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FORUM

Forum es una sección que pretende servir para la publicación de trabajos de temática, contenido o formato diferentes a los de los artículos y notas breves que se publican en *Ardeola*. Su principal objetivo es facilitar la discusión y la crítica constructiva sobre trabajos o temas de investigación publicados en *Ardeola* u otras revistas, así como estimular la presentación de ideas nuevas y revisiones sobre temas ornitológicos actuales.

*The **Forum** section of* Ardeola *publishes papers whose main topic, contents and/or format differ from the normal articles and short notes published by the journal. Its main aim is to serve as a lighter channel for discussion and constructive criticism on papers or reseach lines published either in* Ardeola *or elsewhere, as well as to stimulate the publication of new ideas and short revisions on current ornithological topics.*

A BIBLIOMETRIC REVIEW OF THE RECENT LITERATURE IN ORNITHOLOGY

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SUMMARY.—*A bibliometric review of the recent literature in ornithology*. The number of papers published in zoology between 1978 and 1998 were 1308244, according to the Zoological Records (BIOSIS ®) and 15% of them reported studies on birds. Although the class Insecta had the largest number of papers in that period, more papers were published about mammals and birds than insects in proportion to the number of species in each taxonomic group. We found that the topics of the ornithological literature with more papers published were reproduction and breeding biology, population dynamics and biological conservation and wildlife management. The topics in ornithology with the largest increases in the number of papers were population dynamics (86%), physiology and biochemistry (79%) and predation (79%). The topics with the largest decreases were catalogues, checklists and atlases (-36%) and breeding biology (-21%). For other topics such as migration, habitat selection, behaviour or parasites, diseases and disorders, the number of papers published annually between 1978 and 1998 did not change significantly. We also found that the number of authors per paper in ornithology has increased from 1.03 in 1900 to 2.19 in 1998. In addition to these results, this review shows the exciting posibilities that libraries, personal computers and bibliographic databases will offer to ornithologists.

Key-words: authorship, Aves, historical trends in ornithology, number of authors, number of papers, research topics.

RESUMEN.—*Una revisión bibliométrica de las publicaciones recientes en Ornitología*. Entre 1978 y 1998 los estudios publicados en zoología fueron unos 1308244, según el Zoological Records (BIOSIS ®). Un 15% de estos trabajos eran estudios sobre aves. La clase Insecta tuvo el mayor número de publicaciones en ese período, aunque se publicaron más trabajos sobre mamiferos y aves que sobre insectos en proporción al número de especies de cada grupo taxonómico. Hemos encontrado que los temas de estudio en ornitología con mayor número de trabajos publicados fueron la biología de la reproducción, la dinámica de poblaciones y la biología de la conservación y gestión de la vida silvestre. Los temas que han mostrado un incremento mayor han sido la dinámica de poblaciones (86%), la fisiología (79%) y las relaciones entre depredadores y presas (79%). Los temas que han sufrido una disminución mayor en los últimos 20 años han sido los catálogos, atlas y guías (-36%) y la biología de la reproducción (-21%). Otros temas como la migración, la selección de hábitat, el comportamiento o los parásitos, enfermedades y patologías no han variado significativamente con respecto al número de trabajos publicados cada año entre 1978 y 1998. Además, hemos encontrado que el número de autores por trabajo en ornitología se ha incrementado desde 1,03 en 1900 hasta 2,19 en 1998. Los

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resultados obtenidos en este trabajo son tan sólo una pequeña muestra de las posibilidades que ofrece la información almacenada en las bibliotecas. Esta información está a disposición de los ornitólogos de modo masivo desde hace poco tiempo gracias a la popularización de los ordenadores personales y al desarrollo de las bases de datos.

Palabras clave: autoría, Aves, número de autores, número de trabajos, tendencias históricas en ornitología, temas de investigación en ornitología.

INTRODUCTION

Research on birds is popular because birds are more conspicuous for humans than any other group of animals, and because they are excellent subjects in many areas of biological research (Konishi *et al*., 1989). When compared to vertebrate classes and invertebrate taxa of similar rank, birds are remarkable for the uniformity in their anatomy, physiology and life cycle. In spite of this, birds inhabit all regions of the earth and assume a wide variety of ecological roles. These and many other attributes make birds ideal subjects for research and the ornithology a worthy science, to the extent that research on birds has been pivotal to the development of many fields of both basic and applied biology such as ecology, physiology, conservation biology or evolution (Konishi *et al*., 1989; Nicholson & Crick, 1994).

