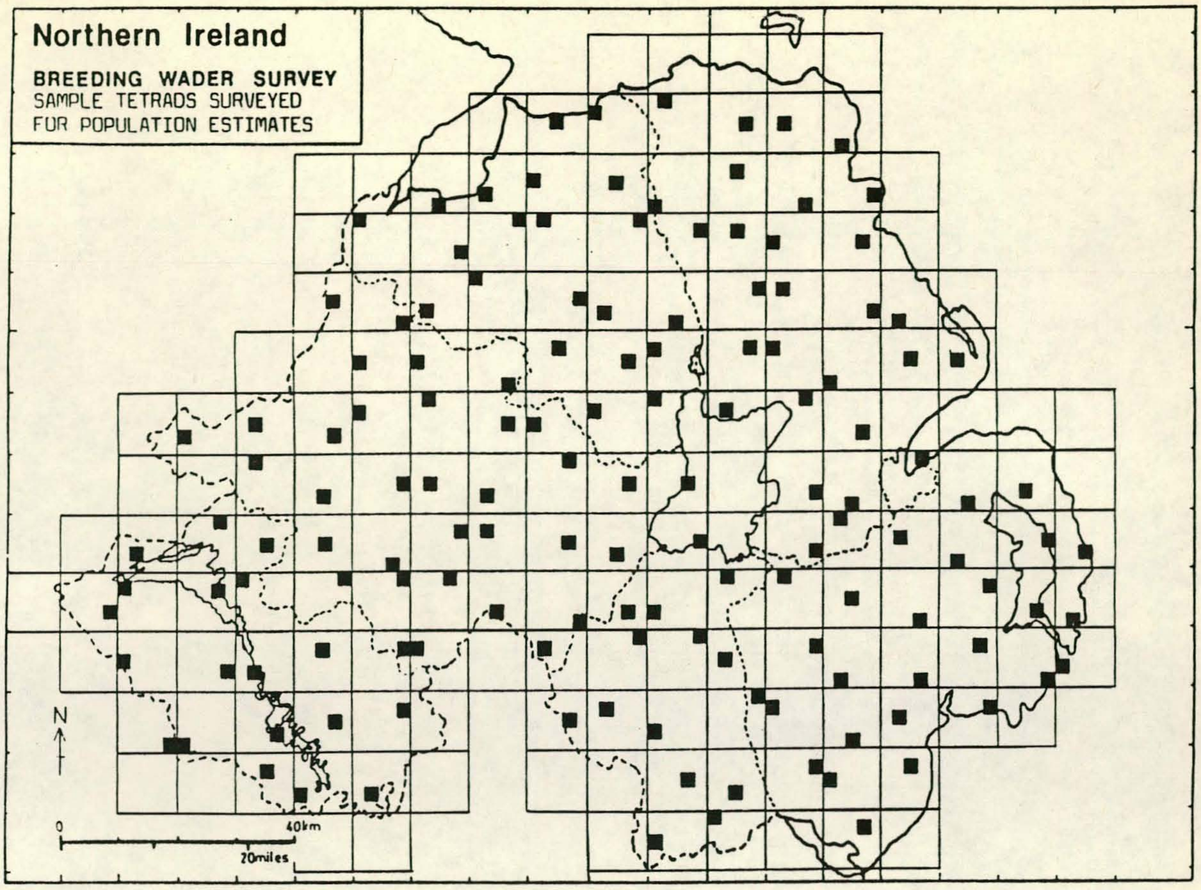

FIGURE 2

Northern Ireland Breeding Wader Survey. One tetrad (2 km × 2 km) was chosen at random from the 25 such tetrads in each 10 km grid square. Figure is reproduced from Partridge (1988) with the permission of the Royal Society for the Protection of Birds, Sandy, United Kingdom.

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monitoring purposes (Temple 1981). Available methods then include transect counts, point counts and standardized mist net captures (see Measured Effort Sites under Bird Ringing below).

For raptors, storks, cranes, bustards, crows and other conspicuous species groups that can conveniently be counted during vehicle transects, road surveys provide a convenient method for monitoring population trends, as suggested by Siegfried (1968, 1985). The roadside survey protocol needs to be made rigorous and systematic so that the data obtained are comparable between observers and years. Simmons (1989, 1990) and Allan (1990) have debated methods for roadside surveys appropriate to southern African conditions. Many of the species in the groups that can be monitored by roadside surveys are at or near the top of their food chains, and indices of their relative abundance would be of particular importance to conservation managers.

The results of the Australian Bird Count project (Ambrose 1989) should be evaluated to see if a project based on the point count method is worth emulating in southern Africa. Such a project could be integrated with ongoing atlasing activity.

A roost record project was considered by the SAOS and a card designed (Anon 1966), but appears not to have been implemented. The objective of the scheme was to record the location of roosts and numbers of roosting birds. Siegfried & Skead (1971) conducted a postal questionnaire survey of Lesser Kestrel *Falco naumanni* roosts; they located 155 roosts and demonstrated the value of roost records in investigating distribution and abundance. A roost record scheme is clearly a project worth further attention, probably limited to a selection of communally roosting birds.

BIRD RINGING

Description and applications

Bird ringing in southern Africa commenced as an SAOS project in 1948. By the early 1970s the ringing scheme had grown to the point where the need for a full-time ringing organiser was essential, and the National Unit for Bird Ringing Administration came into being with C.C.H. Elliott as the first ringing organiser. The name of the unit was changed to the South African Bird Ringing Unit (SAFRING) in 1977 and administration of the project was transferred to the Department of Statistical Sciences at the University of Cape Town in 1990. Since 1972, the unit has published *Safring News*, a journal that provides information to ringers (ageing techniques for birds in the hand, trapping methods, etc) and disseminates the results of ringing activity. Up to 1990, 32 issues of *Safring News* had been published, containing 93 substantial articles. Bird ringing mainly generates three categories of data — ringing data, collected while the bird is in the hand; recovery data, obtained when a bird is reported dead, usually by a member of the public; and retrap data, obtained when a bird is caught and released alive, either at or away from the original ringing site. These are discussed in turn below.

23 reports on the ringing scheme have appeared in *Ostrich* (Table 8). Since 1982, annual ringing statistics have been reported in *Safring News* (Table 9).

TABLE 8
RINGING REPORTS OF THE SOUTH AFRICAN BIRD RINGING UNIT

No.	Author	Year	Reference *(Ostrich)*
1	Ashton, E.H.	1950	21: 106–111
2	—	1952	23: 56–61
3	—	1954	25: 2–12
4	—	1954	25: 130–138
5	Ashton, H.	1956	27: 5–13
6	—	1957	28: 98–115
7	McLachlan, G.R.	1961	32: 36–47
8	—	1962	33: 29–37
9	—	1963	34: 102–109
10	—	1964	35: 101–110
11	—	1965	36: 214–223
12	—	1967	38: 17–26
13	—	1969	40: 37–50
14	Elliott, C.C.H. & Jarvis, M.J.F.	1970	41: 1–117
15	—	1972	43: 236–295, 45: 34–78
16	Elliott, C.C.H.	1974	45: 161–166
17	Vernon, C.J.	1975	46: 125–128
18	—	1976	47: 89–94
19	—	1977	48: 106–109
20	Morant, P.D.	1979	50: 83–87
21	—	1980	51: 204–214
22	—	1981	52: 44–53
23	Oatley, T.B.	1983	54: 141–149

TABLE 9
RINGING STATISTICS FOR THE SOUTH AFRICAN BIRD RINGING UNIT

Author	Year	Reference *(Safring News)*
Oatley, T.B.	1982	11: 9–15
—	1983	12: 27–32
—	1984	13: 18–24
Newton, I.P.	1985	14: 36–41
Oatley, T.B.	1986	15: 29–36
—	1988	17: 15–21
—	1989	18: 49–55
—	1990	19: 27–35

Ringing data

Up to June 1989, approximately 1,25 million birds of 810 species had been ringed with SAFRING rings (Table 10). Ringing data are stored on preprinted forms in ring files, with a microfiche back-up copy. The only species with more than 100 000 individuals ringed in southern Africa is the European Swallow; for a further 21 species, between 10 000 and 100 000 individuals have been ringed (Table 11). The largest numbers of birds ringed in a single year was c 67 000 in 1974/75. Numbers of birds ringed dropped to 17 000 in 1977/78, but increased steadily during the 1980s to 42 000 in 1988/89 (Oatley 1990a, Fig. 1; SAFRING unpubl. data).

TABLE 10
DISTRIBUTION OF RINGING EFFORT WITH SAFRING RINGS BY SPECIES, UP TO JUNE 1989

Number of individuals ringed	Number of species
1–9	178
10–99	250
100–999	245
1 000–9 999	116
10 000–99 999	22
> 100 000	1

An important facet of bird ringing is that it provides an opportunity to obtain data from live birds before they are released (Prŷs-Jones 1984b). Each bird may be aged, measured (discussed under Biometric Data, below), and moult patterns observed (discussed under Moult Records, below).

Ringers can also be trained to take blood and feather samples. Sampling procedures for taking blood from live birds have become so straightforward that samples can be made routinely and inexpensively during bird ringing, and long-term storage of blood in buffers for DNA analyses can now be contemplated (Arctander 1988). Blood smears may be taken on microscope slides and examined for parasites (Earlé & Bennett in press). Smears obtained during a study of Gurney's Sugarbird *Promerops gurneyi* (de Swardt 1989) were found to contain the blood parasite *Leucocytozoon anellobiae*, the first record in Africa of this parasite, otherwise known only from the Australian honeyeaters *Meliphagidae* (Bennett & de Swardt 1989). This significant finding raised fresh questions about the systematic relations of sugarbirds. Feather samples collected while the bird is in the hand can be examined for feather mites; as in the case with blood parasites, studies of feather parasites can be helpful in confirming phylogenetic relationships (Dabert 1990; Earlé & Bennett in press)

Age data, expressed as the percentage of first-year birds in summer samples, were used to determine breeding productivities of Curlew Sandpipers *Calidris ferruginea* (Underhill 1987c) and Sanderlings (Summers *et al.* 1987b). These species breed mainly in the Taimyr Peninsula in north-central Siberia, U.S.S.R., and their breeding productivities are synchronized with the three-year lemming cycles, breeding success being good during periods of increasing lemming abundance (and low predation), and poor during periods of decreasing lemming abundance (and high predation) (Summers & Underhill 1987).

Another by-product of ringing activity is the opportunity for developing ageing and sexing techniques. This is particularly true if it is possible to

TABLE 11
NUMBER OF BIRDS RINGED FOR SPECIES WITH MORE THAN 10 000 INDIVIDUALS RINGED

Species	Number of individuals ringed	Percentage recovery rate
European Swallow *Hirundo rustica*	155 710	0,44
Redbilled Quelea *Quelea quelea*	96 162	0,24
Cape Gannet *Morus capensis*	83 439	1,24
Yellowbilled Duck *Anas undulata*	58 005	1,68
Cattle Egret *Bubulcus ibis*	45 915	0,94
Masked Weaver *Ploceus velatus*	44 109	0,85
Laughing Dove *Streptopelia senegalensis*	39 104	1,51
South African Cliff Swallow *Hirundo spilodera*	36 515	0,24
Red Bishop *Euplectes orix*	35 855	0,32
Cape Sparrow *Passer melanurus*	34 937	0,68
Jackass Penguin *Spheniscus demersus*	26 589	2,12
Redknobbed Coot *Fulica cristata*	25 445	3,12
Curlew Sandpiper *Calidris ferruginea*	22 617	0,42
Cape White-eye *Zosterops pallidus*	16 502	0,30
Little Stint *Calidris minuta*	15 557	0,28
Swift Tern *Sterna bergii*	13 585	1,69
Cape Cormorant *Phalacrocorax capensis*	13 584	1,83
Sacred Ibis *Threskiornis aethiopicus*	13 063	1,93
Redbilled Teal *Anas erythrorhyncha*	12 724	2,59
Cape Weaver *Ploceus capensis*	11 155	1,36
Bronze Mannikin *Spermestes cucullatus*	10 769	0,53
Blackeyed Bulbul *Pycnonotus barbatus*	10 097	0,74

recapture birds ringed as nestlings so that the ages at which they attain various characterisitics can be accurately determined. 25 articles on such techniques appeared in volumes 1–19 of *Safring News*, and Piper *et al.* (1989) have published a set of ageing critera, based on resightings of birds of known ages, for the Cape Vulture *Gyps coprotheres*.

Recovery Data

Processing of recoveries is by computer. The SAFRING recovery file contained approximately 22 000 records in June 1989, and increased by an average of 462 records per year during the 1980s. The file includes details of 345 species recovered with SAFRING rings (Table 12). This is less than half the number of species ringed. For only 27 species are there 100 or more recoveries (Tables 12, 13). The overall SAFRING recovery rate (recoveries per bird ringed) is 1,05%, which is less than half the recovery rate of 2,2% of the British ringing scheme. For species for which over 10 000 individuals have been ringed, the largest recovery rate is for Redknobbed Coot *Fulica cristata* (3,1%), dropping to 0,24% for South African Cliff Swallows *Hirundo spilodera* and Redbilled Queleas *Quelea quelea* (Table 11). The high recovery rate for Redknobbed Coot is attributable to it being a large and hunted species, both for sport and for crop protection. In contrast, most South African Cliff Swallows were ringed at breeding colonies in rural areas of the Orange Free State and they migrate to central Africa for the nonbreeding season (Earlé 1984, 1986). Both breeding and nonbreeding areas are sparsely populated with people sufficiently literate to communicate the finding of a ringed bird. For species with over 2 000 individuals ringed, recovery rates range from 8,4% for Whitebreasted Cormorants *Phalacrocorax carbo*, a large, resident, conspicuous species which is frequently shot by landowners and fisheries managers due to its piscovorous diet, to 0,04% for Willow Warblers and European

TABLE 12
NUMBERS OF BIRDS RECOVERED, UP TO JUNE 1989

Number of recoveries	Number of species
0	460
1–9	236
10–99	88
100–999	26
> 1 000	1

TABLE 13
SPECIES WITH MORE THAN 100 RECOVERIES, UP TO JUNE 1989

Species	No. of recoveries
Cape Gannet *Morus capensis*	1 034
Yellowbilled Duck *Anas undulata*	973
Redknobbed Coot *Fulica cristata*	793
European Swallow *Hirundo rustica*	678
Laughing Dove *Streptopelia senegalensis*	589
Jackass Penguin *Spheniscus demersus*	565
Cattle Egret *Bubulcus ibis*	431
Egyptian Goose *Alopochen aegyptiacus*	385
Masked Weaver *Ploceus velatus*	373
South African Shelduck *Tadorna cana*	364
Redbilled Teal *Anas erythroryncha*	329
Whitebreasted Cormorant *Phalacrocorax carbo*	328
Hartlaub's Gull *Larus hartlaubii*	310
Sacred Ibis *Threskiornis aethiopicus*	252
Cape Cormorant *Phalacrocorax capensis*	248
Cape Sparrow *Passer melanurus*	236
Redbilled Quelea *Quelea quelea*	235
Cape Vulture *Gyps coprotheres*	231
Swift Tern *Sterna bergii*	230
Southern Pochard *Netta erythropthalma*	177
Spurwinged Goose *Plectropterus gambensis*	176
Cape Weaver *Ploceus capensis*	152
Cape Turtle Dove *Streptopelia capicola*	135
House Sparrow *Passer domesticus*	116
Red Bishop *Euplectes orix*	115
Greyheaded Gull *Larus cirrocephalus*	104
European Starling *Sturnus vulgaris*	101

Sedge Warblers *Acrocephalus schoenobaenus*, two small Palearctic migrants (SAFRING unpubl. data). In general, recovery rates for waterbirds are higher than for small passerines.

In addition, details of 1 650 birds recovered in southern Africa with foreign rings, mainly White Storks and tern species, are on file at SAFRING. This latter category of recovery, however, is incomplete: if a foreign ringed bird is recovered in southern Africa, the foreign scheme sometimes informs only the finder of the details, and the information does not automatically find its way into the SAFRING recovery database. Foreign ringing schemes assist SAFRING in searching their records for recoveries in southern Africa, such cooperation being exemplified in Oatley & Rammesmayer (1988) in their review of White Stork recoveries.

Ring recovery data are used for two main purposes; the analysis of survival probabilities that form a key input to studies of population dynamics, and the analysis of the spatial pattern of recoveries to describe the routes and destinations of migrants and the dispersion patterns of more sedentary birds. Some examples of analyses of survival that have been performed on SAFRING recovery data include Jones (1980), who showed that the mortality rates of Redbilled Queleas during a period of intensive attempts to reduce the population size was close to that of other passerine species not subject to control operations, Underhill & Underhill (1986), who estimated survival rates for Hartlaub's Gulls *Larus hartlaubii* and showed that survival rates in the first few weeks after fledging were correlated with early winter storms, a surrogate variable for food supply, and Oatley & Rammesmeyer (1988), who estimated survival rates for White Storks.

Analyses of the spatial information in long distance recoveries of Palaeartic migrants has been incorporated into full-length papers on the ecology of several species, for example, Curlew Sandpipers (Elliott *et al.* 1976), Sanderlings (Summers *et al.* 1987b) and Turnstones (Summers *et al.* 1989). As an example of a study relating to intra-African migrants, Oatley & Prŷs-Jones (1986) have related the dispersal distances for waterfowl (Anatidae) to their number of subspecies, showing an inverse relationship. Oatley (1988) documented the changing recovery patterns of the Cape Gannet *Morus capensis* over nearly 40 years; there has been a decrease in the proportion of recoveries north of latitude 17°S. Statistical methods for analysing the spatial information in recovery data are reviewed by North (1988); the most promising method is by Kania & Busse (1987).

Retrap Data

Retrap data have been submitted by ringers on a voluntary basis since 1982 and computerized. Only retraps more than a year after date of ringing or showing dispersion from the ringing site are reported. By June 1989, the SAFRING retrap file contained 13 441 records of 269 species. During the 1988/89 ringing year, five times as many retraps as recoveries were processed (SAFRING unpubl. data).

Besides providing minimum longevities, e.g. the series of papers by Hanmer (1981, 1983, 1985, 1987, 1989) based on 16 years of regular ringing at Nchalo, Malaŵi, retrap data may be used for the estimation of survival rates, e.g. Dean (1978) for the Cape Sparrow *Passer melanurus* at Barberspan, and for estimating population size, e.g. Underhill & Fraser (1989) for Malachite Sunbirds *Nectarinia famosa* in the Cape of Good Hope Nature Reserve. For birds trapped and retrapped within a single moult cycle, duration of moult can be estimated, e.g. Cooper & Underhill (1991) for European Starlings on Dassen Island. For birds trapped and retrapped between moult cycles, feather abrasion can be estimated (Summers *et al.* 1988, Fig. 1).

Because many migrants to southern Africa are ringed elsewhere, retraps also provide information about bird movements on an intercontinental scale. For example, c 3% of Common Terns reaching the southwestern Cape bear a foreign ring (Underhill & Hofmeyr 1987). On a local scale, of 14 records of movement by Cape Weavers *Ploceus capensis* of distances more than five km, five (36%) were retraps made by ringers operating unsystematically at different sites (Fraser *et al.* 1990). Networks of ringing sites functioning on a regular programme would enable such dispersal to be studied rigorously and possibly quantified.

A different form of retrap data arises when birds are colourmarked and resighted, rather than retrapped. Colourmarks consist either of plumage dyes (which last only until the next moult) or of colour-rings or tags (which should remain on the bird until it dies, but loss of colour-rings or tags can be a major problem in studies). Colourmarking schemes can be divided into two categories. Firstly, those in which the marking is done so that the researcher can identify individual birds, for example, in the long-term studies of the Starred Robin *Pogonocichla stellata* (Oatley 1982a, b, c) and the Longtailed Wagtail *Motacilla clara* (Piper 1987, 1989; Piper & Schultz 1989). Secondly, those in which the support of SAOS members and the public at large is enlisted in the search for marked birds. Summers (1978) reported on a colour-dyeing project for waders, conducted at Langebaan Lagoon; besides information on the extent of local movement, a Curlew Sandpiper was reported from Ethiopia and a Sanderling from the Netherlands. Oschadleus & Fraser (1988) described a colour-ringing project for Cape Sugarbirds *Promerops cafer* in the southwestern Cape, demonstrating hitherto unsuspected movement across the Cape Flats.

In the southern African context, retraps are especially important because they can be used to provide estimates of survival rates for species with very low recovery rates of dead birds. In fact, recoveries and retraps complement each other; species with low recovery rates tend to have high retrap rates and *vice versa* (Oatley 1990a, Fig. 2). Statistical methods for estimating survival rates from retrap and resighting information have been developed by Cormack (1964), Clobert *et al.* (1987), Underhill (1987a) and Ebbinge (in press). Methods have also been developed that use both retrap and recovery information (Buckland 1980). The proportional hazards regression model (Cox 1972) also has the potential to combine both sources of data, but has, to our knowledge, not been used in this context, although Bradley *et al.* (1989) were aware of it. This model was developed to compare survival rates in a medical context when groups of patients subjected to different treatments, and the data consist of patients followed through to death (recoveries, in ringing parlance!) and patients lost to follow-up (retraps).

Future

Mead (1984) considered that at least 500 recoveries for a species were needed to do an analysis of survival and movement, and that once 10 000 recoveries were available it was possible to examine both regional and annual differences in these characteristics. Our primary finding is that, for all except six species (Table 13), the number of birds ringed is as yet too small to have generated sufficient recoveries for meaningful analyses of either survival probabilities or dispersal patterns. For no species are there sufficient recoveries to claim that we have full knowledge of these characteristics. In addition, only those species for which we already have a large number of recoveries will allow future detection of changes in survival or dispersal. We therefore argue that ringing of all species should continue to be further encouraged.

We have noted above that statistical methods for estimating survival rates from retrap data are available, as well as methods for handling retrap and recovery data simultaneously. Because of the generally small numbers of recoveries for virtually all species in southern Africa, the importance of the information contained in retraps for estimating survival rates is magnified. Ringers should be made aware of the value of retraps, and should submit retrap data annually to SAFRING.

It was noted more than 25 years ago that, if ringing in southern Africa were conducted on a more systematic basis, valuable information could be obtained from the ringing operation itself (and not only the resulting recoveries) (Rowan 1964). She proposed that ringing at a site be undertaken regularly and at least monthly. Her ideas have been embodied in the Measured Effort Sites proposal by Underhill & Oatley (1989). A Measured Effort Site is one which is active at least once a month, and a record is kept of the number of nets used and the duration of the ringing session. Catch per unit effort may then be used as an index of relative abundance for a species, so as to monitor population size in the short-term (arrival and departure of nomadic species at a transient food resource (Underhill & Underhill 1990)), on an annual basis (phenology of migrants) and in the long-term (population declines and increases). Studies in which catching effort is controlled are reliable in yielding such information (Haukioja 1971; Baillie *et al.* 1986; Buckland & Baillie 1987; Busse in press).

Techniques for ageing birds in the hand have not been adequately described for southern African birds. There is a long felt need for the local equivalent to the ageing manuals of Svennson (1984) for European birds, Pyle *et al.* (1987) for North American birds and Rodgers *et al.* (1986, 1990) for Australian birds. Fieldwork for establishing ageing criteria requires meticulous descriptions of criteria taken from known-age birds, and examining them again when these birds are retrapped.

BIOMETRIC DATA

Biometric data are frequently gathered by ringers while they have the bird in the hand. The measurements taken may include mass, wing, wing area, culmen, total head length, tarsus, tail, etc. Brown (1989) measured 29 physical characteristics in his morphological study of the Bearded Vulture *Gypaetus barbatus*.

Most biometric data are held by the researchers (mainly ringers) taking the measurements, and there is currently no mechanism whereby such data can be contributed to a central database. Thus, for most species, it is difficult to obtain a large enough sample to perform a satisfactory analysis. However, by pooling the data of several ringers, large samples can be obtained. For example, the biometrics of Curlew Sandpipers was based on a sample of 8 000 birds, (Elliott *et al.* 1976), Sanderlings, n = 2 500, (Summers *et al.* 1987b) and Turnstones, n = 3 000, (Summers *et al.* 1989). Mendelsohn *et al.* (1989) measured nearly 1 000 birds-in-the-hand in their analysis of wing dimensions of raptors.

A cost-effective approach for tracking the available biometric data would be for ringers to submit lists of available data to SAFRING. Data for a species could then be requested when the total sample size is adequate for satisfactory analysis or when required by a researcher.

Mass data are required for estimates of energy consumption (e.g. Underhill 1987b). Maclean (1985) was unable to locate information on the masses of 231 of the 891 species (26%) he described for southern Africa. For 56 species, the sample size was given as one, and for a further 315 species the sample size was less than 30. Thus for some 68% of the region's avifauna, published information on mean mass, let alone regional and seasonal variation in mass, is incomplete.

Biometric measurements are useful in determining the provenance of migrants (e.g. Waltner 1985; Summers *et al.* 1988). However, measurements taken off live birds frequently differ from those of museum specimens, because of shrinkage of the latter (Summers 1976; Nicoll *et al.* 1988; Jenni & Winkler 1989).

NEST RECORD CARDS

Description and applications

The nest record card scheme was initiated in 1952, and by the time the first report was compiled three years later, 11 500 cards had been completed (Campbell 1956). Eight further reports have been published in *Ostrich* (Campbell 1957, 1958; Winterbottom 1964a, 1965; Winterbottom & Underhill 1967a, 1967b, 1969, 1972). The nest record cards are filed at SAFRING, the collection being curated by G.D. Underhill. In February 1990, the collection contained c 117 000 nest record cards for the nests of 696 species, some of the species being extra-limital to southern Africa (Table 14). About one third of the cards are from the southwestern Cape, with the smallest sample for southern Africa being from the sparsely populated Karoo region (Table 15). There are more than 500 cards for 52 species, and more than 1 000 cards for 18 species (Table 16). The current rate of increase of the collection is c 1 500 cards per year (G.D. Underhill pers. comm.) compared to 4 000 cards per year when the scheme was started and when the number of birders was much smaller than at present. One of the first analyses of nest record cards in southern Africa was by Brooke (1958) who calculated and reported incubation and nestling periods for seven species for the first time. Many subsequent papers have made use of data from the nest record card collection. A comprehensive analysis of all cards in the collection has been undertaken (R.P. Prŷs-Jones & I. Newton unpubl. data), complementing similar analyses further north: Zimbabwe (Irwin 1981), Zambia (Benson *et al.* 1971), Malaŵi (Benson & Benson 1977) and Kenya, Uganda and Tanzania (Brown & Britton 1980).

Besides determining incubation and nestling periods, nest record cards provide data on clutch and brood sizes and assist in the description of the phenology of breeding. This was done, for example, for the Fiscal Shrike *Lanius collaris* by Cooper (1971) who showed that breeding is earlier in the winter rainfall region of the southwestern Cape than elsewhere in southern Africa. If enough data are available, inter-year differences in breeding can be detected; Rowan (1983) related the timing of breeding of Cape Turtle Doves *Streptopelia capicola* in the southwestern Cape to the distribution of rainfall each year.

Nest record cards also provide information on nesting success, and causes of nest failure such as predation and flooding. Rates of nest loss can also be estimated using Mayfield's method (Mayfield 1961, 1975; Pollock & Cornelius 1988), as has been done for a subset of the southern African nest record cards for Acacia savanna in Natal (Earlé 1981) and for Laughing Doves *Streptopelia senegalensis* at Barberspan (Dean 1980).

TABLE 14
NUMBERS OF NEST RECORD CARDS, UP TO DECEMBER 1989

Number of nest record cards	Number of species
1–9	123
10–49	195
50–99	119
100–499	207
500–999	33
> 1 000	19

TABLE 15
NUMBERS OF NEST RECORD CARDS, BY REGIONS, UP TO DECEMBER 1989

Region	Number of cards
Southwestern Cape	39 931
Eastern Cape/Transkei	8 050
Karoo	1 447
Orange Free State/Lesotho	3 336
Transvaal/Swaziland	11 980
Natal	7 459
Namibia	4 317
Botswana	1 108
Zimbabwe	33 525
Mocambique	525
Angola	149
Zaire	88
Zambia	2 093
Malaŵi	322

TABLE 16
SPECIES WITH MORE THAN 1 000 NEST RECORD CARDS, UP TO DECEMBER 1989

Species	No. of cards
Redknobbed Coot *Fulica cristata*	3 277
Laughing Dove *Streptopelia senegalensis*	2 920
Cape Turtle Dove *Streptopelia capicola*	2 379
Cape Sparrow *Passer melanurus*	2 366
Kittlitz's Plover *Charadrius pecuarius*	2 042
Red Bishop *Euplectes orix*	1 913
Fiscal Shrike *Lanius collaris*	1 889
Crowned Plover *Vanellus coronatus*	1 880
Cape Wagtail *Motacilla capensis*	1 684
Spotted Prinia *Prinia maculosa*	1 612
Whitefronted Plover *Charadrius marginatus*	1 534
Cape Robin *Cossypha caffra*	1 410
Blacksmith Plover *Hoplopterus armatus*	1 371
Cape Shoveller *Anas smithii*	1 356
Masked Weaver *Ploceus velatus*	1 324
Levaillant's Cisticola *Cisticola tinniens*	1 295
South African Cliff Swallow *Hirundo spilodera*	1 105
Paradise Flycatcher *Terpsiphone viridis*	1 087
African Black Oystercatcher *Haematopus moquini*	1 000

Future

Lack of computerization severely hampers the analysis of data in the Nest Record Card scheme. For example, most analyses of nest record cards require repetitive manual sorting. The development of a computerized nest record database and associated computer software to extract and analyse data is an important step towards enabling this project to fulfil its potential.

A link between the Nest Record Card scheme and the large volume of breeding information in the atlas database needs to be made. The nest record cards make provision for detailed nest information. For the atlas, only the occurrence of breeding is recorded in several categories: these data may be used to document the phenology of breeding. Ideally, each confirmed breeding record in the atlas should be supported by a nest record card.

Species for which large numbers of nest record cards are submitted annually, could have annual indices of breeding productivity computed, quantifying changes in clutch size and number of fledglings per nesting attempt (see Crick *et al.* (1990)

for the BTO's first such analysis). The atlas data could supplement the nest record card information by providing information on the timing and intensity of breeding each year.

MOULT RECORDS

Description and applications

A moult record scheme was started during the 1950s by the Witwatersrand Bird Club but languished during the following two decades. A new SAOS/SAFRING scheme was instituted in 1984, and uses standard recording methods and a moult card based on the BTO design (Ginn & Melville 1983).

In June 1990, there were 4 040 cards of 380 species, 15 species had more than 50 cards, with a maximum of 193 cards for the Olive Sunbird *Nectarinia olivacia* (Oatley 1990b). These records are mostly completed by ringers, but some come from roadkills, museum specimens, bird control exercises, or those washed up on beaches (see Beached Birds, below).

Craig (1983) emphasized the "dearth of published material on moult of southern African passerines." Craig could review the moult of only 114 of 398 passerine species occurring in southern Africa; data for 27 of these 114 species related to European populations.

Statistical techniques for analysing moult data have been developed by Underhill (1986a, 1988), Underhill & Zucchini (1988) and Underhill *et al.* (1990). Four moult studies have applied these techniques. The Turnstone population which migrates to southern Africa moults nine weeks later and takes seven weeks longer to undergo primary moult than the population which migrates to Scotland (Summers *et al.* 1989). An analysis of European Starling moult by Cooper & Underhill (1991) was the first definitive moult study of this extremely common and successful species. The moult of the Willow Warbler was analysed using data from 11 sites in Europe and Africa (Underhill *et al.* in press a); this species is exceptional in that it undergoes two complete primary moults per year. The analysis of the moult of the Sooty Shearwater *Puffinus griseus* differed from the other studies in that it used data obtained from beached seabirds rather than during ringing operations (Cooper *et al.* in press).

Future

Data for this relatively recent project should continue to be curated at SAFRING. Moult, along with breeding and, for some species, migration, is an important element in the annual cycle of bird species, and a knowledge of the timing and duration of moult is thus of conservation significance.

Traditionally, moult cards are completed only for birds in active moult. The analysis methods of Underhill & Zucchini (1988) and Underhill *et al.* (1990) for estimating the duration and timing of primary moult can make effective use of the information contained in observations of birds that have not commenced moult and those which have completed moult. Recording systems need to be modified to accommodate this methodology.

A primary moult index based on percentage feather mass grown (PFMG) generally increases more linearly with time than the conventional moult score, particularly for species for which the relative sizes of the primaries vary considerably (Summers 1980). For example, the outermost primary of the Sooty Shearwater is more than five times heavier than the innermost (Table 17). PFMG can be computed only if the relative masses of the primaries are known. Such data are currently available for a small number of species (Table 17), and represent a new type of biometric data.

BEACHED BIRDS

Description and applications

Members of the African Seabird Group patrol beaches for dead birds on a monthly basis along specific stretches of coast, using a method devised by Cooper (1977) (Table 18, Fig. 3). A series of reports has been published in *Cormorant* (now *Marine Ornithology*) covering the period up to 1985 (Cooper 1978; Avery 1979, 1980, 1981, 1982, 1984, 1985, 1989); the total number of beached seabirds reported was 10 057. These data have

TABLE 17
RELATIVE MASSES OF PRIMARY WING FEATHERS

Species	Primary number 1	2	3	4	5	6	7	8	9	10	Reference
Sooty Shearwater *Puffinus griseus*	3,6	4,1	5,1	6,5	8,3	10,3	12,2	14,3	16,7	18,9	Cooper *et al.* in press
Lesser Kestrel *Falco naumanni*	4,5	5,4	6,6	7,8	9,2	10,8	12,5	14,1	15,1	13,9	R.A. Earlé *in litt.*
Dunlin *Calidris alpina*	4,0	4,9	5,7	6,9	8,5	10,2	11,8	13,7	15,8	18,4	Kania 1990, *in litt.*
Sanderling *Calidris alba*	3,9	4,6	5,4	6,8	8,3	10,2	12,0	14,2	16,0	18,7	Underhill & Zucchini 1988
Turnstone *Arenaria interpres*	4,2	4,7	5,9	7,2	8,7	10,4	12,0	13,7	15,4	17,9	Summers *et al.* 1989
Brownthroated Martin *Riparia paludicola*	5,7	7,4	8,2	9,2	10,9	11,9	13,5	15,9	17,3	-	D.P. Cyrus *in litt.*
Willow Warbler *Phylloscopus trochilus*	7,3	8,8	9,6	11,1	12,3	14,2	13,8	13,0	9,6	0,4	Underhill *et al.* in press a
European Starling *Sturnus vulgaris*	7,2	8,2	9,0	9,8	10,6	11,5	12,8	14,6	16,3	-	Cooper & Underhill 1991

TABLE 18
BEACH PATROLS CONDUCTED MONTHLY BY THE AFRICAN SEABIRD GROUP (FIG. 3)

Locality	Length (km)	Duration
Lambert's Bay	5	Mar 1982–Feb 1985
Eland's Bay	14	Jan 1980–Dec 1981
Yzerfontein	15	Aug 1987, ongoing
Koeberg	7	Sept 1977–Dec 1988
Fish Hoek	1	Jan–Dec 1979; Feb 1981–Dec 1982
False Bay	20	Feb 1977–Dec 1988
Hawston	5	Apr 1978, ongoing
Die Plaat	5	June 1979, ongoing
De Hoop	12	Sept 1985, ongoing
Goukamma	12	Jan 1990, ongoing
Cape Recife	5	Sept 1977–Mar 1980; May 1981, ongoing
Port Alfred	13	Jan 1977–Sept 1978
Rockcliff	4	Dec 1977–Feb 1981
Natal	491	Aug 1979–Dec 1981

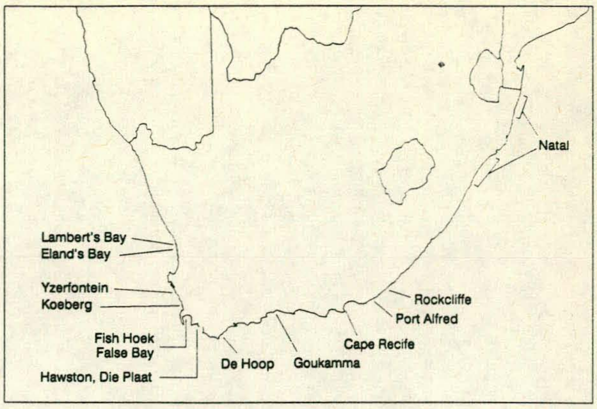

FIGURE 3

Beached bird surveys of the African Seabird Group.

been used to describe the "normal" seasonal occurrence of mortality of seabirds (Avery 1984; Avery & Underhill 1986), to relate this to periodic "wrecks" induced by environmental perturbations (Ryan & Avery 1987; Ryan *et al.* 1989; Avery 1990), and to provide data for the analysis of primary moult (Cooper *et al.* in press). From a paleoecological viewpoint, the data have been used to infer the timing of exploitation of seabirds by prehistoric hunter-gatherers in the Late Holocene (Avery & Underhill 1986) and gross environmental changes in the past 20 000 years (Avery 1990).

Because there have been many ringing programmes for seabirds, beach patrols produce many recoveries. The African Seabird Group annual reports list 54 such recoveries, or one recovery per 186 dead seabirds examined.

Future

Beach surveys provide a systematic method for obtaining data on the relative magnitudes of seabird mortalities between years, and have potential as a tool for monitoring environmental anomalies in the oceans, such as the Benguela Warm Events (Duffy *et al.* 1984; Avery 1985). This is especially important in the context of anticipated global warming. Annual indices of mortality should be computed.

DISCUSSION

Conservation

In order to make meaningful recommendations for conserving southern Africa's avifauna, an understanding of the biology and ecology of each species is important. Effective conservation management depends on qualitative and quantitative information on a suite of demographic characteristics: for example, total population size, population trends, distribution, habitat requirements, etc. (Table 19). Few bird species in southern Africa have been studied intensively enough to provide adequate information on all of these characteristics. Volunteer participation projects have the potential to collect basic information on many species simultaneously over a wide geographical area, thus enabling a broad overview of conservation priorities.

In addition, because global changes in climate are predicted, there is an urgent need to institute monitoring programmes. Although changes are sometimes rapid, catastrophic and, therefore, obvious, they also frequently take place at a slow pace and involve subtle shifts. In these circumstances, the major difficulty in detecting such changes within a reasonable time span, from the statistical viewpoint, is the large amount of sampling effort required on account of the small signal-to-noise ratio in most ecological data sets (Hinds 1984).

Many demographic characteristics and changes in them can, in principle, be determined from one or more of the projects considered in this paper (Table 19). For example, the current atlas project was designed to provide a snapshot description of bird distribution over a five-year period; continued as an ongoing project or repeated at regular intervals, it will provide a dynamic portrayal of range expansions and contractions, thus fulfilling a monitoring role.

Baillie (1990) described the Integrated Population Monitoring Programme instituted by the British Trust for Ornithology (BTO). The programme links and interprets the outputs of all the major volunteer participation projects of the BTO. These projects annually produce indices of abundance, productivity and survival, in relation to a predefined base year. Pienkowski (1991) considered how this information should be translated into conservation action. Although there is long way to go before the BTO Integrated Monitoring Programme can be emulated in southern Africa, this is clearly the direction in which projects should be headed.

Temple & Wiens (1989) considered whether changes in bird populations could be used to provide an "early warning system" to monitor en-

TABLE 19
DEMOGRAPHIC CHARACTERISTICS OF IMPORTANCE TO CONSERVATION PLANNING AND MANAGEMENT AND PROJECTS TO DETERMINE THESE CHARACTERISTICS

Characteristic	Associated methodology
Distribution	atlas
Range expansion/contraction	ongoing atlas
Population size	census capture-recapture
Change in population size	regular censuses repeated capture-recapture
Index of change in population size	ongoing atlas road surveys measured effort sites
Age structure	ringing
Productivity	nest record cards
Change in productivity	annual nest record cards
Dispersal and migration	ringing recoveries colour marking
Survival	capture-recapture ringing recoveries
Mortality factors	ringing recoveries beached bird survey
Seasonality	atlas measured effort sites

vironmental degradation. The answer was ambivalent, their chief problem being the difficulty of establishing cause and effect relationships. In other words, monitoring can establish the existence of change, but it is very much more difficult to pinpoint precisely the environmental or anthropogenic factor that has caused the change. Their conclusion, however, was, "We must continue to monitor the status of bird populations, using a combination of programs, sites and scales."

Research

Although we see conservation as the primary future justification of the schemes described in this paper, most of the published applications which we have described were research oriented. It is certain that these schemes will continue to play a key role in providing data for the theoretical research of many ornithologists, thereby providing greater understanding of avian population ecology.

The combination of all the data sets for the projects listed in this paper is therefore a priceless asset to southern African ornithology. One of the purposes of this paper is to inform researchers of the amounts of data being archived, and the availability of the data sets.

Objectives and goals

From their published progress reports, it is clear that all these projects have emphasised volumes of data. However, this emphasis on quantity, without either specific targets or a commitment to analysis, has lead to a situation where there is an enormous quantity of unprocessed data.

All these projects, with the exception of the atlases and some of the censuses, have been open-ended, and there have been no clear goals for data collection. For example, the nest record card scheme, at its inception, could (with hindsight) have included a goal of publishing an analysis for a species once a target number of cards, say 1 000, had been received. Similarly, the ringing scheme could have undertaken a routine analysis of ringing recoveries once, say, a target of 100 recoveries had accumulated. Such analyses would reveal the gaps in the data, and effort could be directed towards filling them. Lists of species approaching the target number of nest record cards or recoveries could be published annually and would, in the long term, have the effect of systematically directing birding effort across the full spectrum of species. This would result in interest in the projects being maintained, and even increased.

The current situation, therefore, is that there is a backlog of analyses waiting to be undertaken. For example, if we accept the targets of 1 000 nest record cards and 100 ringing recoveries, there are 19 and 27 analyses to be performed respectively (Tables 12–15). On the other hand, since there are more than 1 000 nest record cards for only 19 of the 696 species (2,8%) in the collection and a similarly small percentage of species have over 100 recoveries, these two long-standing projects still have an enormous and urgent task ahead of them simply to produce the base line data against which future change can be measured.

In order to produce annual indices of productivity and survival, large volumes of data are required each year. The BTO's Integrated Population Monitoring Project has set 100 nest record cards and 50 recoveries per year as the threshhold data volumes for annual monitoring of these demographic characteristics (Baillie 1990). Within southern Africa, there are currently no species for which over 100 nest record cards per year are received (G.D. Underhill pers. comm.) and the only species for which more than 50 recoveries per year are received is the Cape Gannet. Achieving these annual goals in southern Africa will provide a stiff challenge to the organizers of these projects and their volunteer participants.

Discussion on goals has centred on ringing and nest record cards. The current bird atlas project has had clearly defined goals since its inception. A monitoring atlas would have to establish a new set of goals. Goals for the remaining projects need to be set in relation to the applications to which the data are to be put. Sample sizes need to be determined bearing in mind the size of change that is biologically meaningful, and the probabilities of both Type I and Type II errors (respectively, the errors of incorrectly concluding that change has occurred, and of failing to detect change when it has occurred). For example, the sample size can be set to detect a change of 20% in a demographic characteristic in such a way that the probability of Type I error (the significance level) is 0,05, and the probability of Type II error is 0,80. These concepts are discussed more fully by Verner & Milne (1990).

The goals of projects have to be set realistically so that the demands of the fieldwork are compatible with the enjoyment of the volunteer participants, for most of whom birdwatching is a hobby (Kerr 1990; Greenwood 1990).

As South Africa enters an era in which funds are likely to be channelled increasingly into social programmes, it becomes even more important for these projects to demonstrate a concrete usefulness in conservation and environmental monitoring. Emphasis on analysis and the reporting of results will help assure that they will continue to enjoy financial support.

Computerization

The data collections described in this paper are, with exceptions, resources which are not readily accessible and utilizable. The crucial next step is to make access to them more "user-friendly". The chief requirement for achieving this is to improve the computerization, and to develop systems for the convenient extraction of subsets of the data.

Lack of effective computerization has lead to projects becoming choked with data. This applied particularly to the African Wildfowl Enquiry and is probably the major barrier to more extensive utilization of other projects. The problem is not unique to southern Africa; when the BTO organized a project, known as the Inland Observation Points scheme, to monitor migration in 1962, over 4 000 records arrived in the post daily and the scheme ground to halt, overwhelmed with data (Hickling 1983, p. 153; Mead 1983, p. 212). Mead commented that if such a scheme were restarted, it would use optical mark readers for the direct input of data from the field cards into the computer. The BTO has recently introduced a new nest record card which uses this technology (H. Crick in litt.).

Another aspect of computerization is the development of suitable software to perform the required statistical analyses. In some cases, available statistical methods are inadequate, and new theoretical approaches need to be developed. The EURING Technical Conferences for ornithologists and statisticians analysing ringing data have provided a forum that addresses these needs (Underhill 1986b, 1989a).

Geographical coverage

For the volunteer participation projects (checklists, atlas, African Wildfowl Enquiry, bird ringing, nest record cards) data are available from widely scattered localities. However, for most of these projects the distribution of observations reflects the distribution of observers, so that, as a broad generalization, little data are available from sparsely populated areas (*c.f.* Table 15). The same problem has been highlighted in Britain (Baillie 1990) and in North America (Kaufman 1989; Welsh 1989).

SABAP has been the first volunteer participation project to address the problem of uneven geographical coverage seriously. This has been achieved in two ways: regular feedback to observers to identify areas for which data are required, and the employment of a field ornithologist. The remaining projects need to consider whether one or both of these strategies need to be employed to improve their coverage.

Establishment of an Avian Demography Unit

Demography is the study of populations, particularly the dynamics of the size and structure of populations. The objective of an Avian Demography Unit for southern Africa would be to investigate the demographic characteristics of bird populations on a subcontinental basis, primarily through well-designed volunteer participation projects (Table 19).

A Bird Populations Data Unit for southern Africa was first suggested by Prŷs-Jones (1984a) and further developed by Ledger (1985a, b). At present, the Southern African Bird Atlas Project, the South African Bird Ringing Unit, the SAOS Nest Record Card Scheme, and aspects of other projects are managed within a single academic department. Thus the administrative impediments to forming an integrated demography unit are minimal.

To function effectively and to provide an efficient avian populations monitoring service, such a unit would require staff and funding in addition to those currently attached to SAFRING and SABAP. Its functions would include the design and management of projects, the analysis and curation of the resulting data, and the publication of results.

RECOMMENDATIONS

The following points bring together the key recommendations made in this paper.

1. The Southern African Bird Atlas Project will provide baseline bird distribution and relative abundance information against which future changes in distribution can be measured. We recommend that
   - 1.1 the data from the regional field card schemes be incorporated into the data base to provide an historical perspective, and
   - 1.2 the atlas become an ongoing project, but on a reduced scale, with short periods of atlasing activity annually to achieve this monitoring goal, and
2. Census projects should be designed mainly to provide indices of abundance. We recommend that
   - 2.1 a waterbird census project be initiated,
   - 2.2 censuses of breeding seabird colonies be conducted regularly,
   - 2.3 censuses of terrestrial birds be undertaken as special projects to establish total population sizes,
   - 2.4 systematic roadside surveys of conspicuous groups such as raptors be extended to provide indices of abundance of these species throughout southern Africa,
   - 2.5 a roost record scheme for selected species be investigated, and
   - 2.6 atlasing and point count censusing methodologies be integrated into a single fieldwork protocol.