Regardless of the importance of birds as subjects of biological research, no studies on the historical change in the research effort devoted to birds has been developed to date. Such an analysis will provide guidance to both junior and senior ornithologists when choosing among reseach topics, as well as a better understanding of the scientific framework of their own research.

Ornithological journals are read by scientists and students, but also by amateurs. For all these people, several questions would come to mind when they look through the huge amount of literature published every year. What is, and what has been, the research effort devoted to birds relative to other animal groups? How many topics are being addressed by ornithologists? Which topic has produced the largest number of papers? How did this production change in the last years? Do ornithologists work alone or integrated into research teams? The answers to these questions lie in the libraries, but an efficient understanding of the recent literature is a time consuming task that requires to check frequently a bunch of journals sometimes not easily accessible. The use of computers and literature databases is an efficient shortcut to deal with this task, as it offers a good picture of the current and past research in ornithology at one's fingertips. With the use of computers and databases one can estimate quantitatively the research effort devoted to both specific and broad topics on the basis of the key-words provided by the authors, as well as to describe the quantitative changes in the number of papers published on each topic and on the number of authors of these papers.

The main aim of this short review of the zoological literature is to provide answers to these questions. Specifically, we will describe a) the temporal changes in the number of ornithological papers published during this century relative to the research effort in zoology; b) the relative number of ornithological papers published in the last twenty years according to the main topics addressed by ornithologists; and c) the temporal changes in the number of authors of ornithological papers, used as an estimate of the size of the research teams in ornithology.

MATERIAL AND METHODS

The Zoological Records (ZR), published by Biological Abstracts Inc. (BIOSIS ®) and the Zoological Society of London, aims to provide an annual index to the world's zoological literature, and is currently the most comprehensive database of zoological papers. Until 1978 it was published on paper, and from this year onwards both paper and CD-Rom editions (ZR on CD) are available. Currently, some 6000 serials published worldwide are indexed yearly in the ZR on CD. Each volume comprises several sections dealing with different animal groups (the systematic index). The number of papers published on each group between 1978 and 1998 were obtained by introducing the key words Amphibia, Annelida, Arthropoda Insec-

ta, Aves, Ctenophora-Cnidaria, Echinodermata, Fishes, Mammalia, Nematoda, Other Arthropods, Platyhelminthes, Porifera, Protozoa, Reptilia and Tunicata in the field «systematics» of the ZR on CD. The number of papers published every ten years both on birds and on all animals were extracted manually from the printed editions of Zoological Records corresponding to the years 1900, 1910, 1920, 1930, 1940, 1950, 1960 and 1970. The values for 1980 and 1990 were extracted from the CD-Rom edition (ZR on CD) as explained above.

The ZR on CD also include a subject index with information arranged under fixed headings (e.g. parasites) with key-words grouped together (e.g. host, avian-host, protozoan-parasites, etc.). An alphabetical list of key-words are also provided. The number of key-words is huge (some thousands), and some key-words are frequently used in most articles while others are not (the ZR on CD indicates the number of times each key-word is included in the database). To estimate the number of papers published according to main topics within ornithology with a reasonable research effort we selected the key-words most frequently used in each topic. To do so, we browsed the key-word index of the ZR on CD noting the key-words wich appeared most often in the analysed 20-year period. We also selected a sample of 250 references per year between 1978 and 1998 in the ZR on CD (i.e., 5000 references in total) to check for between-years consistency of the frequency rank obtained. Only the 616 key-words most frequently used both within and between years were finallly selected. These key-words allowed us to assign more than 75% of the 199210 ornithological papers published in the study period to 14 main topics defined by the fixed headings of the ZR. Details on the search procedure, the methods for key-word combination and the list of key-words are given in the Appendix.

Using the field 'journal' of the ZR on CD, we will also be able to extract the number of papers published in *Ardeola* on each of these topics, so that we could also evaluate whether the main topics of the papers published by this journal fitted the pattern found for the whole zoological literature.

The main purpose of this concise review is to serve as a broad survey of ornithology, instructive enough for most people, that may be used as a primer in ornithology by fledglings. We are aware that every subject in ornithology offers material enough to write a review on its own, and some reviews are indeed as large as books (e.g., Berthold, 1993). To compensate for this shortcoming, we will provide, in addition to the bibliometric data, a selection of reviews on each topic for those interested in going deeper into particular subjects.

Finally, the mean number of authors per paper was calculated with a sample of 1000 references per year from 1978 to 1998 extracted from the ZR on CD. A sample of 200 references in 1900, 1925 and 1950 was also extracted for comparison from the printed edition of ZR.

Results and Discussion

Changes in the research effort on birds during the XXth century

Although the number of papers published on each animal group between 1978 and 1998 was related to the number of species in such groups (Fig. 1; Pearson's coefficient of correlation = 0.65, $P < 0.01$), a strong bias towards bird studies is evident. The number of papers in zoology indexed in the ZR on CD were 1308244, 199210 of them (15%) dealing with birds. Only the Class Insecta received a larger number of papers in that period (332402 references, 25%). The class Insecta was the one with the maximum number of both species and papers, but mammals and birds were the groups of animals with more papers published in proportion to the number of species in each group.

Alternatively to the number of species, we might have selected other indexes of the relative importance of each animal group such as total biomass or the number of individuals and their activity in the ecosystem. However, the figures for these variables are much more difficult to estimate than the crude number of species (Wilson, 1988). The time and effort required to estimate them were enormous, and even those indexes were research subjects themselves. It is true that the number of species on Earth is also unknown, even to the nearest order of magnitude (Wilson, 1985; Wilson, 1988), but nonetheless enough information about it has been obtained (Wilson, 1988) to allow this analysis of scientific taxonomic bias.

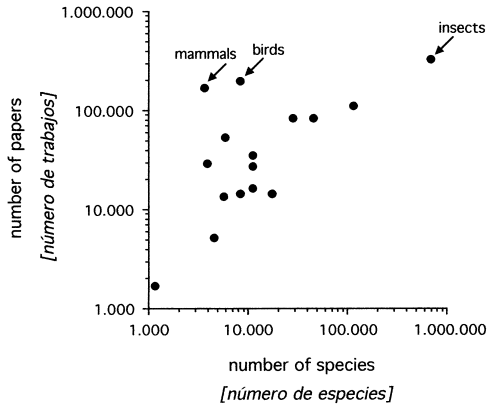

FIG. 1.—The number of papers on each group of animals in the last twenty years of the XXth century as compared to the number of species known for such groups (Wilson, 1988). Mammals and birds were the two groups of animals with the largest number of papers in proportion to their number of species. The number of papers published on each group were obtained by introducing the key words Amphibia, Annelida, Arthropoda Insecta, Aves, Ctenophora-Cnidaria, Echinodermata, Fishes, Mammalia, Nematoda, Other Arthropods, Platyhelminthes, Porifera, Protozoa, Reptilia and Tunicata in the field «systematics» of the ZR on CD.
[Número de publicaciones en los últimos veinte años del siglo veinte en relación al número de especies conocidas en cada grupo de animales (Wilson, 1988). Los Mamiferos y las aves fueron los dos grupos principales de animales con mayor proporción de trabajos respecto al número de especies. El número de trabajos publicados en cada grupo se obtuvo empleando como palabras clave en el campo 'systematics' del ZR en CD las palabras clave Amphibia, Annelida, Arthropoda Insecta, Aves, Ctenophora-Cnidaria, Echinodermata, Fishes, Mammalia, Nematoda, Other Arthropods, Platyhelminthes, Porifera, Protozoa, Reptilia and Tunicata .]

Articles dealing with birds accounted for 15% of the zoological literature between 1978 and 1998 (Fig. 2), but this percentage has varied in the course of the last century. The number of papers published each year in ornithology increased twentyfold from 580 in 1900 to 11000 in the nineties. A similar rise was also found when considering all animal groups together, as some 5000 zoological papers were published in 1900 as compared to the 70000 published in the nineties. We found that ornithological papers accounted for 10-16% of the total number of papers published on animals in the last century (mean ± SE = 12.9 ± 0.6; Figure 2a). Although there was a significant decrease in the proportion of zoological papers devoted to birds since 1991 (Figure 2b), in 1998 this percentage was not different from the mean figure for the whole XXth century (13%, t_9 = -0.01, P = 0.995). Hence, this apparent decrease in the relative effort devoted to birds within zoology lies within the historical range of fluctuation of this effort within the last century, so that it would be risky to conclude whether the decreasing trend detected for the last seven years will hold for the future. At this moment, we can only conclude that ornithology has accounted for 13% of the research effort in zoology throughout the XXth century with some minor fluctuations around this mean value.

Recent changes in the main topics addressed by ornithologists

The largest part of the ornithological literature in the last twenty years of the XXth century dealt with breeding biology, population dynamics and biological conservation and wildlife management (Table 1). This result was unrelated to the number of key-words included for each topic (r = 0.33, n = 14, P = 0.255; Pearson correlation coefficient for the relationship between the number of key-words and the number of papers across main topics). Population dynamics was not only the most popular subject, but also the one with the largest increase (86%) between 1978 and 1998 (Table 1). Other subjects with large increases of the number of papers published were physiology and the relationships between predators and prey. The subjects with the largest decrease in the last 20 years were catalogues, checklists and atlases, and reproduction and breeding biology. The changes in other subjects such as parasites, diseases and disorders, migration, habitat selection or behaviour were not statistically significant (Table 1).