3. Bird ringing provides vital demographic information on survival and movement. We recommend that
   3.1 overall ringing totals be increased to improve the number of recoveries,
   3.2 retrap information should be submitted regularly,
   3.3 ringers be encouraged to participate in Measured Effort Sites which should be developed to the point where they provide indices of abundance,
   3.4 ringers be encouraged to participate in blood and feather sampling schemes,
   3.5 the backlog of analyses of recoveries be undertaken, and
   3.6 a target of 100 recoveries per species be set, after which an analysis will be made.
4. For biometric data, we recommend that procedures be developed for cataloguing the large volumes of data held by ringers.
5. The Nest Record Card project is in need of revitalization, by the setting of priorities annually, and the development of computer systems. We recommend that
   5.1 the backlog of analyses be undertaken,
   5.2 a target of 1000 nest record cards per species be set after which an analysis will be made, and
   5.3 species for which 100 nest record cards per year is a realistic goal be identified, and that, for these species, an annual productivity index be computed.
6. The beached bird surveys of the African Seabird Group should continue. Annual indices of mortality should be calculated.
7. The importance of regular feedback to observers be recognized as crucial to the success of all voluntary participation projects.
8. Finally, our major recommendation is that an Avian Demography Unit be established to integrate research into bird population dynamics, thereby formally recognizing the fact that many of the projects are already operating under a single management structure. Great benefits to ornithological research and particularly to the conservation of birds would follow from such a development.

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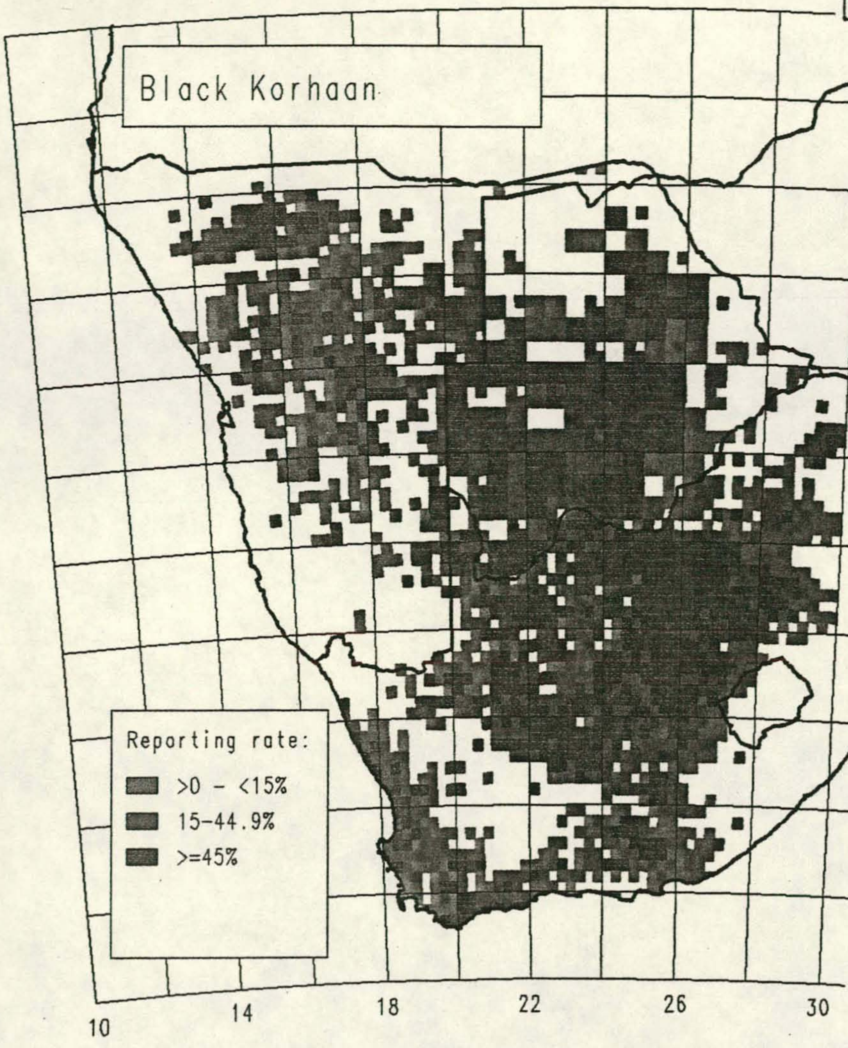
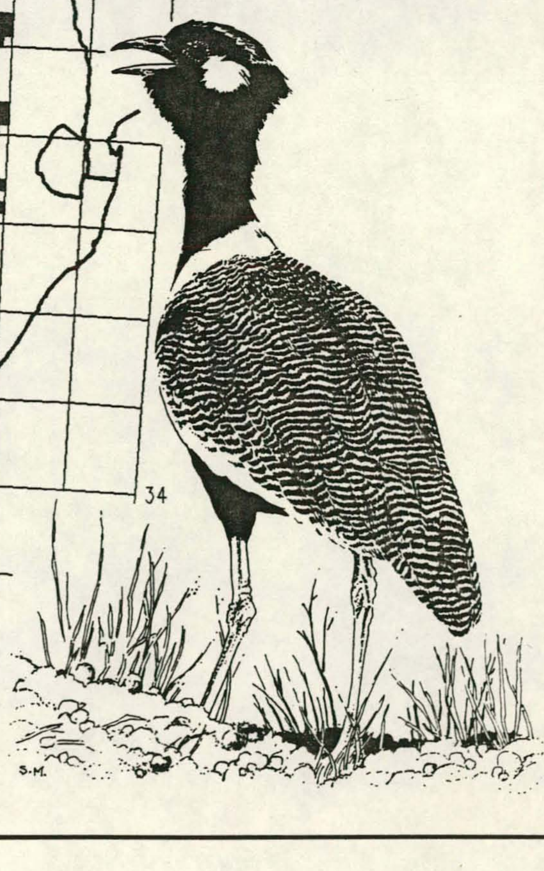
Cover: The distribution of the southern African endemic species *Eupodotis afra* (Black Korhaan) according to data collected for the Southern African Bird Atlas Project (SABAP). The colours denote different relative abundances based on reporting rates (see key). The two races, which are clearly separated over most of their ranges in the western Cape Province, have recently been taxonomically split into two full species. Progress with the bird atlas project is described in the article on page 410. The illustration of the Black Korhaan is by Sally MacLarty.





Recording bird distribution in southern Africa

Suid-Afrikaanse Tydskrif vir Wetenskap

The Southern African Bird Atlas Project databank: five years of growth

James A. Harrison

Since the beginning of 1987 and with the assistance of many volunteers, the Southern African Bird Atlas Project (SABAP) has built up a large computerized databank on bird distribution and seasonality. The project is international with subcontinental scope. The processing of data is based on custom-written software and mainframe hardware. A suite of routines has been developed to generate a range of reports which assist in data verification, feedback to observers and dissemination of information. Considerable demand for SABAP data has arisen in the academic, conservation and commercial spheres. The analysis of atlas data has ranged beyond species distribution to include studies on migration, local movements, long-term trends in abundance and correlation of distribution with environmental variables. Work on the publication of The Atlas of Southern African Birds *has begun. This landmark publication will demonstrate the potential of the reservoir of amateur expertise to gather important scientific data.*

Background

The Southern African Bird Atlas Project (SABAP) was launched at the beginning of 1987 to document current distributions and seasonal movements of southern Africa's roughly 900 bird species.[1] The geographical scope of the project is subcontinental, including the whole of southern Africa south of the Kunene and Zambezi Rivers with the exception of southern Mozambique and has required considerable international co-operation. The geographical and temporal resolutions are the quarter-degree grid square (15′ × 15′) and calendar month, respectively.[2,3]

The structure of the SABAP is based on a three-tier organization: Volunteer observers drawn from the general public collect and submit bird lists to a network of regional atlas committees based at bird clubs. These honorary committees carry out administrative and data-vetting functions and forward processed field cards to the project co-ordinator, based in the Department of Statistical Sciences, University of Cape Town, for computerization. Feedback on progress and priorities is provided by the co-ordinator through a regular newsletter, *SABAP News*. This organizational approach has proved to be effective and cost-efficient and is considered to have been the key to the project's success.

At the time of writing, SABAP stands at the end of five years of data collection and computerization. The year 1992 will be a transition period during which data-collection will cease and the analysis and writing up of the results will gain momentum. However, one of the SABAP's primary aims, namely to build up a computerized databank as an aid to academic ornithology and applied conservation research, has been achieved and hence it is appropriate to report to the scientific community on the project's progress at this juncture.

Size and scope of databank

Since January 1987, approximately 7 500 members of the public have volunteered to do field work. It is estimated that more than 80% of the data were collected by fewer than 2 000 individuals, nevertheless the numbers of fieldcards submitted have far exceeded expectations. The quantities of data and the geographical/temporal coverage which they represent are summarized in Table 1. Although the sampling intensity in different parts of the study area varies by as much as three orders of magnitude, basic coverage in the form of at least five visits per grid square is nearly complete within the Republic of South Africa (including the TBVC states) and Swaziland. Sampling levels in Botswana, Lesotho, Namibia and Zimbabwe are lower but still high relative to bird atlas projects elsewhere in Africa.[4,5]

The thorough coverage in the RSA was aided by a field ornithologist, Mr D.G. Allan, who was employed to visit the areas being omitted by amateurs. Those areas included the Transkei, Bophuthatswana, Lebowa, the Limpopo valley and parts of the arid northern Cape Province.

In addition to data collected in the period 1987 to 1992, large amounts of pre-1987 data, collated for smaller regional atlases, have been incorporated into the databank.[6–10] Where these data fall within the 1980s they will be used to supplement SABAP data for the atlas publication. Pre-1980 data are valuable for studies of historical trends in species' distributions and will be used for such investigations.

With over seven million individual bird sightings entered, the SABAP databank is large — possibly the largest of its kind in the world. It represents the realization of a dream held by many and particularly by the late Jack Winterbottom, who pioneered the effort to collate checklists.[11] Its present and future value as a scientific resource is inestimable.

Computer system and database structure

SABAP data are manipulated and analyzed using the VAX 6000-330 mainframe computer of the Information Technology Services, University of Cape Town. The raw data are captured in fieldcard units, irrespective of any repetitiveness arising from multiple visits to a square in a particular month. Although this would appear redundant, the method is necessary for the calculation of reporting rates, which are an essential and illuminating tool in the analyses.[12,13]

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Table 1. Coverage statistics based on field cards submitted for computerization before the end of February 1992. (There are 12 'square-months' per grid square, one for each calendar month.)

Atlassing regions	Field card total	Record total	Grid squares visited	Fewer than 5 visits	Square-months visited	Species total for region	Remarks
Namibia	17486	459551	1117 (90%)	612 (49%)	5637 (39%)	674	inclusive of approximately 10 000 pre-1987 cards
W. Cape	21222	980741	422 (99%)	71 (17%)	3243 (64%)	494	inclusive of approximately 8 000 pre-1987 cards
E. Cape	16364	791855	293 (99%)	8 (3%)	2906 (82%)	518	inclusive of approximately 3 500 pre-1987 cards
Swaziland	2379	142197	33 (100%)	0 (0%)	410 (98%)	483	inclusive of approximately 300 pre-1987 cards
Natal	13169	715628	196 (99%)	31 (16%)	1783 (75%)	606	pre-1987 cards not included here
Lesotho	897	21709	58 (91%)	25 (40%)	338 (45%)	246	
OFS	6960	302855	184 (99%)	2 (1%)	1906 (86%)	463	inclusive of approximately 2 500 pre-1987 cards
N. Cape	6047	224990	381 (99%)	114 (30%)	2377 (52%)	445	
S. TVL	13668	645897	121 (100%)	2 (2%)	1386 (95%)	547	pre-1987 cards not included here
N. TVL	8387	474038	142 (98%)	10 (7%)	1177 (68%)	525	pre-1987 cards not included here
NE TVL	4390	286565	79 (100%)	3 (4%)	782 (82%)	574	pre-1987 cards not included here
Lowveld	7083	387236	96 (100%)	2 (2%)	1051 (91%)	557	pre-1987 cards not included here
Botswana	2735	144013	226 (97%)	99 (43%)	1174 (42%)	548	inclusive of pre-1987 cards; grid squares are 30′ × 30′
Zimbabwe							statistics for Zimbabwe not available at present
Total	120787	5577275	3348 (96%)	979 (28%)	24170 (58%)	–	If all historical data are included, the record total exceeds 7 million

The approach to summarization, reporting and analysis of data is based on sequential data files and custom-written FORTRAN programs. This is in contrast to the modern trend towards the use of powerful relational database packages. The reasons for this are partly historical but also practical in nature. The effectiveness and cost-efficiency of a computerized system are dependent to a large degree on the working environment in which it is used. In an academic setting, programming skills, particularly in FORTRAN, are readily available and inexpensive. This, coupled with the availability of mainframe storage capabilities and processing power at no direct monetary cost, makes the strategy both workable and attractive.

Custom-written routines have the added advantage that they can be made 'friendly' to end-users who are involved in research into, or curation of, the database. Sophisticated database packages usually require more sophisticated and highly trained users and cannot necessarily provide reports as finely customized as required. Furthermore, in present circumstances, conversion to a database system would require a move to PC or workstation hardware with attendant financial and management implications.

Database packages are not designed to handle complex statistical analyses which are best performed by specialized statistical software, such as GENSTAT. Here again, sequential field data is the more convenient and simple option. The organization of the atlas data on the basis of a regular geographical grid also makes the task of analysis relatively simple in comparison to most spatially referenced information, which is typically linked to irregular polygonal geographical units.

Despite the caveats mentioned, the SABAP is investigating the use of relational database packages, particularly those which can be linked to a geographical information system such as ARC-INFO, as it is anticipated that there will be an increasing need to integrate the atlas data with other, non-gridded geographical data sets as a means of detecting correlations and relationships between distribution patterns and environmental variables.

Publication-quality maps are generated using a digitized base map of southern Africa, combined with a grid overlay and the spatially referenced atlas data, output from the VAX as a PostScript print-file to an HP LaserJet printer (Fig. 1).

Output and contribution to ornithology

The routine computer-generated reports are described in Table 2. The ability to produce updated reports from the databank rapidly is an important feature of the SABAP's operation for three reasons: (1) It allows for ongoing checking and vetting of the data without long

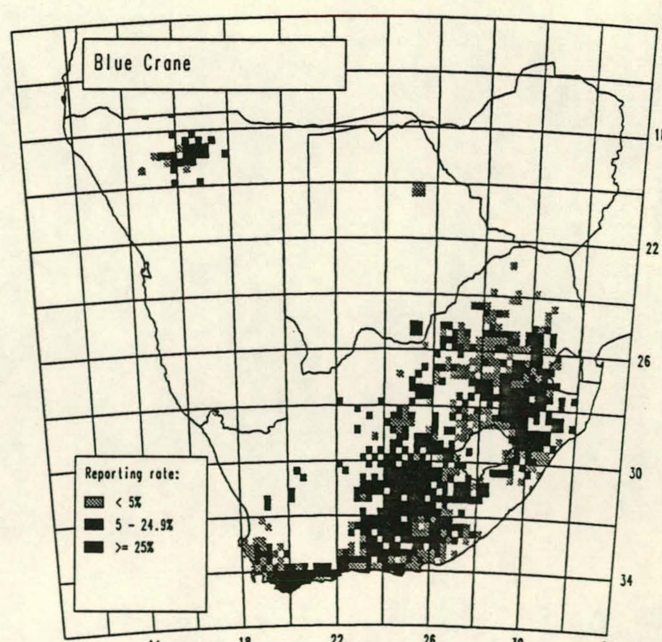

Fig. 1. The distribution of the national bird of the Republic of South Africa, *Anthropoides paradisea* (Blue Crane) from SABAP data. Interesting features of the distribution pattern are the isolated population at the Etosha Pan in Namibia, the colonization of the wheatlands in the southern Cape Province and the anthropogenic disruption of the range in Transkei, Lesotho, northern Orange Free State and southern Transvaal.[34]

Table 2. The suite of basic SABAP computer routines developed by L.G. Underhill, D.B. Holgate, P. Martinez, R.A. Navarro and D.R. Franco, all of the University of Cape Town.

Printouts	Content	Purpose
Phase 1	raw data in field card units but translated into readable English	allow for checking of data entry
Phase 2	summary data for grid squares with species list and reporting rates and breeding information	data vetting by local experts; useful for locally based studies e.g. EIAs
Phase 3	summary data for species in map form, showing reporting rates per square; maps for months or seasons or for total data	data vetting by species experts; useful for species-based studies
Priority maps	maps showing fieldcard totals and species totals per grid square	feedback priorities to observers
Select	raw data extracted according to specifications	allows recovery of any specific subset of data
Specs	summary data by grid square for a specified species	an aid to species-based research

delays between data entry, error detection and data editing. (2) Coverage priorities can be updated and reported regularly. (3) Requests for data can usually be met at short notice, thereby facilitating the development of a data service which quickly disseminates the relevant bird distribution information and generates income for the project.

The number of requests for data is one yardstick by which the value and impact of the databank can be measured. Figure 2 shows how these requests have increased despite the introduction of charges in 1990 and the revision of those charges to more market-related levels in 1991. Different tariffs are applied depending on whether the data are to be used for academic and conservation-related research or commercial purposes.

It is planned to market data actively to the commercial sector involved in environmental impact assessments. This service will be improved with a computer-generated report which will provide a breakdown by habitat of the species list for an area.[14] The full potential of the SABAP databank to aid the rational planning of development has not yet been realized.

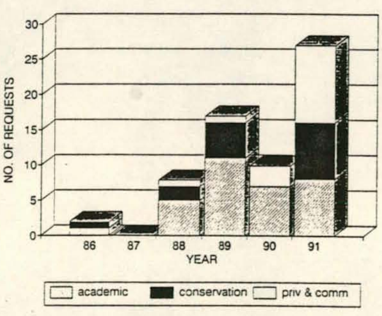

Fig. 2. Requests for data from the SABAP databank originating from academic, conservation, and private and commercial sectors.

It can safely be said that the SABAP's contributions to southern African ornithology will be manifold. In addition to papers already produced,[13,15–18] it is anticipated that research papers on a variety of topics will spring from the databank in the near future. The following are some areas in which contributions will be made:

(i) Ecology: Basic to all single-species ecological studies is a consideration of distribution and seasonal changes in distribution. The methods of the SABAP allow for description of distributions not only on the basis of presence/absence but with the inclusion of a measure of relative abundance based on reporting rates in different parts of the range and in different seasons. These measures allow one to differentiate between the strongholds and the peripheries of a species' range.[12,19]

(ii) Migration: Monthly sampling and the use of statistical modelling techniques allow the timing of departures and arrivals of migrants in different parts of southern Africa to be described with unprecedented accuracy from atlas data.[12,20] The project was invited to present the southern African contribution to the conference on 'The Ecology and Conservation of Palearctic-African Migrants' in Norwich, England, in April 1991.[21] This presentation has been accepted for publication.[13]

(iii) Seasonality: In addition to the gross movements of long-distance migrants, the subtler partial migrations and local movements of populations can be detected, in many cases, from atlas data, thus giving new insight into the ecological requirements of species.[22] As breeding records were also noted and computerized, there is potential for describing the breeding seasonality and the geographical variations in such seasonality for many species.

(iv) Monitoring: The data sets in some parts of the region span several years and, in two cases, the south-western Cape and Zimbabwe, a few decades. The potential exists to describe long-term changes in distribution and relative abundance of species from these data sets.[23] Such studies could form the basis for ongoing monitoring of bird populations.[12,24–27]

(v) Biogeography: Apart from the patterns exhibited by individual species, other interesting biogeographical features can now be described from a sound empirical database. These include the geographical distribution of species richness, both for the whole avifauna and for specific groups of species, such as endemics. The relationship of the various avian distribution patterns with environmental variables such as rainfall, altitude, vegetation, etc., provides many opportunities for analysis and theory formation.[21]

(vi) Conservation: It is clear that all of the areas listed above have direct relevance to the planning and execution of conservation strategies. With the possible exception of the large mammals, there is now no other group of organisms in southern Africa with such a comprehensive information platform on which to base a conservation plan. To what extent this may provide a key to ecosystem conservation has yet to be investigated.

The SABAP has demonstrated unequivocally that the potential exists to assemble important data sets with the aid of an increasingly well-informed and enthusiastic workforce of amateur naturalists in southern Africa. Comparable projects such as bird ringing,[28] the fish-tagging programme[29] and the Protea Atlas Project[30] are drawing on the same human resources. Despite the fact that the biological sciences are experiencing something of a high-tech revolution, there is still a great need for basic inventory keeping of our natural resources.[31] Understanding of the impacts of global environmental change on these resources will depend in part on good baseline information and regular follow-up surveys.[32] One must hope that this basic need will be recognized and that the co-operative programmes required to meet it will receive the necessary financial support from future governments.

The Atlas of Southern African Birds

After the databank itself, the second

major 'product' of the SABAP will be *The Atlas of Southern African Birds*. Planning for this publication is already well advanced under the guidance of a committee appointed by the Southern African Ornithological Society (SAOS). Authors have been appointed and an advisory panel of distinguished ornithologists has been invited to assist in maintaining high standards for the publication.

The approach of the atlas will be to present and interpret atlas data only. There will be no attempt to compete with existing fieldguides or general biological texts such as *Roberts' Birds of Southern Africa*.[33] It is hoped that the manuscript will be completed during 1995.

It is envisaged that the atlas will appear in two volumes running to a total of approximately 1 700 A4 pages. All 900-odd species will be dealt with but species' treatments will be varied according to the quantity and quality of the data available. The roughly 400 species receiving 'full' treatment will have distribution maps showing reporting rates per grid square — similar to that shown on the cover of this issue for the Black Korhaan — a page of text with a pen-and-ink illustration of the species, plus additional seasonal maps and graphical statistics, where appropriate. Smaller maps of distribution only and briefer texts will be used for the approximately 300 species which have relatively small data sets. Pelagic seabirds and species vagrant to the subcontinent constitute the remainder and will receive only brief textual treatments, as the SABAP throws relatively little light on their global distributions.

There can be little doubt that *The Atlas of Southern African Birds* will be a watershed publication. It will become a standard reference, a baseline against which to measure future change and a stimulus to further research.

The SABAP owes its success in large measure to the co-operation and participation of the following organizations: Botswana Bird Club, Cape Bird Club, Eastern Cape Wild Bird Society, Lowveld Bird Club, McGregor Museum, Namibian Ministry of Wildlife Conservation and Tourism, Natal Bird Club, Natal Midlands Bird Club, North-eastern Bird Club, Northern Transvaal Ornithological Society, Orange Free State Ornithological Society, Ornithological Association of Zimbabwe, Southern African Ornithological Society, University of Cape Town, Wildlife Society of Lesotho and Witwatersrand Bird Club.

The SABAP has been fortunate to enjoy the support of several sponsors. They are, in alphabetical order: Endangered Wildlife Trust, Anglo American and De Beers Chairman's Fund, Department of Environment Affairs, Distillers Corporation, Gold Fields Foundation, Mazda Wildlife Fund, Natal Bird Club, Natural History Society of Swaziland, Southern African Nature Foundation, Southern African Ornithological Society, University of Cape Town and the Wildlife Society of Southern Africa. Several private individuals have also made generous donations.

Thousands of volunteers have spent many man-years collecting data, all at some and some at great personal expense. Scores of dedicated individuals have performed regional administrative duties on an honorary basis. The success of the SABAP is a direct result of their inspiring efforts. Sally MacLarty kindly allowed use of her illustration of the Black Korhaan. I gratefully acknowledge the helpful comments of my colleagues in the Avian Demography Unit while preparing this manuscript.

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Seasonal patterns of occurrence of Palaearctic migrants in southern Africa using atlas data

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A statistical method, using presence/absence data from monthly fieldcards, to describe the phenology of migration is developed. The method uses the generalized linear model to fit a Fourier series to binomial-type data giving the proportion of fieldcards reporting a species. A method for estimating mid-arrival and mid-departure dates, and residency period is also developed. The methodology is applied to data collected during the 'Southern African Bird Atlas Project' for the following species: Willow Warbler *Phylloscopus trochilus*, Red-backed Shrike *Lanius collurio*, European Swallow *Hirundo rustica*, White Stork *Ciconia ciconia*, Steppe Buzzard *Buteo buteo* and European Bee-eater *Merops apiaster*.

The primary objective of the Southern African Bird Atlas Project (SABAP) (Harrison 1987, 1989, 1990, 1991) is to map the distribution of all bird species in Africa south of the Zambezi and Kunene Rivers. The collection of data relating to seasonality of distribution is a secondary objective, and it is this aspect of SABAP which is reported here. Detailed distribution maps will be presented in the final atlas publication.

The study area for the project (Fig. 1) covers a 20-degree latitudinal range (15°S–35°S). In broad terms, rainfall increases from west to east (11°E–33°E) across the subcontinent, resulting in a diversity of habitats from desert along the coast of Namibia to forest along the southeastern coast of South Africa.

The focus of this paper is methodological. First, it describes a relatively cheap method of obtaining large volumes of quantitative data on the phenology of migration on a subcontinental scale. Second, a statistical method to describe phenology is also presented.

The previous major review of the phenology of migration in southern Africa was by Broekhuysen (1955/1956, 1971/1974). He summarized records of migrants submitted by observers because they were considered interesting (mainly first and last dates). These results were clearly open to the criticism that they were biased by the self-censoring of observations by recorders.

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MATERIAL AND METHODS

SABAP was a mass-participation project with *c.* 7000 observers. Organizational aspects of SABAP were described in Harrison (1987). The project employed a quarter-degree grid scale (resulting in quarter degree grid 'squares' (QDGS) approximately 27 km north to south × 24 km east to west for its spatial resolution). The temporal resolution was the calendar month; data for the same month in successive years were cumulated.

The fieldwork protocol was for an observer to submit one atlas card for each QDGS visited per calendar month. Each species identified in the month was recorded on the atlas card, regardless of numerical abundance. Observer effort was not measured; some atlas cards were based on a few hours bird-watching, during which only the most conspicuous and abundant species were recorded, others provided comprehensive lists after exhaustive searches throughout all parts of a QDGS. All the records on each atlas card were incorporated into the SABAP database. The computerized database contains cumulative totals of the number of atlas cards for each QDGS per month, and the numbers of these cards that recorded each species.

The fieldwork for the project was scheduled to end in 1991. By the end of 1990, the project's database held five million records (Underhill *et al.* 1991), and it was this subset of the final database that was analysed for this paper. At that stage, atlas cards were available for 98% of the 2020 QDGS in South Africa, Lesotho and Swaziland, for 86% of the 1241 QDGS in Namibia, and 73% of the 602 QDGS in Zimbabwe. Computerization of atlas data for Botswana was in progress, but these were not available in

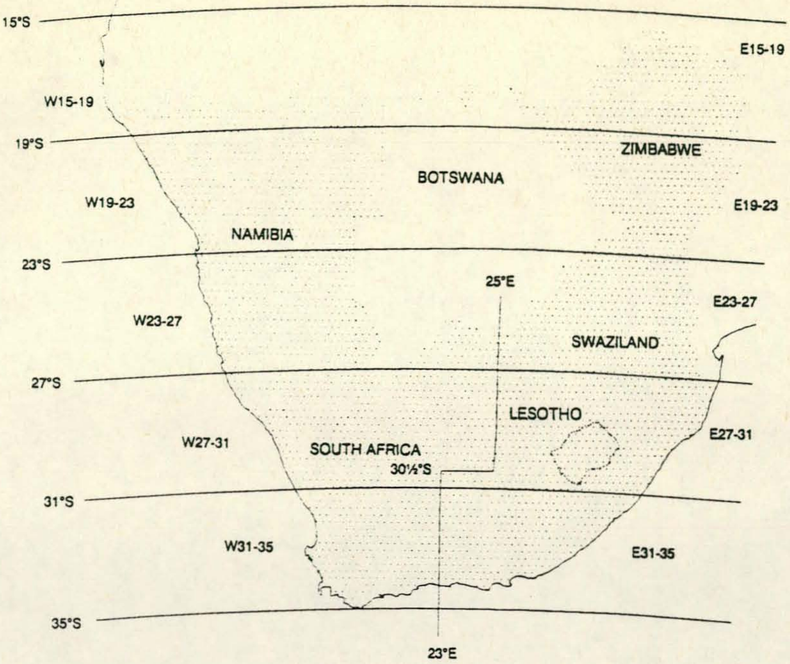

Figure 1. Map of southern Africa, showing the 4°-wide latitudinal zones on the east and west of the subcontinent.

time for this paper. The political situation in Moçambique precluded effective atlas fieldwork there.

The fieldwork and data capture methodology enabled reporting rates to be computed. We define the reporting rate for a species as the percentage of field cards received for a region which record the species as present (Linsdale 1928). The reporting rate may loosely be interpreted as the likelihood of the species being recorded in a region in a calendar month (Temple & Temple 1986). For this paper, we use as regions 4°- latitudinal zones starting at 15°S and split the region into east and west, giving a total of ten regions labelled W15–19, ..., W31–35, E15–19, ..., E31–35 (Fig. 1).

The data for all QDGS within each region were combined, and overall reporting rates for each month were computed. A low reporting rate usually indicated that a species was rare, a high reporting rate that it was common.

We fitted Fourier models to the monthly reporting rates to provide a smoothed description of seasonality. These models are circular in the sense that the end of a year is joined continuously to its start (Zucchini & Adamson 1985, Zucchini *et al.* 1991). The exact form of the model was

$$\text{logit } R = a_0 + b_1 \sin \theta + c_1 \cos \theta + b_2 \sin 2\theta + c_2 \cos 2\theta + b_3 \sin 3\theta + c_3 \cos 3\theta,$$

where R was the reporting rate, logit R = log (R/(1 −R)), the logistic transformation, and θ is 1/24 of 360° for January, 3/24 of 360° for February, ... and 23/24 of 360° for December, i.e. each month's data were considered to refer to the midpoint of the month. Because the data were essentially binomial in character, the seven parameters a_0, b_1, b_2, b_3 c_1, c_2 and c_3 were estimated using a generalized linear model with a binomial distribution, for which the logistic transformation is the appropriate link function (McCullagh & Nelder 1989, Genstat 5 Committee 1987). Thus we fitted a seven-parameter model to 12 data points; this means that there was a relatively small degree of smoothing and that the fitted model closely approximated the observed data (Fig. 2).

In order to compare the phenology of migration across latitudinal bands the following *ad hoc* procedure was adopted. Let the probability that a single bird in a region is detected be p. Suppose there are n birds present in the region. Then the probability that at least one is detected is $1 - (1 - p)^n$. We set this equal to the reporting rate R. It follows that $n \propto -\log(1 - R)$ We define the mid-arrival date as the day t_a by which half the birds have arrived, the mid-departure date as the day t_d by which half the birds have departed, and the residency period as the period between these dates, (t_a, t_d). Mathematically, if R_t is the reporting rate on day t, and R_{max} is the maximum reporting rate, then the mid-arrival date is the day t_a on which $\log(1 - Rt_a)/\log(1 - R_{max})$ first exceeds one-half.

Note that our descriptions of the seasons are austral except where otherwise specified.

RESULTS

Overall migrant representation

Passerine and near-passerine Palaearctic migrants are remarkably poorly represented in the southern African

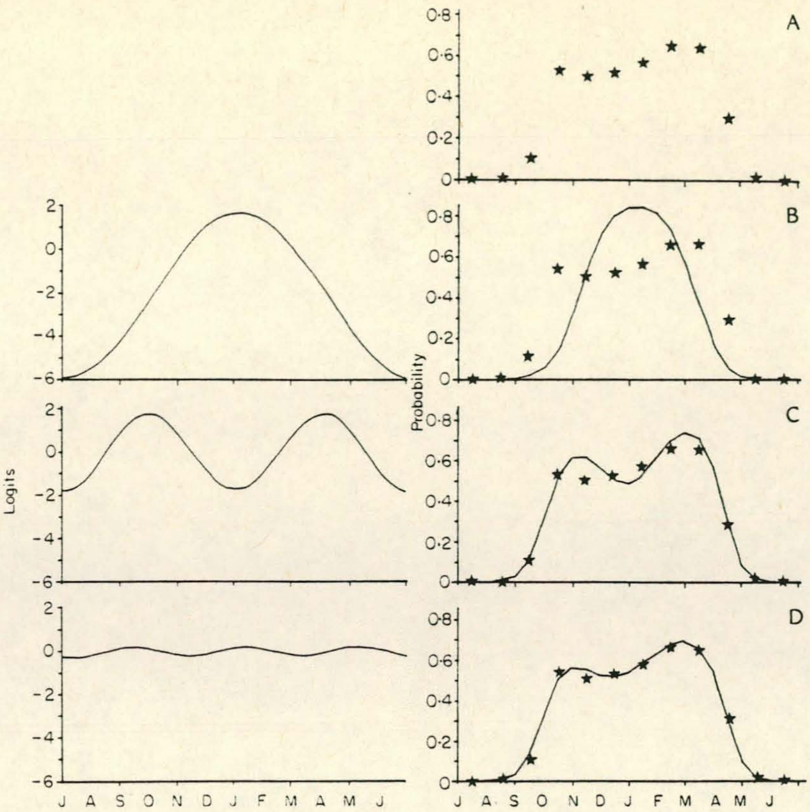

Figure 2. An example of the progressive fitting of the generalized linear model to a set of 12 monthly data points from July to June (A). The fitted model after the inclusion of the first (B), second (C) and third (D) harmonics is shown in the left hand side plots, while the right hand side plots show the fitted first, second and third harmonics prior to transformation back from the logit space.

avifauna. Only 27 of the 91 such species treated by Moreau (1972) had been recorded during atlas fieldwork to the end of 1990, comprising between 5% and 6% of the total number of passerine and near-passerine species present in the subcontinent (*c.* 500). Consideration of other terrestrial non-passerines, i.e. excluding sea, intertidal and freshwater birds, does not alter this picture materially, with only raptors being at all well represented.

The entire subcontinent can thus be seen to lie to the south of that portion of the Afrotropical region in which the majority of Palaearctic terrestrial migrant species spend the boreal winter. Below, we provide examples of the information obtainable from the SABAP database regarding the patterns of occurrence of those migrants which do occur through reference to six of the more common and widespread species which between them encompass the spectrum of variation present.

Willow Warbler *Phylloscopus trochilus*

The distribution pattern of the Willow Warbler reveals a striking decrease in reporting rate from north to south and from east to west (Fig. 3). This exemplifies the most frequent overall pattern of distribution displayed by Palaearctic migrants, in particular the relatively well-represented warblers, although for most species the attenuation in reporting rate from the northeast is much more rapid, resulting in their being almost entirely absent from a greater or lesser part of the mostly arid areas to the south and west of the subcontinent.

On a finer scale, it is apparent that on the eastern side of the region where the species is most common, Willow Warblers arrive progressively later further south, with the mid-arrival date altering progressively from mid-October in E15–19 to December in E31–35 and W31–35. By contrast, departure from all parts of the subcontinent is almost simultaneous, with the mid-departure date near the beginning of April. In consequence, the residency period shortens from *c.* 5.5 months in the north to less than 4 months in the south.

Red-backed Shrike *Lanius collurio*

The reporting rate pattern of the Red-backed Shrike is similar to that of the Willow Warbler as regards an overall decline from north to south, but an east-west cline is less in evidence despite the clear peak in abundance in E19–23, i.e. southern Zimbabwe and northern Transvaal (Fig. 4). The Red-backed Shrike is one of the very few species for which there is evidence currently available which directly links atlas reporting rates to densities. B. Bruderer (pers. comm.) has shown that reporting rates show a positive

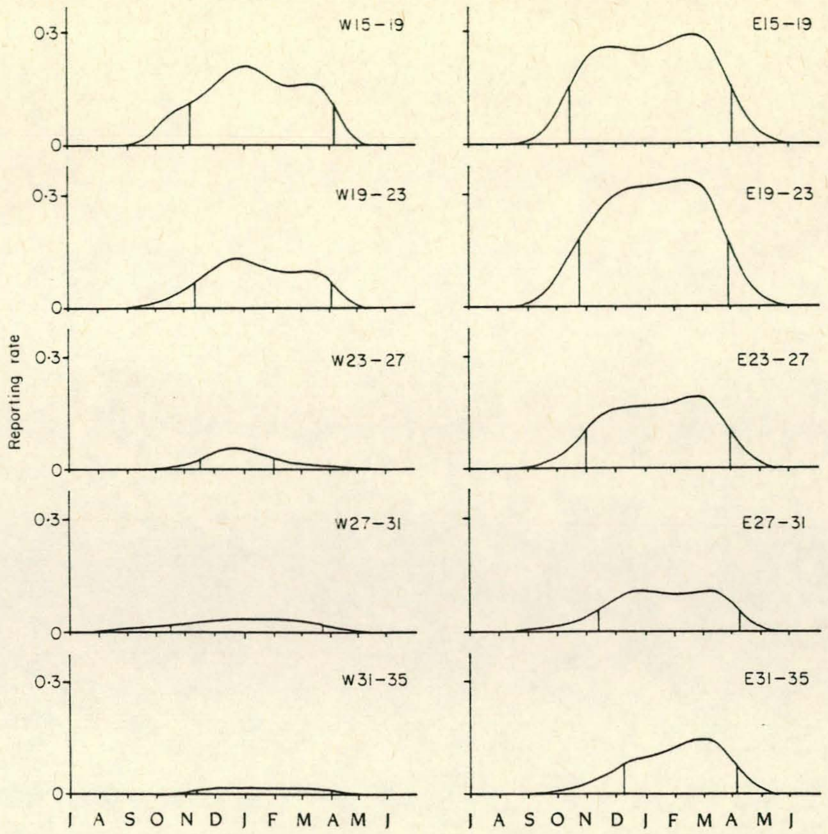

Figure 3. The fitted models for Willow Warbler, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

association with relative abundance within the higher density areas in which they were best able to do strip counts.

In contrast to the staggered arrival of Willow Warblers, mid-arrival dates of Red-backed Shrikes are strikingly synchronized across zones in southern Africa in mid to late November. This might be a result of territorial site fidelity, in contrast to the apparently continually shifting Willow Warblers. This compares with median passage dates from Ottenby, Sweden, of *c.* 14 August, from Khor Arbaat, Sudan, of *c.* 10 September, and from Ngulia, Kenya, of *c.* 15 November.

Departure is similarly synchronized across the subcontinent, with half the birds having left by early to mid-April.

European Swallow *Hirundo rustica*

The European Swallow has the highest overall reporting rate of any Palaearctic migrant, although it is less common in the drier northwestern zones than elsewhere (Fig. 5). As for the Red-backed Shrikes, mid-arrival dates show no clear geographical trend; there is, at best, marginal evidence for a trend from late-October in the northeast to mid-November in the southwest. Departure appears synchronized across zones and occurs in early April.

On a finer analysis, a common factor in all the zones is that the build-up in reporting rate during arrival is slower than the decrease in reporting rate during departure. The converse pattern is observed in Britain, and presumably elsewhere on the breeding grounds; arrival during the boreal spring is rapid, and departure in autumn more gradual (Riddiford & Findlay 1981).

Overwintering has occurred in all zones, but the reporting rate is negligible.

White Stork *Ciconia ciconia*

White Storks are predominantly present in the east, with reporting rates peaking towards the south (Fig. 6). They are largely absent from the drier north-west. Birds reach southern Africa from the northeast; mid-arrival date there is mid-November, progressing to mid-arrival dates of around mid-December in the southeast and southwest. Withdrawal is similarly staggered, with mid-departure in early March in the south and early April in the northeast.

There is a minute breeding population in zone W31–35 (Roberts 1941, Brooke 1984). These birds make a negligible contribution to recorded reporting rates. However, significant numbers of White Storks overwinter, leading to substantial reporting rates, particularly in the northeast.

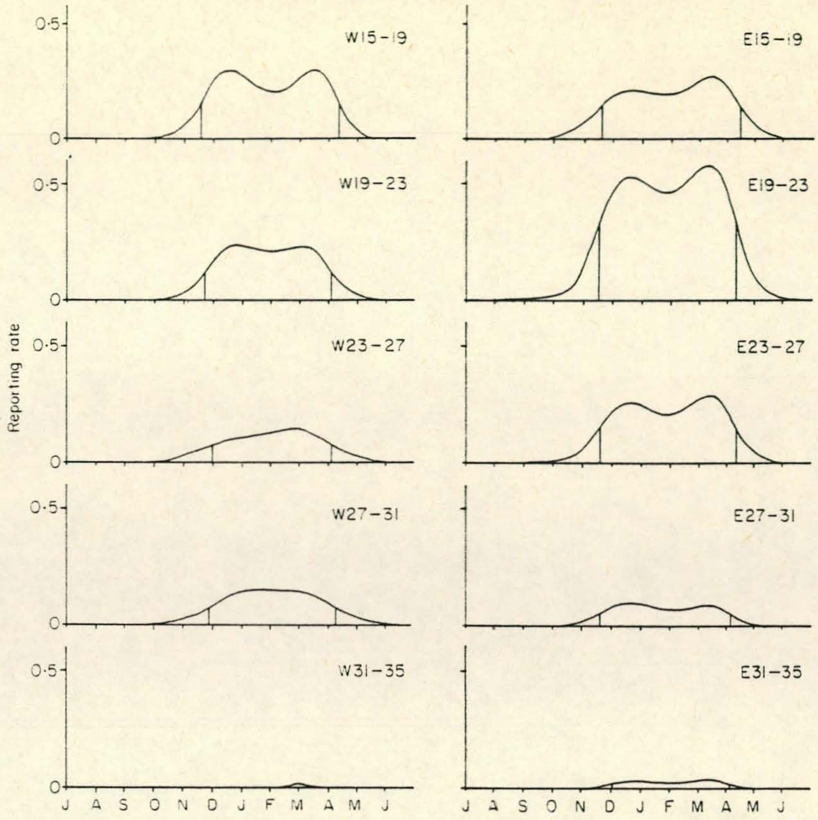

Figure 4. The fitted models for Red-backed Shrike, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

Steppe Buzzard *Buteo buteo*

The Steppe Buzzard has the most distinctive pattern of distribution in southern Africa of any terrestrial Palaearctic migrant. Steppe Buzzard reporting rates show almost the inverse pattern to the 'normal' pattern exemplified by Willow Warblers (Fig. 7)—they are most abundant in the southwestern Cape (zone W31–35), where the reporting rate reaches 45%, compared with only 11% in northern Zimbabwe (zone E15–19). Arrival in the subcontinent is almost simultaneous; similarly departure is well synchronized from all regions. First arrivals occur during September, with October an important arrival month. Departure starts in February, with March being the main departure month, and relatively few birds lingering till April.

The southwestern zone consists mainly of the Cape Floral Region, or Fynbos Biome, the smallest such region in the world (Fraser & McMahon 1988), and an area strongly avoided by most terrestrial Palaearctic migrants. However, it is not clear whether Steppe Buzzards are attracted to pristine fynbos, as their greatest densities in the southwestern Cape are in the wheatfields to the east and north of Cape Town (Hockey *et al.* 1989).

The unusual pattern of increase in abundance from north to south is also shown by extensive roadside transect data; one Steppe Buzzard per 33 km in the Transvaal compared to one per 2 km in the southwestern Cape (Tarboton & Allan 1984, D.G. Allan *in litt.*). However, it needs to be borne in mind that Steppe Buzzards are more conspicuous in the wheatlands of the southwestern Cape than in wooded habitats further north, especially in Zimbabwe.

European Bee-eater *Merops apiaster*

This species is particularly interesting. Like the White Stork, it has a migratory breeding population within Africa, breeding in the southern part of the study area (mainly in the four zones south of 27°S), and wintering in central Africa; unlike the White Stork, there is little overlap in distribution, except in the southwestern Transvaal, between the Palaearctic summer visitors and the breeding population (Brooke & Herroelen 1988).

The presence of the breeding population is revealed by those zones showing mid-arrival dates in mid-September (Fig. 8). By contrast, Palaearctic migrants concentrate in the northeast, and have mid-arrival dates *c.* 1 month later, in mid-October. The breeding populations withdraw northwards to a wintering area between 15°S and the equator (Brooke & Herroelen 1988), depar-

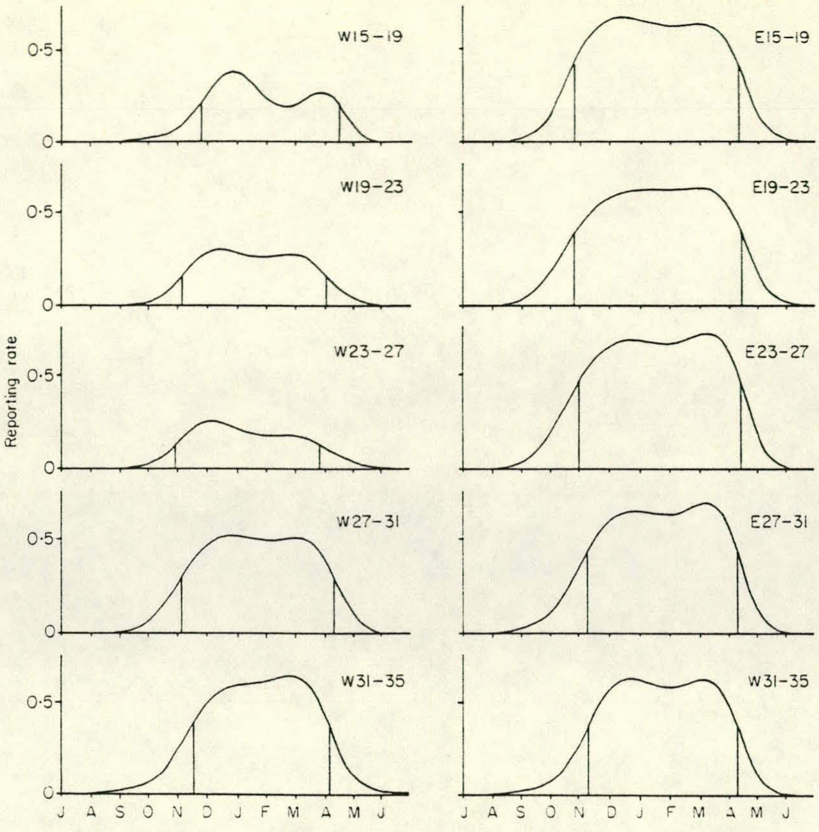

Figure 5. The fitted models for European Swallow, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

ture commencing during late January and February, having a mid-departure date *c.* 2 months in advance of the Palaearctic migrants (Fig. 7, see also Underhill 1990).