These results describe synthetically which subjects have attracted the attention of ornithologists and which subjects have increased their 'popularity' in the last twenty years. Although some avian studies extend their scope beyond the selected key-words used in this review, the fact that 75% of the publications were

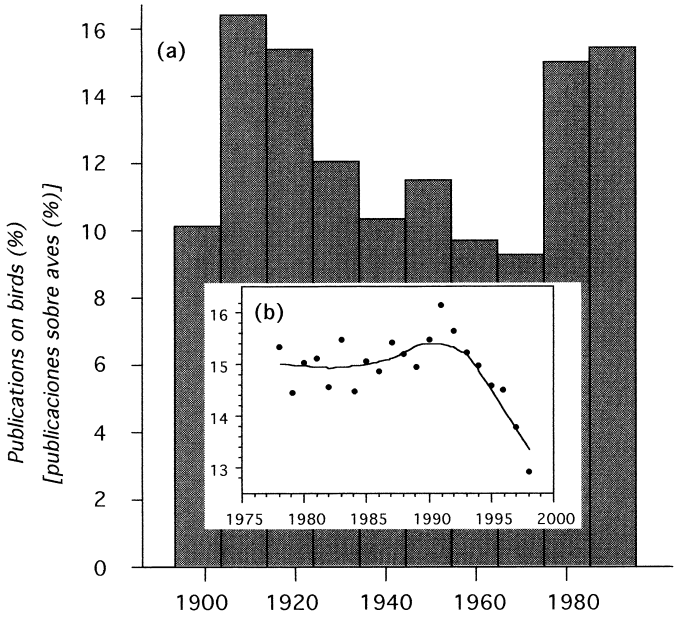

FIG. 2.—Percentage of publications on birds with respect to the total number of papers published in zoology (a) every ten years since 1900 and (b) every year since 1978. The number of papers published every ten years both on birds and on all animals were extracted manually from the printed editions of the Zoological Records corresponding to the years 1900, 1910, 1920, 1930, 1940, 1950, 1960 and 1970. The corresponding values for 1980 and 1990, as well as the yearly numbers of papers for the period 1978-1998, were extracted from the CD-Rom edition (ZR on CD) with the method described in Fig. 1. The line in (b) displays the lowest locally-weighted smoothed trend (tension = 66; SAS, 1998).
[Porcentaje de publicaciones sobre aves con respecto del número total de trabajos publicados en zoología desde 1900 (a) y desde 1978 (b). El número de publicaciones sobre aves y el total de publicaciones recogidas en la base de datos Zoological Records (ZR) fueron contados cada diez años desde 1900 hasta 1970. El promedio de los porcentajes anuales para las décadas 1980 y 1990 (Fig. 2a) fue calculado con el número de publicaciones recogidas en la base de datos ZR en CD (Fig. 2b). La linea en (b) muestra un ajuste suavizado por mínimos locales (tensión = 66; SAS 1998)]

covered by only 616 key-words suggests that the missed key-words describe fields of research that have atracted little attention in the last twenty years. It should be kept in mind, however, that this analysis is based on the 'popularity' of research expressed as number of publications in main topics. We do not claim that avian research should be driven by principles of 'popularity' alone. In fact, some of the most 'popular' concepts in ornithology throughout the last twenty years were novel ideas, previously disregarded, and they have required a laborious effort to get published (e.g., 'the handicap principle', first proposed by Zahavi in 1975 and 1977 and now included in most textbooks on avian evolution).

The distribution of papers among topics in *Ardeola* was significantly predicted by the ZR pattern ($F_{1,13}$ = 11.23, P = 0.006, R^2 = 0.44, linear regression analysis of the number of papers in *Ardeola* and ZR across topics; Table 1). Nonetheless, *Ardeola* has published a larger proportion of papers dealing with predation, foraging and habitat selection, and less papers on biological conservation and wildlife management and behaviour, in the lasts twenty years as compared to the whole ornithological literature (residual analysis of the linear regression results).

The scope of *Ardeola* is devoted to papers on all aspects of ornithology, but a special acknowledgement of papers dealing with ornithology in areas of Mediterranean climate and on

TABLE 1

Number of key-words and number of papers in fourteen broad topics of research in ornithology indexed in the Zoological Records (ZR) database. The percentage of change was accepted as significant when the Pearson´s correlation coefficient between the number of papers per year and the year was statistically significant (**: $P < 0.01$).
*[Número de palabras clave y número de publicaciones en catorce temas amplios de investigación en ornitología recogidas en la base de datos Zoological Records (ZR). El porcentaje de cambio fue considerado significativo cuando el coeficiente de correlación simple entre el número de publicaciones recogidas en el ZR cada año y el año fue estadísticamente significativo (**: P < 0,01).*

Main topics *[temas principales]*	number of key-words *[número de palabras clave]*	number of papers in ZR *[número de publicaciones en el ZR]*	1978-1998 increase (%) *[incremento entre 1978 y 1998 (%)]*	*P*	number of papers in *Ardeola* *[número de publicaciones en* Ardeola*]*	Some recent reviews of the topic [1] *[Algunas revisiones recientes sobre el tema [1]]*
A Catalogues, checklist, and atlases *[Catálogos, guías y atlas]*	10	4.931	–36	**	1	Cramp *et al.,* 1977-1994; Del Hoyo *et al.,* 1999
B Pollution *[Contaminación]*	20	5.169	77	**	4	Furness & Greenwood, 1993; Kendall & Lacher, 1994; Beyer *et al.,*1996
C Evolution *[Evolución]*	46	10.232	64	**	18	Endler, 1986; Ridley, 1996; Andersson, 1994; Harvey & Nee,1997
D Parasites, diseases and disorders *[Parásitos, enfermedades y patologías]*	59	10.860	29	0,19	2	Loye & Zuk, 1991; Grenfell & Dobson, 1995; Clayton & Moore, 1997
E Migration *[Migración]*	8	13.714	9	0,20	44	Berthold, 1993
F Predation *[Predación]*	17	14.140	79	**	77	Lima, 1986; Inman& Krebs, 1987; Burger,1988; Suhonen *et al.,* 1993; Lima, 1998
G Physiology and biochemistry *[Fisiología]*	109	18.763	79	**	38	Holmes & Austad,1995; Carey, 1996
H Foraging, nutrition and diet *[Alimentación, nutrición y dieta]*	28	21.727	50	**	124	Stephens & Krebs,1986; Carey, 1996; Kacelnik & Bateson,1996; Perry & Pianka, 1997
I Habitat selection *[Selección de hábitat]*	25	23.218	31	0,64	98	Cody, 1985; Block & Brennan, 1993
J Morphology and biometry *[Morfología y biometría]*	87	24.264	53	**	48	Liem & Wake, 1985; Wake, 1992
K Behaviour *[Comportamiento]*	69	30.195	24	0,06	45	Alcock, 1993; Carranza, 1994
L Biological conservation and wildlife management *[Biología de la conservación y gestión de la vida silvestre]*	70	37.030	13	**	45	Nicholson & Crick, 1994; Tellería, 1999
M Reproduction and breeding biology *[Biología de la reproducción]*	49	37.613	–21	**	85	Magrath, 1990; Potti & Moreno, 1996; Hahn *et al.,* 1997
N Population dynamics *[Dinámica de poblaciones]*	33	43.780	86	**	153	Curio, 1989; Newton, 1989; Sinclair, 1989; Finch, 1990; Roff, 1993; Stearns, 1993; Sutherland,1996

[1] See *Current Ornithology, Vols. 1-15* for a complete list of reviews in ornitology.
[Véase Current Ornithology, *vols. 1-15 para una lista completa de revisiones en ornitología.]*

the conservation on birds and their habitats has been established recently. We have shown that the research effort devoted to the topic of biological conservation and wildlife management has been relatively large and stable throughout the last 20 years, thus indicating a broad scope of *Ardeola* within this field. To analyse the scope for Mediterranean ornithology, three key-words were used (see the Appendix for details). In the last 20 years, 910 papers dealing with ornithology in areas of Mediterranean climate have been published in some journals indexed in ZR on CD. The relative number of papers on this topic has increased 150% in the last 20 years (Figure 3). The number of papers in the areas of Mediterranean climate made the largest contribution in 1997, when they accounted for more than 0.8% of all ornithological papers. The editorial guideline of promoting studies on birds in Mediterranean habitats was thus supported by our bibliometric analysis, because the editorial team has picked out a subject with a large and stable increase of its publication share in ornithology in the last twenty years.