DISCUSSION

Methodology

We believe that the approach documented in this paper offers a powerful, cost-effective method for assessing year-round patterns of occurrence on a subcontinental scale without making impossible demands on a limited observer-force. The project has, in fact, provided a large stimulus to volunteer field ornithology in southern Africa. This is attributed to its straightforward methodology and the attention that has been paid to rapid feedback of information to participants, directing them to areas where little fieldwork has been done and providing field identification techniques. Effective computerization and data-processing systems have also enabled the project to cope with large volumes of data.

There are three important caveats to the interpretation of reporting rates, and to the modelled curves. First, reporting rates confound three variables: numerical abundance, conspicuousness and identifiability. Thus, comparisons of the relative abundance between species can only be valid if they are equally conspicuous and identifiable. Even within a species, conspicuousness can vary greatly between biomes: for example, a European Swallow is more conspicuous over desert than in forest, and more likely to be observed and reported. Conspicuousness and identifiability can also vary between seasons: many of the Palaearctic migrants are more vocal and active in the weeks preceding migration than they have been through the summer months, when many of them are moulting and tend to skulk. Bias in reporting rates may also be introduced if the identification skills of the observers vary between regions. We have no reason to suspect that this is a major problem with these data, each region having many observers with a broad mix of experience in identifying birds. In summary, any analysis of the reporting rates of a species must take account of the biology of that species.

Second, the relationship between reporting rate and numerical abundance is not linear, but has been shown by experience to be approximately monotonic; in general, if the reporting rate for a species is low, the species is relatively rare, and if it is high, the species is relatively abundant (e.g. Temple & Temple 1986, Hockey *et al.* 1989). At present few data relating bird densities to reporting rate are available. Further fieldwork aimed at calibrating this

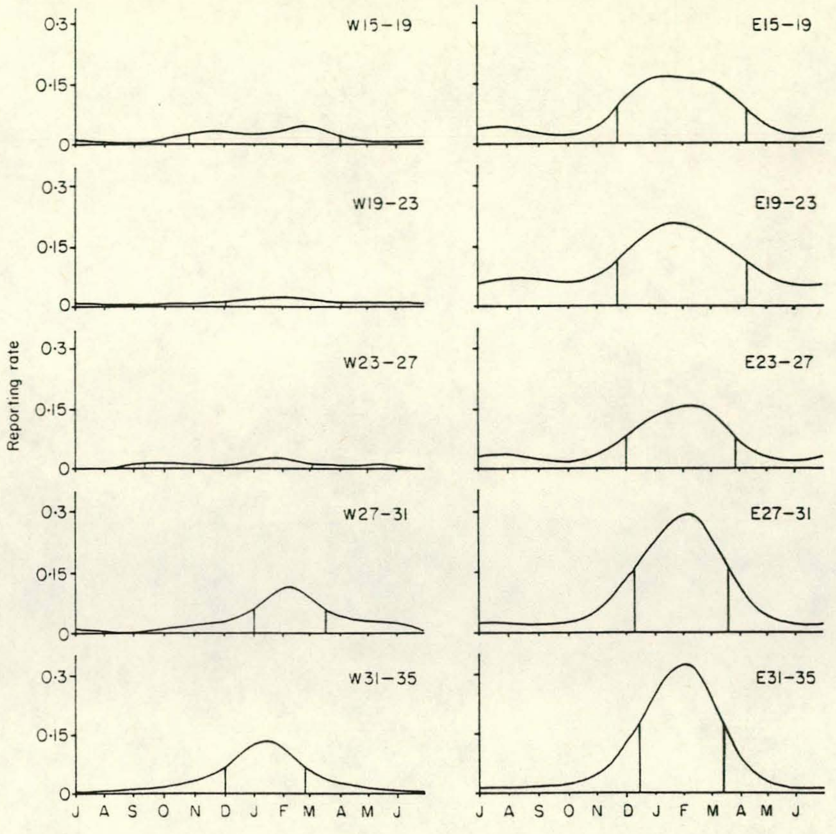

Figure 6. The fitted models for White Stork, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

relationship would be invaluable. Reporting rate data can be gathered over large areas relatively inexpensively. These data could then be used to make estimates of the total population in a region.

Third, in fitting the model, the reporting rate for each observation period (here, the month) was considered to refer to the midpoint of the period. This is an approximation to the strictly correct interpretation that the reporting rate should be equal to the area under the modelled curve for the period. The approximation becomes closer to reality as the number of time periods increases. Periods of 1 month are the coarsest for which this approximation is acceptable.

The difficulties in determining arrival times for migrants were reviewed by von Haartman & Söderholm-Tana (1983), who considered only the first sighting of an individual of a species in an area. They pointed out various sources of bias in this method; in particular, they noted that the larger a population, the earlier the first individuals tend to arrive. The method described in this paper to highlight differences in arrival and departure between latitudinal zones was used to infer the date when approximately 50% of the birds had arrived or departed, a more useful measure of the phenology of migration than first arrivals (or last departures). Our method can, in theory, be used to determine mid-arrival and mid-departure rates to the day. However, the data were collected on a monthly time scale; a certain amount of interpolation is acceptable, but with the available data interpolation should not be to periods shorter than one week. However, our results for the relative timing of arrival and departure for a species between regions are likely to be correct.

The 1 month time scale used by SABAP has, with hindsight, proved too coarse to enable fine-scale resolution of differences in timing of arrival and departure of migrants between latitudinal zones to be made with confidence. Any project using the SABAP methodology with the primary objective of describing the phenology of migration should use a finer time scale. The extreme possibility is to produce field cards on a daily basis. The Fourier method of describing seasonality can equally well be applied to such data; this was done by Zucchini & Adamson (1984) in modelling daily probabilities of rainfall. However, a balance needs to be maintained between demands on amateur observers, volumes of data, and the possibility of statistical interpolation to a finer time-resolution than that of the adopted time scale. We recommend that a weekly time scale is the obvious alternative to the month.

Implicit in the fitting of a generalized linear model is the concept that the reporting rate represents the prob-

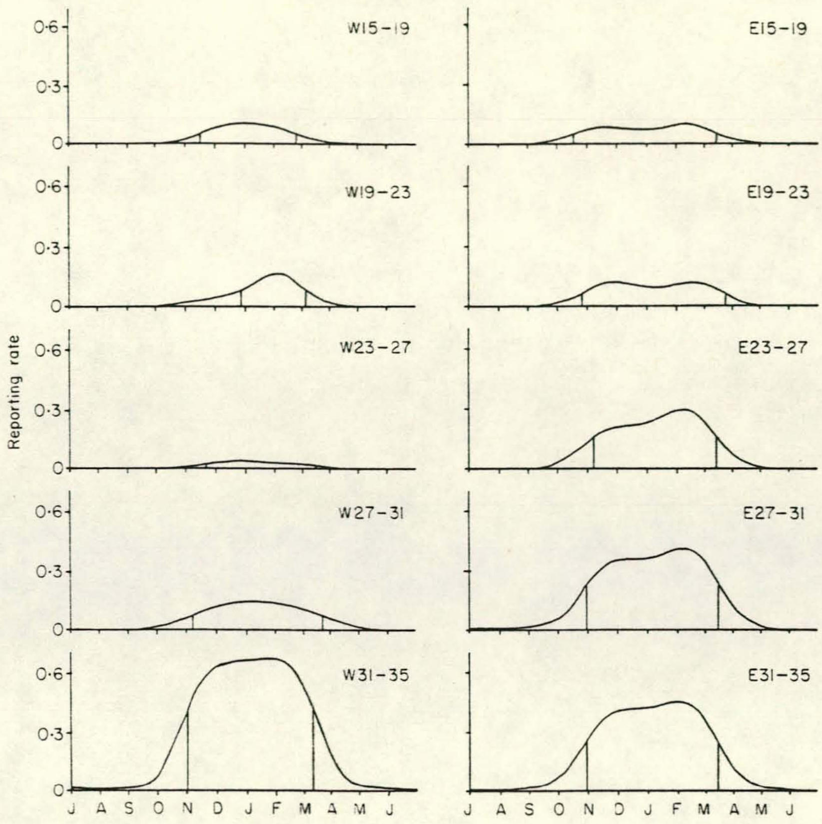

Figure 7. The fitted models for Steppe Buzzard, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

ability of a species being recorded in a month. Although we make this assumption in doing the modelling, we distance ourselves from this strict interpretation. The probability of a species being seen during a month clearly depends not only on numerical abundance, conspicuousness and identifiability, but also on the time spent observing and the skills of a particular observer.

The phenology provided by the methodology describes residency at the population level, and not at the individual level. Thus, we are unable to distinguish whether a staggered arrival pattern is due to leap-frog migration (with later arriving individuals being forced to occupy areas to the south of earlier arrivals) or blanket migration (where the entire population moves southwards). To distinguish between such patterns it is necessary to mark individual birds.

Results

There is considerable interspecific variation in spatial patterns of occurrence among Palaearctic migrants. However, the most predominant overall pattern is of a decline in representation towards the south and/or towards the drier west.

Certain species, notably the Steppe Buzzard, are exceptions to this pattern of decline for reasons which have not yet been adequately documented. In this context, it needs to be noted that discussion of patterns in a clinal context is complicated by the presence in the southwestern Cape of a region which is unique within the subcontinent both climatically (winter rainfall) and in its vegetation (high species diversity and endemism) (Fraser & McMahon 1988). Both the Fynbos and the Karoo biomes lack grass and trees, which are important bird habitats, especially for passerines.

Despite restrictions on the temporal resolution of the methodology, as discussed above, considerable variation is apparent between species in the way they structure their arrival and departure strategies and their range occupancy. An emerging pattern for many species is that they display staggered arrival and synchronized departure.

Future directions

Within southern Africa, the project should be followed up by detailed studies relating reporting rate to relative (or even absolute) densities, as pioneered by B. Bruderer (pers. comm.) for the Red-backed Shrike. This calibration will enable the concepts of mid-arrival and mid-departure dates, and residency period, to be better defined. Within the context of global warming, and intensifying habitat

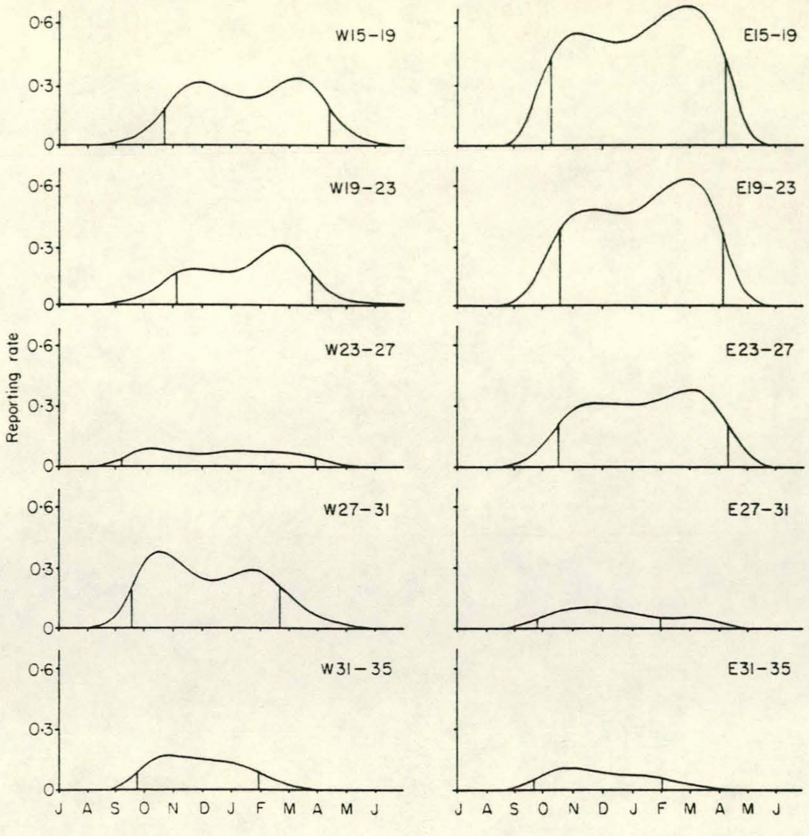

Figure 8. The fitted models for European Bee-eater, for each of the regions defined in Figure 1. Mid-arrival and mid-departure dates are indicated by vertical lines.

destruction in Europe and Africa, an ongoing atlas project could provide valuable information on range contraction or expansion of migrants (Underhill *et al.* 1991). Reporting rates also have the potential to monitor changes in relative abundance (Underhill & Hockey 1988, Harrison 1989).

Detailed comparisons of the phenology of Palaearctic migrants in southern Africa with that in Europe are surprisingly difficult. Europe tends to lack equivalent standardized studies on the appropriate temporal and spatial scales. Most European atlas projects have suffered two major constraints: the year is perceived as consisting of two discrete periods, the breeding season in spring and summer, and winter, with little of interest in between; the projects are defined on a country-by-country basis, and have boundaries which have little relevance to bird populations. A Europe-wide, amateur-based, study of migration phenology would seem a project which has scientific merit and is attainable.

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MODELLED REPORTING RATES AS INDICES OF CHANGES IN RELATIVE ABUNDANCE WITH ALTITUDE AND SEASON.

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ABSTRACT

Checklist data collected for the Southern African Bird Atlas Project were analyzed for a region of southern Africa with a steep altitudinal gradient. The analysis made use of a generalized linear model to describe changes in relative abundance between altitudes and months and to detect interaction between these variables. Trends in modern bird atlases and the use of reporting rate as an index of relative abundance are reviewed. Incorporation of protocols and analyses to produce measures of relative abundance for comparison of geographical areas and seasons is advocated for future atlas projects.

INTRODUCTION

The methods of the Southern African Bird Atlas Project (SABAP) were based directly on those of a smaller provincial forerunner which had demonstrated their efficacy (Hockey et al 1989). These methods are very simple in comparison to techniques such as those being used in the new atlas of breeding birds in Britain and Ireland (Gibbons 1989). Simple methods of data collection do not preclude sophisticated methods of analysis however, especially where large quantities of data are concerned. A quotation from Temple and Temple (1984) is pertinent: "Although the records kept by each individual are alone of only slight value ..., the compiled records of many observers in a geographic area can be analyzed in such a way that they become highly accurate indicators of the regional status of birds."

The SABAP collected data for an area south of the Kunene and Zambezi Rivers including South Africa, Namibia, Botswana, Zimbabwe, Swaziland and Lesotho, but excluding southern Mozambique, during the years 1987 to 1992. Approximately 5000 observers collected in excess of five million records during this period. *The Atlas of*

Southern African Birds has still to be compiled and is scheduled to appear in a few years from now (Harrison in press).

The SABAP's guiding philosophy has been composed of these elements:

1) Keep the task simple for the observers.

2) Maximize the size and scope of the data set.

3) Maximize the information derived by applying appropriate statistical techniques and integrating atlas data with other geographically referenced environmental information.

We will demonstrate here that the methods used in the SABAP yield useful information beyond presence/absence patterns of distribution. Specifically we will show that atlas data of an elementary nature can yield new information on seasonal changes in abundance, associations between habitat type and abundance and the interaction of these two phenomena.

SABAP reporting rates have previously been used to model the timing of arrival and departure of Palearctic migrants in southern Africa and the variation in these times with latitude and longitude (Underhill et al 1991). In this study we examined localized seasonal movements which are generally more subtle in that fractions of populations rather than whole populations migrate (Oatley and Tinley 1987). Variation in reporting rates over the twelve months of the year and five altitude categories is described. Generalized linear modeling techniques were used to screen the variables of seasonality and altitude and to produce statistically smoothed plots.

METHODS

Reporting rate:

The concept of a "reporting rate" is that of a number of checklists which include a given species, expressed as a proportion or percentage of the total number of checklists. The reporting rate is then used as a simple index of relative abundance such that, for a given species, a large value denotes a relatively high abundance/density and a low value the converse. The index is used to compare different study areas or to compare the same study area at different times for the same species (Harrison 1989) but usually not to compare different species (see discussion).

The relevant methodological aspects of the collection of data are the following:

a) The spatial and temporal sampling units were the quarter degree grid square (15'x15') and calendar month respectively. All grid squares and months were sampled although any particular grid square was not necessarily visited in all twelve months.

b) Observers where asked to submit lists, for grid squares, of all species seen over any period of time, within the limits of a calendar month. Counts of individuals were not included in the protocol.

c) Repeated visits to grid squares over the five year atlas period were encouraged, i.e. multiple replicates were obtained wherever possible. Intensity of sampling was inevitably uneven. The number of checklists submitted per grid square for the 116 grid squares in the study area, ranged from one to 772 (mean = 86, standard deviation = 136). The numbers of grid squares and checklists used for each altitude class and month are given in Table 1 and Table 2 respectively. Note that the data set is poor for altitude class 5 in the months June to November, especially in August and September.

Study area:

The study area is a southeastern portion of southern Africa and is a small fraction of the total area covered by SABAP. It was chosen for the steep altitudinal gradient it encompasses as the land slopes from the Indian Ocean coastline in the province of Natal to the top of the escarpment in eastern Lesotho. The range of altitude is from sea level to 3000 metres within a distance of 160 kilometers (Fig.1). The highest peak, Injasuti, rises to 3459m.

Frost is absent at the coast but can occur during six months of the year in the highlands, especially above 1800m. Mean daily temperature in July varies from >17°C at the coast to <10°C at the *foot* of the escarpment (Cyrus and Robson 1980). Snowfalls are a regular occurrence on the peaks of the escarpment and high plateau during the winter months. The natural vegetation ranges from humid bush and coastal forest at the coast, through woodland and sour grasslands in the mid and highlands, to alpine scrub and heath on the high peaks. Afromontane forest occurs in patches in the deeply incised river valleys and gorges from the midlands to the Drakensberg foothills (Cyrus and Robson 1980).

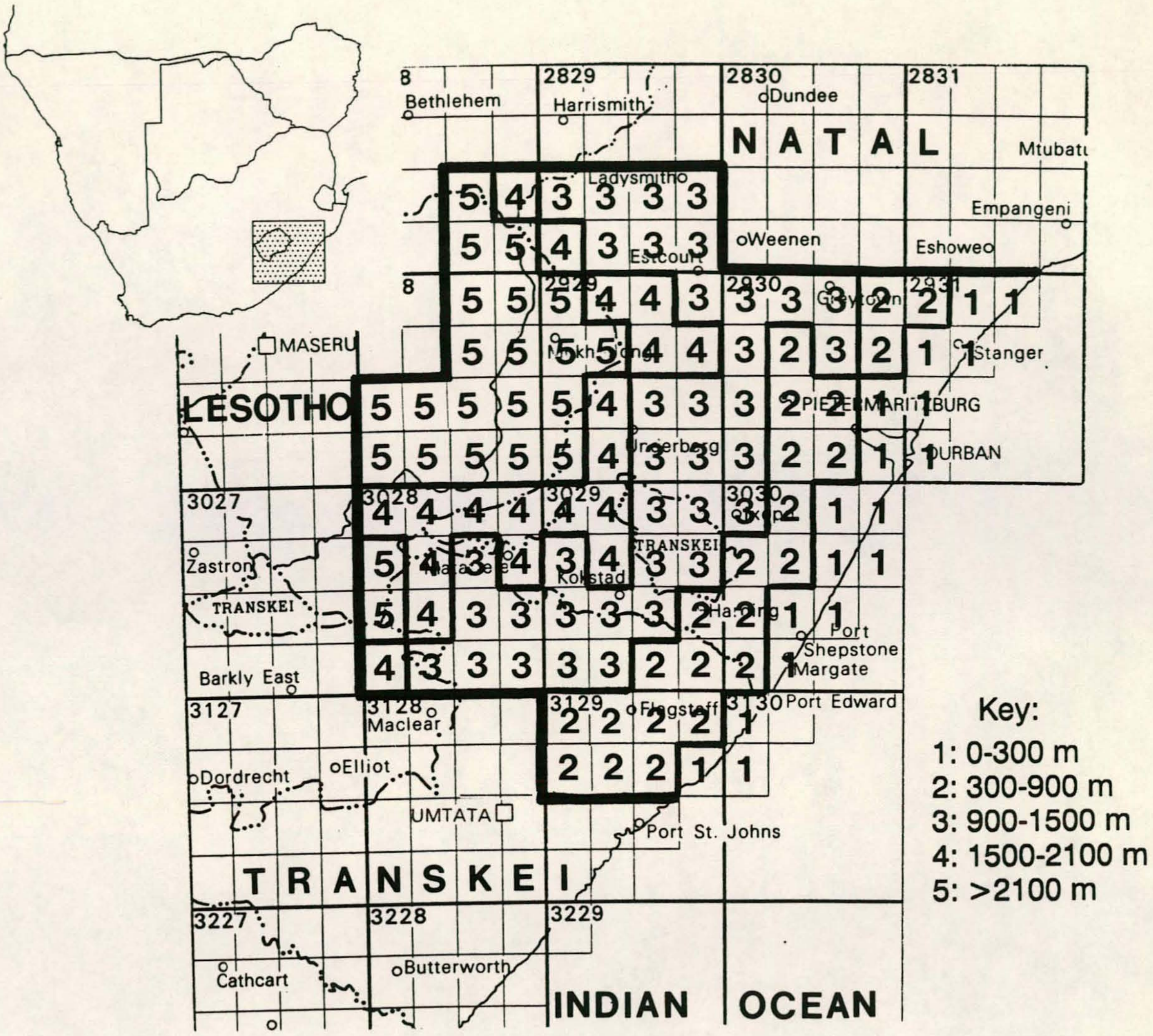

Figure 1: The study area in south-eastern southern Africa. The numerals 1 through 5 denote the five altitude classes.

Grid squares in the study area were classified according to five classes of dominant altitude using 1:250 000 topographical maps (Fig.1). Dominant altitude was defined as the altitude class which covered the largest area in each grid square. Where this was not immediately apparent by inspection, the class containing the greatest number of towns and roads was selected as atlassing activity would tend to be concentrated there.

Statistical methods:

The generalized linear modelling (see below) was done using the GENSTAT package (Lane 1987). For each species the information entered into the procedure comprised:

1) the month (transformed into its Fourier representation; see below),
2) the altitude class,
3) the number of checklists which recorded the species,
4) the total number of checklists,

in turn for each grid square in the study area.

Checklists for each grid square within the selected altitude class were combined and reporting rates for each month-grid square were computed. Fourier representations were applied to the monthly reporting rates to provide a smoothed description of seasonality; up to three harmonics were considered. These models are circular in the sense that there is no discontinuity in reporting rate between the end of one year and the start of the next (Zucchini and Adamson 1985). The Fourier representation of time was fitted to the data in conjunction with a dummy factor with values which correspond to the altitudinal categories. The question asked was whether the same seasonal pattern was applicable to each altitude class, in a model of the form:

$$L = a + (s_1 \sin(\tilde{O}) + c_1 \cos(\tilde{O})) + \ldots + (s_3 \sin(3\tilde{O}) + c_3 \cos(3\tilde{O}))$$

or whether a seasonal pattern peculiar to each altitude class was appropriate, in a model of the form:

$$L = a_i + (s_{i1} \sin(\tilde{O}) + c_{i1} \cos(\tilde{O})) + \ldots + (s_{i3} \sin(3\tilde{O}) + c_{i3} \cos(3\tilde{O}))$$

where $L = \log(R/(1-R))$ is the logistic transformation of R, the reporting rate; $\tilde{O}$ is 15° for mid-January, 45° for February, ... and 345° for December; i is the altitudinal category (from 1 to 5); and a, (s_1, c_1),..., (s_3, c_3) are the parameters of the model.

The parameters of the models were estimated using a generalized linear model with a binomial error and the logit link function (Lane 1987).

The number of terms of the type

$$s_j \sin(j\tilde{O}) + c_j \cos(j\tilde{O})$$

(called harmonics) was determined from the same analysis. The predicted values for L were transformed into reporting rates with the expression:

$$R = e^L/(1 + e^L)$$

Each month's data were considered to refer to the middle of the month.

Generalized linear models are an extension or generalization of the ordinary linear regression model of the form: $y = b_0 + b_1x_1 \ldots + b_px_p$. In this model a quantity y depends upon one or more other quantities, denoted by $x_1, x_2, \ldots, x_p$, and a set of coefficients or parameters, denoted by $b_0, b_1, \ldots, b_p$, whose values we would like to know. To generalize this model we need to describe the way in which the values of y vary about their means, i.e. the distribution of the ys at any particular value of the xs. We also have to specify the kind of distribution (e.g. Normal, Poisson, Binomial, Gamma, Inverse Normal) of the ys about their means. Generalized linear models can handle classification variables, which have discrete levels, continuous variables, which measure quantity, as well as binomial variables, which measure presence or absence only. Generalized linear models can be used for many different types of analyses, e.g. regression, analysis of variance, partial correlation, response-surface models, probit analysis, log-linear models for contingency tables, etc. All these features make generalized linear modeling a powerful tool for the analysis of mixed data types, as in the present case presence or absence of a bird species was related to time (through a wave curve) and discrete altitude categories.

RESULTS

Figure 2 shows a plot of the modelled curve for the Dusky Flycatcher *Muscicapa adusta* at the lowest altitude, in relation to the actual reporting rates per grid square per month, and the means of these observed values. It can be seen that, although the reporting rate values for individual grid squares in a particular month vary considerably, the means of these values display a pattern which agrees well with the modelled curve.

Results for only four species with contrasting patterns are given here as examples of our analysis (Table 3, Figs.3-6). All four species display significant differences in reporting rate between altitudes. Three of the species also display significant seasonality at one or more altitude (Figs.4-6). It is the interaction between altitude and season which is most interesting, however, as it is more revealing of the seasonal movements and ecology of the species.

The Jackal Buzzard *Buteo rufofuscus* (Fig.3) is provided as a standard of comparison for the other three species. Its reporting rate is significantly correlated with altitude but no significant seasonality was detected. In contrast the other three species all have significant seasonal patterns of variation in reporting rate and significant interaction between altitude and season (Table 3). In other words, they display significant patterns of seasonality which are significantly different at different altitudes.

The Greater Striped Swallow *Hirundo cucullata* (Fig.4) is an intra-African migrant which is virtually absent from the whole of southern Africa during winter. Here we can detect the added detail that it spends less time (arrives later and leaves earlier) at the highest altitude (>2100m) than at the next altitude class down (1500-2100m). The minor fluctuations in reporting rate during the period October to March are statistically significant according to the estimates produced by the generalized linear model. These fluctuations and the fact that they are not synchronized at different altitudes are interesting features requiring further investigation.

Both the Dusky Flycatcher (Fig.5) and the Stonechat *Saxicola torquata* (Fig.6) are usually referred to as "residents" but it is clear that both undergo partial local migration. The former shows a strong preference for coastal conditions in winter while the latter displays an intolerance of the extreme winter conditions on the high escarpment. The results for the Stonechat are an extension of comparable findings elsewhere in Africa (Pomeroy 1989).

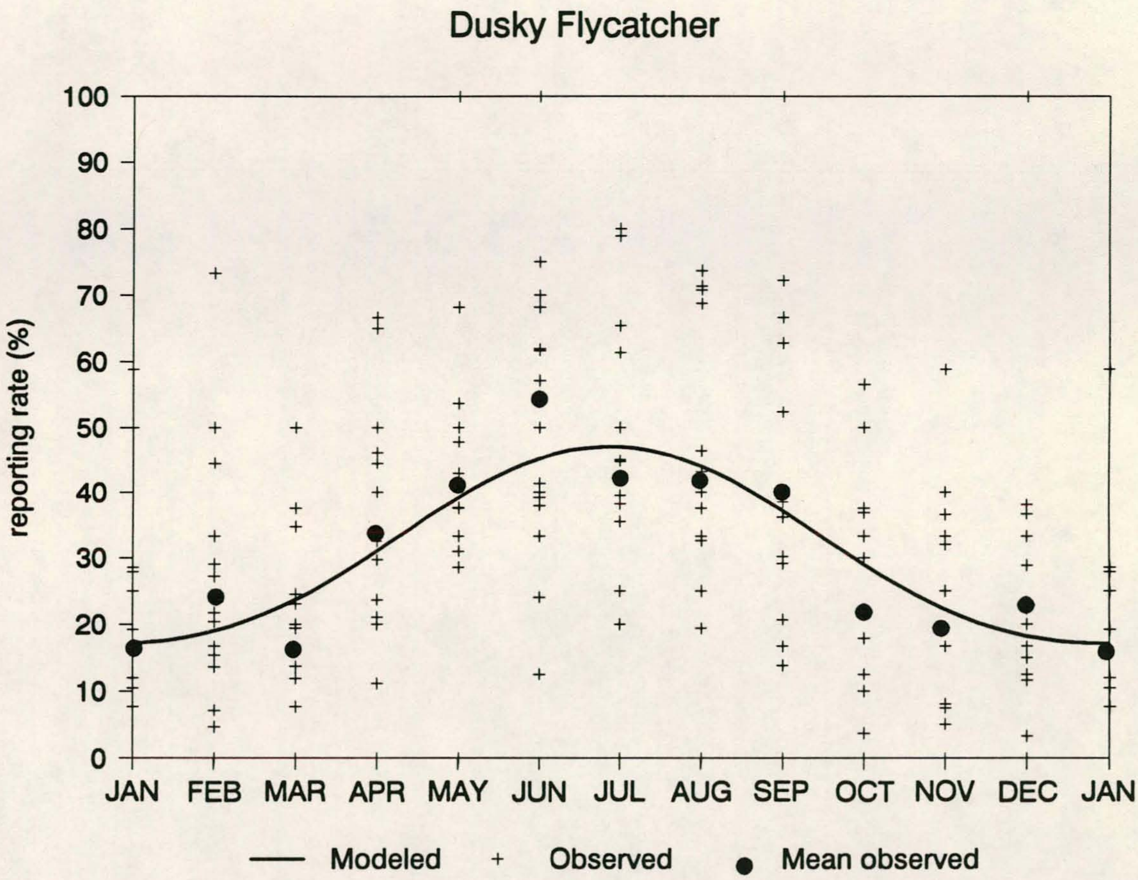

Figure 2: An example of a model. The Fourier model of reporting rate at altitude class 1 for the Dusky Flycatcher is contrasted with the observed reporting rates per grid square and their means.

Table 3: Summary of results of modelling for four species. Significance is given at the 5% level.

	No. of harmonics	Significant effect of: altitude	seasonality	interaction
Jackal Buzzard	2	yes	no	no
G. S. Swallow	3	yes	yes	yes
Stonechat	1	yes	yes	yes
Dusky Flycatcher	1	yes	yes	yes

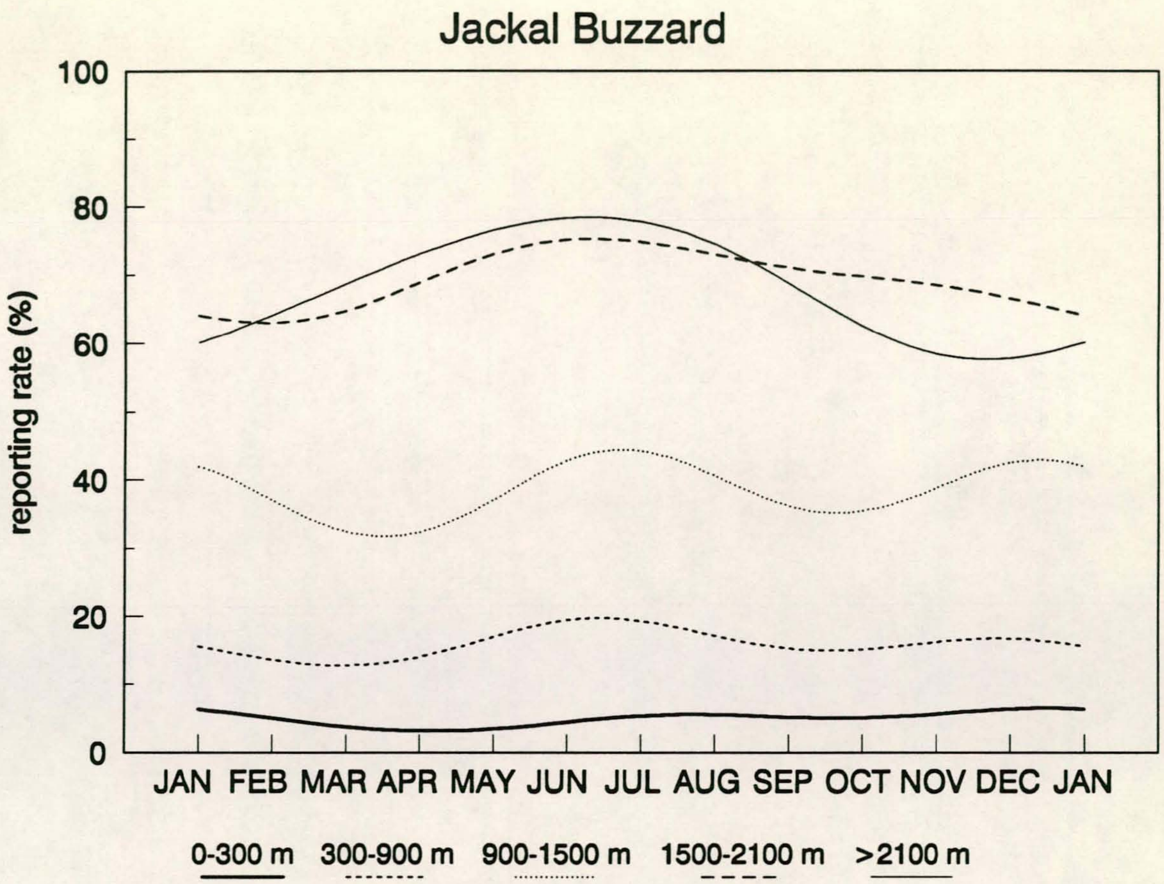

Figure 3: Fitted reporting rates for the Jackal Buzzard.

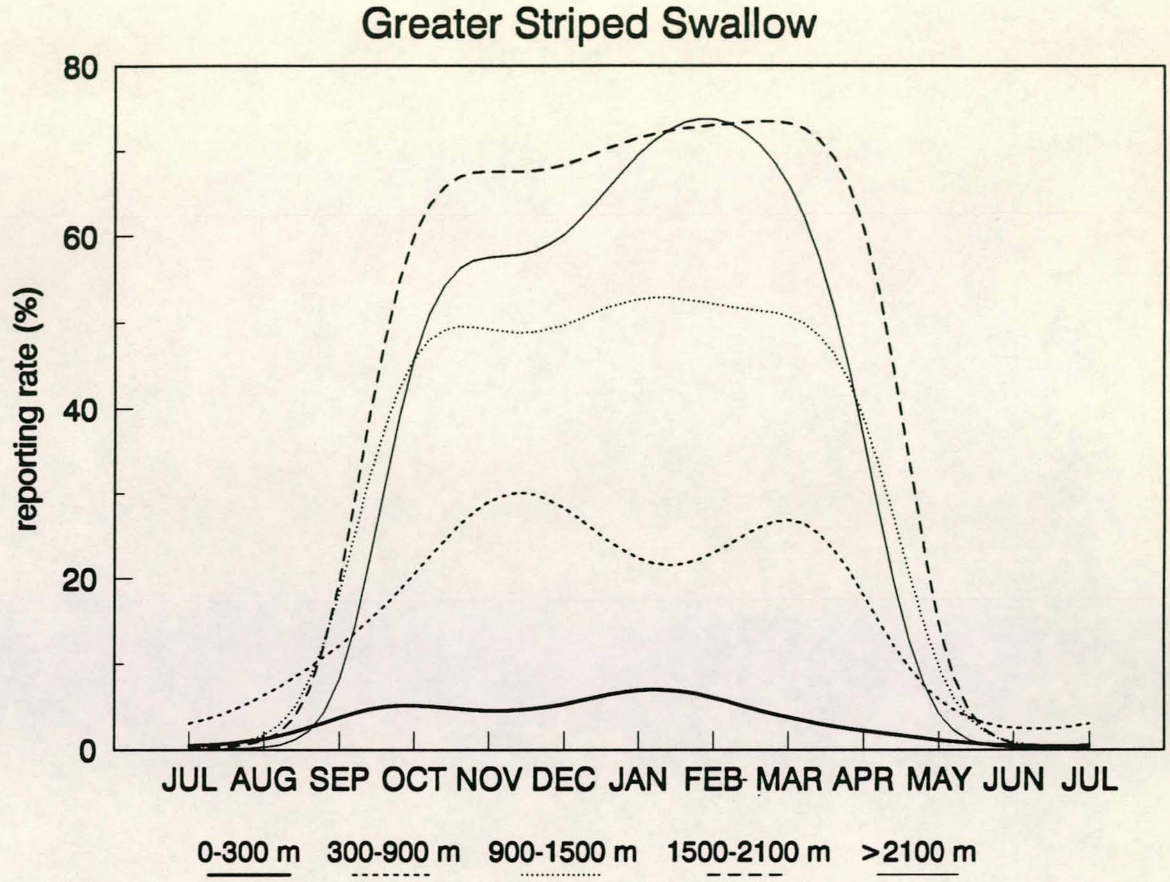

Figure 4: Fitted reporting rates for the Greater Striped Swallow.

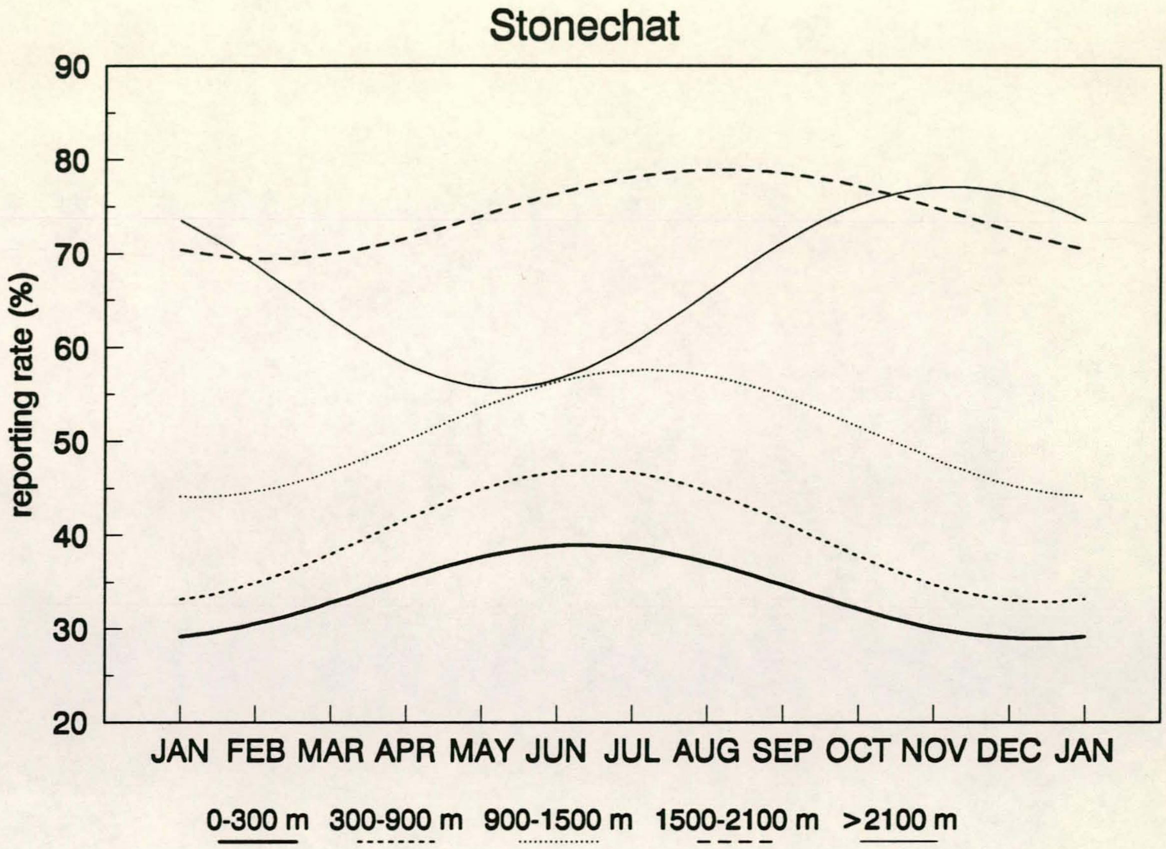

Figure 6: Fitted reporting rates for the Stonechat.

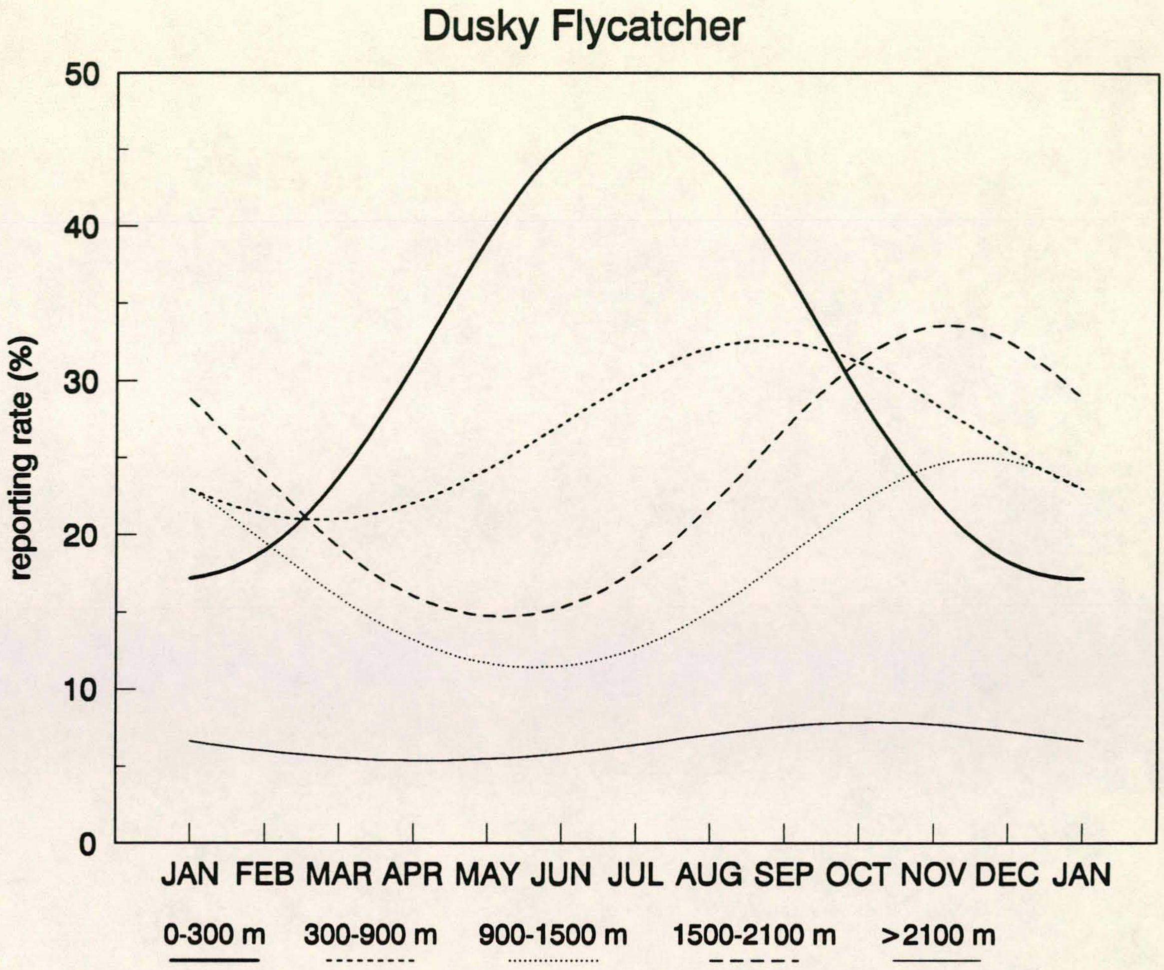

Figure 5: Fitted reporting rates for the Dusky Flycatcher.

DISCUSSION

The Findings

Altitudinal migrations have been reported for the study area (Brown and Barnes 1984, Oatley 1966, 1982, Cyrus 1989) and for other parts of Africa (Irwin 1957, Oatley 1966, Oatley and Tinley 1987). Given the range of altitudes and climatic conditions found across short distances, these phenomena could be expected. However, what has been lacking is firstly, a description of the phenomenon at all levels of the altitudinal range rather than at one or a few study sites only, and secondly, a quantification of the phenomenon in both the spatial and temporal dimensions. The four species presented as examples here show that SABAP data are able to provide new information, albeit with certain limitations.

The limitations hinge on these facts:

(1) Reporting rates confound abundance/density with conspicuousness and identifiability (Temple and Temple 1984, Underhill et al 1991);

(2) reporting rate increases monotonically with absolute abundance/density, but not linearly (Underhill et al 1991).

(3) the grid is coarse.

The implications of these limitations are, in the first case, that while the shapes of the plots and their relationships to each other can be compared between species, the amplitudes of the plots, that is the reporting rate values on the y-axis, cannot legitimately be compared for different species, unless they are equally observable and identifiable.

In the second case, the implication is that simple multiples of reporting rate do not imply simple multiples in population size although increases or decreases in reporting rate do indicate population changes in the same direction (Bruderer and Bruderer in press, Temple and Temple 1986(b)).

Thirdly, the grid squares are too large to allow discrimination between, for example, the alpine and sub-alpine belts which are located above 2865m and 1829m respectively. It is known that altitudinal migrations do take place between these belts (Brown and Barnes 1984) but SABAP data are not able to resolve these phenomena.

A general weakness in the method presented here is the implied assumption that all checklists are equivalent. As there was no control of, nor weighting for, the amount of effort used in compiling each card, nor for the various levels of observer skill, this is clearly not a valid assumption. Instead we assume that the local variability in checklists with respect to effort and skill, is uniform over all months and all grid squares. In other words, we assume that the theoretical "average" checklist is uniform in space and time. This assumption is more nearly true and becomes more so the larger the geographical areas and numbers of checklists one compares. In this study, most altitude/month units comprise many grid squares and many cards (Tables 1 and 2) and we therefore consider the assumption to be valid in the main.

It should be remembered that while changes in relative abundance at different altitudes may strongly suggest migration in a particular direction, they by no means prove it; movements of individual birds were not recorded and alternative explanations involving birds outside of the study area can be invoked. Even if one accepts, for example, that there is a movement of Dusky Flycatchers from higher ground to the coast during winter, one is still left with important questions. Which individuals in a population move and which remain sedentary? What distances do they move? What are the proximal causes of movement and what benefits are derived by those that move and those that stay? Only the combination of ringing and ecological field studies can answer these questions. Atlas studies with their broad scope and large data sets provide the basis for hypothesis formation, but not the ultimate answers to complex ecological and physiological questions.

Trends in Bird Atlassing

Bird atlas projects usually have a broad scope in terms of geographical area and number of species studied, but the scope of their scientific objectives is often narrow. The aim, at least in as far as the atlas publication is concerned, is typically to map distributions of species on a presence/absence basis - often in only one season - and little else. The most frequently encountered extension to this basic format is the inclusion of breeding information in the species distribution maps (Dybbro 1976, Lewis and Pomeroy 1989, Nikolaus 1987, Nitsche and Plachter 1987, Sharrock 1976).

Table 1: The numbers of grid squares per month per altitude class which were used in the analysis.

Month	Altitude category 1	2	3	4	5	Total
Squares	18	23	36	19	22	118
JAN	16	16	31	16	18	97
FEB	16	14	26	12	13	81
MAR	15	13	32	18	15	93
APR	16	16	28	12	14	86
MAY	16	16	27	17	15	91
JUN	16	12	27	12	12	79
JUL	15	13	29	11	14	82
AUG	16	18	25	14	6	79
SEP	16	13	25	13	7	74
OCT	16	15	27	14	9	81
NOV	15	15	27	12	8	77
DEC	16	14	26	17	17	90
Total	189	175	330	168	148	1010

Table 2: The numbers of checklists per month per altitude class which were used in the analysis.

Month	Altitude category 1	2	3	4	5	Total
Squares	18	23	36	19	22	118
JAN	345	123	233	103	54	858
FEB	294	110	213	98	43	758
MAR	336	126	246	113	49	870
APR	366	137	234	104	51	892
MAY	352	127	223	116	42	860
JUN	357	116	242	96	21	832
JUL	389	134	232	97	24	876
AUG	371	146	224	67	11	819
SEP	342	124	215	87	12	780
OCT	335	126	239	108	26	834
NOV	307	131	214	71	21	744
DEC	320	124	241	113	55	853
Total	4114	1524	2756	1173	409	9976

Atlases notable for their inclusion of other objectives and a more analytic approach to the data are Blakers et al 1984, Buckland et al 1990, Hockey et al 1989, Lack 1986, Root 1988, SOVON 1987 and Temple and Cary 1987. These projects deal with relative abundance/density in different parts of species' ranges and some also address the issue of seasonal changes in abundance. Attempting to describe spatial and, to a lesser extent, temporal changes in abundance can be identified as trends in modern bird atlassing.

Another trend is an increasing effort to relate atlas data to environmental variables such as altitude, vegetation, moisture, etc (Osborne and Tigar 1990, Sitters 1988). These analyses can be done appropriately on a *post hoc* basis, however, and do not necessarily involve an advance in the atlassing protocol (i.e. data-gathering) in the field. A notable exception is Buckland et al (1990) in which data collection was geared to units defined by habitat type. This was possible for the relatively small area covered but is probably not a viable option for atlas projects conducted at a national scale.

In contrast to *post hoc* analyses, a project which aims to measure relative abundance should have that objective explicitly stated at the outset and the methods of data collection need to be designed accordingly. The Southern African Bird Atlas Project (SABAP) is an example of where this was done (Harrison 1987).

The Reporting Rate Index

Although the reporting rate as an index of relative abundance has a long history, it is probably true to say that it has been both under-rated and under-utilized as a technique for measuring relative abundance. Linsdale (1928) discussed the properties of reporting rates, or "frequency of occurrence" as she termed it, provided an example of its application (Linsdale 1932) and strongly advocated its use in the pre-war era. Our search of the literature has yielded few additional examples of the use of reporting rates. Although it has been recognized that all methods of bird censusing seldom yield more than a relative (as opposed to absolute) measure of abundance/density (Dawson 1981(a), Temple 1981), there appears to be resistance to using techniques which do not involve an actual count of individuals.

An index which superficially resembles the reporting rate is the "proportion of squares" index. This approach takes the proportion of grid squares in which a species has been recorded as an index of its relative abundance in a particular class of squares. Sitters (1988) used proportions of squares to describe altitude preference for species. Pomeroy and Tengecho (1986(a)) and Pomeroy (1989) employed the index to analyze distributions in terms of altitude and an index of moisture.

Although both reporting rates and proportions of squares are based on simple proportions, the reporting rate is based on a *proportion of checklists for a unit of area* whereas the other is based on a *proportion of grid squares within a larger unit of area*, usually defined according to some variable such as altitude. Checklists of one kind or another are the basic unit of sampling in atlas fieldwork and it is well known that the number of species recorded for a site increases with effort and time spent observing and with the number of checklists completed (Pomeroy and Tengecho 1986(b), Dawson 1981(b)). In the case of a species which occurs at a very low but even density throughout an area, its presence in all grid squares may not be reflected by a low sampling intensity, but may be reflected if the sampling intensity is increased. In a very real sense, therefore, the proportion of squares index - at least in the way it is most often used - depends on less than exhaustive coverage of squares such that the proportions of squares in which a species is recorded is a reflection of its relative abundance. Although this does not preclude a study specially designed to employ such an index, the approach is clearly at variance with the fundamental objective of an atlas project which is to map a species' presence in all grid squares in which it occurs, regardless of relative abundance. The proportion of squares index has been applied inappropriately to atlas data without adequate controls for the differences in sampling intensity between the categories of squares. This index can be used with confidence only if the grid squares are small relative to patches of habitat and/or territories of birds - not usually the case in atlas projects - and all grid squares receive "saturation coverage" (Robbins et al. 1989).

The reporting rate index does not suffer from the same shortcomings because (a) it is both assumed and empirically true that any single checklist cannot provide an exhaustive list of species and that many checklists are required to provide a complete list, even of regularly occurring species and (b) in this process the rate at which a species is reported is determined, in part, by its abundance/density.

Amongst the few workers to have employed the reporting rate index are Pomeroy and Tengecho (1986(a,b)) whose work used "timed species counts" to provide indices of relative abundance at different sites which could then be used to interpret species distributions in terms of habitat preference.

The best non-African example of the use of reporting rates that we have encountered is by Temple and Cary (1987). Reporting rates were used effectively to show spatial variation in relative abundance within a species' range (Temple and Temple 1986(a)). The authors also documented seasonal changes in relative abundance by plotting reporting rates against time of year. Comparison of such plots for two ecological regions of Wisconsin helped to elucidate the direction and timing of seasonal movements (Temple and Temple 1984).

Important to note is that the results presented in this paper would tend not to emerge from presence/absence mapping alone as all four species occur at all altitudes in all seasons, but - and this is the crux - at different levels of relative abundance. The phenomena are by nature relative, not absolute, and therefore require a measure of abundance to detect and describe them. Ironically this requirement can be satisfied by simple binomial (presence/absence) data, compiled to produce reporting rates.

CONCLUSIONS

Modern bird atlassing as a technique for compiling current biogeographical data (as opposed to atlases as a form of literature review), traces its history from the *Atlas of the British Flora* (Perring and Walters 1962). It is therefore a young science characteristically lacking concensus on appropriate aims and methods. It seems reasonable to us, in the light of work done in various parts of the world and that reported here, that the guiding principle for future atlas projects articulated by Udvardy (1981) more than ten years ago, be reaffirmed and extended. That principle might be dubbed the "relative abundance principal" and be worded as follows: Biological atlas projects, in particular those for birds, should incorporate data-collection protocols and methods of analysis which enable statements to be made about relative abundance, both in different parts of species' geographical distributions and between seasons. The motivation for this principle is that its application greatly extends the biological meaning of atlas data by providing opportunities to investigate the ecological factors which underpin distribution and seasonal movement.

We have demonstrated, as have Underhill et al (1991) before us, that simple checklist data collected by the SABAP, can be used in modelling seasonal and spatial variation in relative abundance. In view of the simplicity of the data-gathering protocol, we suggest that reporting rates derived from checklist data are eminently suitable for describing relative abundance in situations where a volunteer workforce might be capable of gathering large quantities of data but would be deterred by more rigorous and sophisticated methods. We would advocate, however, that checklists be made more comparable by controlling for time spent observing and for observer skill.

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Thousands of volunteers have spent many man-years collecting data, all at some and some at great personal expense. Scores of dedicated individuals have performed regional administrative duties on an honorary basis. The success of the SABAP is a direct result of their inspiring efforts.

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Seasonal migration of terrestrial birds along the southern and eastern coasts of southern Africa.

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Running title: Migration of terrestrial birds in coastal SA.

Abstract

Several species of terrestrial birds migrate in summer southwestwards along the coastal zone of southeastern Africa to breed, followed by a reverse migration to wintering grounds within Africa. These migrations were investigated using the Southern African Bird Atlas Project data base and the reporting rate as an index of relative abundance. Models of seasonality in the reporting rate for 18 bird species in each of six coastal areas from the Southwestern Cape to Northern Natal were fitted using Fourier series and generalized linear models. Altitudinal movements of each species were investigated in the two northernmost zones (Natal). New migration patterns are suggested for two species and the currently accepted migration movements of three other species are rejected. Known migrations are confirmed in greater detail for another four species. Several factors other than migration may explain an increase in winter reporting rates for some resident forest species. The migration of the Spotted Thrush *Zoothera guttata* in Southern Africa is apparently a truncated form of the migration existing in other forest bird species.

INTRODUCTION

Bird migrations between Eurasia and Africa are well known (e.g. Morel and Morel 1992, Pearson and Lack 1992, Underhill *et* al. 1992), compared to the attention given to seasonal intraAfrican migrations. Oatley (1966) stated that altitudinal movements are widespread in bird species in the eastern half of southern Africa, yet few subsequent studies have investigated such movements (Oatley 1982, Cyrus 1989, Harrison and Navarro in press, Maclean and Johnson this conference).

This investigation of seasonal migrations of birds along the southern and eastern littoral of southern Africa was stimulated by the apparently unique migration of the South African population of the Spotted Thrush Zoothera guttata. At the outset of this investigation, it seemed to be the only Southern African bird species in which the population breeds in the Transkei and winters in Natal (Clancey 1964, Maclean 1985). We used the data base of the Southern African Bird Atlas Project (SABAP) to investigate seasonal migrations of several terrestrial forest or woodland bird species along the southern and southeastern coasts of Africa to gain insight into the apparently unique migration of the Spotted Thrush.

METHODS

We used the SABAP data base to calculate the reporting rates of selected bird species in the coastal zone of southern and southeastern Africa. SABAP is described by Harrison (1987, 1992) and records are based on a monthly reporting of the presence of bird species in quarter degree grid squares (QGDS). The reporting rate is the fraction of checklists which include a given species and is expressed as a proportion or percentage of the total number of checklists for the given QDGS, or any combination of QDGSs. The reporting rate is used as a simple index of relative abundance (Harrison and Navarro in press). A high values represents relatively high abundance/density and a low value represents relatively low abundance/density. Variations in reporting rate are meaningful only for intraspecific comparisons, and not across species because of differences in conspicuousness and identifiability (Underhill et al. 1992). The modelling of the reporting rate parameter using generalised linear modelling and Fourier transformation is described by Underhill et al. (1992) and Harrison and Navarro (in press).

The study area is the eastern and southern coastal region of southern Africa from Cape Town in the southwest to the border of Natal and Mozambique in the northeast. This area was divided into six regions of approximately equal length of coastline (Fig. 1). Within the three Cape zones (Southwestern Cape, Southern Cape and Eastern Cape), a QDGS was included if it was situated on the seaward side of the Cape Fold mountains which run more or less parallel to the coast as far as the Transkei. On the landward side of these mountains, arid conditions exist which exclude the species under investigation in this paper. For Southern Natal, Northern Natal and Transkei, a QDGS was included if the dominant altitude was less than 1500m, because most coastal species either do not occur, or are far less abundant, above this altitude.

To investigate whether the occurrence in winter of the selected species at the coast in Natal may be attributed to altitudinal rather than coastal migration, Natal was divided into altitudinal ranges of 0-300m, 300-900m and 900-1500m a.s.l. A QDGS was classified according to one of these three dominant altitudinal classes using 1:250000 topographical maps (Fig. 2).

The migration patterns suggested by the reporting rates were then compared with the literature, including published bird atlases for the Southwestern Cape (Hockey et al. 1989) and Natal (Cyrus and Robson 1980).

The selection of bird species

In southern Africa, many breeding bird species of the forests or dense woodlands have a narrow distributional range which begins on the coast somewhere along the western, southern or eastern Cape, and which then broadens inland along tha Transkei and Natal coasts northwards into the eastern Transvaal and Mozambique (Maclean 1985). Seasonal coastal movements have been reported in several species that show this distribution (Maclean 1985). Where the range of the these species broadens inland from Natal northwards, seasonal altitudinal movements have also been reported (Clancey 1964, 1971). We restricted our analysis to forest species with the distribution described above, including migratory and non-migratory species. We also included three widely distributed, abundant and resident species of more open habitats to act as controls for the analysis.

Fig. 1. Coastal Zones

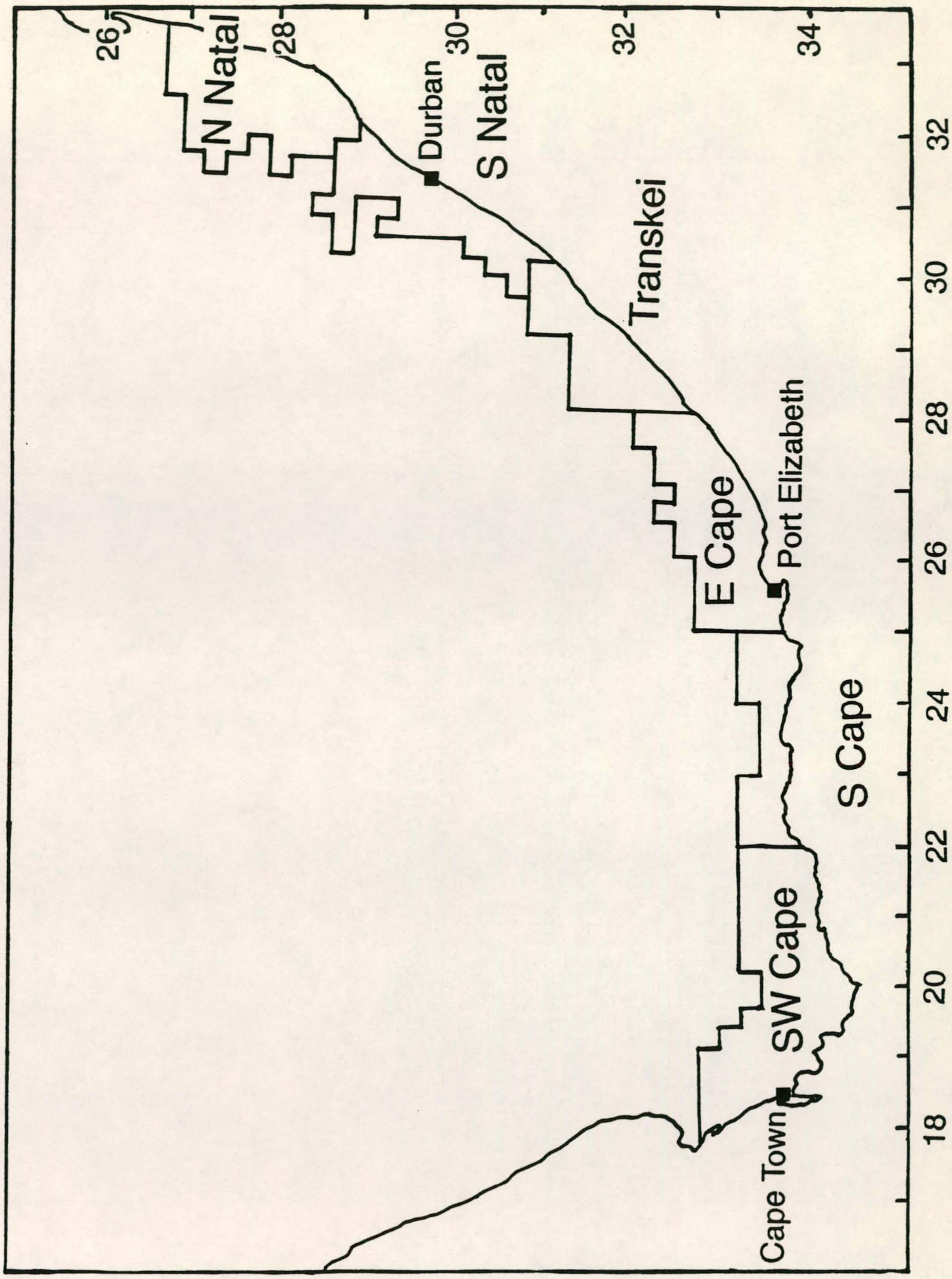
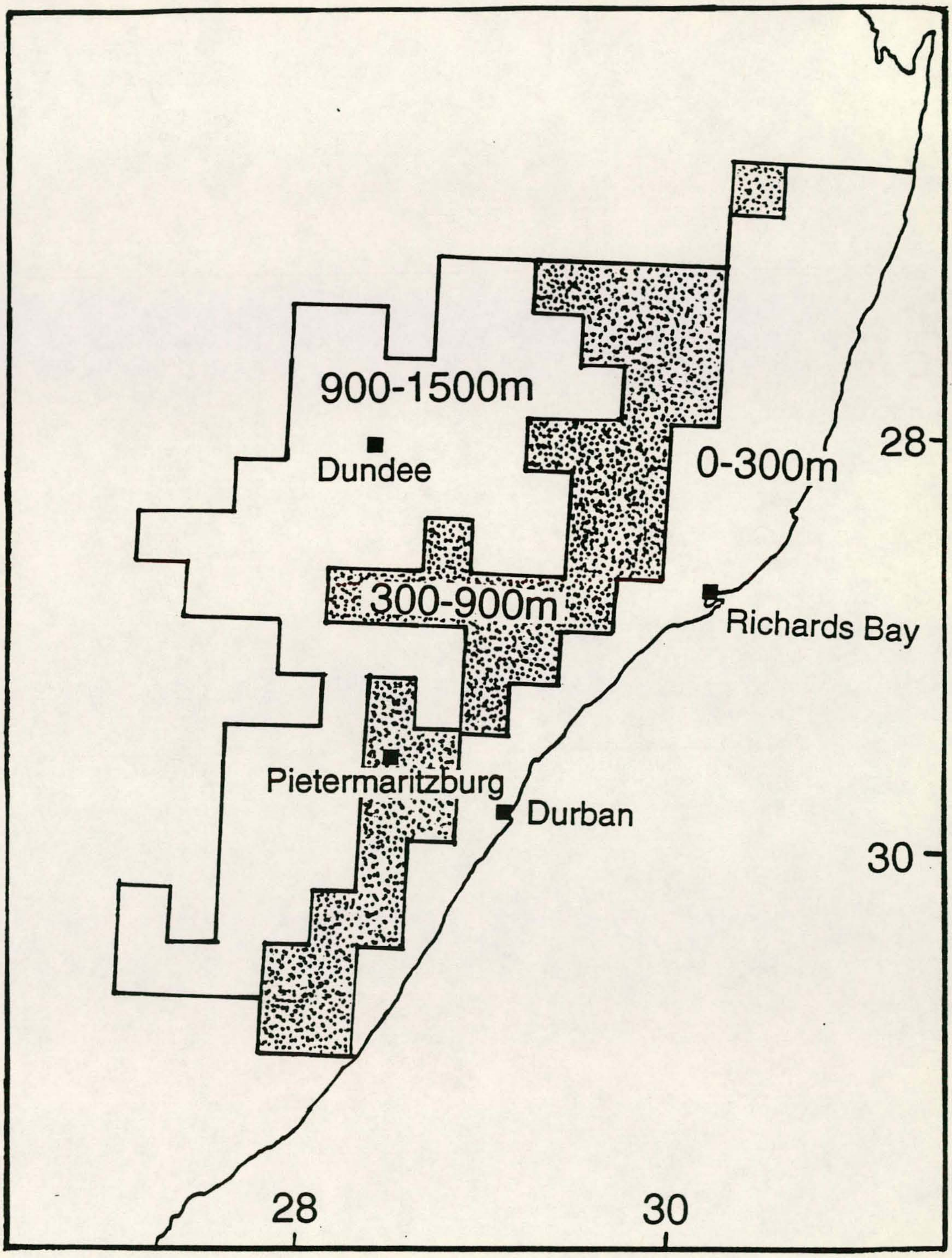


FIGURE 1. The six coastal zones designated for the investigation of coastal migration.

FIGURE 2. The three altitudinal classes in the Southern and Northern Natal zones used to investigate altitudinal migration.

Fig. 2. Altitudinal classes



RESULTS

The data base of the Southern African Bird Atlas.

A total of 34577 cards formed the data base for the coastal analysis. The number of field cards in each month in each zone is given in Table 1. The Transkei zone had less cards than any other region. The number of cards per month was approximately the same within each zone. The number of cards used in the coastal migration analysis for each species is given in Table 3. The analyses of three species are based on less than 400 records (less than 1,2% of all cards) for three species (Mangrove Kingfisher _Halcyon senegaloides_ (89 records), Spotted Thrush _Zoothera guttata_ (208 records) and Knysna Warbler _Bradypterus sylvaticus_ (200 records).

A total of 12058 cards were used for the altitudinal migration analysis (Table 3). The number of cards per month was approximately the same within each altitude class (Table 2). Two species (Knysna Warbler and Mangrove Kingfisher) were recorded only in the lowest altitude class whilst the three records of the Spotted Thrush above 900m were regarded as misidentifications of the Groundscraper Thrush _Turdus litsitsirupa_.

Patterns and species accounts

The patterns of seasonal variation in reporting rates are divided into five different types (Table 4).

Group 1. No changes in seasonality.

The three widespread species (Cape Turtle Dove Streptopelia capicola, Fiscal Shrike Lanius collaris and House Sparrow Passer domesticus), which are regarded as sedentary, showed no marked variations in reporting rate (e.g. Fiscal Shrike, Fig. 3). However the small seasonal variations in reporting rates may represent real demographic changes (eg recruitment of juveniles) or changes in conspicuousness (eg winter flocking).

Migratory movements have not been described for these three species in South Africa (Clancey 1964, 1971, Maclean 1985, Hockey et al. 1989, Quickelberge 1989), although Irwin (1981) reported local movements in the Cape Turtle Dove in Zimbabwe related to water supply.

Group 2. Coastal migration.

The patterns of seasonality of five species (Pygmy Kingfisher Ispidina picta, Mangrove Kingfisher, Black Sawwing Swallow Psalidoprocne holomelas, Spotted Thrush and Paradise Flycatcher Terpsiphone viridis) are characterised by a summer or winter peak in reporting rate in one or more zones, for which the most parsimonious explanation is migration. The reporting rates of the Paradise Flycatcher and Pygmy Kingfisher show increasingly later arrivals and earlier departures from west to east.

The Pygmy Kingfisher is a summer migrant to South Africa,

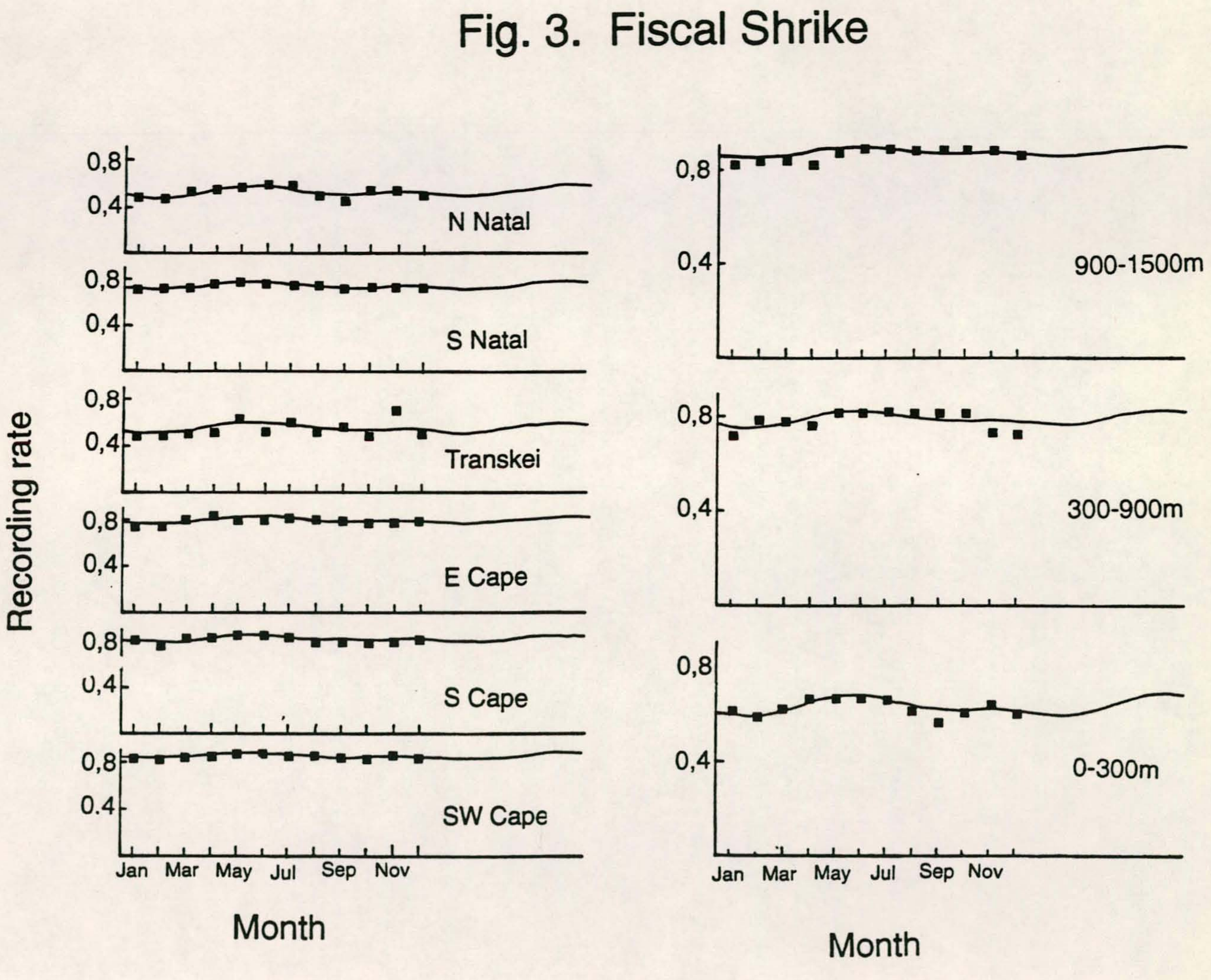


FIGURE 3. The reporting rates for the Fiscal Shrike <u>Lanius collaris</u> in coastal zones and altitudinal classes as an example of a resident species.

occurring as far south as the Eastern Cape zone, arriving mainly in October and with most birds departing by April (Fig. 4). There are records throughout the year, although some of these may be the result of confusion with the Malachite Kingfisher Alcedo cristata. The species was regarded as a coastal migrant in the Transkei (Quickelberge 1989) and Natal (Cyrus and Robson 1980). Clancey (1964) stated the species arrived in Natal to breed in early October and departed in March and April, with a few laggards, mainly young birds, still present in mid-May (Clancey 1964). In Mozambique, Clancey (1971) described the species as a summer breeding resident between the months of October and May. He also found birds present in the cool months, especially north of the Save river, and felt that these birds could have been wintering or resident birds. The present analysis shows a rapid, synchronous arrival in all parts of its South African range in October, and a slow unsynchronized departure between February to May. Small numbers of birds overwinter, mainly in Natal.

The Mangrove Kingfisher showed a summer peak in the Transkei zone and a winter peak in the Northern Natal zone, with a slight winter increase in the Southern Natal zone (Fig. 5). This pattern would be consistent with migration from summer breeding grounds in the Transkei to coastal wintering grounds in Northern Natal, and possibly further north. The breeding status and migratory pattern of this species in South Africa is poorly known. It is described as being present on the Natal and Mozambique coasts in winter, moving inland to breed (Clancey 1964, 1971, Cyrus and Robson 1980, Maclean 1985). However, there appear to be no

Fig. 4. Pygmy Kingfisher

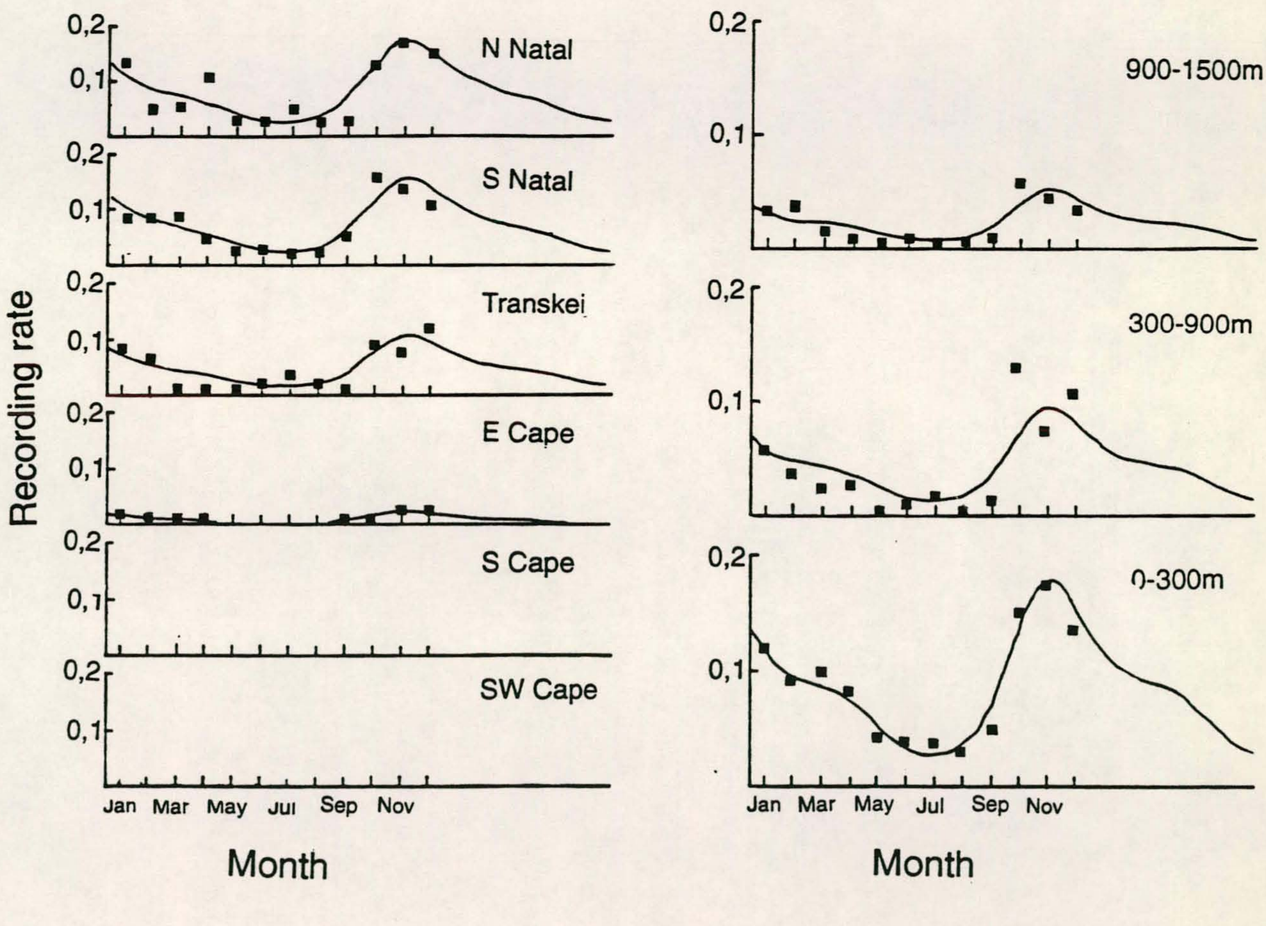


FIGURE 4. The reporting rates for the Pygmy Kingfisher <u>Ispidina picta</u> in coastal zones and altitudinal classes.

Fig. 5. Mangrove Kingfisher Knysna Warbler

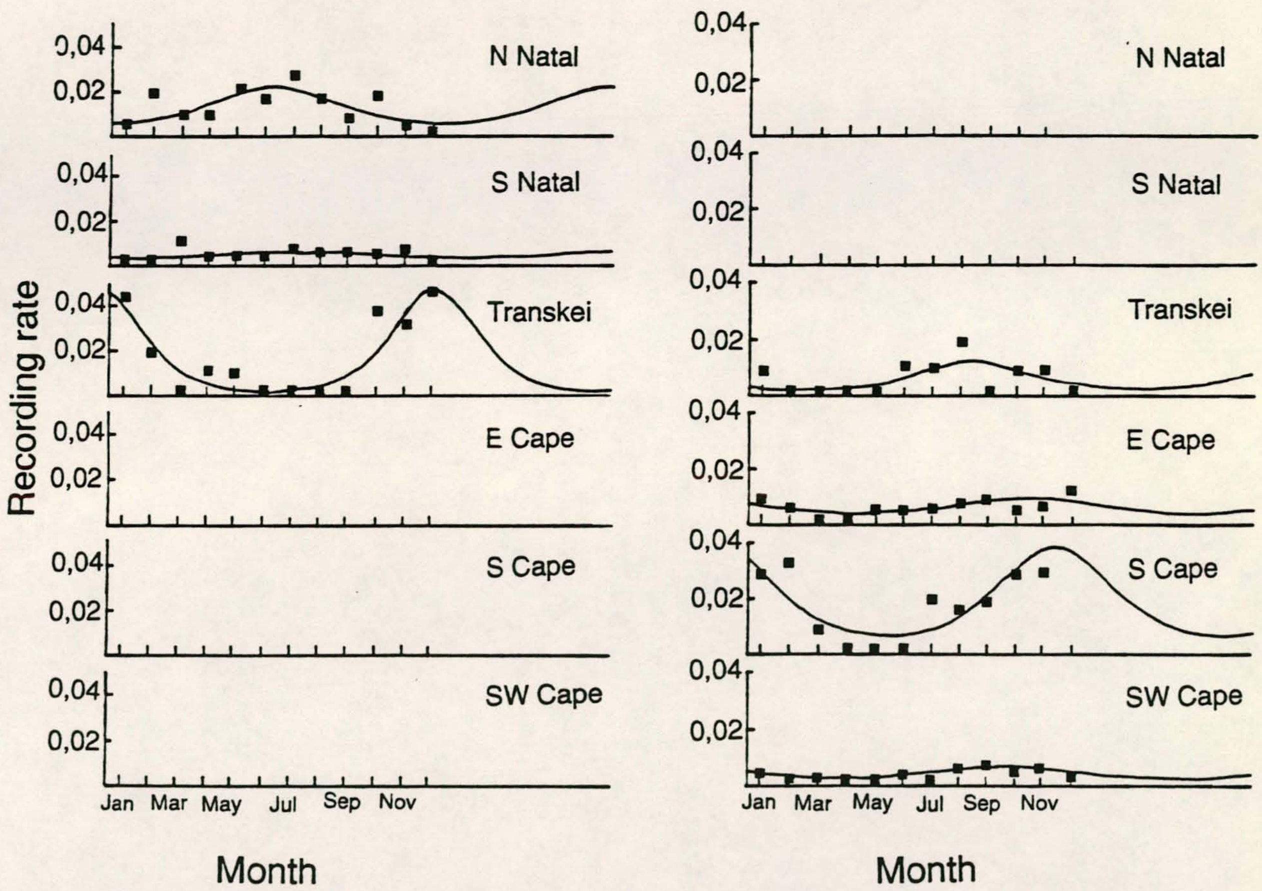


FIGURE 5. The reporting rates for the Mangrove Kingfisher <u>Halcyon senegaloides</u> and Knysna Warbler <u>Braypterus sylvaticus</u> in coastal zones.

confirmed breeding records for Natal (e.g. Dean 1971). Inland records need to be regarded with caution. Tarboton et al. (1987) question all six records of this species from the Kruger National Park because of the possibility of misidentification with immature Woodland Kingfishers Halcyon senegalensis. Quickelberge (1989) described the species as a sparse breeding resident in the Transkei (see Cooper and Swart 1992), breeding on the coast and inland, with summer and winter records. However, this analysis showed few winter records, despite the existence of similar numbers of field cards for the Transkei in winter. Thus this analysis, although based on only 89 positive records, suggests the winter migration of Mangrove Kingfishers from their breeding area in the Transkei to Northern Natal, moving through Southern Natal, presumably because of the lack of mangroves which is their preferred winter habitat. This is the first time that this migration has been proposed for the South African population.

The Black Sawwing Swallow showed a clear pattern of migration, with birds arriving from the Southwestern Cape zone to the Transkei zone in August, and with departures beginning in April (Fig. 6). Both arrivals and departures are synchronised in the southern part of the range. However, the pattern differs in the Southern and Northern Natal zones, where birds winter in large numbers. In the two Natal zones, the species also shows an altitudinal shift in distribution, with few birds occurring above 900m between May and August. It is not known whether birds that occur at higher altitudes in Natal move eastwards to the coast or northwards to Mozambique. This species has previously been

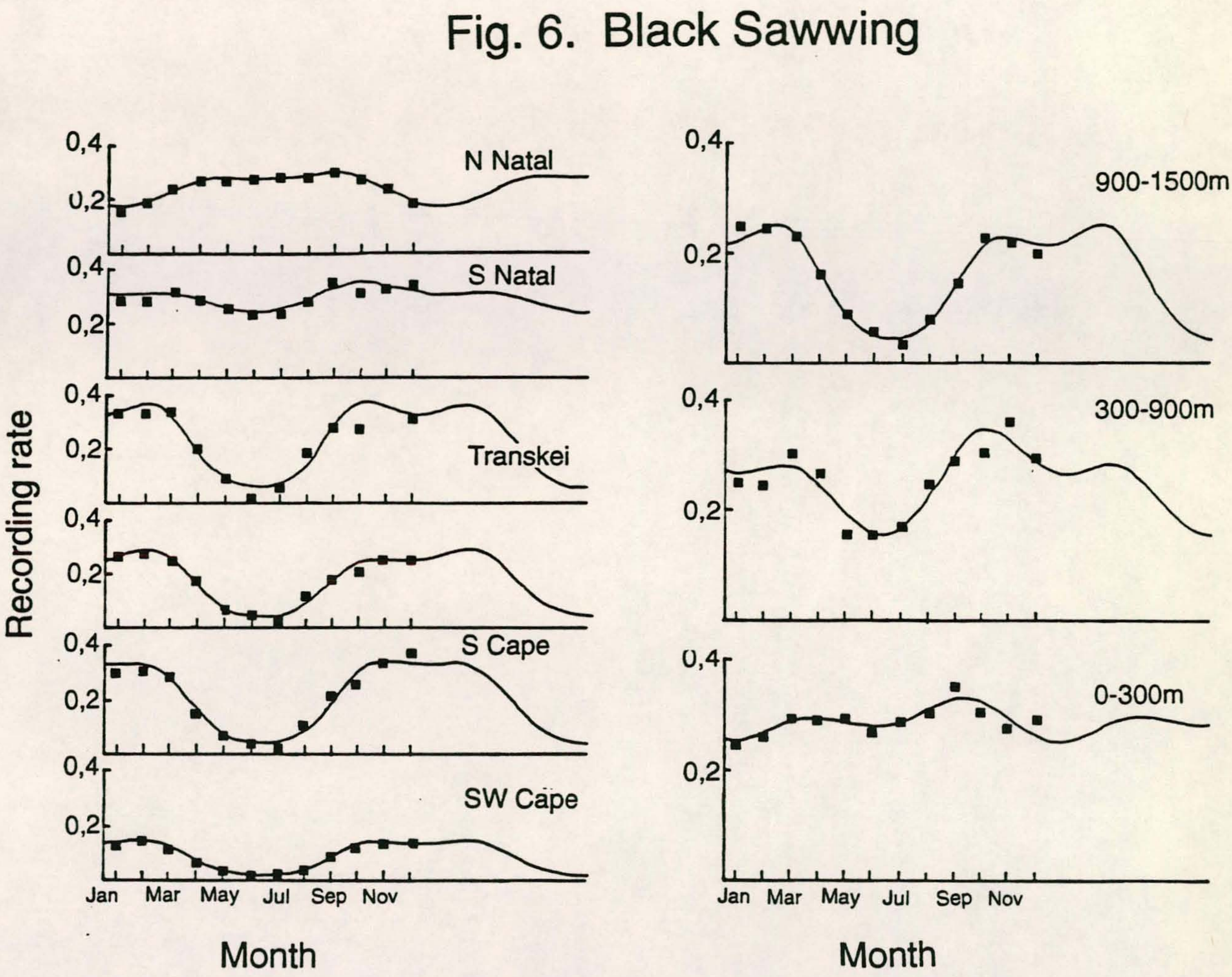


FIGURE 6. The reporting rates for the Black Sawwing Swallow <u>Psalidoprocne holomelas</u> in coastal zones and altitudinal classes.

regarded as resident in Natal (Clancey 1964), largely resident in the Transkei (Quickelberge 1989), partially migratory (Maclean 1985) and as both summer migrant and resident in the Southwestern Cape (Hockey et al. 1989). In southern Mozambique, Clancey (1971) described the species as apparently resident, but with an influx of birds from further south in winter, and also said that it occurred north of the Save River only as a nonbreeding visitor. This analysis demonstrates the importance of Natal as a wintering ground, and that this coastal migrant (in the southern part of its range) has the most synchronised arrival and departure of the migrants in this analysis.

The Spotted Thrush did not show any marked peaks in reporting rates throughout the year in the Northern Natal and Transkei zones, but a very distinct winter peak in the Southern Natal zone, strongly suggesting a winter migration into the Southern Natal zone (Fig. 7). However, there is no correspondingly clear pattern of movement away from the major breeding area in the Transkei, or the smaller breeding area in the Northern Natal zone. This may be explained by the fact that this species is particularly elusive when breeding and may therefore be under-reported in summer. This species has been regarded as a winter migrant to Natal from the Transkei (Clancey 1964). Quickelberge (1989) regarded the species as a breeding summer visitor to the Transkei, although he reported several winter records. The movements of the birds breeding in Zululand are not known, and it has been suggested that these populations may migrate to the Zululand coast in winter (Ginn et al. 1989).

Fig. 7. Spotted Thrush

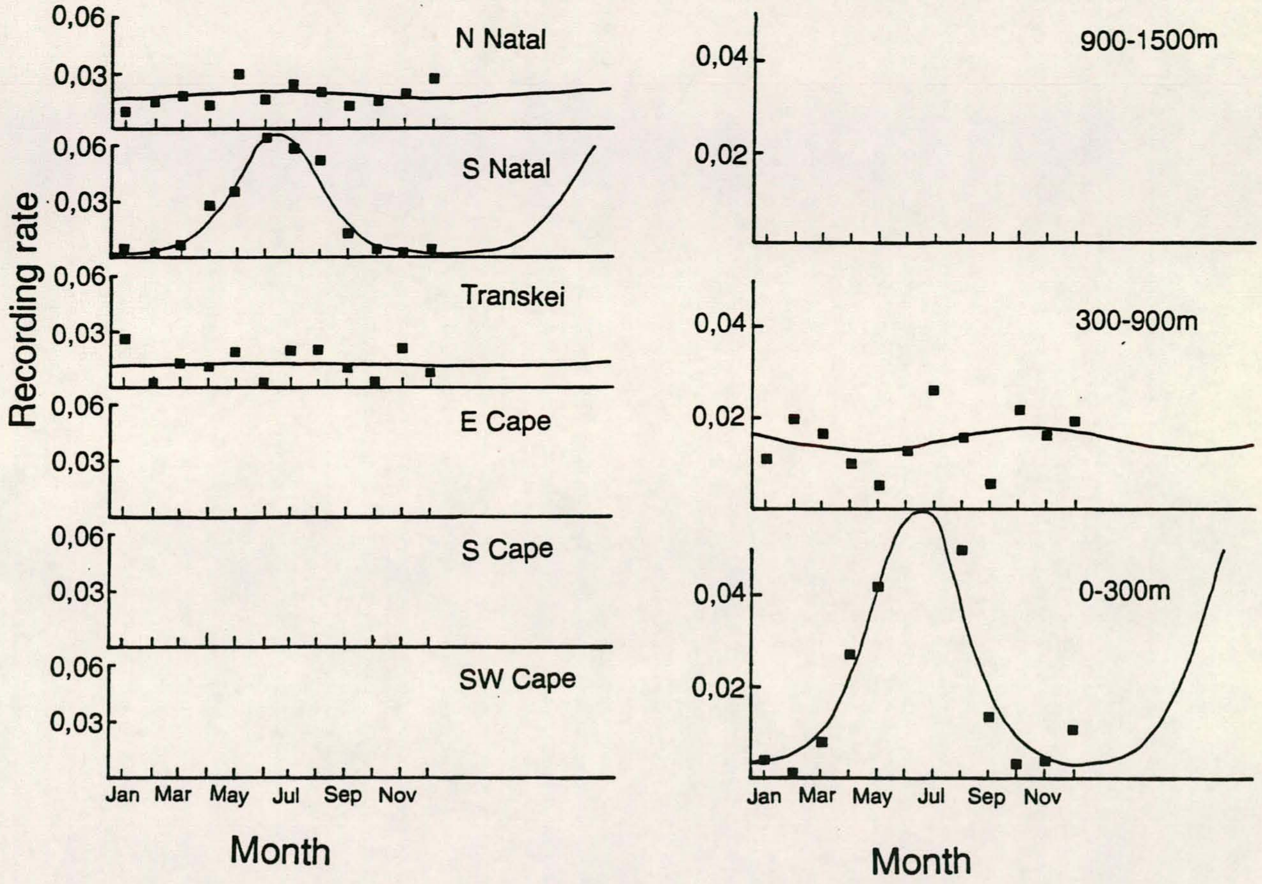


FIGURE 7. The reporting rates for the Spotted Thrush <u>Zoothera guttata</u> in coastal zones.

This analysis is based on only 200 records. The migration of this species is discussed further later.

The Paradise Flycatcher showed a clear migratory pattern, with distinct seasonal changes in reporting rates from the Southwestern Cape to Southern Natal zones (Fig. 8). Arrivals were synchronised in September. Departures are less synchronised than arrivals, and occur earliest in the Southwestern Cape zone, taking place later as one progresses towards the northeast. The proportion of wintering birds increases from the Eastern Cape zone to the Northern Natal zone. In the two Natal zones, reporting rates decrease dramatically between May and August above 300m a.s.l. In the Northern Natal zone, reporting rates show little seasonal differences. The breeding areas of birds wintering in Natal are not known, but Maclean (1985) reported the recovery of a bird ringed in Pietermaritzburg in Mozambique. The Paradise Flycatcher was previously regarded as migratory in the western Cape (Hockey et al. 1989), Transkei (Quickelberge 1989), and was described as migratory with overwintering in Natal (Clancey 1964, Cyrus and Robson 1980). In southern Mozambique, Clancey (1971) regarded the species as migratory with the breeding race plumbiceps migrating north in winter and being replaced by the southerly race granti between April and October. This analysis clearly demonstrates the importance of Natal as a wintering ground.

Group 3. Summer or spring peak in reporting rates (apparent coastal migration).