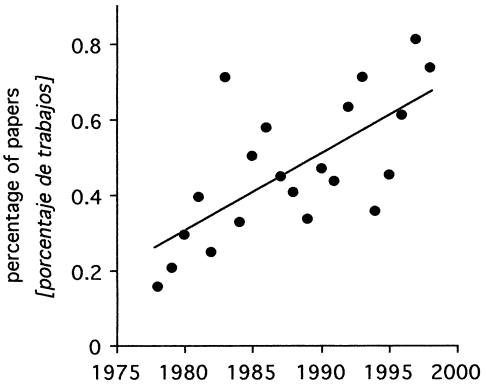

FIG. 3.—The number of papers on birds of Mediterranean habitats. The number of papers is shown as a percentage of the total number of papers on birds indexed in the Zoological Records on CD each year. The line shows the linear regression fit (number of papers (%) = -39,55 + 0,02 * year; $R^2 = 0,47$; $P < 0,01$).
*[Número de publicaciones sobre aves en hábitats mediterráneos. El número de trabajos se muestra como porcentaje del número total de publicaciones sobre aves recogidas en la base de datos Zoological Records en CD cada año. La linea muestra el ajuste a un modelo de regresión lineal (número de trabajos (%) = -39.55 + 0.02 * año; $R^2 = 0.47$; $P < 0.01$).]*

Trends in the number of authors

Most disciplines in zoology are becoming collaborative disciplines (Fitter, 1999). The need for collaborating would have probably changed in the last hundred years, so we also address what is the current number of authors per publication in ornithology and how this figure has changed in the last century. An increase in the mean number of authors per paper may be also due to an increase in the number of ornithologists in most countries in the last hundred years (e.g. Nicholson & Crick, 1994). In fact, an authorship 'inflation' is taking place in many zoological disciplines other than ornithology (e.g. entomology, Carolina Martín, pers. comm.). To our knowledge, this is the first attempt to show the historical trend in the number of authors per paper in ornithology. Such an analysis may be also relevant because students may wonder how many people are required to carry out a study in ornithology and when a team becomes a crowd.

Papers in ornithology have been written typically by one person during most part of the XXth century (median number of authors per paper = 1). However, there has been an accelerated increase in the number of author per paper since 1900 (Fig. 4). In fact, the average

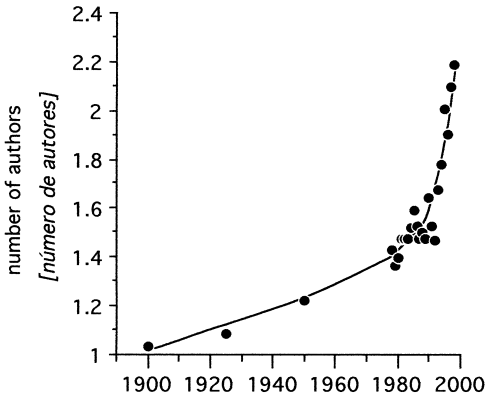

FIG. 4.—The mean number of authors per publication in Ornithology in 1900, 1925, 1950 and every year from 1978 to 1998. The line displays the lowest locally-weighted smoothed trend (tension = 66; SAS 1998).
[Número medio de autores por trabajo en Ornitología en 1900, 1925, 1950 y cada año entre 1978 y 1998. La linea muestra un ajuste suavizado por mínimos locales (tensión = 66; SAS, 1998)

number of authors per paper has doubled from one to more than two in the nineties. An increase in the number of authors per paper may be an index that ornithologists are joining their efforts to cope with new challenges, making ornithology a collaborative discipline. Indeed this is an exciting time for ornithology (Konishi *et al*., 1989; Krebs & Davies, 1997), and the increasing use of advanced and complicated techniques requires the pooling of 'know-how' from different researchers. But there are other reasons that could explain such increase. Benefits other than scientific progress may be operating (Aparicio & Cordero, 1999; Woodell, 1999), because collaboration may increase the number of papers of each author (Aparicio & Cordero, 1999), and the number of papers may decide the fate of a career in ornithology and in science (Rennie & Flanagin, 1994; Garfield, 1995; Schoonbaert & Roelants, 1996; Drummond, 1999; Kokko & Sutherland, 1999).

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APPENDIX

Key-words selected and the main topic in which they were included (A: Catalogues, checklists and atlases; B: Pollution; C: Evolution; D: Parasites, diseases and disorders; E: Migration; F: Predation; G: Physiology; H: Foraging, nutrition and diet; I: Habitat Selection; J: Morphology and biometry; K: Behaviour; L: Biological Conservation and Wildlife Management; M: Reproduction and breeding biology; N: Population dynamics). The number of publications in each subject was obtained with all keywords typed separately with the logical operator «or» in the window «search» of the ZR on CD. The list of keywords was typed with the year separated with the logical operator «and» to obtain the number of references for each year and subject. Some key-words can be included in more than one subject. In this review twenty-one keywords were included in two subjects because we were unable to assign them to only one. For instance, the term *industrial-activity* was included in the subject Pollution, but also in the subject Conservation Biology and Wildlife Management. No key-word was included in three or more subjects. Occasionally there was more than one key-word with the same meaning (e.g., *mediterranea*, *Mediterranean* and *mediterraneo*). The root of the word plus a wildcard character (*) were used in these cases (e.g., *mediter**).

We grouped the key-words into 14 subjects according to the criteria described in the indexes of the printed version of the ZR. Although some of the subjects described in the ZR were grouped (e.g., respiration and excretion were included in physiology), we used in this review the main index of subjects provided by the ZR. Only one subject used in this review was not isolated in the ZR (bird migration). We may have selected more subjects, adding realism and also increasing the scope of the review. However the costs were several. First, some dialectic questions about what should be a subject in ornithology increased as the number of potential subjects increased. Second, some specific research fields have changed their key-words over time. For instance, in 1980 there was a peak in the number of papers reporting the keyword *optimal foraging* when studying the subject *foraging, nutrition and diet*. In 1995 there were also publications about optimal foraging, but the field has expanded and the keyword «*optimal foraging*» has been replaced by others terms of the research subject (*Bayesian models, public information, linear operator models*, etc. (Giraldeau, 1997)). These and other keywords are present in optimal foraging papers, but the keyword *optimal foraging* may not be included as a descriptor of them. The number of articles on a narrow subject based solely in the use of the key-word *optimal foraging* seems to decline, but it is in fact expanding (Vásquez & Kacelnik, 1998). A key-word may define more than one subject and one paper may be included in more than one subject. Thus, there was an overlap between subjects and the sum of the number of papers in each subject was larger than the total number of papers in ornithology. The work of characterizing independent subjects with a little overlap between them was a huge task, and perhaps a non-sense one.

*[Palabras clave empleadas en la revisión y el tema en el que fueron incluidas (A: Catálogos, guías y atlas; B: Contaminación; C: Evolución; D: Parásitos, enfermedades y patologías; E: Migración; F: Predación; G: Fisiología; H: Alimentación, nutrición y dieta; I: Selección de hábitat; J: Morfología y biometría; K: Comportamiento; L: Biología de la conservación y gestión de la vida silvestre; M: Biología de la reproducción; N: Dinámica de poblaciones). El número de publicaciones en cada tema se obtuvo combinando todas las palabras clave separadas con el operador lógico «or» en la ventana «search» del ZR en CD. Para obtener el número de referencias de cada tema en cada año, la lista de palabras clave fue escrita otra vez añadiendo el año con el operador lógico «and». Agunas palabras clave pueden ser incluidas en más de un tema. En esta revisión, 21 palabras clave se incluyeron en dos temas porque no fue posible asignarles un solo tema. Por ejemplo, el término «*actividad industrial*» fue incluido en el tema* Contaminación*, pero también en el tema* Biología de la Conservación y Gestión de la vida silvestre. *Ninguna palabra clave fue incluida en tres o más temas. En ocasiones hubo más de una palabra clave con el mismo significado (e.g.,* mediterranea*,* Mediterranean *y* mediterraneo*). En estos casos se usó la raiz de la palabra más un carácter comodín (e.g.* mediter**).*

Las palabras clave fueron agrupadas en 14 temas siguiendo el criterio descrito en la versión impresa del ZR, aunque algunos temas descritos en el ZR fueron agrupados (e.g., respiración *y* excreción *fueron agrupados dentro de* fisiología*). Sólo un tema empleado en esta revisión no aparece citado en el ZR (*migración de aves*) Obviamente, podríamos haber seleccionado más temas, añadiendo realismo e incrementando la amplitud de la revisión. No obstante, los costos de esa decisión fueron varios. Primero, las cuestiones dialécticas sobre qué debía ser un tema en ornitología aumentaban a medida que se incrementaba el número posible de temas. Segundo, algunos temas de investigación han cambiado sus palabras clave con el tiempo. Por ejemplo, en 1980 el número de trabajos con la palabra clave «*optimización alimentaria*» alcanzó un máximo en el tema* Alimentación*,* Nutrición y Dieta. *En 1995 aún hubo artículos sobre «*optimización alimentaria*», pero el tema de investigación se había expandido y la palabra clave «*optimización alimentaria*» había sido reemplazada por otras palabras clave del mismo tema (*«modelos bayesianos», «información pública», «modelos de operador lineales», *etc.; Giraldeau, 1997). Estas y otras palabras clave se emplean en los artículos sobre optimización alimentaria, pero el término* «optimización alimentaria» *puede no emplearse. El número de artículos*