Fig. 8. Paradise Flycatcher

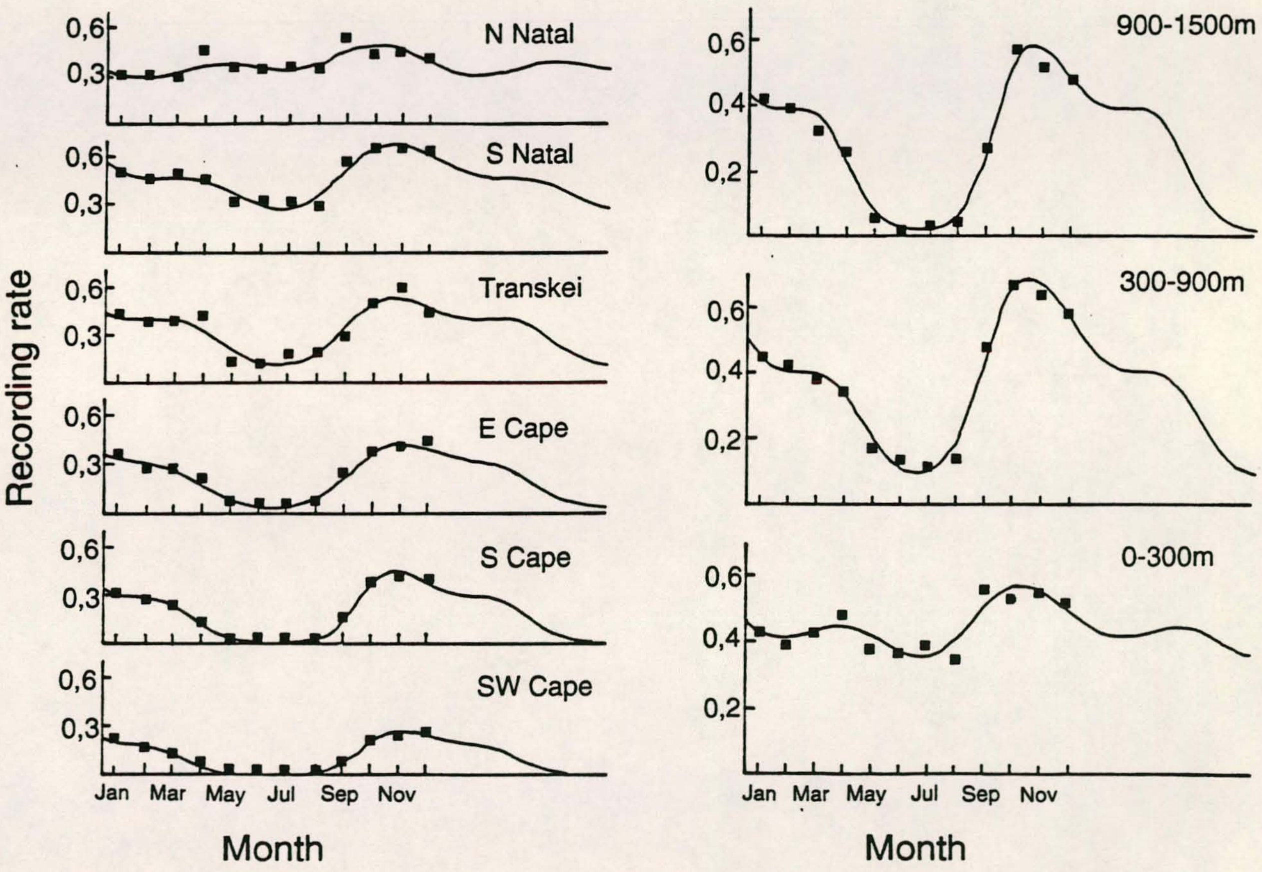


FIGURE 8. The reporting rates for the Paradise Flycatcher <u>Terpsiphone viridis</u> in coastal zones and altitudinal classes.

This group of three species (Buffspotted Flufftail Sarothrura elegans (Fig. 9), Narina Trogon Apaloderma narina (Fig. 10) and Knysna Warbler (Fig. 5)) show a summer or spring peak in reporting rate which is consistent with coastal migration. They are grouped separately because all three species are usually detected by vocalisations, and it can be argued that the seasonality of reporting rate reflects nothing more than seasonal changes in vocalisations, because there are winter records for each species in most zones in which they occur. The data are insufficient, however, to distinguish between the alternatives that these species are either partially migratory or merely seasonally vocal.

Both the Buffspotted Flufftail and Narina Trogon show increasing reporting rates and proportions of wintering birds in the north (Transkei and Natal zones (Figs. 9 & 10), similar to the patterns shown by three migrants Pygmy Kingfisher, Paradise Flycatcher and Black Sawwing Swallow. The Buffspotted Flufftail has not previously described as migratory (Clancey 1964, Maclean 1985), although unusual records have been recorded (Irwin 1981). Movements of this species, based on sight and specimen records, marked individuals, have been studied independently by Taylor (ms.) in Natal. He established that the species is absent in winter from areas above 1400m a.s.l., but is present in winter below 1250m a.s.l., except in the winter of 1992 when severe drought conditions prevailed. He concluded that birds (usually adults) are normally present all year in lowland areas if food and cover were available. Taylor (ms) suggests that there may be

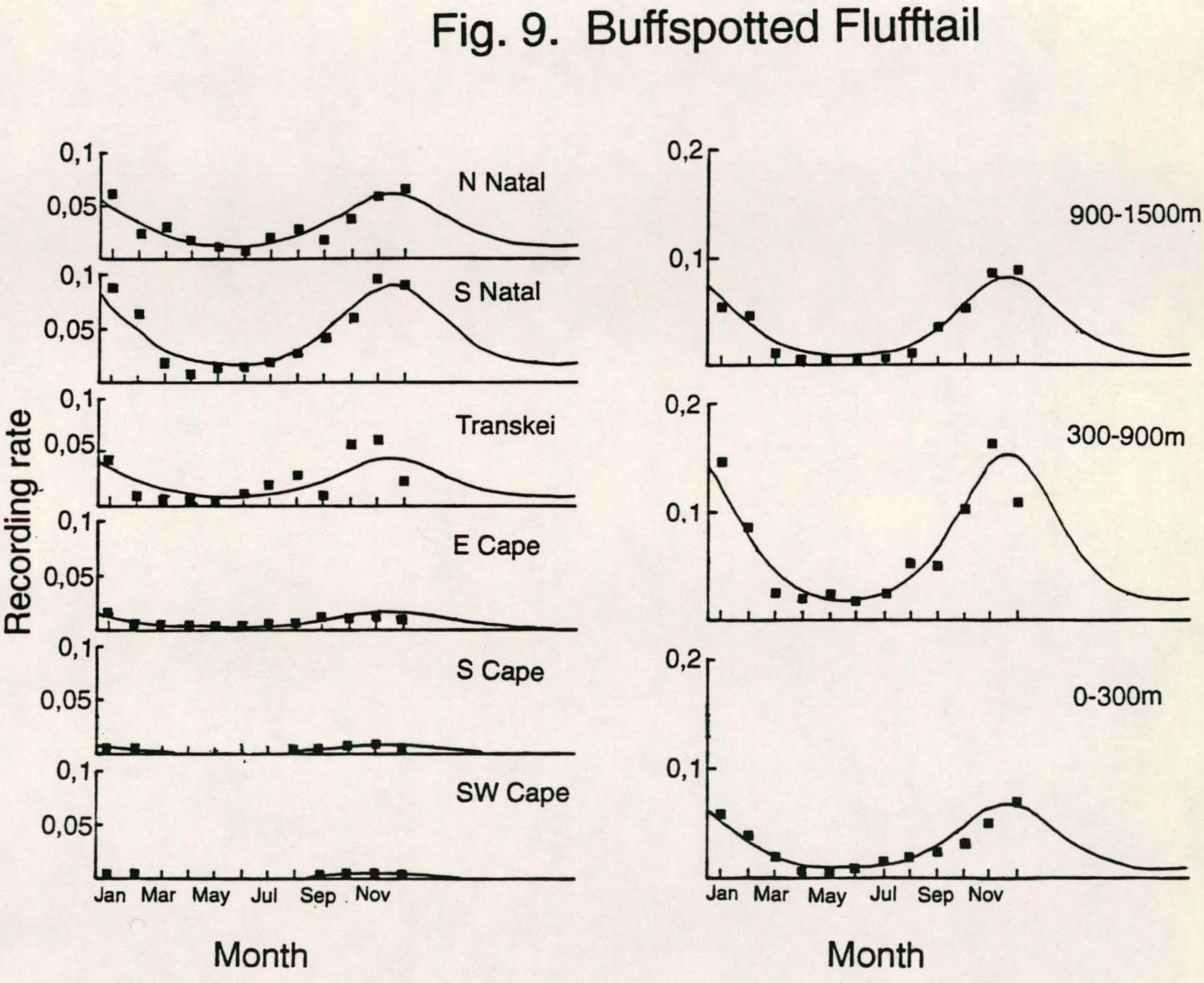


FIGURE 9. The reporting rates for the Buffspotted Flufftail Sarothrura elegans in coastal zones and altitudinal classes.

Fig. 10. Narina Trogon

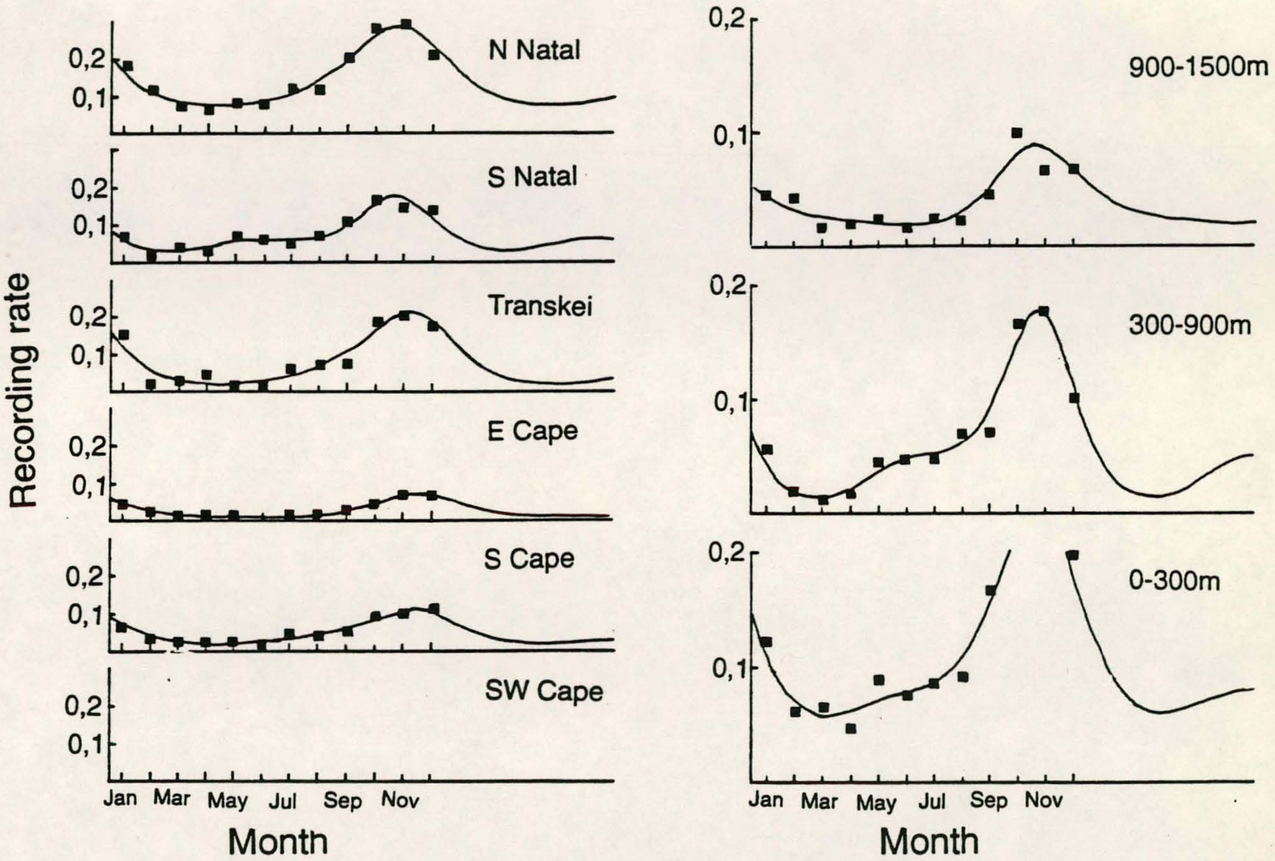


FIGURE 10. The reporting rates for the Narina Trogon Apaloderma narina in coastal zones and altitudinal classes.

a coastal migration of birds, mainly immatures, in May, and another (presumably return movement) in September to October. It is concluded that there is altitudinal movement of this species, whilst coastal movement is suggested but not proven.

The Narina Trogon has previously been regarded as a partial migrant (Clancey 1964, Quickelberge 1989, Maclean 1985). Clancey (1971) stated that resident populations of this species in southern Mozambique are augmented by the immigration of birds from further south. The pattern of seasonality shown by this analysis is consistent with coastal and altitudinal migration, but does not eliminate the possibility that seasonality in vocalisations is responsible for much of the seasonality in reporting rates.

The pattern for the Knysna Warbler (Fig. 5) is based on very few records, because the species is localised and difficult to identify, either visually or by call, except when in full song. Reporting rates are highest from the Southern Cape to the Transkei. The patterns do not support migration. The reporting rates in the Western and Eastern Cape zones show little variation. Reporting rates are highest from June to January in the Transkei, and from June to February in the Southern Cape. Nowhere does an increase coincide with a decrease, which would be consistent with migration. The Knysna Warbler was previously regarded as a coastal migrant in the Transkei and Southern Natal zones (Clancey 1964), and as a resident in the Southwestern Cape zones (Hockey et al. 1989). The species has not been positively identified in Natal since 1966, and may now be extinct there, with no evidence of winter migration into that area (Berruti et al. 1993). All species which show coastal migration, or partial migration, show increasing migratory tendencies (i.e. earliest departures and lowest proportions of overwintering bird) in the western populations of the Cape.

Group 4. Winter peak in reporting rate.

Five species (Crowned Hornbill *Tockus alboterminatus*, Grey Cuckooshrike *Coracina caesia*, Natal Robin *Cossypha natalensis*, Bluegrey Flycatcher *Muscicapa caerulescens*, Bluemantled Flycatcher *Trochocercus cyanomelas*) show a winter peak in reporting rates in coastal and altitudinal zones, which is not explained by migration. The possible causes of winter increases in reporting rates are discussed later.

The Crowned Hornbill is not regarded as a migrant (Clancey 1964, Tarboton et al. 1987, Quickelberge 1989), although Maclean (1985) reported 'some local movements' and Clancey (1971) termed the species somewhat nomadic. There were clear synchronised winter peaks in reporting rates in all zones (Fig. 11).

The Grey Cuckooshrike is usually vaguely described as showing some movement in winter. Clancey (1964) reported that this species was a seldom-recorded winter visitor to the coast of Natal. Maclean (1985) reported 'some fairly extensive local movements after breeding'. Quickelberge (1989) reported that it

Fig. 11. Crowned Hornbill

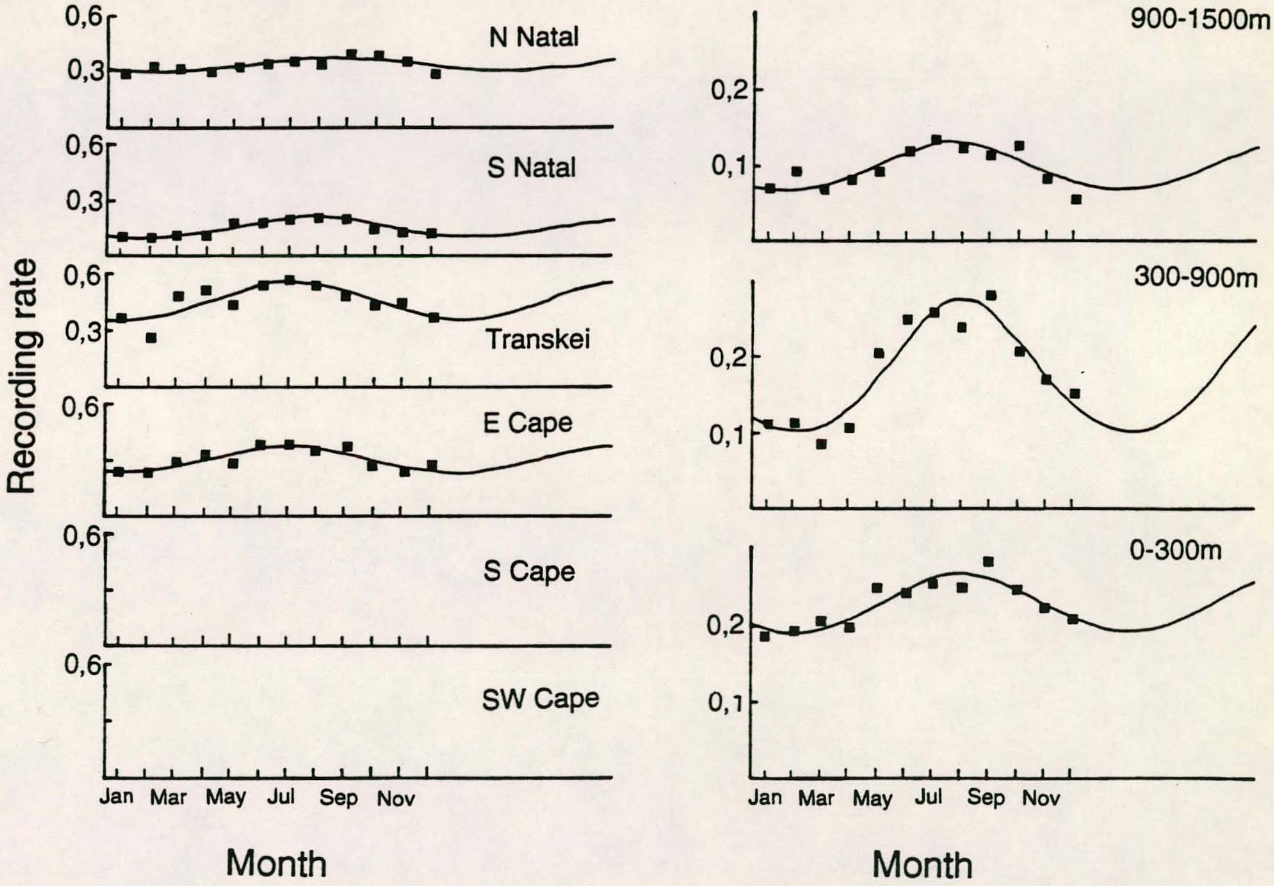


FIGURE 11. The reporting rates of the Crowned Hornbill <u>Tockus alboterminatus</u> in coastal zones and altitudinal classes showing winter peaksin reporting rates.

was subject to post-breeding dispersive movements. Tarboton et al. (1987) described the species as an altitudinal migrant down the eastern escarpment of the Transvaal in winter. This analysis shows a winter peak in reporting rates in three zones, but no evidence of altitudinal or coastal migration.

The pattern of reporting rates of the Natal Robin from the coastal zones are best described as showing a postbreeding (February-March) drop in records, rather than a winter peak in reporting rates (Fig. 12). Altitudinal movements are difficult to interpret. The altitudinal reporting rates show a postbreeding drop in the 0-300m a.s.l. class, and a small increase in winter. The species is present throughout the year above 900m a.s.l., although as a comparatively rare resident, and seems to be most often recorded during the early breeding season in the 300-900m a.s.l. class. If altitudinal migration occurs, it is confined to a smaller subset of the population. There is no evidence of coastal migration, even in the two southernmost zones of its occurrence (Fig. 12). This pattern is in contradiction to that suggested by Clancey (1991), who suggested extensive migratory movements for all populations of the Natal Robin. He proposed the following movements for the two South African races: the southern race egregior breeds in the eastern Cape and Transkei and migrates to Natal and southern Mozambique between April and September, with some first-year birds spending their first full summer on the Natal coast; the nominate race breeds from Natal to eastern Transvaal and southern Mozambique, and migrates in winter to Mozambique. This model of migration was invoked by described the species as a common localised resident and partial migrant, breeding September to January. Lawson (1963) suggested that the race adusta (which breeds in the Cape and inland areas of the Transkei, Natal, eastern OFS and eastern Transvaal) wintered in Natal, southern Mozambique and Swaziland. Clancey (1964) regarded adusta as a winter migrant to southern Natal, and the race fuscula a breeding resident on the coast. In the Transkei, Quickelberge (1989) suggested that adusta of the high-level forests wintered on the coast, whilst fuscula is the endemic subspecies of littoral forests. On the coast to the south of the Transkei, it was present only in winter, presumably the temperate forest race adusta (Quickelberge 1989). In southern Mozambique, Clancey (1971) regarded this species as a nonbreeding visitor from further south, present between late April and September, although possibly breeding at higher levels in the Lebombo montains. Harrison and Navarro (in press) showed conclusively that the Dusky Flycatcher in Natal shows a strong altitudinal migration, with reporting rates dropping above 300m a.s.l. in winter but a dramatic increase below 300m. It is suggested that the reason that the reporting rates do not increase in winter in the three Cape zones is because there are no large inland populations which migrate to the coast as in Natal. The present analysis shows that coastal movement, if present at all, must be very limited, because the reporting rates vary little throughout the Southwestern, Southern and Eastern Cape. The primary movement of this species appears to be altitudinal. In the Transvaal, Tarboton et al. (1987) report that there is altitudinal movement to lower altitudes in winter.

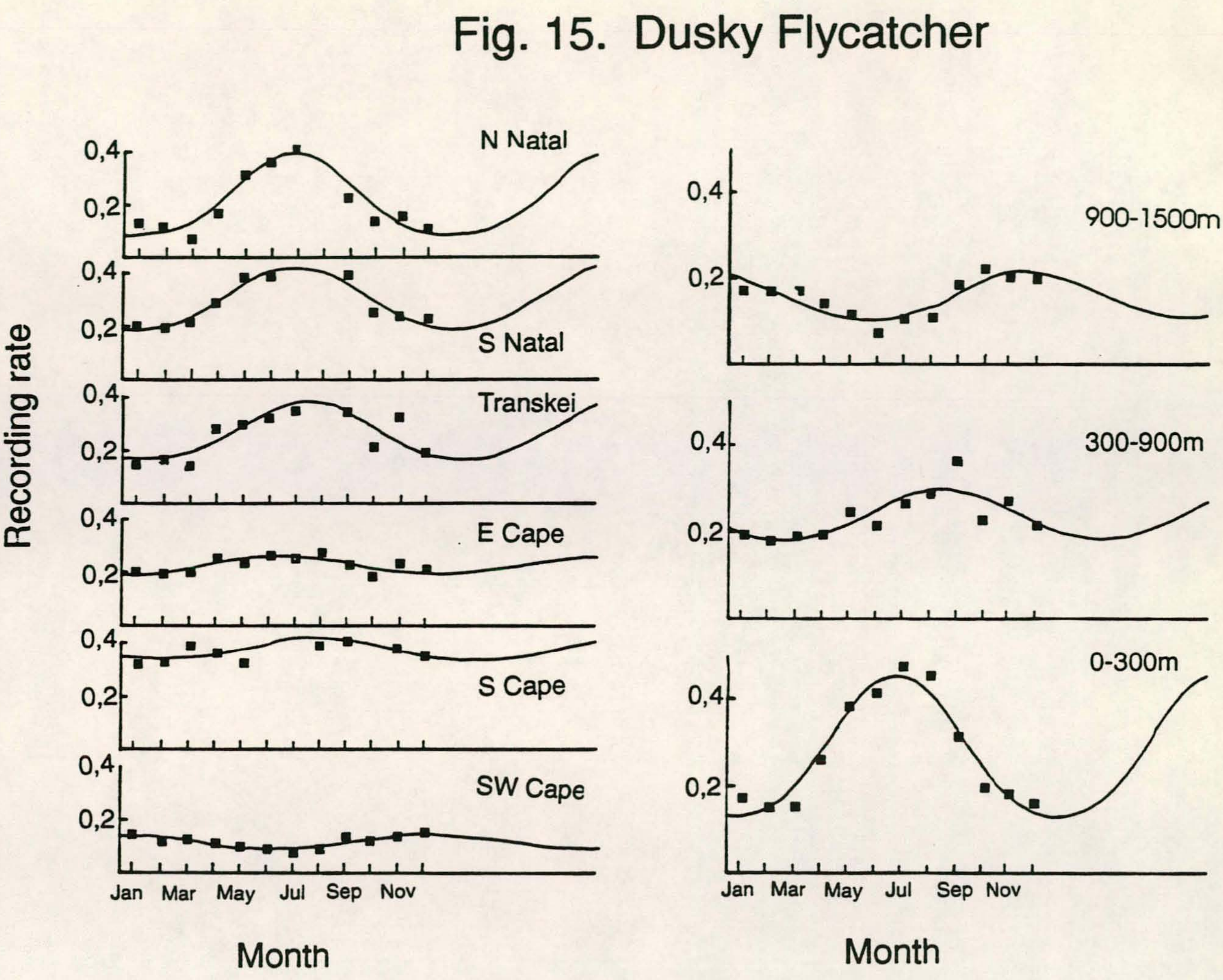


FIGURE 15. The reporting rates for the Dusky Flycatcher <u>Mucisicapa adusta</u> in coastal zones and altitudinal classes.

DISCUSSION

Methodology

Are patterns in reporting rate indicative of real demographic changes, or are they artefacts of either the statistical technique or observer bias? The use of the reporting rate has been discussed by Underhill et al. (1992), Navarro et al. 1993, Harrison and Navarro (in press). Reporting rates confound three variables: numerical abundance, conspicuousness and identifiability. Although the reporting rate is an index of abundance (Underhill et al. 1992, Harrison and Navarro in press), any analysis of the reporting rate of a species must take the biology of the species into account (Underhill et al. 1992). The conspicuous, abundant and widely-distributed species of open habitats, which were regarded as residents and hence as controls, showed no unexpected seasonality in reporting rates. We believe that the reporting rate is a robust quantification of species presence, although further work is required to investigate the phenomenon of the unexpected winter peak in reporting rates of several forest species (see following discussion).

Migrations

This study provides evidence overturning the previously understood migration patterns in four species: the Mangrove Kingfisher, Natal Robin, Knysna Warbler and Dusky Flycatcher.

Currently understood coastal or altitudinal migration patterns are confirmed and quantified for four species: Pygmy Kingfisher, Black Sawwing Swallow, Paradise Flycatcher and Starred Robin and is weakly supported for the Spotted Thrush. Previously suggested migratory patterns in the Narina Trogon and Buffspotted Flufftail are consistent with the results of this study, but the evidence does not eliminate the competing hypothesis of seasonality in vocalisations. This analysis shows that five forest species (Crowned Hornbill, Grey Cuckooshrike, Natal Robin, Bluegrey Flycatcher, Bluemantled Flycatcher) show a winter peak in reporting rates. These species are usually regarded as resident, and are apparently subject to changes in vegetation density or their own behaviour or habitat selection which make them more frequently reported by observers. In some species, the apparent winter increase is better regarded as a postbreeding decrease in reporting rates. Nevertheless, there are consistent suggestions of localised small scale winter movements, primarily to lower altitudes (Tarboton et al. 1987). These patterns seem to be most marked at higher altitudes or periphery of ranges, e.g in the eastern Transvaal (Irwin 1981, Tarboton et al. 1987).

Oatley (1966) noted that many populations of the thrushes and robins showed winter altitudinal migrations. Importantly, he noted that the migration was partial, and that no population showed complete emigration from a particular forest. These results are confirmed in this analysis of the Spotted Thrush, Natal and Starred Robins. Subsequent studies of the Starred Robin (Oatley 1982) and Natal Robin (Farkas 1969, Boon 1993) have shown that territorial males or adults do not migrate.

Non-migrational seasonality in reporting rate

In this analysis, two types of seasonal pattern in reporting rates can be attributed to factors other than migration. The first of these is a summer peak in reporting rates for secretive species which are mainly recorded on the basis of vocalisations during the breeding season. In this analysis, the species involved were the Buffspotted Flufftail, Narina Trogon and Knysna Warbler. In all three cases, the existence of winter records demonstrates that migration is, at best, partial. In these circumstances, this type of analysis alone cannot reveal whether migration occurs, and supplementary evidence is required to detect migration.

The second type of pattern in reporting rate which is apparently under the influence of non-migratory seasonality is the winter peak in reporting rates of five forest species; a phenomenon which has apparently not previously been reported in South Africa. This was not noted in species showing coastal migration or in the conspicuous, widespread species of more open habitats. This pattern occurred in five species including two non-passerines. The decline in summer could be regarded as an increase in parental bird secretiveness, including reduced levels of vocalisations following egglaying. This explanation may account for the decline in reporting rate in summer, but does not account for the subsequent increase in reporting rates in winter.

One or more of several factors may account for this phenomenon: the vegetation in the dense habitats occupied by these birds may become less dense in the dry winter; birds may be more active for a greater proportion of the observer's day to find sufficient food under conditions of reduced availability; birds may alter habitat usage on a local scale or behavioural patterns such as flocking. This aspect requires further investigation.

Is the migration of the Spotted Thrush in southern Africa unique?

We begin with the caveat that the extent and direction of winter migration in the small populations of Spotted Thrush breeding in Zululand are still poorly understood. These birds may move altitudinally to the coast (Ginn et al. 1989) or remain in the forests. However, past and new evidence clearly shows a winter migration from the Transkei into Natal (Clancey 1964, Cyrus and Robson 1980, Harebottle in prep.). The question is whether any population of other bird species breeding along the coast of Cape or Transkei winters in Natal. This analysis has revealed three other species which appear to show similar types of migration. The movements of the Mangrove Kingfisher from the Transkei, where it breeds in summer, to Natal where it overwinters, is very similar to that of the Spotted Thrush. Large numbers of the Black Sawwing Swallow and Paradise Flycatcher, which breed as far west as Cape Town, overwinter in Natal. However, for these species, precise definition of the breeding grounds of the birds which winter in Natal is not known.

The Spotted Thrush migration might still be regarded as unique because the wintering population is wholly contained within Natal. However, the migration of the southernmost (Transkei) population of the Mangrove Kingfisher appears to be very similar, although further confirmation is required. We argue that the migration of the Spotted Thrush should be seen as a truncated form of a migration shown by other species. The distribution of the Spotted Thrush is clearly relict, with four other races in Africa; two described on the basis of one specimen only, and the other two races numbering 40 pairs or less (Collar and Stuart 1985). The race <u>fischeri</u> of Kenya and Tanzania shows an altitudinal winter migration to the coast. It is argued that in the evolutionary past, the Spotted Thrush was more widely distributed under more favourable environmental conditions, and the species showed more extensive migrations. It has suffered evolutionary range contraction, and does not migrate further north than Natal because of its presently restricted population and range.

Winter migrations to Natal

Why do certain species breeding in the Transkei, Cape and upland Natal overwinter on the Natal coast? Two potential interrelated factors are temperature and food supply. All these species are invertebrate feeders, and the availability of invertebrates (mediated by rainfall and temperature) in winter may be the proximate factor controlling coastal migration in Natal. Oatley (1966, 1982) has argued that food availability was not the cause of migration. However, data on the food availability given in Oatley (1982) suggest times of food shortage in winter, although these may be brief in duration. It is known that territorial Starred and Natal Robins do not migrate (Oatley 1982, Boon 1993). Non-migratory territorial adults may exclude inexperienced birds from prime habitat, forcing them to occupy sub-optimal habitats as floating individuals. In addition, at higher altitudes or more southerly coastal areas, the temperature stress at night for poorly provisioned birds would be greater. Altitudinal and coastal migration may relieve temperature stress.

ACKNOWLEDGEMENTS

This paper depends on SABAP data. The SABAP owes its success in large measure to the co-operation and participation of the following organisations: Botswana Bird Club, Cape Bird Club, Eastern Cape Wild Bird Society, Lowveld Bird Club, McGregor Museum, Namibian Ministry of Wildlife Conservation and Tourism, Natal Bird Club, Natal Midlands Bird Club, North-eastern Bird Club, Northern Transvaal Ornithological Society, Orange Free State Ornithological Society, Ornithological Association of Zimbabwe, Southern African Ornithological Society, University of Cape Town, Wildlife Society of Lesotho and Witwatersrand Bird Club. Thousands of volunteers have spent many man-years collecting data, all at some and some at great personal cost. The success of SABAP is a direct result of their inspiring efforts.

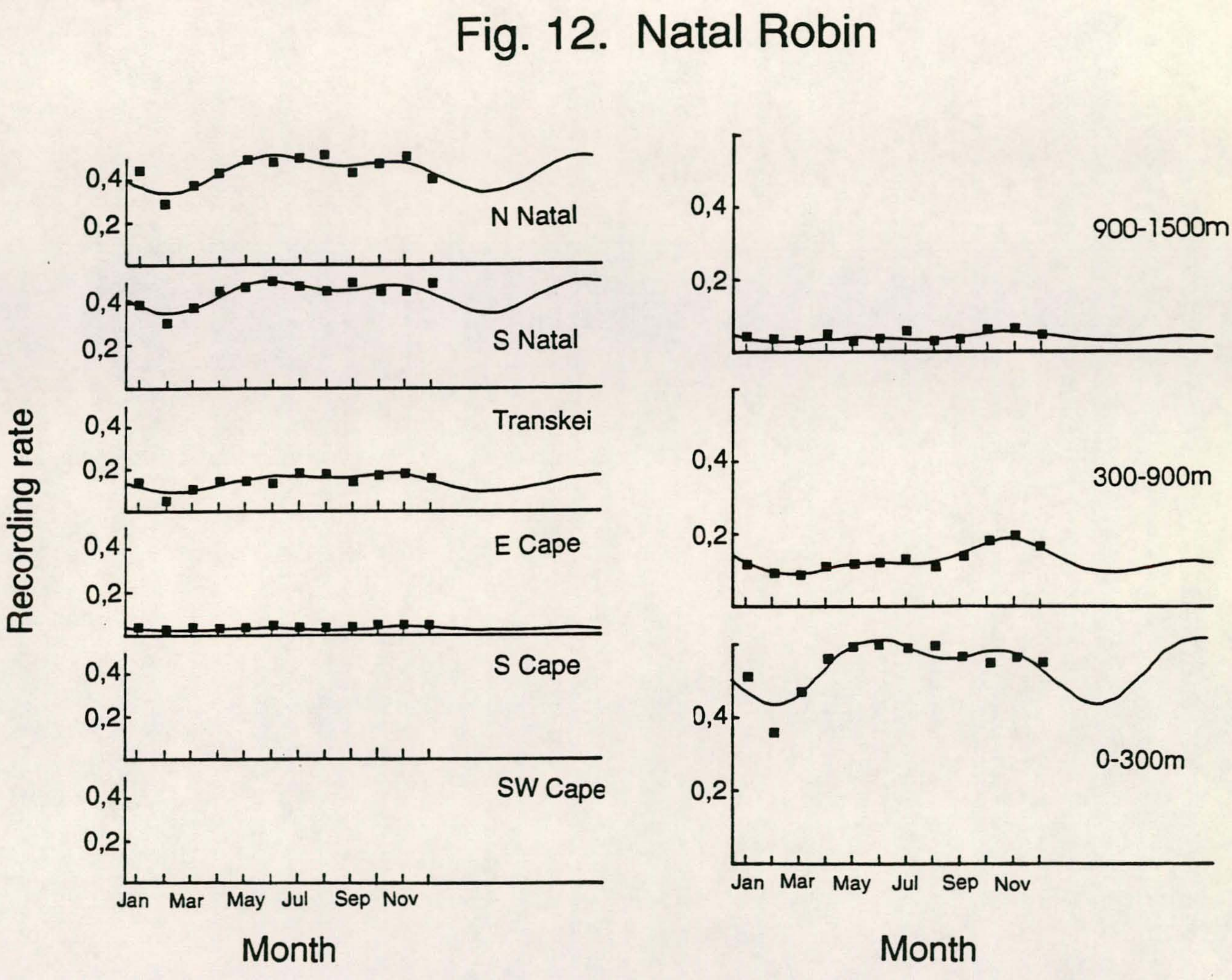


FIGURE 12. The reporting rates for the Natal Robin <u>Cossypha natalensis</u> in coastal zones and altitudinal classes.

Clancey (1991) to account for the variation in plumage of specimens collected within the same geographic area. An opposing view was offered by Hall (1958), who argued for a conservative approach to the description of races of the Natal Robin, citing extensive intra-population variation. Ringing studies by Farkas (1969) in the eastern Transvaal and Boon (1993) in Pigeon Valley Park (Durban) have shown that all, or most, breeding adults remain on breeding grounds in winter, but that there is a dispersal of juveniles from breeding areas. In the Transkei, Quickelberge (1989) reported that there was no noticeable winter movement away from the breeding grounds. In the Transvaal, Tarboton et al. (1987) regarded the species as a seasonal migrant in some areas and resident in others. Irwin (1981) reported extensive winter movements of this species in the eastern highlands of Zimbabwe which seemed to be altitudinal in nature. The present analysis suggests that the Natal Robin is essentially resident. The studies of Farkas (1969) and Boon (1993) suggest that adults are resident and that juveniles disperse, although adults of at least some high altitude populations (eastern Transvaal and Zimbabwe) may show winter migration.

The Bluegrey Flycatcher was been described as resident by Maclean (1985), but as being more mobile in winter in Natal (Clancey 1964) and the Transkei (Quickelberge 1989). Clancey (1971) suggested that the race caerulescens occurs in the Maputo district of southern Mozambique very largely as a non-breeding visitor from further south. Tarboton et al. (1987) reported that there is apparently altitudinal movement down the eastern

Transvaal escarpment in winter. This analysis shows no signs of coastal or altitudinal migration of this species in South Africa, although there is a winter peak in reporting rates.

The pattern of reporting rates for the Bluemantled Flycatcher is best described as showing a postbreeding drop, rather than a winter increase. The Bluemantled Flycatcher was not described as migratory by Clancey (1964), although Maclean (1985) suggested that seasonal movements occurred. Quickelberge (1989) suggested that this species tended to move inland to breed in the Transkei. Interestingly, the winter increase in reporting rate is strongest in the Transkei (Fig. 13), supporting the suggestion of altitudinal movement in this region. Tarboton et al. (1987) reported small scale winter movement down the escarpment of the eastern Transvaal and along the larger rivers in winter. In Natal, the reporting rate dropped slightly in winter above 900m a.s.l., whereas it increased markedly in winter at lower altitudes, suggesting limited altitudinal movement. There is therefore no evidence of coastal migration, but some evidence to suggest limited altitudinal migration.

Group 5. Altitudinal migration only.

The reporting rates of the two species (Starred Robin Pogoncichla stellata and Dusky Flycatcher Muscicapa adusta) indicated altitudinal movement.

The Starred Robin was recorded in small numbers, but shows

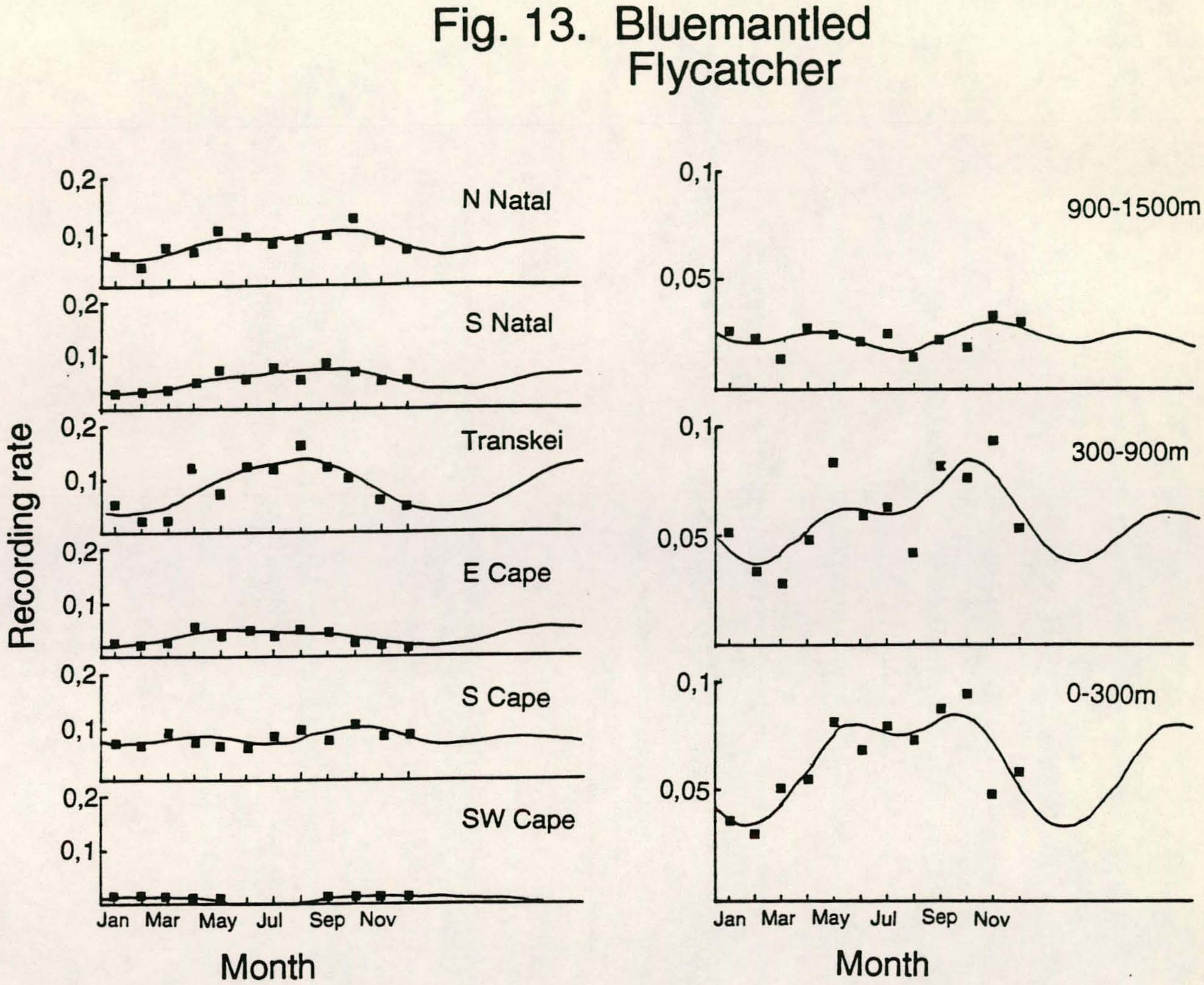


FIGURE 13. The reporting rates for the Bluemantled Flycatcher <u>Trochocercus cyanomelas</u> in coastal zones and altitudinal classes.

small winter increases in reporting rates from the Southern Cape zone through to Northern Natal zone (Fig. 14). This pattern is similar to that of the previous group of birds, which show a winter increase in abundance. Although reporting rates in the altitudinal classes are erratic, there is a restricted winter peak below 300m a.s.l. (Fig. 14), whereas the reporting rates of species in the previous group showed a longer winter duration or postbreeding drop in reporting rates. The Starred Robin is regarded as an altitudinal migrant in Transkei (Quickelberge 1989), Natal (Clancey 1964, Cyrus and Robson 1980) and southern Mozambique (Clancey 1971), being present on the coast in winter. Interestingly, it is regarded as a resident in Eastern Transvaal (Tarboton et al. 1987). Oatley (1982) described a clear but partial altitudinal movement in Natal. Breeding areas are always occupied and males never vacated their territories. This analysis confirmed the partial migration, as there are still many birds wintering at higher altitudes. Patterns of altitudinal movement in this and other forest species, may be masked by the increase in winter conspicuousness of terrestrial forest birds.

The Dusky Flycatcher shows a relatively flat pattern in reporting rate from the Southwestern Cape to the Eastern Cape, and marked winter peaks from the Transkei to Northern Natal (Fig. 15). There is distinct altitudinal seasonality in Natal, with numbers decreasing markedly above 900m in winter and a converse increase below 300m. This pattern of reporting rates is unexpected because the Dusky Flycatcher is regarded as a coastal migrant. For the Southwestern Cape, Hockey et al. (1989)

Fig. 14. Starred Robin

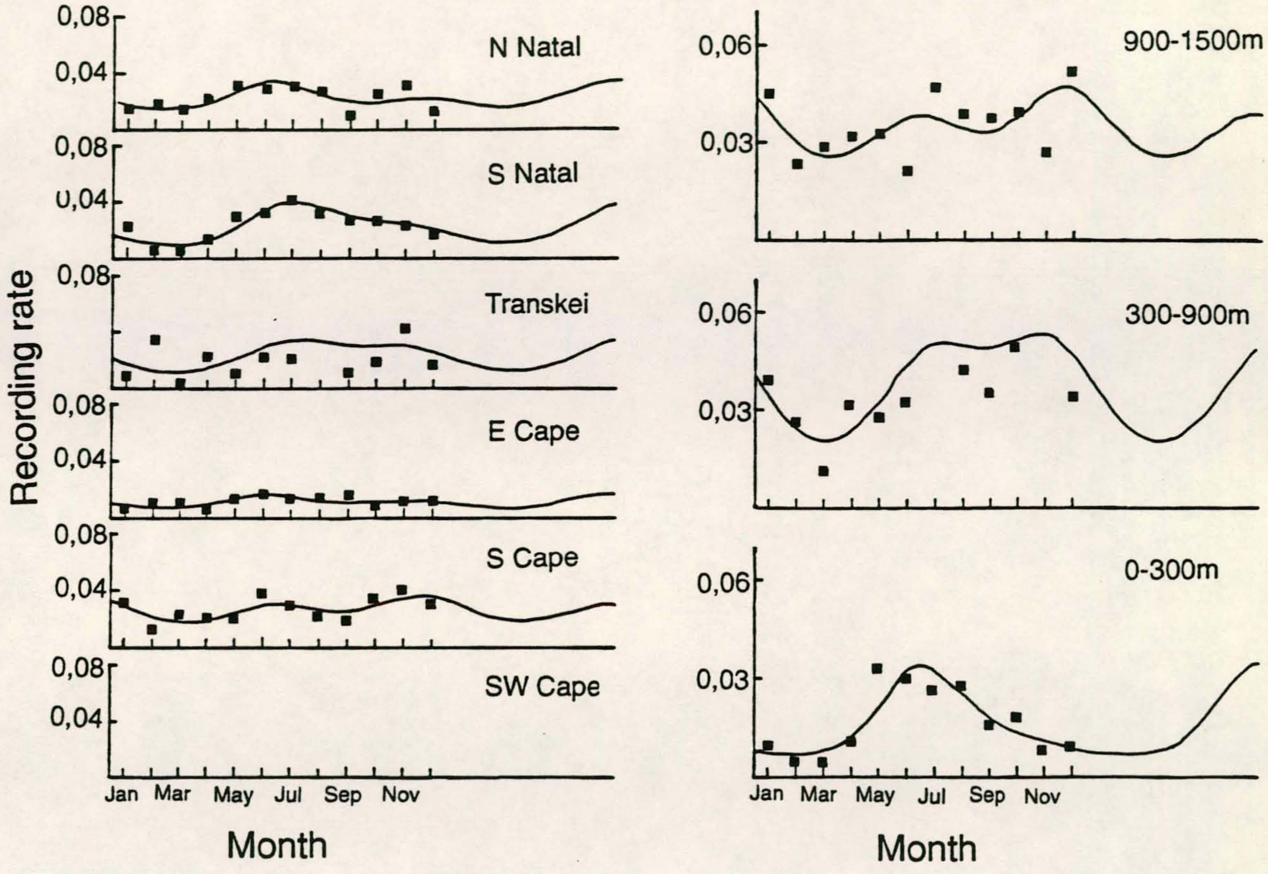


FIGURE 14. The reporting rates for Starred Robin <u>Pogonocichla stellata</u> in coastal zones and altitudinal classes.

The SABAP has several sponsors. They are, in alphabetical order: Conservation Trust of Swaziland, Endangered Wildlife Trust, De Beers Chairman's Fund, Dept. of Environment Affairs, Distillers Corporation, Gold Fields Foundation, Mazda Wildlife Fund, Natal Bird Club, Natural History Society of Swaziland, Southern African Nature Foundation, Southern African Ornithological Society, University of Cape Town and the Wildlife Society of Southern Africa. Several private individuals also made generous donations.

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TABLE 1. Numbers of record cards per month for each coastal zone. Coastal zone numbers: 1 = Southwestern Cape, 2 = Southern Cape, 3 = Eastern Cape, 4 = Transkei, 5 = Southern Natal and 6 = Northern Natal.

Month	Coastal Zone No.						Total
	1	2	3	4	5	6	
January	1071	375	551	118	465	231	2811
February	983	302	515	113	394	216	2523
March	1106	333	489	79	455	230	2692
April	1171	348	527	92	493	252	2883
May	1140	348	639	105	477	279	2988
June	1023	318	554	88	467	254	2704
July	1207	339	610	100	520	292	3068
August	1122	306	570	103	515	257	2873
September	1335	369	547	104	474	275	3104
October	1303	349	679	108	457	282	3178
November	1079	366	666	98	442	232	2883
December	1087	361	538	131	448	305	2870
Total	13627	4114	6885	1239	5607	3105	34577

TABLE 2. Numbers of record cards per month for three altitudinal classes (0-300m, 300-900m and 900-1500m) in Southern and Northern Natal.

Month	Altitude class (m a.s.l.)			Total
	0-300	300-900	900-1200	
January	513	177	289	979
February	459	150	255	864
March	508	177	279	964
April	555	188	283	1026
May	575	180	276	1031
June	567	153	283	1003
July	620	191	276	1087
August	583	189	260	1032
September	579	170	266	1015
October	556	183	304	1043
November	491	182	262	935
December	548	205	326	1079
Total	6554	2145	3359	12058

TABLE 3. Total numbers of records for each species given as the percentage of all cards used in the coastal analysis and as the percentage of the cards in the zones in which that species occurs.

Species	Coastal		Altitudinal	
	n	% Total	n	% Total
Buffspotted Flufftail	476	1,4	466	3,9
Cape Turtle Dove	24198	70,0	6598	54,7
Narina Trogon	1476	4,3	1068	8,9
Pygmy Kingfisher	800	2,3	742	6,2
Mangrove Kingfisher	89	0,3	-	-
Crowned Hornbill	4548	13,2	2212	18,3
Black Sawwing Swallow	6051	17,5	2992	24,8
Grey Cuckooshrike	985	2,9	505	4,2
Spotted Thrush	204	0,6	191	1,6
Natal Robin	4258	12,3	4002	33,2
Starred Robin	418	1,2	317	2,6
Knysna Warbler	200	0,6	-	-
Dusky Flycatcher	7369	21,3	2897	24,0
Bluegrey Flycatcher	1085	3,1	1028	8,5
Bluemantled Flycatcher	1360	3,9	638	5,3
Paradise Flycatcher	8109	23,5	4732	39,2
Fiscal Shrike	26821	77,6	5957	49,4
House Sparrow	15928	46,1	8701	72,2

TABLE 4. The five patterns of seasonality in reporting rates of 18 bird species in this analysis.

Group	Type of pattern	No. of species	Species names
1	None	3	Cape Turtle Dove Fiscal Shrike House Sparrow
2	Coastal migration	5	Pygmy Kingfisher Mangrove Kingfisher Black Sawwing Swallow Spotted Thrush Paradise Flycatcher
3	Peak summer abundance (possible coastal migration)	3	Buffspotted Flufftail Narina Trogon Knysna Warbler
4	Peak winter abundance	5	Crowned Hornbill Grey CuckooShrike Natal Robin Bluegrey Flycatcher Bluemantled Flycatcher
5	Altitudinal migration	2	Dusky Flycatcher Starred Robin

CORRELATING RELATIVE ABUNDANCE AND RAINFALL: A TIME-SERIES ANALYSIS OF CHECKLISTS

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Summary

Navarro, R.A., Harrison, J.A., Allan, D.G. and Zucchini, W. 1993. Correlating relative abundance and rainfall: a time-series analysis of checklists. Proc.VIII Pan-Afr.Orn.Congr. 379-388.

Time series checklist data (1982/1983-1990/1991) collected for a region of South Africa were correlated with total annual rainfall. The analysis used standard techniques for time-series analyses. Of the 104 species analyzed, 20 showed significant correlations with rainfall in the same year but lag effects were detected for only 1 species. This study shows that reporting rates derived from simple presence/absence checklist data can provide useful results when analyzed by sophisticated statistical procedures.

Key words: atlases, time-series analysis, reporting rate, rainfall, Orange Free State, South Africa

Introduction

Amateur ornithologists are avid compilers of lists. The Southern African Bird Atlas Project (SABAP) and its predecessors have exploited this enthusiasm by making the "checklist" the basic data sample unit (Cyrus and Robson 1980, Earlé and Grobler 1987, Tarboton *et al* 1987, Hockey *et al* 1989). Southern African bird clubs have encouraged compilation of checklists and have amassed collections of data spanning several years or even decades.

This invaluable historical data, built up by thousands of observers, awaits detailed analysis and doubtless holds much important information. As a first step in exploiting this resource, the SABAP has accessed most of the data sets and computerized each checklist. The potential now exists to analyze time series of checklists which incorporate both the historical and the recent SABAP data.

The value of a time series of checklists is the opportunity provided to detect changes in populations of species. To go beyond a mere statement of appearance or disappearance of species based on presence or absence on checklists, an index of relative abundance must be developed, based on the frequency at which species are reported.

This paper shows that:

* reporting rates are subject to variation due to factors other than changes in abundance and must be corrected before being used as an index of relative abundance;
* the reporting rate index varies over time in a manner consistent with its use as an index of relative abundance; and
* the potential exists to relate the reporting rate index to environmental variables, such as rainfall, thus providing insights into species ecology.

Study area

The study area is part of the province of the Orange Free State (OFS) in South Africa (Figure 1). The area was chosen for its 11-yr series of checklists collected for the atlas project of the OFS Ornithological Society, 1982-1986 (Earlé and Grobler 1987) and for SABAP, 1987-1991 (Harrison 1987). Coincidence with a period of dramatically fluctuating rainfall also influenced the choice of area. Boundaries were set to include a relatively homogeneous ecological area falling entirely in the grassland biome (Rutherford and Westfall 1986).

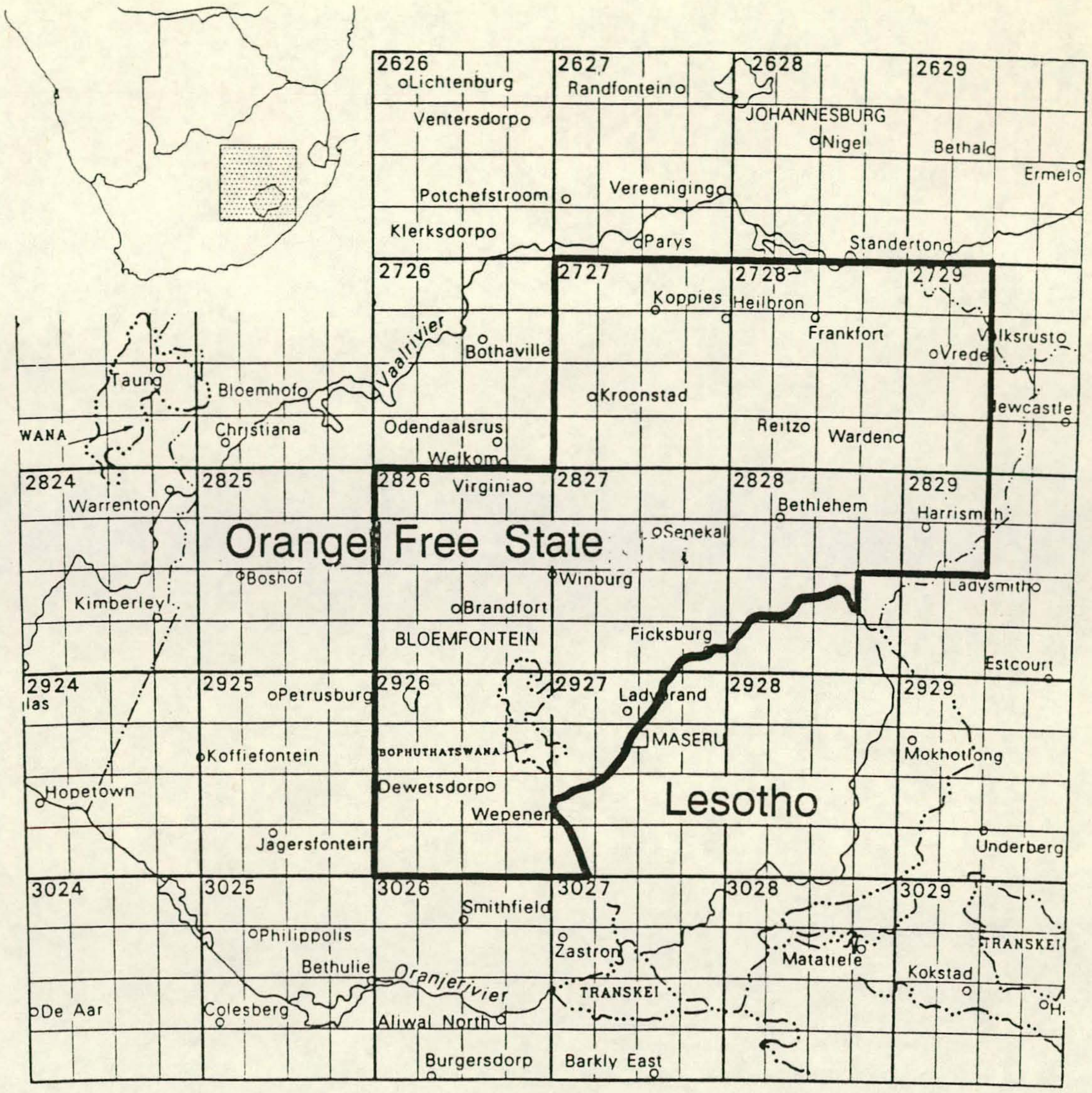

Figure 1 The Orange Free State study area, part of the Southern African Bird Atlas Project

Materials and methods

Reporting rate

The checklists were collected at the spatial and temporal resolutions of the ¼^6 grid square (15'x 15') and calendar month (Earlé and Grobler 1987, Harrison 1992). Since there was no control of the amount of time, effort, or observer skill when data were collected, a statistical standardization was applied to the data).

In this study, all checklists from the study area for a "rainfall year" were combined to provide reporting rates at this particular scale of geographical and temporal resolution. The rainfall year is the 12 mo September-August, designed to include the whole of 1 rainy season. Rainfall years 1981/1982 and 1991/1992 were excluded because of insufficient data, leaving 9 yr from 1982/1983 to 1990/91 inclusive. Checklists used in each rainfall year numbered 171, 463, 555, 410, 569, 844, 864, 559, and 349: mean checklist length (= number of species) was 33, 30, 35, 41, 38, 37, 47, 59, and 61.

In its most basic form, reporting rate for a particular species, for a unit of time and space, is obtained by calculating the proportion or percentage of all checklists which record that species. The reporting rate is used as an index of relative abundance when comparisons are made between time periods and/or between geographical areas (Harrison 1989).

Rainfall
Rainfall data were obtained from the Computer Centre for Water Research, Pietermaritzburg. Totals were obtained from as many stations as possible and averaged over the study area. Rainfall for 1980/1981 and 1981/1982 is included as these years were used to test lagged responses in 1982/1983 and 1983/1984. Drought persisted from 1982/1983 to 1986/1987 while 1987/1988 was a wet year in which floods occurred in many parts of the OFS. Mean rainfall for the study area is 600-700 mm per annum.

Analysis
In order to assess validly the relationship between reporting rate (or some quantity derived from it) with rainfall (or any other variable) it is necessary to "prewhiten" (Chatfield 1989 p. 139, Peach *et al* 1991) each of the time series being related. Unless this is done, spurious correlations between the 2 series can arise. The use of much longer data sets has shown that total annual rainfall in the OFS is not serially correlated (Zucchini and Adamson 1984) and consequently requires no prewhitening. The reporting rates do exhibit serial correlation structure, however, and therefore do need prewhitening. To do this, the autoregression-moving average family of models (Box and Jenkins 1976, Chatfield 1989) was used to identify and then fit the appropriate model to each reporting rate series and then compute the residual series. These residuals were then related to rainfall.

A series of steps was carried out for each species analyzed:

* a simple linear regression between reporting rate and checklist length was applied to remove the trend resulting from increased mean checklist length over time by isolating the residual reporting rate -- index *R*, which can be interpreted as a reporting rate corrected for checklist length;
* *R* was checked for serial correlation structure to avoid artifacts caused by spurious regression and, if significant, the residuals from the appropriate model (autoregressive or moving average) were estimated (Box and Jenkins 1976, Chatfield 1989);
* the time series of *R* values exhibits, or does not exhibit serial correlation structure and if the former was the case the residuals from the model fitted to the *R* series were related to rainfall, whereas in the latter case the *R* series itself was related to rainfall but whichever option was applied, the corresponding series was cross-correlated with rainfall to search for correlations with rainfall in the same year (no lag), rainfall in the previous year (1-yr lag) and rainfall 2 yr previously (2-yr lag).

This procedure was applied to 104 species, including all having reporting rates in excess of 10% in most of the rainfall years. The rarer species, for which reporting rates are unlikely to provide a reliable index of relative abundance, were excluded as were species likely to have been greatly affected by improved observer skills in identification over time. All cisticolas (Sylviidae, *Cisticola* spp.), pipits (Motacillidae, *Anthus* spp.) and most larks (Alaudidae) were excluded. Swallows and martins (Hirundinidae) and corvids (Corvidae) were also excluded as these groups had been the subject of intensive investigations during parts of the study period which may have affected reporting rates relative to the remainder of the period.

Results

A total of 21 of the 104 species analyzed showed significant ($p < 0.05$) or near-significant ($p < 0.1$) correlations with rainfall (Table 1): 18 of these species showed a significant correlation ($p < 0.05$) with mean checklist length (Table 1, Figure 2) and therefore required correction. After correction, 15 species showed a significant positive correlation between R and rainfall in the same year (Table 1, Figure 3a) while 5 showed a significant negative correlation (Table 1, Figure 3b). The Hamerkop *Scopus umbretta* was the only species to show near-significant ($p < 0.1$) positive correlation with a 1-yr lag on rainfall (Table 1). Corrected reporting rates for 4 species known or suspected to be increasing in range and abundance showed positive correlations with rainfall in the same year (Table 1 Figure 4).

Discussion

Avian responses to variations in rainfall
It is emphasized that the aim of this paper is to present a method of analyzing checklist data to help detect changes in relative abundance over time in relation to environmental variables. No *a priori* hypotheses with regard to the response of birds to rainfall were tested and the results cannot therefore be taken as proof of any such phenomenon. To do this we need to analyze the avian community as a whole and check the results for each species in the light of information about its movements, feeding habits and breeding biology. Despite this important caveat and bearing in mind the inadequate length of the time series, the results obtained, are sufficiently consistent with expected results to give us confidence that reporting rates can be analyzed usefully in this manner.

Table 1 Correlation coefficients (r) between bird data series and card length, and between corrected reporting rate and rainfall

Species		Correlation coefficient[a)]			
Common name	Scientific name	Card length	Same year	1-yr lag	2-yr lag
Long-tailed Cormorant[b)]	*Phalacrocorax africanus*	0.94**	0.63+	0.61	0.13
Grey Heron	*Ardea cinerea*	0.97**	0.76*	0.08	-0.08
Cattle Egret	*Bubulcus ibis*	0.74*	0.81**	0.46	-0.13
Hamerkop	*Scopus umbretta*	0.93**	0.48	0.63+	-0.02
Hadada	*Bostrychia hagedash*	0.91**	0.82**	0.03	-0.20
Red-billed Teal	*Anas erythrorhyncha*	0.96**	0.65+	0.59	0.11
South African Shelduck	*Tadorna cana*	0.56	-0.74*	-0.49	-0.04
Secretary Bird	*Sagittarius serpentarius*	0.60+	-0.66*	-0.36	0.21
Lesser Kestrel	*Falco naumanni*	0.65+	-0.70*	-0.60	0.04
Swainson's Francolin	*Francolinus swainsonii*	0.98**	0.79*	0.23	-0.16
Helmeted Guineafowl	*Numida meleagris*	0.98**	0.61+	0.07	-0.17
Speckled Pigeon	*Columba guinea*	0.95**	0.81**	0.41	-0.35
Laughing Dove	*Streptopelia senegalensis*	0.86**	0.60+	0.20	-0.16
Speckled Mousebird	*Colius striatus*	0.98**	0.70*	0.45	-0.10
Crested Barbet	*Trachyphonus vaillantii*	0.91**	0.82**	0.14	-0.12
Spike-heeled Lark	*Chersomanes albofasciata*	0.94**	-0.73*	-0.32	-0.03
Red-capped Lark	*Calandrella cinerea*	0.91**	-0.60+	-0.43	-0.01
African Red-eyed Bulbul	*Pycnonotus nigricans*	0.87**	0.65+	0.28	0.01
Bokmakierie	*Telophorus zeylonus*	0.96**	0.61+	0.18	-0.39
Indian Myna	*Acridotheres tristis*	0.87**	0.66*	0.37	-0.35
White-browed Sparrow-weaver	*Plocepasser mahali*	0.85**	0.59+	0.41	-0.34

Note: a) d.f. = 7, 6, and 5 for same year, 1-yr lag and 2-yr lag
b) corrected for autocorrelation
+ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$

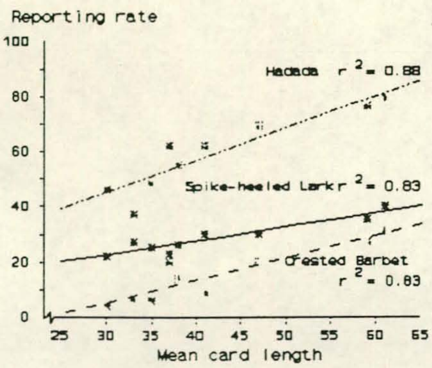

Figure 2 Sample relationships between species reporting rate and checklist length

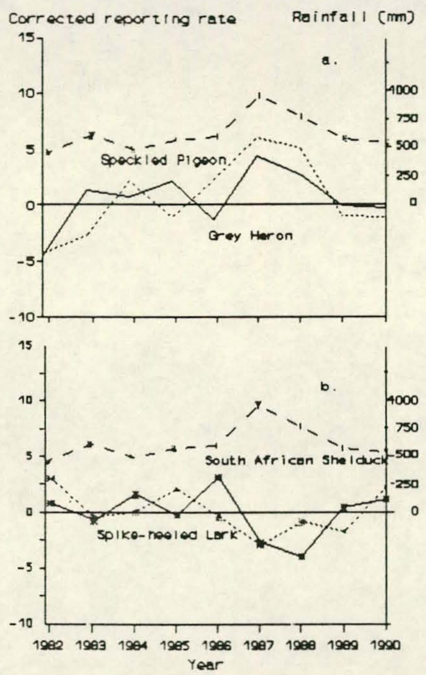

Figure 3 Corrected reporting rates for two species each with: a. positive; and b. negative correlation with rainfall in the same year

The importance of rain, or lack of it, as a determinater of local movements (Maclean 1970, 1974, Cunningham-van Someren 1984, Martin *et al* 1986), timing of breeding (Skead

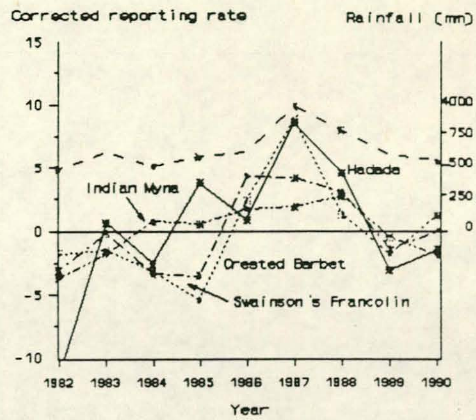

Figure 4 Corrected reporting rate for four species known or suspected to be increasing in distribution and abundance in the study area and showing positive correlations with rainfall in the same year

1975, Martin *et al* 1986) and breeding success (Grobler 1988, Kemp 1991) in Africa is well known, although seldom quantified. That reporting rates do not display a significant lagged response to precipitation suggests that rainfall events in grassland areas result in relatively short term responses by birds, although these events may be prolonged and extend over subsequent years. Lagged effects on breeding in southern Africa appear to have been described only for woodland birds, where tree leaf and fruit production is suggested as the mediating factor (Kemp 1973, Vernon 1978, Earlé 1981).

Significant immediate responses to variations in rainfall might have been expected to be evident in a larger proportion of species than was found in this study. Changes in reporting rates associated with rainfall variation could result from fluctuations in population density due to breeding productivity or movement in to or out of the area, changes in conspicuousness due to breeding activity, or a combination of these factors. Many birds are known to exploit wetter conditions by increasing breeding productivity (Grant and Grant 1987, Grobler 1988). Water birds, in particular, colonize temporary water bodies after rain (Geldenhuys 1976a) so a higher proportion of these species could be expected to show a significant immediate rise in reporting rate.

The expectation of increased reporting rates after increased precipitation in species which benefit from more mesic conditions, due to increased density from immigration and/or enhanced breeding success, and increased conspicuousness due to breeding displays by males, may not be met. This is because these factors might be balanced by lush vegetation growth and secretiveness in breeding females, that reduce conspicuousness in some species.

Reporting rate is a relatively inelastic measure of abundance (Underhill and Hockey 1988). This means that large changes in abundance may result in small changes in reporting rate. The amount of flooding after the heavy rains of 1987/1988 may have created conditions that were so unusual that many species did not show the short-term positive responses ordinarily expected after a more normal increase in rainfall (Grobler 1988). It is possible that the results of the present analysis are influenced by this extreme rainfall (Figures 3 and 4). A longer time series would be needed to control for such unusual events and to cover several consecutive wet/dry precipitation cycles.

Aquatic species

Positive response to rainfall

Only 4 of the 20 species showing significant immediate responses to variations in rainfall are water birds. Positive correlations between Long-tailed Cormorant *Phalacrocorax africanus*, Grey Heron *Ardea cinerea* and Red-billed Teal *Anas erythrorhyncha* and rainfall are predictable, as increased precipitation would lead to more aquatic habitat. The increased reporting rate of these species cannot, however, automatically be interpreted as an increase in total population size. During dry periods, the populations may be concentrated at the relatively few large, permanent water bodies and populations could be expected to disperse to numerous seasonal wetlands following rain, thus affecting reporting rate. The impact of changes in patterns of dispersal on reporting rates is poorly known but needs to be considered when interpreting the latter.

The Hamerkop was the only species to show a 1-yr lagged response to rainfall. As an aquatic species, a positive response to increased rainfall is predictable but why it should be lagged by 1 yr is not clear. The Hamerkop is characterized by 3 unusual features: solitary habits while feeding and breeding; specialized diet of *Xenopus* adults and tadpoles; and high visibility (Siegfried 1975). Observers may have recorded this species from nests seen, in addition to actual sightings of the birds, and some factor(s) associated with these features may be responsible for the lagged response.

Negative response to rainfall

The immediate negative response to increased rainfall shown by the South African Shelduck *Tadorna cana*, is rather surprising although it has been shown that it avoids areas with rainfall in excess of 600 mm (Geldenhuys 1981). A major reduction in reporting rate occurred in the 2 years with rainfall above 600 mm (Figure 3). Avoidance of high rainfall may be due to wetlands under these conditions supporting luxuriant emergents and dense littoral hydrophytes which are habitats unsuitable for this species (Geldenhuys 1976b). Flooding of the underground breeding sites of this species (L. van Erck pers.comm.) and changes in population dispersal patterns within the study area could also play a role. The OFS grasslands may serve as a drought refuge for the shelduck which may disperse into the Karoo, its major distribution area, following widespread rains there (SABAP, unpublished data).

Terrestrial species

Positive response to rainfall

Only the Cattle Egret *Bubulcus ibis* (Tarboton *et al.* 1987) and Laughing Dove *Streptopelia senegalensis* (Rowan 1983) of the 12 terrestrial species showing immediate positive responses to rainfall are known to undertake widespread movements, although the Speckled Pigeon may also be nomadic (Rowan 1983). This suggests that immigration was responsible for the observed increases in these species.

The implication is that increases in reporting rates of the other species are due to previously unsuspected movements, to enhanced breeding success, to increased conspicuousness, or to a combination of these factors. Increased conspicuousness is thought possibly relevant in only 4 species.

All of Swainson's Francolin *Francolinus swainsonii*, Helmeted Guineafowl *Numida meleagris* and Bokmakierie *Telophorus zeylonus* have distinctive and far-carrying advertising calls which may be more frequent during higher rainfall periods. White-browed Sparrow-weavers *Plocepasser mahali*, like Hamerkops, build conspicuous nests and it is also possible that this species appears on checklists from nests seen, in addition to sightings of the birds. If increased rainfall results in increased nest production the increased reporting rate may reflect more nests, rather than more sparrow-weavers.

Swainson's Francolin, Helmeted Guineafowl, Speckled Pigeon, Laughing Dove, and White-browed Sparrow-weaver, all of which were subject to increased reporting, are strongly associated with maize fields, where they feed on fallen seeds and other food (Grafton 1969, Ferguson 1983, Rowan 1983, Maclean 1985). Increased rainfall resulting in good maize production would probably benefit these species.

A feature of the list of terrestrial species which showed a positive response to rainfall, is that no less than 4 are known to be rapidly expanding in range and abundance in the OFS and elsewhere (Figure 4). These are Hadada *Bostrychia hagedash* (Macdonald *et al* 1986), Swainson's Francolin (Clancey 1965), Crested Barbet *Trachyphonus vaillantii* (Earlé and Grobler 1987, Heroldt and Earlé 1987, du Plessis 1989) and Indian Myna *Acridotheres tristis* (Earlé and Grobler 1987). Why these species in particular should display such fine-tuned responses to variations in rainfall is unclear and warrants further investigation.

Negative response to rainfall
The Secretary Bird *Sagittarius serpentarius*, Spike-heeled *Chersomanes albofasciata*, and Red-capped *Calandrella cinerea* Larks showed immediate negative responses to rainfall. This is not wholly unexpected as all 3 are known to be nomadic to some extent and to avoid the dense grasslands resulting from increased rainfall (Steyn 1982, Maclean 1985). The Spike-heeled Lark is always rare or absent in the highest rainfall, sour grasslands of eastern South Africa (SABAP, unpublished data). Changes in conspicuousness of these ground-dwelling species due to the masking effect of taller grass resulting from increased rainfall cannot, however, be ruled out as a contributory factor to changes in reporting rates.

The reasons for the negative response shown by the Lesser Kestrel *Falco naumanni* are unclear. Changes in conspicuousness due to vegetation cover or breeding activity can be ruled out for this obvious and non-breeding migrant which hunts from elevated perches and by hovering. It is possible the study area serves as a drought refuge for the species, which may spread into the adjacent Karoo following widespread rain. The Lesser Kestrel is reported to be undergoing a decrease in overall population size (Collar and Andrew 1988) but the current data show no obvious negative trend in the study area, probably due to the relatively inelastic nature of reporting rates for a conspicuous species and the short study period.

It is the results for these species which lend credence to the positive responses displayed by others, strongly suggesting that artifacts of unknown bias in data collection or analysis are not involved.

Reporting rate
Some limitations are inherent in the use of reporting rates as an index of relative abundance:

* they confound abundance/density with conspicuousness and identifiability (Temple and Temple 1984, Underhill *et al* 1992); and
* the relationship between reporting rate and absolute abundance/density is monotonic but not linear (Underhill *et al* 1992);

The implications of these limitations are, in the first case, that while the models can be compared qualitatively, it is not legitimate to do so in quantitative terms for different species unless they are equally observable and identifiable at all times and under all conditions. In the second case, simple multiples of reporting rates do not necessarily imply simple multiples in population size, although increases or decreases in reporting rates do indicate population changes in the same direction (Temple and Temple 1986b, Bruderer and Bruderer 1993).

An upward trend in checklist length with time -- an increase in the number of species recorded per list -- has been noted elsewhere (Temple and Temple 1976, Underhill and Hockey 1988) and is an obvious phenomenon in the SABAP databank. It is easily understood in terms of 3 observer-related trends:

* observers' skill at observing and identifying birds improves with time;
* many recruits fall out of large-scale projects, leaving a smaller body of enthusiastic and serious participants who produce relatively long lists; and
* as a project such as the SABAP progresses a more serious and goal-oriented attitude develops, leading to increased effort to produce lists of high quality (Underhill and Hockey 1988).

These factors tend to have a marked effect where there is no control for skill or effort employed in the compilation of checklists, as was the case in the SABAP. As reporting rate increases with increasing checklist length, a spurious upward trend in relative abundance tends to appear, requiring a correction/standardization procedure (Temple and Temple 1976). The effect of this phenomenon is not likely to be the same on different species and depends on relative observability and identifiability. Standardization was therefore based on a regression calculated separately for each species.

The reporting rate as an index of relative abundance has a long history but it has been under-rated and under-utilized as a technique for measuring relative abundance. The properties of reporting rates or "frequency of occurrence" were discussed, and an example of their application provided, a long time ago (Linsdale 1928, 1932) and their use strongly advocated. A search of the literature has, however, yielded few additional examples. It has been recognized that most bird census methods yield little more than a relative measure of abundance/density (Dawson 1981, Temple 1981) but there still appears to be resistance to using techniques which do not involve actual counts of individuals.

Some workers have employed the reporting rate index using "Timed Species Counts" to provide indices of relative abundance at different sites (Pomeroy and Tengecho 1986a, 1986b). These have then been used to interpret distributions in terms of habitat preferences. Reporting rates have been used in North America (Temple and Cary 1987) and used effectively to show spatial variation and seasonal changes in relative abundance within a species' range by plotting reporting rates against time of year (Temple and Temple 1986a). Comparison of such plots for 2 ecological regions of Wisconsin helped to elucidate the direction and timing of avian seasonal movements (Temple and Temple 1984).

Of particular relevance to this study is work in which reporting rates have been used to analyze time series, such as the checklists used to detect changes in relative abundance of 35 species in New York State (Temple and Temple 1976). Reporting rates have also been to describe year-to-year variations in migration phenology (Temple and Cary 1987) and to study nomadism in the Gull-billed Tern *Sterna nilotica* over a 5-yr period (Davies 1984) using reporting rates derived from checklists compiled for the Australian atlas (Blakers *et al* 1984). Population trends in rare birds have been described based on reporting rates in British county records (Mason 1990) although the study did not involve checklists as such.

The results in this paper would not be evident from presence/absence mapping alone as all species occur in all years but at different levels of relative abundance. The phenomena are relative and not absolute by nature and therefore a measure of abundance to detect and describe them. Ironically this need can be satisfied by simple presence/absence data compiled to produce reporting rates.

Conclusions

The body of work using reporting rates is small but the approach has repeatedly shown its usefulness in describing, and detecting trends in time in, relative abundance. A recurring theme in analyses of this type is the use of checklists and reporting rates as simple but useful tools in monitoring bird populations over large geographical areas and for a broad spectrum of species. More rigorous census techniques tend to be more limited in scope.

In this paper a method whereby a time series of reporting rate indices can be statistically correlated with an explanatory variable, namely rainfall, has been demonstrated.

In a North American context it has been suggested that "... checklist records can be of great value in elucidating long-term trends in bird populations..." (Temple and Temple 1976), and their collection in other regions advocated. The results presented in this paper support others (Macdonald 1992, Underhill *et al* 1992) which show that checklist-based projects are an appropriate technique for population monitoring in an African context.

The developing nations have a great need to monitor their wildlife populations in these times of rapid environmental change. In many cases, this has to be done in the absence of the basic information that is usually available in the developed world. It is therefore appropriate that data-collection protocols encourage the broadest geographic and taxonomic scope, while allowing sophisticated analysis of the data to monitor changes in relative abundance. The checklist and the reporting rate statistic appear eminently suited to this purpose, particularly if there is control for observer-related effects.

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THE DISTRIBUTION AND RELATIVE ABUNDANCE OF CRANES IN SOUTH AFRICA AS ASSESSED BY BIRD ATLAS DATA

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INTRODUCTION

A national conservation plan for cranes in South Africa requires information for each of the three species on its distribution and relative abundance in different parts of its range. This information should identify the regions with the highest concentrations of each species. In addition, an examination of the amount of geographical overlap between the three species should reveal the areas deserving the highest priority for conservation action, as they support significant populations of all three species. Distribution and relative abundance data for the three cranes (Wattled *Grus carunculatus*, Blue *Anthropoides paradisea* and Crowned *Balearica regulorum* Cranes) found in South Africa were extracted from the databank of the Southern African Bird Atlas Project and are presented and discussed here.

SOUTHERN AFRICAN BIRD ATLAS PROJECT (SABAP)

Two of the major aims of SABAP are to map the current distributions of all of southern Africa's bird species and to examine the relative abundance of each within its range, using reporting rates (Harrison 1989). The project encompasses all of the countries of southern Africa, except Mozambique, i.e. South Africa, including the dependent and independent 'homelands', Lesotho, Swaziland, Namibia, Botswana and Zimbabwe. Only data from South Africa, Lesotho and Swaziland, i.e. 'geographical South Africa' (Siegfried 1989), are presented here. Data collection was initiated in January 1987 and most of the data presented here are from the period 1987-1989 with a few records from 1990. Several local atlassing schemes, however, were already in existence at the time of SABAP's launch and the pre-1987 data in these schemes have been included here. For the eastern Cape therefore the period is extended back to 1985, for the Orange Free State to 1983, and for the southwestern Cape to 1982. All the data plotted in Figures 1-4 therefore are restricted to the period 1982-90.

Over 5000 voluntary observers had contributed to the project by December 1989. The *modus operandi* of the volunteer atlassers was to complete fieldcards for all the bird species recorded within the boundaries of a quarter degree square (ca 25 x 27 km) within the temporal boundaries of one calendar month. All the fieldcards used here have been vetted at least once by regional atlas committees. Cranes are easily and reliably identified to species and the distributional and relative abundance data presented here can be regarded as reliable.

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Reporting rates for each species, as discussed here and used as a measure of relative abundance, are the percentage of fieldcards from a quarter degree square that record the relevant species. It is assumed that a species is more common where its reporting rate is high than where it is low. The confidence in such conclusions increases with sample size, i.e. the number of fieldcards from each square. Reporting rates therefore pinpoint regions with the highest concentrations of cranes as opposed to other areas within their distribution where they are less frequent or even vagrant. Coverage of the regions within the ranges of all three species was considered adequate, except perhaps for the Transkei where there was a paucity of data from the inland areas of this region.

THE CURRENT DISTRIBUTION AND RELATIVE ABUNDANCE OF THE WATTLED, BLUE AND CROWNED CRANES IN SOUTH AFRICA

Figures 1-3 show the distribution of each species from SABAP records and their reporting rates per quarter degree square divided into three categories, i.e. less than 5% (low), 5-25% (medium), or 26-100% (high) of fieldcards from that square.

Figure 1 reveals little new about the distribution and abundance of the Wattled Crane, which has been the subject of intensive recent research, e.g. Vernon & Boshoff (1986) and Tarboton, Barnes & Johnson (1987). The close match between the known distribution and the SABAP map for this species, however, greatly increases the credibility of the maps for the Blue and Crowned Cranes, whose distribution and abundance have been less intensively investigated.

Figure 2 shows the Blue Crane to be widely distributed, with three separate areas of relatively high population density. These are the wheat and small-stock farming areas of the coastal plain between Caledon and Mossel Bay in the southern Cape, the eastern Karoo, and the sour grasslands in the area where the southeastern Transvaal, eastern Orange Free State and northwestern Natal abut. Another less obvious but possibly significant area of concentration is along the eastern foothills of the Drakensberg in Natal and the eastern Cape.

A surprising feature of the Blue Crane map is the relative scarcity of this species in the arid grasslands of the western Transvaal and central Orange Free State. This area corresponds with the most intensive maize farming regions of South Africa. The species has probably decreased in this large region due to disturbance, habitat loss and, perhaps especially, poisoning. The Blue Crane is also virtually entirely absent from the Transkei. Its distribution skirts the political boundaries of this region, which suggests that the species is excluded from the Transkei by persecution, disturbance or habitat degradation. In contrast the Crowned Crane is recorded from many quarter degree squares in the Transkei, frequently at high reporting rates, which confirms the absence of the Blue Crane as real and not an artifact of insufficient coverage of this area. The Crowned Crane (but presumably not the Blue Crane) receives a measure of protection from persecution in the Transkei due to local superstition (Quickelberge 1989).

The Crowned Crane is concentrated in the far eastern Cape, Transkei, western Natal, especially in the southwest, far eastern Orange Free State and the southeastern Transvaal. All three species are absent or rare in Lesotho and Swaziland.

Figure 4 shows the quarter degree squares where Blue and Crowned Cranes have high reporting rates and where Wattled Cranes have medium to high reporting rates. The areas where all three species overlap geographically, all with medium to high reporting rates, lie within the high, moist, sour grasslands and associated wetlands of the greater Drakensberg foothills and attendant escarpment areas. The high degree of overlap, at relatively high abundance, of all three species in these areas indicates the importance of these highly threatened grasslands and wetlands as habitat for all three cranes.

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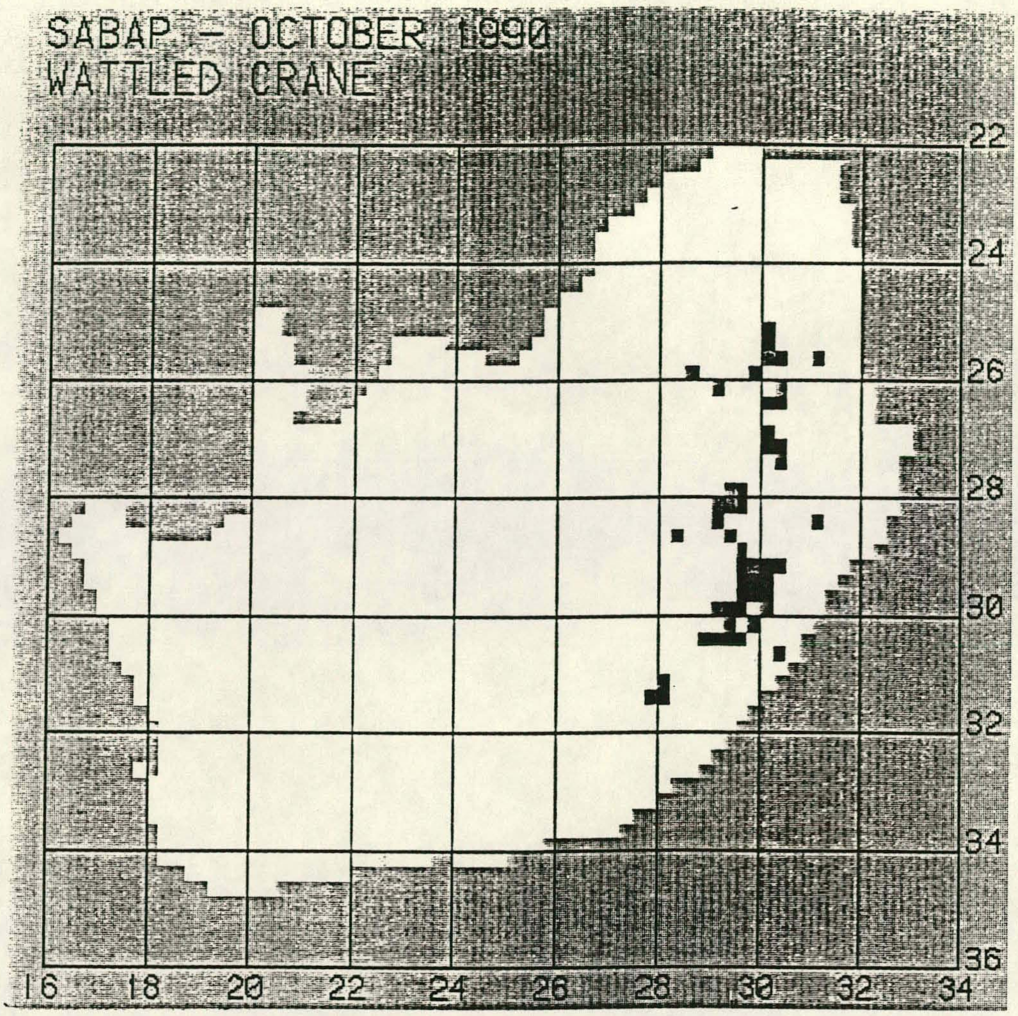

FIGURE 1: The distribution of the Wattled Crane according to SABAP data. The different shades indicate different reporting rates as follows :

light grey	:	< 5%
dark grey	:	5% - 25%
black	:	25% - 100%
white	:	no records

The percentages represent the proportion of field cards which record the species.

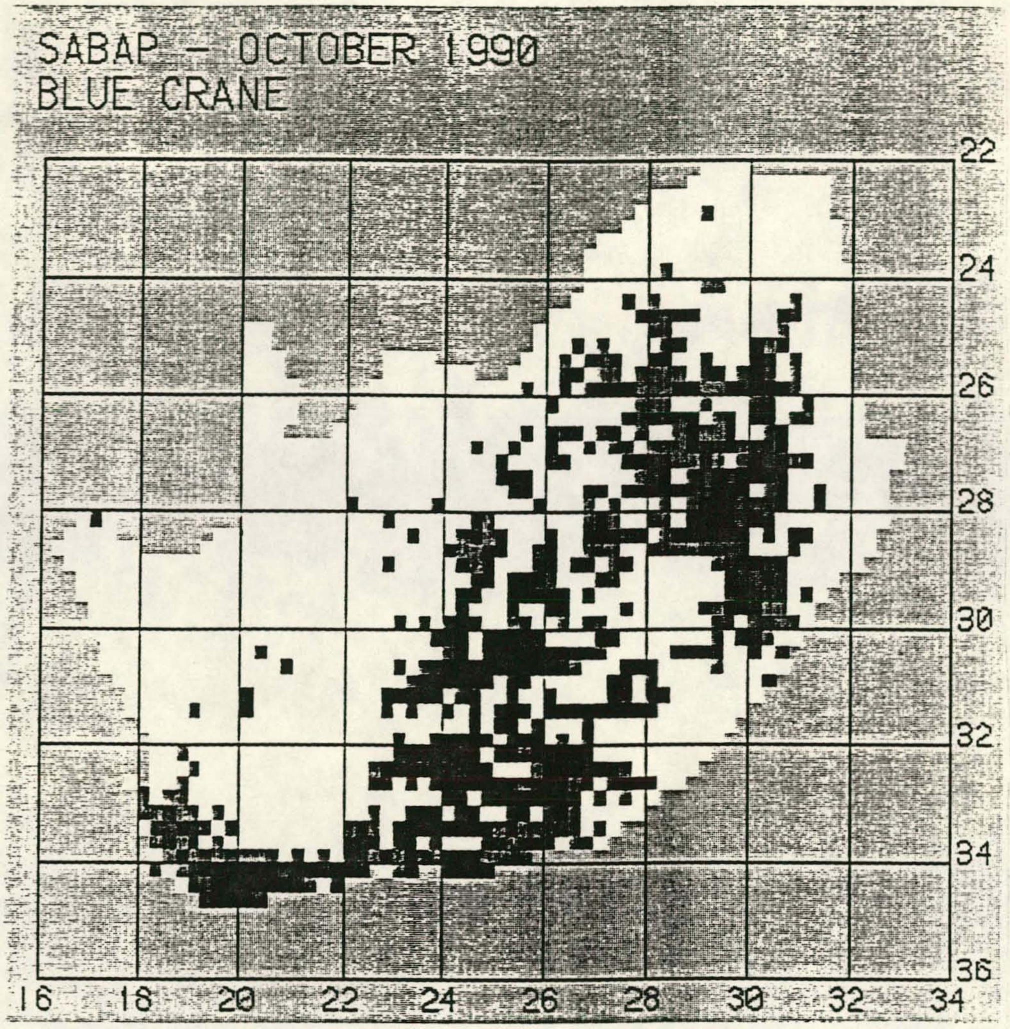

FIGURE 2: The distribution of the Blue Crane according to SABAP data. The different shades indicate different reporting rates as follows :

light grey	:	< 5%
dark grey	:	5% - 25%
black	:	25% - 100%
white	:	no records

The percentages represent the proportion of field cards which record the species.

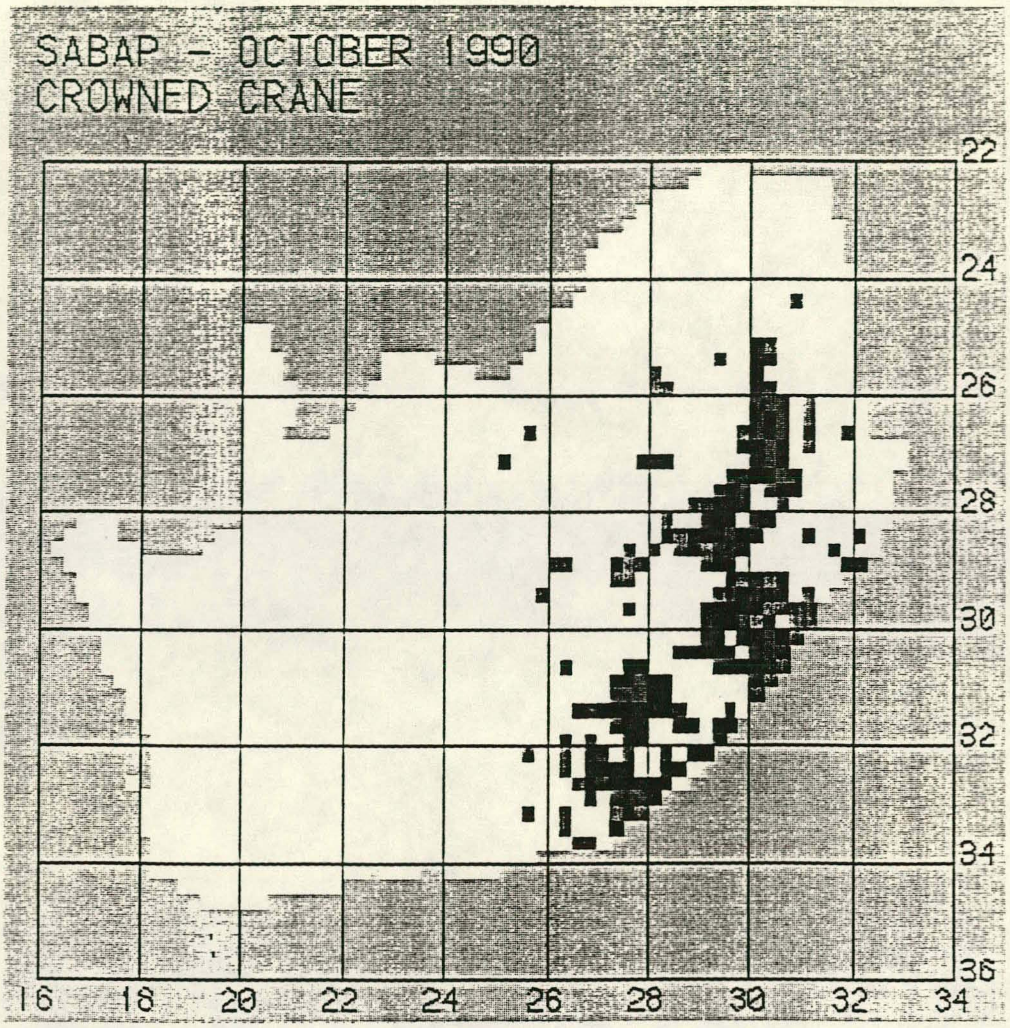

FIGURE 3: The distribution of the Crowned Crane according to SABAP data. The different shades indicate different reporting rates as follows :

light grey	:	< 5%
dark grey	:	5% - 25%
black	:	25% - 100%
white	:	no records

The percentages represent the proportion of field cards which record the species.

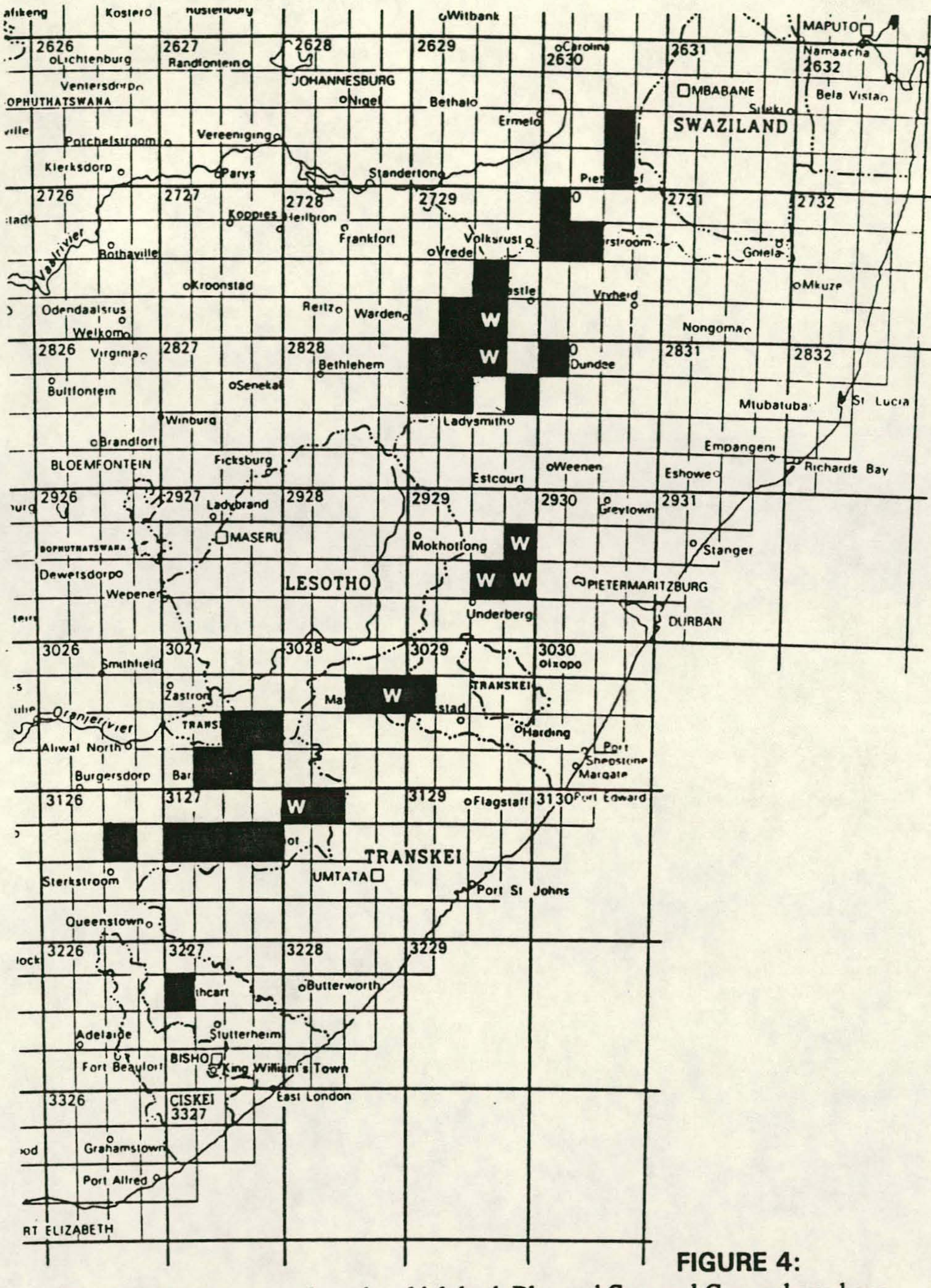

FIGURE 4:

The shaded squares are those in which both Blue and Crowned Cranes have been recorded at high reporting rates (25 - 100%). Those marked with a 'W' are those which also have Wattled Crane reported at medium to high rates (5 - 100%).

HABITAT TYPE	MAR	PEL	SHO	AQU	LOT	REX	REM	ROP	LAC	WEX	WEM	WOP	ROC	FOR	COA	MON	EDG	WOO	IND	ACA	BRO	THI	RIV	GRA	NAT	SWE	SOU	MOI	SCR	FYN	KAR	UNC	EXT
HIERARCHY LEVEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
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SPECIES																																	
CAPE SUGARBIRD..773	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	I	-	-	-
MALACHITE SUNBIRD..775	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-
ORANGBRSTD SUNBIRD..777	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	I	-	-	-
LSR DBLCLR SUNBIRD..783	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-
CAPE WHITE-EYE..796	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-
HOUSE SPARROW..801	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
CAPE SPARROW..803	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
CAPE WEAVER..813	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-
MASKED WEAVER..814	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
RED BISHOP..824	-	-	-	A	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YELLOWRUMPED WIDOW..827	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	A	A	A	-	-	-
COMMON WAXBILL..846	-	-	-	A	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PINTAILED WHYDAH..860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
CHAFFINCH..868	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
CAPE CANARY..872	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
CAPE SISKIN..874	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	I	-	-	-
BULLY CANARY..877	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
YELLOW CANARY..878	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	A	A	A	-	-
WHITETHRTED CANARY..879	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A	-	-
CAPE BUNTING..885	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	A	-	-	-	-
(R126)YLLWBLL KITE..888	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
MALLARD..891	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Summary statistics for square

Frequency of Species Recorded	Indicators No.	Indicators %	Associates No.	Associates %	Total No.	Total %
Marine	34	77	15	83	49	79
Marine Pelagic	17	81	1	100	18	82
Marine Shore	10	67	12	80	22	73
Aquatic	48	56	28	61	76	58
Aquatic Lotic	1	11	41	61	42	55
Wetland Lotic Exposed Shore	0	0	7	88	7	70
Wetland Lotic Emergent Vegetat	0	0	13	43	13	41
Aquatic Lotic Open Water	1	25	9	75	10	63
Wetland Lacustrine	22	59	51	61	73	61
Wetland Lacustrine Exposed Sho	0	0	14	88	14	82
Wetland Lacustrine Emergent Ve	5	33	18	43	23	40
Aquatic Lacustrine Open Water	7	88	17	81	24	83
Montane and Rocky	6	30	5	50	11	37
Forest	2	7	12	16	14	14
Forest Edge	0	0	3	13	3	12
Woodland	8	5	16	13	24	8
Woodland Indigenous	0	0	5	5	5	3
Woodland Indigenous Thicket	0	0	4	13	4	13
Woodland Indigenous Riverine	0	0	2	5	2	5
Grassland	5	16	17	26	22	22
Grassland Natural	0	0	8	27	8	16
Grassland Natural Sour	0	0	3	50	3	18
Grassland Natural Moist	0	0	2	25	2	18
Scrub	8	29	20	38	28	35
Scrub Fynbos	3	50	11	100	14	82
Scrub Karoo	0	0	7	25	7	17
Unclassified	0	0	43	60	43	60

Total of raptor species..... 18
Total of breeding species... 147
Total of all species........ 320

HABITAT TYPE	MAR	PEL	SHO	AQU	LOT	REX	REM	ROP	LAC	WEX	WEM	WOP	ROC	FOR	COA	MON	EDG	WOO	IND	ACA	BRO	THI	RIV	GRA	NAT	SWE	SOU	MOI	SCR	FYN	KAR	UNC	EXT
HIERARCHY LEVEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
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SPECIES																																	
BURCHELL'S COUCAL..391	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-
BARN OWL..392	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
MARSH OWL..395	-	-	-	A	-	-	-	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	-	-	-	-	-
CAPE EAGLE OWL..400	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPOTTED EAGLE OWL..401	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
FIERYNCK NIGHTJAR..405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK SWIFT..412	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
WHITERUMPED SWIFT..415	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
LITTLE SWIFT..417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
ALPINE SWIFT..418	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
SPECKLED MOUSEBIRD..424	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHTEBCKD MOUSEBIRD..425	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REDFACED MOUSEBIRD..426	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PIED KINGFISHER..428	-	-	-	A	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GIANT KINGFISHER..429	-	-	-	A	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MLCHITE KINGFISHER..431	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOOPOE..451	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PIED BARBET..465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LESSER HONEYGUIDE..476	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GROUND WOODPECKER..480	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLAPPER LARK..495	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	A	-	-	-	-
REDCAPPED LARK..507	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	A	-	A	-	-
EUROPEAN SWALLOW..518	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
WHITETHRTD SWALLOW..520	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRTR STRPD SWALLOW..526	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	A	-	-	-	-
ROCK MARTIN..529	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOUSE MARTIN..530	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
BROWNTHRTED MARTIN..533	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLK SAWWNG SWALLOW..536	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK CROW..547	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
PIED CROW..548	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
WHITENECKED RAVEN..550	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE BULBUL..566	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-
SOMBRE BULBUL..572	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-
OLIVE THRUSH..577	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE ROCK THRUSH..581	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SENTNL ROCK THRUSH..582	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	A	A	-	A	-	A	A	-	-	-
FAMILIAR CHAT..589	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
STONECHAT..596	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	A	-	-	-	-
CAPE ROBIN..601	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-
KAROO ROBIN..614	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	A	A	-	-
AFR MARSH WARBLER..631	-	-	-	A	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE REED WARBLER..635	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AFR SEDGE WARBLER..638	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BARTHROATED APALIS..645	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	A	-	-	A	-	-	-	-	-	-	A	A	-	-	-
LONGBILLED CROMBEC..651	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-
GRASSBIRD..661	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	A	-	A	A	-	-	-
FANTAILD CISTICOLA..664	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-
CLOUD CISTICOLA..666	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-
GREYBCKD CISTICOLA..669	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	A	A	-	-
LEVAILNT CISTICOLA..677	-	-	-	A	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	A	-	-	-	-	-
NEDDICKY..681	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-
SPOTTED PRINIA..686	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	A	-	-
DUSKY FLYCATCHER..690	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FISCAL FLYCATCHER..698	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE BATIS..700	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PARADSE FLYCATCHER..710	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-
CAPE WAGTAIL..713	-	-	-	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RICHARD'S PIPIT..716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-
PLAINBACKED PIPIT..718	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-
ORNGTHRTD LONGCLAW..727	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-
FISCAL SHRIKE..732	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
SOUTHERN BOUBOU..736	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-
BOKMAKIERIE..746	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-
EUROPEAN STARLING..757	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
PIED STARLING..759	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
WATTLED STARLING..760	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
REDWINGED STARLING..769	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HABITAT TYPE	MAR	PEL	SHO	AQU	LOT	REX	REM	ROP	LAC	WEX	WEM	WOP	ROC	FOR	COA	MON	EDG	WOO	IND	ACA	BRO	THI	RIV	GRA	NAT	SWE	SOU	MOI	SCR	FYN	KAR	UNC	EXT
HIERARCHY LEVEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
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SPECIES																																	
JACKAL BUZZARD..152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
REDBRS SPARROWHAWK..155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
AFRICAN GOSHAWK..160	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AFR MARSH HARRIER..165	-	-	-	I	-	-	-	-	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OSPREY..170	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PEREGRINE FALCON..171	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LANNER FALCON..172	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
ROCK KESTREL..181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
GREYWING FRANCOLIN..190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	-	-	A	-	-	-	-
CAPE FRANCOLIN..195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	A	A	-	-
HELMETD GUINEAFOWL..203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
AFRICAN RAIL..210	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK CRAKE..213	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRIPED FLUFFTAIL..221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	A	-	A	-	A	A	-	-	-
PURPLE GALLINULE..223	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOORHEN..226	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REDKNOBBED COOT..228	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PAINTED SNIPE..242	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A BK OYSTERCATCHER..244	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RINGED PLOVER..245	A	-	A	A	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITEFRONTD PLOVER..246	A	-	A	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KITTLITZ'S PLOVER..248	-	-	-	A	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THREEBANDED PLOVER..249	-	-	-	I	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREY PLOVER..254	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CROWNED PLOVER..255	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-
BLACKSMITH PLOVER..258	-	-	-	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TURNSTONE..262	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COMMON SANDPIPER..264	A	-	A	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WOOD SANDPIPER..266	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARSH SANDPIPER..269	-	-	-	I	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREENSHANK..270	A	-	A	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KNOT..271	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CURLEW SANDPIPER..272	A	-	A	A	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LITTLE STINT..274	A	-	A	A	-	-	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SANDERLING..281	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RUFF..284	-	-	-	I	-	-	-	-	I	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ETHIOPIAN SNIPE..286	-	-	-	I	-	-	-	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CURLEW..289	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHIMBREL..290	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AVOCET..294	-	-	-	I	-	-	-	-	I	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACKWINGED STILT..295	-	-	-	I	-	-	-	-	I	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPOTTED DIKKOP..297	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
WATER DIKKOP..298	A	-	A	A	A	A	-	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARCTIC SKUA..307	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POMARINE SKUA..309	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUBANTARCTIC SKUA..310	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KELP GULL..312	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREYHEADED GULL..315	A	-	A	A	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HARTLAUB'S GULL..316	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SABINE'S GULL..318	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CASPIAN TERN..322	A	-	A	A	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SWIFT TERN..324	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SANDWICH TERN..326	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COMMON TERN..327	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARCTIC TERN..328	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANTARCTIC TERN..329	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHISKERED TERN..338	-	-	-	I	-	-	-	-	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITEWINGED TERN..339	-	-	-	A	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-
FERAL PIGEON..348	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
ROCK PIGEON..349	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
RAMERON PIGEON..350	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REDEYED DOVE..352	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE TURTLE DOVE..354	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
LAUGHING DOVE..355	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
NAMAQUA DOVE..356	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
REDCHESTED CUCKOO..377	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KLAAS'S CUCKOO..385	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DIEDERIK CUCKOO..386	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	-	-	-	-	-	-	-	-	-

SUMMARY TABLE **

The table below summarizes the information given above in a format which may be more convenient to some users. "A" denotes associate, "I" indicator and "X" unclassified species.

HABITAT TYPE	MAR	PEL	SHO	AQU	LOT	REX	REM	ROP	LAC	WEX	WEM	WEP	ROC	FOR	CRA	MON	EDG	WOO	IND	ACA	BRO	THI	RIV	GRA	NAT	SWE	SOU	MOI	SCR	FYN	KAR	UNC	EXT
HIERARCHY LEVEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
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SPECIES																																	
OSTRICH..001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
JACKASS PENGUIN..003	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GRT CRESTED GREBE..006	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACK-NECKED GREBE..007	A	A	-	A	-	-	-	-	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DABCHICK..008	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SHY ALBATROSS..011	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLKBROWD ALBATROSS..012	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YELLWNSE ALBATROSS..014	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STHRN GIANT PETREL..017	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NTHRN GIANT PETREL..018	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PINTADO PETREL..021	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOFTPLUMAGD PETREL..024	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BROADBILLED PRION..029	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITECHINND PETREL..032	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CORY'S SHEARWATER..034	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREAT SHEARWATER..035	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOOTY SHEARWATER..037	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITE PELICAN..049	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE GANNET..053	I	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITBRST CORMORANT..055	A	-	-	A	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE CORMORANT..056	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BANK CORMORANT..057	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REED CORMORANT..058	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CROWNED CORMORANT..059	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DARTER..060	-	-	-	I	A	-	-	A	A	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREY HERON..062	A	-	A	A	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACKHEADED HERON..063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
PURPLE HERON..065	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREAT WHITE EGRET..066	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LITTLE EGRET..067	A	-	A	A	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YELLOWBILLED EGRET..068	-	-	-	I	-	-	-	-	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CATTLE EGRET..071	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
BLKCRN NIGHT HERON..076	A	-	-	A	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LITTLE BITTERN..078	-	-	-	I	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HAMERKOP..081	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITE STORK..083	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
BLACK STORK..084	-	-	-	A	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SACRED IBIS..091	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
GLOSSY IBIS..093	-	-	-	I	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HADEDA IBIS..094	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
AFRICAN SPOONBILL..095	-	-	-	I	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GREATER FLAMINGO..096	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LESSER FLAMINGO..097	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITEFACED DUCK..099	-	-	-	I	A	-	-	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHITEBACKED DUCK..101	-	-	-	I	-	-	-	-	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EGYPTIAN GOOSE..102	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S AFRICAN SHELDUCK..103	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
YELLOWBILLED DUCK..104	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AFRICAN BLACK DUCK..105	-	-	-	I	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE TEAL..106	-	-	-	I	-	-	-	-	I	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOTTENTOT TEAL..107	-	-	-	I	-	-	-	-	I	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REDBILLED TEAL..108	-	-	-	I	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAPE SHOVELLER..112	-	-	-	I	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOUTHERN POCHARD..113	-	-	-	I	-	-	-	-	I	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPURWINGED GOOSE..116	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MACCOA DUCK..117	-	-	-	I	-	-	-	-	I	-	A	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BLACKSHOULDRD KITE..127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
BLACK EAGLE..131	-	-	-	-	-	-	-	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BOOTED EAGLE..136	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
AFRICAN FISH EAGLE..148	-	-	-	I	A	-	-	-	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STEPPE BUZZARD..149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-

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           BARN OWL..392 (  95) (RB) (BREEDING)
  SPOTTED EAGLE OWL..401 ( 385) (RB) (BREEDING)
        BLACK SWIFT..412 ( 593) (IB) (BREEDING)
   WHITERUMPED SWIFT..415 ( 311) (IB) (BREEDING)
       LITTLE SWIFT..417 ( 364) (IB) (BREEDING)
       ALPINE SWIFT..418 ( 552) (IB)
   EUROPEAN SWALLOW..518 ( 416) (PN)
       HOUSE MARTIN..530 (  22) (PN)                  (RED DATA - INDETERMINATE)
         BLACK CROW..547 (  28) (RB)            (E4)
          PIED CROW..548 ( 456) (RB) (BREEDING)
       FAMILIAR CHAT..589 ( 489) (RB) (BREEDING)  (E4)
       FISCAL SHRIKE..732 (1184) (RB) (BREEDING)  (E4)
   EUROPEAN STARLING..757 (1282) (RB) (BREEDING)
       PIED STARLING..759 (  23) (RB)             (E1)
    WATTLED STARLING..760 (  22) (RB)
       HOUSE SPARROW..801 ( 557) (RB) (BREEDING)
        CAPE SPARROW..803 ( 959) (RB) (BREEDING)  (E2)
       MASKED WEAVER..814 ( 316) (RB) (BREEDING)  (E4)
    PINTAILED WHYDAH..860 ( 208) (RB) (BREEDING)  (E4)
           CHAFFINCH..868 ( 103) (RB) (BREEDING)
         CAPE CANARY..872 ( 886) (RB) (BREEDING)  (E4)
        BULLY CANARY..877 ( 490) (RB) (BREEDING)  (E4)
 (R126)YLLWBLL KITE..888 (  24) (IB)              (M2)
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RELEGATION FACTOR: This report attempts to describe the avifauna of an area in terms of those species which are resident or regular visitors. In order to eliminate species which are probably only vagrants to the area, any species with a reporting rate (see standard Ph2 listing for definition of reporting rate) of less than that printed below, has been omitted from the previous lists but is listed below. Note that it is possible that some of these may be resident but very rare and/or very inconspicuous as opposed to vagrant.

Relegation factor = 1.0%

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WANDERNG ALBATROSS..010     DKML STY ALBATROSS..015     ANTARCTIC FULMAR..019
GREATWINGED PETREL..023     ATLANTIC PETREL..026        BLUE PETREL..028
SLENDERBILLD PRION..030     FLESHFT SHEARWATER..036     MANX SHEARWATER..038
LITTLE SHEARWATER..039      EURPN STORM PETREL..042     LEACH STORM PETREL..043
WILSN STORM PETREL..044     REDTAIL TROPICBIRD..047     SQUACCO HERON..072
SECRETARYBIRD..118          HONEY BUZZARD..130          LONGCRESTED EAGLE..139
MARTIAL EAGLE..140          FOREST BUZZARD..150         LITTLE SPARROWHAWK..157
BLACK SPARROWHAWK..158      BLACK HARRIER..168          GYMNOGENE..169
HOBBY FALCON..173           LESSER KESTREL..183         COMMON QUAIL..200
BLUE CRANE..208             REDCHSTD FLUFFTAIL..217     AMR PRPL GALLINULE..225
BLACK KORHAAN..239          AFRICAN JACANA..240         CHESTNUTBND PLOVER..247
SAND PLOVER..251            TEREK SANDPIPER..263        BAIRD'S SANDPIPER..278
BARTAILED GODWIT..288       GREY PHALAROPE..291         REDNECKD PHALAROPE..292
LONGTAILED SKUA..308        ROSEATE TERN..330           DAMARA TERN..334
LITTLE TERN..335            BLACK TERN..337             TAMBOURINE DOVE..359
CINNAMON DOVE..360          ROSYFACED LOVEBIRD..367     WOOD OWL..394
FRECKLED NIGHTJAR..408      HORUS SWIFT..416            HLFCLRD KINGFISHER..430
BRWNHD KINGFISHER..435      EUROPEAN BEE-EATER..438     OLIVE BEE-EATER..439
BLUECHKD BEE-EATER..440     WHTFRNT BEE-EATER..443      EUROPEAN ROLLER..446
SMTRBLD WOODHOOPOE..454     GREATER HONEYGUIDE..474     CARDINL WOODPECKER..486
OLIVE WOODPECKER..488       LONGBILLED LARK..500        THICKBILLED LARK..512
GREYBCKD FINCHLARK..516     PEARLBRSTD SWALLOW..523     LSR STRIPD SWALLOW..527
SAND MARTIN..532            BANDED MARTIN..534          BLACK CUCKOOSHRIKE..538
FORKTAILED DRONGO..541      CAPE PENDULINE TIT..557     REDEYED BULBUL..567
MOUNTAIN CHAT..586          CAPPED WHEATEAR..587        SICKLEWING CHAT..591
ANTEATING CHAT..595         CAPE ROCKJUMPER..611        TITBABBLER..621
ICTERINE WARBLER..625       KNYSNA WARBLER..640         WILLOW WARBLER..643
SPOTTED FLYCATCHER..689     BLUEMTL FLYCATCHER..708     AFR PIED WAGTAIL..711
YELLOW WAGTAIL..714         GREY WAGTAIL..715           LONGBILLED PIPIT..717
REDBACKED SHRIKE..733       BRUBRU..741                 GLOSSY STARLING..764
PALEWINGD STARLING..770     GTR DBLCLR SUNBIRD..785     DUSKY SUNBIRD..788
BLACK SUNBIRD..792          FOREST CANARY..873          PROTEA CANARY..880
STREAKYHDED CANARY..881     LARKLIKE BUNTING..887       BUDGERIGAR..890
SHEATHBILL..899
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          GRASSBIRD..661 ( 545) (RB) (BREEDING)  (E2)
      SPOTTED PRINIA..686 (1105) (RB) (BREEDING)  (E2)
   MALACHITE SUNBIRD..775 ( 687) (RB) (BREEDING)  (E4)
  LSR DBLCLR SUNBIRD..783 ( 900) (RB) (BREEDING)  (E1)
      CAPE WHITE-EYE..796 (1216) (RB) (BREEDING)  (E2)
 YELLOWRUMPED WIDOW..827 ( 391) (RB) (BREEDING)  (E4)
       YELLOW CANARY..878 ( 190) (RB) (BREEDING)  (E2)
 WHITETHRTED CANARY..879 (  25) (RB) (BREEDING)  (E2)
        CAPE BUNTING..885 ( 393) (RB) (BREEDING)  (E3)

            - FYNBOS SECONDARY CATEGORY

Birds of fynbos (macchia) scrub.

******INDICATORS******

      CAPE SUGARBIRD..773 ( 600) (RB) (BREEDING)  (E1)
  ORANGBRSTD SUNBIRD..777 ( 652) (RB) (BREEDING)  (E1)
         CAPE SISKIN..874 ( 184) (RB)             (E1)

******ASSOCIATES******

      CAPE FRANCOLIN..195 ( 984) (RB) (BREEDING)  (E1)
   STRIPED FLUFFTAIL..221 (  17) (RB)             (E4) (RED DATA - RARE)
  SENTNL ROCK THRUSH..582 (  29) (RB) (BREEDING)  (E1)
          CAPE ROBIN..601 (1143) (RB) (BREEDING)  (E4)
         KAROO ROBIN..614 ( 115) (RB) (BREEDING)  (E2)
  BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)  (E4)
           GRASSBIRD..661 ( 545) (RB) (BREEDING)  (E2)
  GREYBCKD CISTICOLA..669 ( 288) (RB) (BREEDING)  (E2)
      SPOTTED PRINIA..686 (1105) (RB) (BREEDING)  (E2)
 YELLOWRUMPED WIDOW..827 ( 391) (RB) (BREEDING)  (E4)
       YELLOW CANARY..878 ( 190) (RB) (BREEDING)  (E2)

            - KAROO SECONDARY CATEGORY

Birds of succulent and Nama Karoo scrub.

******ASSOCIATES******

      CAPE FRANCOLIN..195 ( 984) (RB) (BREEDING)  (E1)
      REDCAPPED LARK..507 (  66) (RB) (BREEDING)
         KAROO ROBIN..614 ( 115) (RB) (BREEDING)  (E2)
  GREYBCKD CISTICOLA..669 ( 288) (RB) (BREEDING)  (E2)
      SPOTTED PRINIA..686 (1105) (RB) (BREEDING)  (E2)
       YELLOW CANARY..878 ( 190) (RB) (BREEDING)  (E2)
 WHITETHRTED CANARY..879 (  25) (RB) (BREEDING)  (E2)

UNCLASSIFIED CATEGORY ********************************************

 Birds associated primarily with man-made habitats and species whose
 habitat requirements are either too general or too varied or too
 difficult to define, to be used here.

             OSTRICH..001 ( 173) (RB) (BREEDING)
   BLACKHEADED HERON..063 ( 775) (RB) (BREEDING)
        CATTLE EGRET..071 (1017) (RB) (BREEDING)
         WHITE STORK..083 (  32) (PN)             (M4) (RED DATA - RARE)
         SACRED IBIS..091 ( 662) (RB) (BREEDING)
         HADEDA IBIS..094 (  35) (RB)             (E4)
  BLACKSHOULDRD KITE..127 (1006) (RB) (BREEDING)
        BOOTED EAGLE..136 (  18) (PN)             (M )
      STEPPE BUZZARD..149 ( 413) (PN)
      JACKAL BUZZARD..152 ( 246) (RB)             (E2)
  REDBRS SPARROWHAWK..155 ( 253) (RB) (BREEDING)  (E4)
       LANNER FALCON..172 (  63) (RB)
        ROCK KESTREL..181 ( 635) (RB) (BREEDING)
  HELMETD GUINEAFOWL..203 ( 926) (RB) (BREEDING)
      SPOTTED DIKKOP..297 ( 824) (RB) (BREEDING)  (E4)
        FERAL PIGEON..348 ( 602) (RB) (BREEDING)
         ROCK PIGEON..349 ( 888) (RB) (BREEDING)  (E4)
    CAPE TURTLE DOVE..354 (1232) (RB) (BREEDING)  (E4)
       LAUGHING DOVE..355 (1231) (RB) (BREEDING)
        NAMAQUA DOVE..356 (  19) (RB)
```

- NATURAL GRASSLAND SECONDARY CATEGORY

Birds of primary natural grasslands excluding pastures, lawns, airfields, cultivated lands etc. Range from semi-arid to moist grasslands and may include grassy patches within other habitats. Includes sweet and sour and mixed grasslands.

******ASSOCIATES******

```
    GREYWING FRANCOLIN..190 ( 216) (RB)              (E4)
     STRIPED FLUFFTAIL..221 (  17) (RB)              (E4) (RED DATA - RARE)
             MARSH OWL..395 (  60) (RB) (BREEDING)
    SENTNL ROCK THRUSH..582 (  29) (RB) (BREEDING)   (E1)
             GRASSBIRD..661 ( 545) (RB) (BREEDING)   (E2)
    LEVAILNT CISTICOLA..677 ( 702) (RB) (BREEDING)   (E4)
    YELLOWRUMPED WIDOW..827 ( 391) (RB) (BREEDING)   (E4)
          CAPE BUNTING..885 ( 393) (RB) (BREEDING)   (E3)
```

- SOUR TERTIARY CATEGORY

Birds of sour (high rainfall, often montane) natural grassland.

******ASSOCIATES******

```
     STRIPED FLUFFTAIL..221 (  17) (RB)              (E4) (RED DATA - RARE)
    SENTNL ROCK THRUSH..582 (  29) (RB) (BREEDING)   (E1)
             GRASSBIRD..661 ( 545) (RB) (BREEDING)   (E2)
```

- MOIST TERTIARY CATEGORY

Birds of natural grasslands which are distinctly wet to marshy in the rainy season.

******ASSOCIATES******

```
    LEVAILNT CISTICOLA..677 ( 702) (RB) (BREEDING)   (E4)
    YELLOWRUMPED WIDOW..827 ( 391) (RB) (BREEDING)   (E4)
```

SCRUB HABITATS - PRIMARY CATEGORY **

Birds of scrubby (woody shrubs) vegetation including Karoo scrub, fynbos, strandveld and the characteristic scrub of hillslopes and kloofs. Excludes the relatively tall thornbush to be found in watercourses in the Karoo and Kalahari which falls under woodland.

******INDICATORS******

```
        CAPE FRANCOLIN..195 ( 984) (RB) (BREEDING)   (E1)
           KAROO ROBIN..614 ( 115) (RB) (BREEDING)   (E2)
    GREYBCKD CISTICOLA..669 ( 288) (RB) (BREEDING)   (E2)
              NEDDICKY..681 ( 237) (RB) (BREEDING)   (E4)
           BOKMAKIERIE..746 ( 994) (RB) (BREEDING)   (E2)
        CAPE SUGARBIRD..773 ( 600) (RB) (BREEDING)   (E1)
    ORANGBRSTD SUNBIRD..777 ( 652) (RB) (BREEDING)   (E1)
           CAPE SISKIN..874 ( 184) (RB)              (E1)
```

******ASSOCIATES******

```
    GREYWING FRANCOLIN..190 ( 216) (RB)              (E4)
     STRIPED FLUFFTAIL..221 (  17) (RB)              (E4) (RED DATA - RARE)
          CLAPPER LARK..495 (  40) (RB) (BREEDING)   (E2)
        REDCAPPED LARK..507 (  66) (RB) (BREEDING)
    GRTR STRPD SWALLOW..526 ( 457) (IB) (BREEDING)   (M2)
           CAPE BULBUL..566 (1124) (RB) (BREEDING)   (E1)
    SENTNL ROCK THRUSH..582 (  29) (RB) (BREEDING)   (E1)
             STONECHAT..596 ( 147) (RB) (BREEDING)
            CAPE ROBIN..601 (1143) (RB) (BREEDING)   (E4)
    BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)   (E4)
    LONGBILLED CROMBEC..651 (  87) (RB) (BREEDING)   (E3)
```

- INDIGENOUS SECONDARY CATEGORY

Birds of indigenous woodland where indigenous trees form a more or less discontinuous canopy and have understories which are usually dominated by grass. Includes wooded habitats refered to as woodland, savannah, thornveld, bushveld, mixed woodland, etc. Birds of the relatively tall, thorny vegetation found along arid watercourses would be included here or in the Acacia sub-sub-category.

******ASSOCIATES******

```
     BURCHELL'S COUCAL..391 ( 560) (RB) (BREEDING)
         SOMBRE BULBUL..572 ( 356) (RB) (BREEDING)  (E4)
    BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)  (E4)
    PARADSE FLYCATCHER..710 ( 223) (IB) (BREEDING)
       SOUTHERN BOUBOU..736 ( 801) (RB) (BREEDING)  (E2)
```

- THICKET TERTIARY CATEGORY

Birds of tall woody vegetation forming dense, impenetrable tangles and lacking a clearly defined canopy and understory.

******ASSOCIATES******

```
     BURCHELL'S COUCAL..391 ( 560) (RB) (BREEDING)
    BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)  (E4)
    PARADSE FLYCATCHER..710 ( 223) (IB) (BREEDING)
       SOUTHERN BOUBOU..736 ( 801) (RB) (BREEDING)  (E2)
```

- RIVERINE SECONDARY CATEGORY

Birds of tall riverine woodland typical of the banks of larger rivers in the northern parts of the country, also termed riverine forest.

******ASSOCIATES******

```
         SOMBRE BULBUL..572 ( 356) (RB) (BREEDING)  (E4)
    PARADSE FLYCATCHER..710 ( 223) (IB) (BREEDING)
```

GRASSLAND HABITATS - PRIMARY CATEGORY **********************************

Birds of open grassland, including cleared areas in woodland and cultivated pastures, lawns, airfields. Also includes birds using agricultural crop fields, eg. maize, wheat, sugarcane, etc., in otherwise wooded, fynbos karoo or other habitats.

******INDICATORS******

```
        CROWNED PLOVER..255 ( 789) (RB) (BREEDING)  (E4)
    FANTAILD CISTICOLA..664 (  88) (RB) (BREEDING)
       RICHARD'S PIPIT..716 ( 167) (RB) (BREEDING)
     PLAINBACKED PIPIT..718 (  87) (RB) (BREEDING)  (E4)
    ORNGTHRTD LONGCLAW..727 ( 375) (RB) (BREEDING)  (E2)
```

******ASSOCIATES******

```
    GREYWING FRANCOLIN..190 ( 216) (RB)             (E4)
     STRIPED FLUFFTAIL..221 (  17) (RB)             (E4) (RED DATA - RARE)
      WHITEWINGED TERN..339 ( 192) (PN)
       DIEDERIK CUCKOO..386 (  49) (IB)
             MARSH OWL..395 (  60) (RB) (BREEDING)
          CLAPPER LARK..495 (  40) (RB) (BREEDING)  (E2)
        REDCAPPED LARK..507 (  66) (RB) (BREEDING)
    GRTR STRPD SWALLOW..526 ( 457) (IB) (BREEDING)  (M2)
    SENTNL ROCK THRUSH..582 (  29) (RB) (BREEDING)  (E1)
             STONECHAT..596 ( 147) (RB) (BREEDING)
             GRASSBIRD..661 ( 545) (RB) (BREEDING)  (E2)
       CLOUD CISTICOLA..666 (  43) (RB) (BREEDING)  (E3)
    LEVAILNT CISTICOLA..677 ( 702) (RB) (BREEDING)  (E4)
           CAPE WEAVER..813 ( 921) (RB) (BREEDING)  (E1)
    YELLOWRUMPED WIDOW..827 ( 391) (RB) (BREEDING)  (E4)
         YELLOW CANARY..878 ( 190) (RB) (BREEDING)  (E2)
          CAPE BUNTING..885 ( 393) (RB) (BREEDING)  (E3)
```

FOREST HABITATS - PRIMARY CATEGORY **

Birds of closed-canopy indigenous evergreen forest with typical forest understory. Includes all Afromontane/mistbelt and lowland/east coast forest. Many of these birds can also be found in alien plantations of eucalypts and pines where these occur close to natural forest.

******INDICATORS******

```
     DUSKY FLYCATCHER..690 ( 331) (RB) (BREEDING)  (E4)
           CAPE BATIS..700 ( 182) (RB) (BREEDING)  (E2)
```

******ASSOCIATES******

```
      AFRICAN GOSHAWK..160 (  84) (RB)             (E4)
       RAMERON PIGEON..350 ( 216) (RB) (BREEDING)  (E4)
    REDCHESTED CUCKOO..377 ( 110) (IB)             (E4)
   BLK SAWWNG SWALLOW..536 (  95) (IB)             (E4)
        SOMBRE BULBUL..572 ( 356) (RB) (BREEDING)  (E4)
         OLIVE THRUSH..577 ( 672) (RB) (BREEDING)  (E4)
           CAPE ROBIN..601 (1143) (RB) (BREEDING)  (E4)
   BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)  (E4)
   PARADSE FLYCATCHER..710 ( 223) (IB) (BREEDING)
      SOUTHERN BOUBOU..736 ( 801) (RB) (BREEDING)  (E2)
   LSR DBLCLR SUNBIRD..783 ( 900) (RB) (BREEDING)  (E1)
       CAPE WHITE-EYE..796 (1216) (RB) (BREEDING)  (E2)
```

- FOREST EDGE SECONDARY CATEGORY

Birds of the rank grass, scrub and woody thickets typical of forest edges.

******ASSOCIATES******

```
           CAPE ROBIN..601 (1143) (RB) (BREEDING)  (E4)
      SOUTHERN BOUBOU..736 ( 801) (RB) (BREEDING)  (E2)
   LSR DBLCLR SUNBIRD..783 ( 900) (RB) (BREEDING)  (E1)
```

WOODLAND HABITATS - PRIMARY CATEGORY ***********************************

Birds of wooded habitats characterised by the presence of trees but excluding true forests. Many of these birds can also be found in stands of alien trees, parks and gardens, sometimes in otherwise treeless areas.

******INDICATORS******

```
       KLAAS'S CUCKOO..385 ( 147) (IB) (BREEDING)
    FIERYNCK NIGHTJAR..405 ( 221) (RB) (BREEDING)  (E4)
   SPECKLED MOUSEBIRD..424 ( 651) (RB) (BREEDING)  (E4)
   WHTEBCKD MOUSEBIRD..425 ( 332) (RB) (BREEDING)  (E2)
   REDFACED MOUSEBIRD..426 ( 185) (RB) (BREEDING)  (E4)
          PIED BARBET..465 ( 671) (RB) (BREEDING)  (E2)
    LESSER HONEYGUIDE..476 (  17) (RB)             (E4)
    FISCAL FLYCATCHER..698 ( 220) (RB) (BREEDING)  (E1)
```

******ASSOCIATES******

```
      AFRICAN GOSHAWK..160 (  84) (RB)             (E4)
         REDEYED DOVE..352 ( 787) (RB) (BREEDING)  (E4)
    REDCHESTED CUCKOO..377 ( 110) (IB)             (E4)
      DIEDERIK CUCKOO..386 (  49) (IB)
    BURCHELL'S COUCAL..391 ( 560) (RB) (BREEDING)
               HOOPOE..451 ( 147) (RB) (BREEDING)
        SOMBRE BULBUL..572 ( 356) (RB) (BREEDING)  (E4)
         OLIVE THRUSH..577 ( 672) (RB) (BREEDING)  (E4)
           CAPE ROBIN..601 (1143) (RB) (BREEDING)  (E4)
   BARTHROATED APALIS..645 ( 211) (RB) (BREEDING)  (E4)
   LONGBILLED CROMBEC..651 (  87) (RB) (BREEDING)  (E3)
             NEDDICKY..681 ( 237) (RB) (BREEDING)  (E4)
   PARADSE FLYCATCHER..710 ( 223) (IB) (BREEDING)
      SOUTHERN BOUBOU..736 ( 801) (RB) (BREEDING)  (E2)
       CAPE WHITE-EYE..796 (1216) (RB) (BREEDING)  (E2)
          CAPE WEAVER..813 ( 921) (RB) (BREEDING)  (E1)
```

******ASSOCIATES******

PURPLE HERON..065	(439)	(RB)	(BREEDING)		
BLKCRN NIGHT HERON..076	(450)	(RB)	(BREEDING)		
LITTLE BITTERN..078	(147)	(RB)	(BREEDING)		(RED DATA - RARE)
WHITEFACED DUCK..099	(18)	(RB)			
MACCOA DUCK..117	(87)	(RB)		(E4)	
BLACK CRAKE..213	(121)	(RB)	(BREEDING)	(E4)	
PURPLE GALLINULE..223	(417)	(RB)	(BREEDING)		
MOORHEN..226	(742)	(RB)	(BREEDING)		
PAINTED SNIPE..242	(39)	(RB)			
RUFF..284	(83)	(PN)			
ETHIOPIAN SNIPE..286	(220)	(RB)	(BREEDING)	(E4)	
MARSH OWL..395	(60)	(RB)	(BREEDING)		
AFR MARSH WARBLER..631	(92)	(IB)	(BREEDING)	(M2)	
CAPE REED WARBLER..635	(595)	(RB)	(BREEDING)	(E4)	
AFR SEDGE WARBLER..638	(457)	(RB)	(BREEDING)	(E4)	
LEVAILNT CISTICOLA..677	(702)	(RB)	(BREEDING)	(E4)	
RED BISHOP..824	(102)	(RB)	(BREEDING)	(E4)	
COMMON WAXBILL..846	(719)	(RB)	(BREEDING)		

- OPEN WATER TERTIARY CATEGORY

Birds of open water in wetlands.

******INDICATORS******

GRT CRESTED GREBE..006	(512)	(RB)	(BREEDING)		
WHITE PELICAN..049	(589)	(RB)	(BREEDING)		(RED DATA - RARE)
GREATER FLAMINGO..096	(152)	(RB)			(RED DATA - INDETERMINATE)
LESSER FLAMINGO..097	(30)	(RB)			(RED DATA - INDETERMINATE)
S AFRICAN SHELDUCK..103	(88)	(RB)		(E2)	
CAPE TEAL..106	(656)	(RB)	(BREEDING)		
MALLARD..891	(28)	(RB)			

******ASSOCIATES******

BLACK-NECKED GREBE..007	(192)	(RB)	(BREEDING)		
DABCHICK..008	(725)	(RB)	(BREEDING)		
WHITBRST CORMORANT..055	(1080)	(RB)	(BREEDING)		
REED CORMORANT..058	(797)	(RB)	(BREEDING)		
DARTER..060	(758)	(RB)	(BREEDING)		
WHITEFACED DUCK..099	(18)	(RB)			
SOUTHERN POCHARD..113	(420)	(RB)	(BREEDING)		
MACCOA DUCK..117	(87)	(RB)		(E4)	
AVOCET..294	(397)	(RB)			
BLACKWINGED STILT..295	(708)	(RB)	(BREEDING)		
CASPIAN TERN..322	(474)	(RB)			(RED DATA - RARE)
WHITEWINGED TERN..339	(192)	(PN)			
PIED KINGFISHER..428	(849)	(RB)	(BREEDING)		
GIANT KINGFISHER..429	(504)	(RB)		(E4)	
MLCHITE KINGFISHER..431	(339)	(RB)	(BREEDING)	(E4)	
WHITETHRTD SWALLOW..520	(257)	(IB)		(M2)	
BROWNTHRTED MARTIN..533	(457)	(RB)	(BREEDING)		

MONTANE AND ROCKY HABITATS - PRIMARY CATEGORY *************************

Birds of montane and/or exposed rocky habitats. This category is not mutually exclusive with some other general categories so a species designated an indicator in this category may also be designated an indicator or an associate in another general category, eg. grassland.

******INDICATORS******

BLACK EAGLE..131	(334)	(RB)	(BREEDING)	
CAPE EAGLE OWL..400	(23)	(RB)		(E4)
GROUND WOODPECKER..480	(183)	(RB)	(BREEDING)	(E1)
CAPE ROCK THRUSH..581	(270)	(RB)	(BREEDING)	(E2)
SENTNL ROCK THRUSH..582	(29)	(RB)	(BREEDING)	(E1)
CAPE SISKIN..874	(184)	(RB)		(E1)

******ASSOCIATES******

PEREGRINE FALCON..171	(65)	(RB)	(BREEDING)	(E4)	(RED DATA - RARE)
ROCK MARTIN..529	(560)	(RB)	(BREEDING)	(E4)	
WHITENECKED RAVEN..550	(568)	(RB)	(BREEDING)	(E4)	
REDWINGED STARLING..769	(1127)	(RB)	(BREEDING)	(E3)	
CAPE BUNTING..885	(393)	(RB)	(BREEDING)	(E3)	

```
   YELLOWBILLED DUCK..104 ( 804) (RB) (BREEDING)  (E4)
  AFRICAN FISH EAGLE..148 ( 401) (RB) (BREEDING)  (E4)
              OSPREY..170 (  20) (PN)
         AFRICAN RAIL..210 (  42) (RB) (BREEDING)
          BLACK CRAKE..213 ( 121) (RB) (BREEDING)  (E4)
     PURPLE GALLINULE..223 ( 417) (RB) (BREEDING)
             MOORHEN..226 ( 742) (RB) (BREEDING)
      REDKNOBBED COOT..228 ( 868) (RB) (BREEDING)
        PAINTED SNIPE..242 (  39) (RB)
        RINGED PLOVER..245 ( 215) (PN)
  WHITEFRONTD PLOVER..246 ( 635) (RB) (BREEDING)  (E4)
   KITTLITZ'S PLOVER..248 ( 180) (RB) (BREEDING)
  THREEBANDED PLOVER..249 ( 467) (RB) (BREEDING)  (E4)
   BLACKSMITH PLOVER..258 (1110) (RB) (BREEDING)  (E4)
     COMMON SANDPIPER..264 ( 215) (PN)
       WOOD SANDPIPER..266 ( 150) (PN)
          GREENSHANK..270 ( 388) (PN)
     CURLEW SANDPIPER..272 ( 319) (PN)
         LITTLE STINT..274 ( 125) (PN) (BREEDING)
      ETHIOPIAN SNIPE..286 ( 220) (RB) (BREEDING)  (E4)
         WATER DIKKOP..298 ( 242) (RB) (BREEDING)  (E4)
      GREYHEADED GULL..315 ( 253) (RB)
         CASPIAN TERN..322 ( 474) (RB)                  (RED DATA - RARE)
     WHITEWINGED TERN..339 ( 192) (PN)
            MARSH OWL..395 (  60) (RB) (BREEDING)
      PIED KINGFISHER..428 ( 849) (RB) (BREEDING)
     GIANT KINGFISHER..429 ( 504) (RB)              (E4)
  MLCHITE KINGFISHER..431 ( 339) (RB) (BREEDING)  (E4)
  WHITETHRTD SWALLOW..520 ( 257) (IB)              (M2)
  BROWNTHRTED MARTIN..533 ( 457) (RB) (BREEDING)
   AFR MARSH WARBLER..631 (  92) (IB) (BREEDING)  (M2)
   CAPE REED WARBLER..635 ( 595) (RB) (BREEDING)  (E4)
   AFR SEDGE WARBLER..638 ( 457) (RB) (BREEDING)  (E4)
  LEVAILNT CISTICOLA..677 ( 702) (RB) (BREEDING)  (E4)
         CAPE WAGTAIL..713 (1172) (RB) (BREEDING)  (E4)
          RED BISHOP..824 ( 102) (RB) (BREEDING)  (E4)
       COMMON WAXBILL..846 ( 719) (RB) (BREEDING)
```

- EXPOSED SHORE TERTIARY CATEGORY

Birds of exposed wetland shorelines lacking vegetation.

******ASSOCIATES******

```
        RINGED PLOVER..245 ( 215) (PN)
  WHITEFRONTD PLOVER..246 ( 635) (RB) (BREEDING)  (E4)
   KITTLITZ'S PLOVER..248 ( 180) (RB) (BREEDING)
  THREEBANDED PLOVER..249 ( 467) (RB) (BREEDING)  (E4)
   BLACKSMITH PLOVER..258 (1110) (RB) (BREEDING)  (E4)
     COMMON SANDPIPER..264 ( 215) (PN)
          GREENSHANK..270 ( 388) (PN)
     CURLEW SANDPIPER..272 ( 319) (PN)
         LITTLE STINT..274 ( 125) (PN) (BREEDING)
                RUFF..284 (  83) (PN)
              AVOCET..294 ( 397) (RB)
   BLACKWINGED STILT..295 ( 708) (RB) (BREEDING)
         WATER DIKKOP..298 ( 242) (RB) (BREEDING)  (E4)
         CAPE WAGTAIL..713 (1172) (RB) (BREEDING)  (E4)
```

- EMERGENT/MARGINAL VEGETATION TERTIARY CATEGORY

Birds of emergent, floating or tall marginal vegetation, eg. reeds, rushes, sedges, etc., in or adjacent to wetlands.

******INDICATORS******

```
  YELLOWBILLED EGRET..068 ( 355) (RB) (BREEDING)
    WHITEBACKED DUCK..101 (  27) (RB)              (E4)
       HOTTENTOT TEAL..107 (  50) (RB)              (E4)
   AFR MARSH HARRIER..165 ( 279) (RB) (BREEDING)  (E4)
       WHISKERED TERN..338 (  76) (RB) (BREEDING)
```

```
            MOORHEN..226 ( 742) (RB) (BREEDING)
       PAINTED SNIPE..242 (  39) (RB)
   AFR MARSH WARBLER..631 (  92) (IB) (BREEDING)  (M2)
   CAPE REED WARBLER..635 ( 595) (RB) (BREEDING)  (E4)
   AFR SEDGE WARBLER..638 ( 457) (RB) (BREEDING)  (E4)
  LEVAILNT CISTICOLA..677 ( 702) (RB) (BREEDING)  (E4)
          RED BISHOP..824 ( 102) (RB) (BREEDING)  (E4)
      COMMON WAXBILL..846 ( 719) (RB) (BREEDING)
```

- OPEN WATER TERTIARY CATEGORY

Birds of open water in rivers and/or streams.

******INDICATORS******

```
   AFRICAN BLACK DUCK..105 (  82) (RB) (BREEDING)  (E4)
```

******ASSOCIATES******

```
            DABCHICK..008 ( 725) (RB) (BREEDING)
   WHITBRST CORMORANT..055 (1080) (RB) (BREEDING)
       REED CORMORANT..058 ( 797) (RB) (BREEDING)
              DARTER..060 ( 758) (RB) (BREEDING)
      PIED KINGFISHER..428 ( 849) (RB) (BREEDING)
     GIANT KINGFISHER..429 ( 504) (RB)             (E4)
   MLCHITE KINGFISHER..431 ( 339) (RB) (BREEDING)  (E4)
   WHITETHRTD SWALLOW..520 ( 257) (IB)             (M2)
   BROWNTHRTED MARTIN..533 ( 457) (RB) (BREEDING)
```

- LACUSTRINE SECONDARY CATEGORY

Birds of wetland habitats characterized by totally or nearly stationary water, eg. marshes, vleis, pans, dams, sewage works, etc.

******INDICATORS******

```
    GRT CRESTED GREBE..006 ( 512) (RB) (BREEDING)
        WHITE PELICAN..049 ( 589) (RB) (BREEDING)       (RED DATA - RARE)
   YELLOWBILLED EGRET..068 ( 355) (RB) (BREEDING)
          GLOSSY IBIS..093 ( 172) (RB) (BREEDING)
    AFRICAN SPOONBILL..095 ( 469) (RB) (BREEDING)  (E4)
     GREATER FLAMINGO..096 ( 152) (RB)                  (RED DATA - INDETERMINATE)
      LESSER FLAMINGO..097 (  30) (RB)                  (RED DATA - INDETERMINATE)
     WHITEBACKED DUCK..101 (  27) (RB)             (E4)
   S AFRICAN SHELDUCK..103 (  88) (RB)             (E2)
           CAPE TEAL..106 ( 656) (RB) (BREEDING)
       HOTTENTOT TEAL..107 (  50) (RB)             (E4)
       REDBILLED TEAL..108 ( 386) (RB) (BREEDING)  (E4)
       CAPE SHOVELLER..112 ( 617) (RB) (BREEDING)  (E2)
     SOUTHERN POCHARD..113 ( 420) (RB) (BREEDING)
          MACCOA DUCK..117 (  87) (RB)             (E4)
    AFR MARSH HARRIER..165 ( 279) (RB) (BREEDING)  (E4)
      MARSH SANDPIPER..269 ( 101) (PN)
                RUFF..284 (  83) (PN)
              AVOCET..294 ( 397) (RB)
    BLACKWINGED STILT..295 ( 708) (RB) (BREEDING)
       WHISKERED TERN..338 (  76) (RB) (BREEDING)
             MALLARD..891 (  28) (RB)
```

******ASSOCIATES******

```
   BLACK-NECKED GREBE..007 ( 192) (RB) (BREEDING)
            DABCHICK..008 ( 725) (RB) (BREEDING)
   WHITBRST CORMORANT..055 (1080) (RB) (BREEDING)
       REED CORMORANT..058 ( 797) (RB) (BREEDING)
              DARTER..060 ( 758) (RB) (BREEDING)
          GREY HERON..062 ( 927) (RB) (BREEDING)
        PURPLE HERON..065 ( 439) (RB) (BREEDING)
    GREAT WHITE EGRET..066 (  62) (RB) (BREEDING)
        LITTLE EGRET..067 ( 877) (RB) (BREEDING)
   BLKCRN NIGHT HERON..076 ( 450) (RB) (BREEDING)
       LITTLE BITTERN..078 ( 147) (RB) (BREEDING)       (RED DATA - RARE)
            HAMERKOP..081 ( 377) (RB) (BREEDING)
         BLACK STORK..084 (  86) (RB)                  (RED DATA - INDETERMINATE)
      WHITEFACED DUCK..099 (  18) (RB)
```

- LOTIC SECONDARY CATEGORY

Birds of riverine and/or stream habitats characterized by flowing water.

******INDICATORS******

AFRICAN BLACK DUCK..105	(82)	(RB)	(BREEDING)	(E4)	

******ASSOCIATES******

DABCHICK..008	(725)	(RB)	(BREEDING)		
WHITBRST CORMORANT..055	(1080)	(RB)	(BREEDING)		
REED CORMORANT..058	(797)	(RB)	(BREEDING)		
DARTER..060	(758)	(RB)	(BREEDING)		
GREY HERON..062	(927)	(RB)	(BREEDING)		
PURPLE HERON..065	(439)	(RB)	(BREEDING)		
GREAT WHITE EGRET..066	(62)	(RB)	(BREEDING)		
LITTLE EGRET..067	(877)	(RB)	(BREEDING)		
BLKCRN NIGHT HERON..076	(450)	(RB)	(BREEDING)		
LITTLE BITTERN..078	(147)	(RB)	(BREEDING)		(RED DATA - RARE)
HAMERKOP..081	(377)	(RB)	(BREEDING)		
BLACK STORK..084	(86)	(RB)			(RED DATA - INDETERMINATE)
WHITEFACED DUCK..099	(18)	(RB)			
YELLOWBILLED DUCK..104	(804)	(RB)	(BREEDING)	(E4)	
AFRICAN FISH EAGLE..148	(401)	(RB)	(BREEDING)	(E4)	
OSPREY..170	(20)	(PN)			
AFRICAN RAIL..210	(42)	(RB)	(BREEDING)		
BLACK CRAKE..213	(121)	(RB)	(BREEDING)	(E4)	
PURPLE GALLINULE..223	(417)	(RB)	(BREEDING)		
MOORHEN..226	(742)	(RB)	(BREEDING)		
REDKNOBBED COOT..228	(868)	(RB)	(BREEDING)		
PAINTED SNIPE..242	(39)	(RB)			
WHITEFRONTD PLOVER..246	(635)	(RB)	(BREEDING)	(E4)	
THREEBANDED PLOVER..249	(467)	(RB)	(BREEDING)	(E4)	
BLACKSMITH PLOVER..258	(1110)	(RB)	(BREEDING)	(E4)	
COMMON SANDPIPER..264	(215)	(PN)			
WOOD SANDPIPER..266	(150)	(PN)			
GREENSHANK..270	(388)	(PN)			
WATER DIKKOP..298	(242)	(RB)	(BREEDING)	(E4)	
PIED KINGFISHER..428	(849)	(RB)	(BREEDING)		
GIANT KINGFISHER..429	(504)	(RB)		(E4)	
MLCHITE KINGFISHER..431	(339)	(RB)	(BREEDING)	(E4)	
WHITETHRTD SWALLOW..520	(257)	(IB)		(M2)	
BROWNTHRTED MARTIN..533	(457)	(RB)	(BREEDING)		
AFR MARSH WARBLER..631	(92)	(IB)	(BREEDING)	(M2)	
CAPE REED WARBLER..635	(595)	(RB)	(BREEDING)	(E4)	
AFR SEDGE WARBLER..638	(457)	(RB)	(BREEDING)	(E4)	
LEVAILNT CISTICOLA..677	(702)	(RB)	(BREEDING)	(E4)	
CAPE WAGTAIL..713	(1172)	(RB)	(BREEDING)	(E4)	
RED BISHOP..824	(102)	(RB)	(BREEDING)	(E4)	
COMMON WAXBILL..846	(719)	(RB)	(BREEDING)		

- EXPOSED SHORE TERTIARY CATEGORY

Birds of exposed riverine shorelines lacking vegetation.

******ASSOCIATES******

WHITEFRONTD PLOVER..246	(635)	(RB)	(BREEDING)	(E4)
THREEBANDED PLOVER..249	(467)	(RB)	(BREEDING)	(E4)
BLACKSMITH PLOVER..258	(1110)	(RB)	(BREEDING)	(E4)
COMMON SANDPIPER..264	(215)	(PN)		
GREENSHANK..270	(388)	(PN)		
WATER DIKKOP..298	(242)	(RB)	(BREEDING)	(E4)
CAPE WAGTAIL..713	(1172)	(RB)	(BREEDING)	(E4)

- EMERGENT/MARGINAL VEGETATION TERTIARY CATEGORY

Birds of emergent, floating or tall marginal vegetation, eg. reeds, rushes, sedges, etc., in or adjacent to rivers and/or streams.

******ASSOCIATES******

PURPLE HERON..065	(439)	(RB)	(BREEDING)		
BLKCRN NIGHT HERON..076	(450)	(RB)	(BREEDING)		
LITTLE BITTERN..078	(147)	(RB)	(BREEDING)		(RED DATA - RARE)
BLACK CRAKE..213	(121)	(RB)	(BREEDING)	(E4)	
PURPLE GALLINULE..223	(417)	(RB)	(BREEDING)		

GLOSSY IBIS..093	(172)	(RB)	(BREEDING)		
AFRICAN SPOONBILL..095	(469)	(RB)	(BREEDING)	(E4)	
GREATER FLAMINGO..096	(152)	(RB)			(RED DATA - INDETERMINATE)
LESSER FLAMINGO..097	(30)	(RB)			(RED DATA - INDETERMINATE)
WHITEFACED DUCK..099	(18)	(RB)			
WHITEBACKED DUCK..101	(27)	(RB)		(E4)	
S AFRICAN SHELDUCK..103	(88)	(RB)		(E2)	
YELLOWBILLED DUCK..104	(804)	(RB)	(BREEDING)	(E4)	
AFRICAN BLACK DUCK..105	(82)	(RB)	(BREEDING)	(E4)	
CAPE TEAL..106	(656)	(RB)	(BREEDING)		
HOTTENTOT TEAL..107	(50)	(RB)		(E4)	
REDBILLED TEAL..108	(386)	(RB)	(BREEDING)	(E4)	
CAPE SHOVELLER..112	(617)	(RB)	(BREEDING)	(E2)	
SOUTHERN POCHARD..113	(420)	(RB)	(BREEDING)		
MACCOA DUCK..117	(87)	(RB)		(E4)	
AFRICAN FISH EAGLE..148	(401)	(RB)	(BREEDING)	(E4)	
AFR MARSH HARRIER..165	(279)	(RB)	(BREEDING)	(E4)	
OSPREY..170	(20)	(PN)			
AFRICAN RAIL..210	(42)	(RB)	(BREEDING)		
BLACK CRAKE..213	(121)	(RB)	(BREEDING)	(E4)	
PURPLE GALLINULE..223	(417)	(RB)	(BREEDING)		
MOORHEN..226	(742)	(RB)	(BREEDING)		
REDKNOBBED COOT..228	(868)	(RB)	(BREEDING)		
PAINTED SNIPE..242	(39)	(RB)			
THREEBANDED PLOVER..249	(467)	(RB)	(BREEDING)	(E4)	
WOOD SANDPIPER..266	(150)	(PN)			
MARSH SANDPIPER..269	(101)	(PN)			
RUFF..284	(83)	(PN)			
ETHIOPIAN SNIPE..286	(220)	(RB)	(BREEDING)	(E4)	
AVOCET..294	(397)	(RB)			
BLACKWINGED STILT..295	(708)	(RB)	(BREEDING)		
WHISKERED TERN..338	(76)	(RB)	(BREEDING)		
MLCHITE KINGFISHER..431	(339)	(RB)	(BREEDING)	(E4)	
WHITETHRTD SWALLOW..520	(257)	(IB)		(M2)	
BROWNTHRTED MARTIN..533	(457)	(RB)	(BREEDING)		
CAPE REED WARBLER..635	(595)	(RB)	(BREEDING)	(E4)	
AFR SEDGE WARBLER..638	(457)	(RB)	(BREEDING)	(E4)	
MALLARD..891	(28)	(RB)			

******ASSOCIATES******

BLACK-NECKED GREBE..007	(192)	(RB)	(BREEDING)		
WHITBRST CORMORANT..055	(1080)	(RB)	(BREEDING)		
GREY HERON..062	(927)	(RB)	(BREEDING)		
LITTLE EGRET..067	(877)	(RB)	(BREEDING)		
BLKCRN NIGHT HERON..076	(450)	(RB)	(BREEDING)		
BLACK STORK..084	(86)	(RB)			(RED DATA - INDETERMINATE)
EGYPTIAN GOOSE..102	(990)	(RB)	(BREEDING)		
SPURWINGED GOOSE..116	(592)	(RB)	(BREEDING)	(E4)	
RINGED PLOVER..245	(215)	(PN)			
WHITEFRONTD PLOVER..246	(635)	(RB)	(BREEDING)	(E4)	
KITTLITZ'S PLOVER..248	(180)	(RB)	(BREEDING)		
BLACKSMITH PLOVER..258	(1110)	(RB)	(BREEDING)	(E4)	
COMMON SANDPIPER..264	(215)	(PN)			
GREENSHANK..270	(388)	(PN)			
CURLEW SANDPIPER..272	(319)	(PN)			
LITTLE STINT..274	(125)	(PN)	(BREEDING)		
WATER DIKKOP..298	(242)	(RB)	(BREEDING)	(E4)	
GREYHEADED GULL..315	(253)	(RB)			
CASPIAN TERN..322	(474)	(RB)			(RED DATA - RARE)
WHITEWINGED TERN..339	(192)	(PN)			
MARSH OWL..395	(60)	(RB)	(BREEDING)		
PIED KINGFISHER..428	(849)	(RB)	(BREEDING)		
GIANT KINGFISHER..429	(504)	(RB)		(E4)	
AFR MARSH WARBLER..631	(92)	(IB)	(BREEDING)	(M2)	
LEVAILNT CISTICOLA..677	(702)	(RB)	(BREEDING)	(E4)	
CAPE WAGTAIL..713	(1172)	(RB)	(BREEDING)	(E4)	
RED BISHOP..824	(102)	(RB)	(BREEDING)	(E4)	
COMMON WAXBILL..846	(719)	(RB)	(BREEDING)		

- PELAGIC SECONDARY CATEGORY

Birds of open ocean not usually found on the shore unless wrecked or dead.

******INDICATORS******

SHY ALBATROSS..011 (77) (SN)
BLKBROWD ALBATROSS..012 (83) (SN)
YELLWNSE ALBATROSS..014 (18) (SN)
STHRN GIANT PETREL..017 (65) (SN)
NTHRN GIANT PETREL..018 (17) (SN)
PINTADO PETREL..021 (21) (SN)
SOFTPLUMAGD PETREL..024 (16) (SN) (RED DATA - VULNERABLE)
BROADBILLED PRION..029 (17) (SN)
WHITECHINND PETREL..032 (185) (SN)
CORY'S SHEARWATER..034 (21) (PN)
GREAT SHEARWATER..035 (29) (SN)
SOOTY SHEARWATER..037 (129) (SN)
CAPE GANNET..053 (537) (RB)
ARCTIC SKUA..307 (56) (PN)
POMARINE SKUA..309 (17) (PN)
SUBANTARCTIC SKUA..310 (46) (SN)
SABINE'S GULL..318 (16) (PN)

******ASSOCIATES******

BLACK-NECKED GREBE..007 (192) (RB) (BREEDING)

- SHORE SECONDARY CATEGORY

Birds of sandy and/or rocky coastal shores.

******INDICATORS******

A BK OYSTERCATCHER..244 (658) (RB) (BREEDING) (E2)
GREY PLOVER..254 (67) (PN)
TURNSTONE..262 (242) (PN)
KNOT..271 (25) (PN)
SANDERLING..281 (193) (PN)
CURLEW..289 (15) (PN)
WHIMBREL..290 (236) (PN)
SWIFT TERN..324 (672) (RB)
SANDWICH TERN..326 (400) (PN)
COMMON TERN..327 (486) (PN)

******ASSOCIATES******

GREY HERON..062 (927) (RB) (BREEDING)
LITTLE EGRET..067 (877) (RB) (BREEDING)
RINGED PLOVER..245 (215) (PN)
WHITEFRONTD PLOVER..246 (635) (RB) (BREEDING) (E4)
COMMON SANDPIPER..264 (215) (PN)
GREENSHANK..270 (388) (PN)
CURLEW SANDPIPER..272 (319) (PN)
LITTLE STINT..274 (125) (PN) (BREEDING)
WATER DIKKOP..298 (242) (RB) (BREEDING) (E4)
GREYHEADED GULL..315 (253) (RB)
HARTLAUB'S GULL..316 (1259) (RB) (BREEDING) (E2)
CASPIAN TERN..322 (474) (RB) (RED DATA - RARE)

AQUATIC - PRIMARY CATEGORY ************************************

Birds of all lacustrine (i.e. wetlands, eg. marshes, vleis, lakes, pans, dams, sewage works, etc.) and lotic habitats (rivers and streams).

******INDICATORS******

GRT CRESTED GREBE..006 (512) (RB) (BREEDING)
DABCHICK..008 (725) (RB) (BREEDING)
WHITE PELICAN..049 (589) (RB) (BREEDING) (RED DATA - RARE)
REED CORMORANT..058 (797) (RB) (BREEDING)
DARTER..060 (758) (RB) (BREEDING)
PURPLE HERON..065 (439) (RB) (BREEDING)
GREAT WHITE EGRET..066 (62) (RB) (BREEDING)
YELLOWBILLED EGRET..068 (355) (RB) (BREEDING)
LITTLE BITTERN..078 (147) (RB) (BREEDING) (RED DATA - RARE)
HAMERKOP..081 (377) (RB) (BREEDING)

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***********************************
*                                 *
*   & AD CAPE PENINSULA           *
*                                 *
***********************************


 333     4    11     888     A    BBBB
3   3   44   1 1    8   8   A A   B   B
    3  4 4     1    8   8  A   A  B   B
  33  4  4     1     888   AAAAA  BBBB
    3 44444    1    8   8  A   A  B   B
3   3    4     1    8   8  A   A  B   B
 333     4   11111   888   A   A  BBBB
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MARINE - PRIMARY CATEGORY ***********************************

Birds of all true marine habitats including shore (coastal) and pelagic (open ocean) habitats.

******INDICATORS******

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      JACKASS PENGUIN..003 ( 162) (RB) (BREEDING)  (E2) (RED DATA - VULNERABLE)
        SHY ALBATROSS..011 (  77) (SN)
   BLKBROWD ALBATROSS..012 (  83) (SN)
   YELLWNSE ALBATROSS..014 (  18) (SN)
   STHRN GIANT PETREL..017 (  65) (SN)
   NTHRN GIANT PETREL..018 (  17) (SN)
       PINTADO PETREL..021 (  21) (SN)
   SOFTPLUMAGD PETREL..024 (  16) (SN)                   (RED DATA - VULNERABLE)
    BROADBILLED PRION..029 (  17) (SN)
   WHITECHINND PETREL..032 ( 185) (SN)
    CORY'S SHEARWATER..034 (  21) (PN)
     GREAT SHEARWATER..035 (  29) (SN)
     SOOTY SHEARWATER..037 ( 129) (SN)
          CAPE GANNET..053 ( 537) (RB)
       CAPE CORMORANT..056 ( 992) (RB) (BREEDING)  (E2)
       BANK CORMORANT..057 ( 467) (RB) (BREEDING)  (E2)
    CROWNED CORMORANT..059 ( 437) (RB)             (E2)
   A BK OYSTERCATCHER..244 ( 658) (RB) (BREEDING)  (E2)
          GREY PLOVER..254 (  67) (PN)
            TURNSTONE..262 ( 242) (PN)
                 KNOT..271 (  25) (PN)
           SANDERLING..281 ( 193) (PN)
               CURLEW..289 (  15) (PN)
             WHIMBREL..290 ( 236) (PN)
          ARCTIC SKUA..307 (  56) (PN)
        POMARINE SKUA..309 (  17) (PN)
    SUBANTARCTIC SKUA..310 (  46) (SN)
            KELP GULL..312 (1198) (RB) (BREEDING)
        SABINE'S GULL..318 (  16) (PN)
           SWIFT TERN..324 ( 672) (RB)
        SANDWICH TERN..326 ( 400) (PN)
          COMMON TERN..327 ( 486) (PN)
          ARCTIC TERN..328 (  52) (PN)
       ANTARCTIC TERN..329 ( 128) (PN)                   (RED DATA - RARE)
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******ASSOCIATES******

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   BLACK-NECKED GREBE..007 ( 192) (RB) (BREEDING)
   WHITBRST CORMORANT..055 (1080) (RB) (BREEDING)
           GREY HERON..062 ( 927) (RB) (BREEDING)
         LITTLE EGRET..067 ( 877) (RB) (BREEDING)
   BLKCRN NIGHT HERON..076 ( 450) (RB) (BREEDING)
        RINGED PLOVER..245 ( 215) (PN)
   WHITEFRONTD PLOVER..246 ( 635) (RB) (BREEDING)  (E4)
     COMMON SANDPIPER..264 ( 215) (PN)
           GREENSHANK..270 ( 388) (PN)
     CURLEW SANDPIPER..272 ( 319) (PN)
         LITTLE STINT..274 ( 125) (PN) (BREEDING)
         WATER DIKKOP..298 ( 242) (RB) (BREEDING)  (E4)
     GREYHEADED GULL..315 ( 253) (RB)
      HARTLAUB'S GULL..316 (1259) (RB) (BREEDING)  (E2)
         CASPIAN TERN..322 ( 474) (RB)                   (RED DATA - RARE)
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SABAP databank. This number can be used to assess the reporting rates quoted in the standard (Phase 2) listing of species for grid squares.

GENERAL STATUS CATEGORIES: categorize species according to their status in South Africa (NOT southern Africa).

S: Pelagic seabirds which breed in the Antarctic and/or sub-Antarctic and visit South Africa's offshore waters.
P: Inter-continental migrants, almost all Palearctic.
I: Intra-African migrants.
R: "Residents" which may or may not have local seasonal movements within South Africa.
V: Vagrants and species extremely marginal to South Africa:
B: Breeds in South Africa (but not necessarily in the given grid square.
N: Does not breed in South Africa.

BREEDING: The word "breeding" appears where a species has been recorded breeding in the given grid square in the SABAP databank. Note that breeding records should be seen as being far from complete.

ENDEMISM CATEGORIES: Endemism is a relative concept and must be qualified by a definition of the region to which the species is endemic:

E1 = endemic to South Africa and/or Swaziland and Lesotho.
E2 = endemic to southern Africa south of the Zambezi and Kunene Rivers.
E3 = near-endemic to southern Africa but occuring marginally in neighbouring territories.
M1 = migrant to South Africa only
M2 = migrant to southern Africa only
M3 = migrant to southern Africa and immediately neighbouring regions

RED DATA CATEGORIES: The Red Data categories and species are as given in: "South African Red Data Book - Birds" by RK Brooke (1984). The status of a few species has been revised in consultation with RK Brooke.

ENDANGERED: species in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are species whose numbers have been reduced to a critical level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.

VULNERABLE: species believed likely to move into the endangered category in the near future if the causal factors continue operating. Included are species of which all or most of the populations are decreasing because of overexploitation, extensive destruction of habitat or other environmental disturbance, species with populations which have been seriously depleted and whose ultimate security is not yet assured, and species with populations which are still sizeable but are under threat from serious adverse factors throughout their range.

RARE: species with small populations which are not at present endangered or vulnerable but which are at risk. These species are usually localized within restricted geographical areas or habitats, or are thinly scattered over a somewhat more extensive range. In practice, a species with only one or two colonies or less than about 200 breeding pairs in South Africa have been classified as rare.

INDETERMINATE: species that are suspected of belonging to the categories Endangered, Vulnerable or Rare but for which insufficient information is currently available. These vary from probably endangered to doubtfully rare.

MARGINAL: species which are at the edge of their ranges in South Africa and are therefore rare or very restricted in a South African context but probably not so in a wider African context.

allocated to the most specific category possible to allow for a more detailed breakdown. Species in more specific categories are automatically members of more general categories, higher up in the hierachy.

Unclassified species include those associated primarily with man-made habitats and species whose habitat requirements are either too general or too varied or too difficult to define, to be used here. Note that species which are essentially extralimital to the RSA, Swaziland and Lesotho were not used as their choice of habitat here may not be typical of the species in other parts of its range. To minimize the effect of variation in habitat choice which some species display over large geographic areas, only the RSA, Lesotho and Swaziland were considered when allocating species to habitat categories. This report is therefore applicable only to areas lying within these countries.

Three levels of hierarchy: | (1) | (2) | (3)

1) MARINE
    *pelagic
    *shore

2) AQUATIC
    *lotic
        -exposed shore
        -emergent vegetation
        -open water
    *lacustrine
        -exposed shore
        -emergent vegetation
        -open water

3) MONTANE AND ROCKY

4) FOREST
    *coastal forest
    *Afromontane forest
    *forest edge

5) WOODLAND
    *indigenous
        -acacia
        -broadleaved
        -thicket
        -riverine

6) GRASSLAND
    *natural
        -sweet
        -sour
        -moist

7) SCRUB
    *fynbos
    *Karoo

8) UNCLASSIFIED

9) EXTRALIMITAL

Descriptions of each category are given at the beginning of each listing.

NB: There are several well-defined habitat types which are not included in this breakdown for the simple reason that birds are not suitable indicators of those types.

In addition to the habitat-specific listings, individual species are annotated with respect to Roberts' number, total number of records, general status, breeding records, endemism and Red Data status.

ROBERTS' NUMBER: Refers to the reference numbers given to species in Roberts' Birds of Southern Africa by Maclean (1984).

TOTAL RECORDS: Refers to the total number of sightings recorded in the

SABAP ANNOTATED SPECIES LISTS

The object of this report is to provide additional information to complement the SABAP data for a particular geographical area. This information should be used in conjunction with the standard (Phase 2) listing provided by SABAP and should be viewed as an interpretation of that listing. The reliability of the report is dependent on the assumptions underpinning the analysis and on the quality of the dataset itself. Therefore the report should be critically evaluated and preferably be confirmed by fieldwork on site.

It is envisaged that the standard listing together with this report will be an aid to those needing to know more about the avifauna of an area for research and/or survey purposes. The advantage of the analysis is that it breaks down the list of species into habitat-related sub-lists which are useful from at least three perspectives:

1) they indicate the available habitat types in the area;
2) they provide some measure of the "richness" of those habitats;
3) they provide additional information about each species including information which may be relevant to conservation efforts.

It is hoped that particularly those workers who are not trained in ornithology may benefit from the report as an alternative to a detailed study of the literature.

At the ADU we would like to have feedback on how useful or otherwise you found this report. Your comments will be gratefully received.

James Harrison
SABAP Project Coordinator

BACKGROUND TO THE APPROACH AND THE CATEGORIES

Species are listed under a number of habitat categories and subcategories. Each list is divided into two groups, namely INDICATORS and ASSOCIATES. It is important that these two groups be distinguished clearly.

INDICATORS: The presence of an indicator species in an area will indicate with a high degree of certainty that the habitat type in question is present in the area. In other words, the presence of an indicator species is sufficient evidence of the presence of a given habitat type. (It should be remembered that all birds are capable of vagrancy and therefore anomalies may occur.)

Seen from a conservation perspective, indicator species are highly vulnerable to disturbance of their habitat as they are totally dependent on it for their livelihood.

ASSOCIATES: The presence of an associate species does NOT in itself indicate the presence of the habitat type but, should it be known that the relevant habitat type is present in the area, it is highly likely that the species will utilize that habitat, that is, it will be associated with it. Naturally, the larger the number of associates of a particular habitat there are, the stronger the evidence that the habitat in question is itself present.

Associate species will be affected by disturbance of their habitats to a greater or lesser degree depending on the species and the habitat type.

It follows that indicators will appear under one habitat category only while associates may appear under more than one category, although no attempt has been made to be exhaustive for associates. Species have been called associates of a habitat type only if there is apparently a strong link between the species and that habitat. If a species only occasionally or rarely occurs in a habitat, it is not classified as an associate of that habitat. A species is seldom classed as an associate of more than two and never more than three habitat types.

The habitat categories themselves are listed below. Note that there are seven primary categories and most of these also have more specific secondary categories and sometimes tertiary categories. Species were

APPENDIX

Sample output from habitat analysis routine (HAR) as referred to in Harrison *et al* (in press).

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surveys and planning. This aspect has been touched on only slightly in Harrison *et al* (1989) and has by no means been fully investigated here. This omission is deliberate as work in this regard is ongoing and is to form the basis of a PhD thesis.

ACKNOWLEDGMENTS

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hold greater potential for planning the location of reserves than the distribution maps of individual species alone (Harrison *et al* 1989).

It is appropriate to ask how successful the work outlined above has been in furthering the application of bird atlas data to the needs of wildlife conservation. I will now address this question.

The descriptive papers (Harrison 1989, 1992; Underhill *et al* 1991) have served to bring the progress and achievements of the SABAP to the attention of the scientific community and thereby improve the prospects of the data being used and correctly interpreted.

The papers dealing with patterns of seasonality have highlighted the fact that species with extensive seasonal movements cannot be conserved in reserves which occupy a mere corner of their ranges. The need is for a network of reserves - preferably linked by corridors - which accommodate their full range of seasonal requirements. Clearly atlas data have much to offer in discovering and describing both the timing and direction of such movements (Underhill *et al* 1992; Harrison and Navarro, in press; Berruti *et al*, in press).

The optimism of Harrison (1989) and Underhill *et al* (1991) with regard to the potential of atlasing as a method of fine-scale population monitoring may have been premature. Navarro *et al* (1993) have shown that, while potential does exist, the need to improve the standardization of methods for this purpose is crucial as the changes needing to be detected may be slow and subtle relative to the dramatic seasonal changes in abundance typical of migratory species. Repeated atlas projects undoubtedly have the potential to function as a form of pulsed monitoring, but the year-to-year indices of change which are needed will require the design of new methods. Navarro *et al* (1993) has been instructive in highlighting these points, particularly to those of us who were directly involved in the analysis.

Environmental impact assessments (EIAs) and their contributions to integrated environmental management may yet prove to be key factors in the future success or failure of wildlife conservation. Any means by which the information base of EIAs can be improved, must be a positive contribution (Harrison *et al*, in press).

Perhaps the greatest potential contribution of the SABAP to conservation is to highlight areas of high biodiversity and thereby provide a focus for further conservation-oriented

DISCUSSION

In this discussion I will highlight conclusions which can be drawn from the papers which have been presented. These should be seen in the context of the objectives of the thesis as given in the introduction.

Firstly, it was shown that the Southern African Bird Atlas Project (SABAP) has been a success in terms of the large volumes of accurate and up-to-date data on species' distributions and patterns of seasonality acquired (Harrison 1992). Also the decision to harness the energies of amateur volunteers was shown to have been appropriate but not without certain drawbacks (Navarro *et al* 1993). Central to the success of SABAP has been its three-tier organization with volunteer observers forming the base, the regional organizers the amateur management level and the central coordinator the professional management level (Harrison 1992).

An important methodological point was that the methods of atlasing and of computerization of the data need to be carefully planned so as to permit statistical analysis of the data. If this is done, reporting rates can provide an index of relative abundance which can, in turn, permit the application of atlas data to many questions beyond that of mere range extent (Harrison 1989). The analysis of reporting rates is particularly illuminating in the description of seasonal patterns of occurrence and therefore, by inference, of seasonal movement. This has been demonstrated both for long-distance migration (Underhill *et al* 1992) and for relatively local movement (Harrison and Navarro, in press; Berruti *et al*, in press).

The use of reporting rates as a means of monitoring the changing status of populations through time, is problematic owing to the fact that the profile of the observer workforce, and therefore of the fieldcards which they submit, also changes with time. The potential for monitoring would improve if checklists could be standardized to a much greater extent (Navarro *et al* 1993).

The demand for atlas data as an aid in environmental consultancy was reported (Harrison 1992) and the potential to improve its relevance to this user group was demonstrated (Harrison *et al*, submitted).

Beyond the obvious importance of species' distributions and patterns of relative abundance to the field of conservation planning, it has been shown that the combination of atlas information for a suite of species can yield an index of diversity which may

	MR1	PL2	SH2	AQ1	LT2	RX3	RM3	RP3	LC2	WX3	WM3	WP3	RC1	FR1	CA2	MN2	EG2	WO1	IN2	AC3	BR3	TH3	RV3	GR1	NT2	SW3	SU3	MI3	SC1	FY2	KR2
PINKTHRTD TWINSPOT														A			A	A	A			A									
BLUEBLLD FIREFINCH														A			A	A	A			A									
JAMESON FIREFINCH																		A	A			A									
REDBILLD FIREFINCH																		A	A	Ā											
BLUE WAXBILL																		A	A	A											
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LIST OF UNCLASSIFIED SPECIES (i.e. habitat generalists)

Ostrich, Blackheaded Heron, Cattle Egret, White Stork, Abdim's Stork, Sacred Ibis, Hadeda Ibis, Mute Swan, Secretarybird, Cape Vulture, Yllwbll Kite, Black Kite, Blackshouldrd Kite, Tawny Eagle, Booted Eagle, Longcrested Eagle, Martial Eagle, Blkbrs Snake Eagle, Steppe Buzzard, Jackal Buzzard, Redbrs Sparrowhawk, Ovambo Sparrowhawk, Gymnogene, Lanner Falcon, Hobby Falcon, Sooty Falcon, Rock Kestrel, Chukar Partridge, Helmetd Guineafowl, Redshank, Spotted Dikkop, Redwing Pratincole, Ylwthrt Sandgrouse, Feral Pigeon, Rock Pigeon, Cape Turtle Dove, Laughing Dove, Namaqua Dove, Rosering Parakeet, Barn Owl, Spotted Eagle Owl, European Nightjar, European Swift, Black Swift, Bradfield's Swift, Whiterumped Swift, Horus Swift, Little Swift, Alpine Swift, Palm Swift, European Bee-eater, Ground Hornbill, European Swallow, Pearlbrstd Swallow, House Martin, Black Crow, Pied Crow, House Crow, Familiar Chat, Fiscal Shrike, European Starling, Indian Myna, Pied Starling, Wattled Starling, House Sparrow, Cape Sparrow, Masked Weaver, Redbilled Quelea, Pintailed Whydah, Chaffinch, Cape Canary, Bully Canary.

NUMBERS OF SPECIES PER CATEGORY

	I	A	TOT
Marine	44	18	62
Marine Pelagic	21	1	22
Marine Shore	15	15	30
Aquatic	86	46	132
Aquatic Lotic	9	67	76
Wetland Lotic Exposed Shore	2	8	10
Wetland Lotic Emergent Vegetation	2	30	32
Aquatic Lotic Open Water	4	12	16
Wetland Lacustrine	37	83	120
Wetland Lacustrine Exposed Shore	1	16	17
Wetland Lacustrine Emergent Vegetation	15	42	57
Aquatic Lacustrine Open Water	8	21	29
Montane and Rocky	20	10	30
Forest	30	73	103
Forest Coastal	5	17	22
Forest Montane	3	4	7
Forest Edge	2	24	26
Woodland	155	128	283
Woodland Indigenous	102	95	197
Woodland Indigenous Acacia	21	29	50
Woodland Indigenous Broadleaved	8	5	13
Woodland Indigenous Thicket	2	30	32
Woodland Indigenous Riverine	2	40	42
Grassland	32	66	98
Grassland Natural	19	30	49
Grassland Natural Sweet	1	1	2
Grassland Natural Sour	11	6	17
Grassland Natural Moist	3	8	11
Scrub	28	53	81
Scrub Fynbos	6	11	17
Scrub Karoo	14	28	42
Unclassified	-	-	72

	MR1	PL2	SH2	AQ1	LT2	RX3	RM3	RP3	LC2	WX3	WM3	WP3	RC1	FR1	CA2	MN2	EG2	WO1	IN2	AC3	BR3	TH3	RV3	GR1	NT2	SW3	SU3	MI3	SC1	FY2	KR2
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APPENDIX: HABITAT CLASSIFICATION OF SPECIES

Species common names as given in Roberts' Birds of Southern Africa (Maclean 1985) and listed in Roberts' number order.

KEY:
A = associate; I = indicator; 1 = primary category; 2 = secondary category; 3 = tertiary category; MR = marine; PL = pelagic; SH = shore; AQ = aquatic; LT = lotic; RX = open water; RM = exposed shore; RP = emergent/marginal vegetation; LC = lacustrine; WX = open water; WM = exposed shore; WP = emergent/marginal vegetation; RC = montane and rocky habitats; FR = forest habitats; CA = east coast forest; MN = afromontane forest; EG = forest edge; WO = woodland habitats; IN = indigenous; AC = thicket; BR = acacia; TH = broadleaved; RV = riverine; GR = grassland habitats; NT = natural; grassland; SW = sour; SU = sweet; MI = moist; SC = scrub habitats; FY = fynbos; KR = karoo

	MR 1	PL 2	SH 2	AQ 1	LT 2	RX 3	RM 3	RP 3	LC 2	WX 3	WM 3	WP 3	RC 1	FR 1	CA 2	MN 2	EG 2	WO 1	IN 2	AC 3	BR 3	TH 3	RV 3	GR 1	NT 2	SW 3	SU 3	MI 3	SC 1	FY 2	KR 2
JACKASS PENGUIN	I																														
GRT CRESTED GREBE				I					I			I																			
BLACK-NECKED GREBE	A	A		A					A			A																			
DABCHICK				I	A			A	A			A																			
SHY ALBATROSS	I	I																													
BLKBROWD ALBATROSS	I	I																													
YELLWNSE ALBATROSS	I	I																													
STHRN GIANT PETREL	I	I																													
NTHRN GIANT PETREL	I	I																													
PINTADO PETREL	I	I																													
GREATWINGED PETREL	I	I																													
SOFTPLUMAGD PETREL	I	I																													
BROADBILLED PRION	I	I																													
WHITECHINND PETREL	I	I																													
CORY'S SHEARWATER	I	I																													
GREAT SHEARWATER	I	I																													
SOOTY SHEARWATER	I	I																													
EURPN STORM PETREL	I	I																													
WILSN STORM PETREL	I	I																													
WHITE PELICAN				I					I			I																			
PINKBACKED PELICAN				I					I			I																			
CAPE GANNET	I	I																													
WHITBRST CORMORANT	A			A	A			A	A			A																			
CAPE CORMORANT	I																														
BANK CORMORANT	I																														
REED CORMORANT				I	A			A	A			A																			
CROWNED CORMORANT	I																														
DARTER				I	A			A	A			A																			
GREY HERON	A		A	A	A				A																						
GOLIATH HERON				I	A				A																						
PURPLE HERON				I	A		A		A		A																				
GREAT WHITE EGRET				I	A				A																						
LITTLE EGRET	A		A	A	A				A																						
YELLOWBILLED EGRET				I					I		I																				
BLACK EGRET				I					I		A																				
SQUACCO HERON				I	A		A		A		A																				
GREENBACKED HERON				I	A		A		A		A																				
RUFOUSBELLD HERON				I					I		I																				
BLKCRN NIGHT HERON	A			A	A		A		A		A																				
WHTBCK NIGHT HERON				I	I		I																								
LITTLE BITTERN				I	A		A		A		A																				
DWARF BITTERN				I					I		I																				
BITTERN				I					I		I																				
HAMERKOP				I	A				A																						
BLACK STORK				A	A				A																						
WOOLLYNECK STORK				A																				A							

	MR 1	PL 2	SH 2	AQ 1	LT 2	RX 3	RM 3	RP 3	LC 2	WX 3	WM 3	WP 3	RC 1	FR 1	CA 2	MN 2	EG 2	WO 1	IN 2	AC 3	BR 3	TH 3	RV 3	GR 1	NT 2	SW 3	SU 3	MI 3	SC 1	FY 2	KR 2
OPENBILL STORK				I	A				A																						
SADDLEBILL STORK				I	A				A																						
MARABOU STORK																		A	A												
YELLOWBILL STORK				I	A				A																						
BALD IBIS																								I	I		I				
GLOSSY IBIS				I					I																						
AFRICAN SPOONBILL				I					I																						
GREATER FLAMINGO				I					I			I																			
LESSER FLAMINGO				I					I			I																			
WHITEFACED DUCK				I	A				A		A	A																			
FULVOUS DUCK				I					I		A																				
WHITEBACKED DUCK				I					I		I																				
EGYPTIAN GOOSE				A																											
S AFRICAN SHELDUCK				I					I			I																			
YELLOWBILLED DUCK				I	A				A																						
AFRICAN BLACK DUCK				I	I			I																							
CAPE TEAL				I					I			I																			
HOTTENTOT TEAL				I					I		I																				
REDBILLED TEAL				I					I																						
CAPE SHOVELLER				I					I																						
SOUTHERN POCHARD				I					I			A																			
PYGMY GOOSE				I					I		I																				
KNOBBILLED DUCK				I					I		A	A																			
SPURWINGED GOOSE				A																											
MACCOA DUCK				I					I		A	A																			
BEARDED VULTURE													I											I	I		A				
HOODED VULTURE																		I	I												
WHITEBACKD VULTURE																		I	I												
LAPPETFACD VULTURE																		I	I												
WHITHEADED VULTURE																		I	I												
CUCKOO HAWK														A				A													
BAT HAWK																		A													
HONEY BUZZARD																		A													
BLACK EAGLE													I																		
STEPPE EAGLE																		I	I												
LSSR SPOTTED EAGLE																		I	I												
WAHLBERG'S EAGLE																		I	I												
AFRICAN HAWK EAGLE																		I	I												
AYRES' EAGLE																		A													
CROWNED EAGLE														A				A	A				A								
BROWN SNAKE EAGLE																		I	I												
BNDED SNAKE EAGLE														A	A			A	A				A								
BATELEUR																		I	I												
PALMNUT VULTURE														I	I																
AFRICAN FISH EAGLE				I	A				A																						
FOREST BUZZARD														I																	
LIZARD BUZZARD																		I													
LITTLE SPARROWHAWK														A				A													
BLACK SPARROWHAWK														A				A													
LTTL BNDED GOSHAWK																		I													
AFRICAN GOSHAWK														A				A													
GABAR GOSHAWK																		I	I	I											
PALE CNTNG GOSHAWK																		A	A	A									A		A
DARK CNTNG GOSHAWK																		I	I		I										
AFR MARSH HARRIER				I					I		I																				
MONTAGU'S HARRIER																		A	A					A	A						
PALLID HARRIER																		A	A					A	A						
BLACK HARRIER																								A					A		
OSPREY				I	A				A																						

TABLE 3

DEFINITION OF MIGRATORY STATUS

Pelagic	seabirds which breed in the Antarctic and/or sub-Antarctic and visit South Africa's offshore waters;
Inter-continental	long-distance migrants, almost all Palearctic;
Intra-African	migrants which move between South Africa and other parts of Africa;
"Resident"	birds which may or may not have local seasonal movements within South Africa;
Vagrant	species occurring only as vagrants and species extremely marginal to South Africa.

TABLE 2

DEFINITION OF ENDEMISM CATEGORIES

E1	=	endemic to the Republic of South Africa and/or the Kingdoms of Swaziland and Lesotho.
E2	=	endemic to southern Africa south of the Zambezi and Kunene Rivers.
E3	=	near-endemic to southern Africa but occurring marginally in neighbouring territories.
M1	=	migrant to South Africa only.
M2	=	migrant to southern Africa only.
M3	=	migrant to southern Africa and immediately neighbouring regions.