*sobre un tema basado en el uso de una palabra clave como «*optimización alimentaria*» parece disminuir, cuando en realidad aumenta (Vásquez & Kacelnik, 1998). Una palabra clave puede definir más de un tema y un artículo puede ser incluido en más de un tema. Por tanto, hubo un solapamiento entre temas y la suma de trabajos en cada tema fue mayor que el número total de trabajos en ornitología. El trabajo de caracterizar temas independientes con muy poco solapamiento entre ellos era un trabajo enorme y quizás tampoco tenga sentido realizarlo.]*

A - Catalogues, checklists and atlases;
Atlases, Catalogues, Checklists-, Directories-, Faunal-Works, Field-Guides, Field-Identification, Identification-Guides, Identification-Techniques, Natural-History-Accounts.

B - Pollution
Acid-Pollution, Chemical-Pollution, Environmental-Indicators, Fertilizer-and-Pesticide-Pollution, Fertilizers-and-Pesticides, Industrial-Activity, Industry-, Metal-Pollution, Metals-, Organic-Chemicals, PCB, Petrochemical-Pollution, Petrochemicals-, Physical-Pollution, Pollutant-Content, Pollutant-Metabolism, Pollutants-, Pollution-, Radioactive-Pollution, Radioactivity-.

C - Evolution
Adaptive-Radiation, Allopatric-Speciation, Colony-Formation, Continental-Drift, Convergence-, Chromosome-Structure, Chromosomes-, Evolution-, Evolutionary-Adaptation, Evolutionary-Trends, Extinction, Fossil-Assemblages, Fossil-Tracks, Gene-Flow, Gene-Frequency, Gene-Pool, Genetic-Techniques, Genetic-Variation, Genetics-, Genetics-Of-Polymorphism-and-Variation, Geological-Time-Periods, Heterotypic-Associations, Heterozygosity-, Hibridization, Homology-, Inbreeding-, Irruption-, Karyotype-, Molecular-Genetics, Mutation-, Mutualism, Natural-Selection, Nucleic-Acids, Nucleoplasm, Ontogenesis-, Origin-Of-Taxon, Phylogeny-, Pollination-, Radiation-, Sexual-Selection, Sibling-Species, Speciation-, Species-Diversity, Sympatry-, Synanthropy-, Zonation-.

D - Parasites, diseases and disorders
Acanthocephalan-Parasites, Amphibian-Hosts, Annelid-Hosts, Arachnid-Parasites, Avian-Hosts, Bacterial-Diseases, Cestode-Parasites, Coleopteran-Hosts, Coleopteran-Parasites, Crustacean-Hosts, Definitive-Hosts, Diagnosis-Of-Parasites, Digenean-Parasites, Dipteran-Hosts, Dipteran-Parasites, Diseases-, Diseases-and-Disorders, Disorders-, Distribution-Upon-Host, Distribution-Within-Host, Epidemiology, Epizootiology, Fungal-Diseases, Fungal-Parasites, Helminth-Parasites, Hemipteran-Parasites, Host-, Host-Parasite-Relationships, Host-Specifity, Human-Hosts, Hymenopteran-Parasites, Insect-Parasites, Intermediate-Hosts, Lepidopteran-Parasites, Mallophagan-Parasites, Mammalian-Hosts, Molluscan-Hosts, Nematode-Parasites, Neoplastic-Diseases, Parasites-, Parasites-Diseases-and-Disorders, Piscean-Hosts, Plant-Host, Prevalence-, Protozoan-Parasites, Reaction-Of-Host-To-Parasite, Reptilian-Hosts, Rickettsial-Diseases, Siphonapteran-Parasites, Transmission-By, Transmission-Of-Bacteria, Transmission-Of-Fungi, Transmission-Of-Parasites, Transmission-Of-Rickettsiae, Transmission-Of-Viruses, Treatment-Of-Disease, Treatment-Techniques, Trematode-Diseases, Viral-Diseases.

E - Migration
Emigration-, Homing-, Magnetism-, Magnetoreception-, Migration-, Navigation-, Orientation-, Spatial-Orientation.

F - Predation
Amphibian-Prey, Annelid-Prey, Avian-Predators, Avian-Prey, Crustacean-Predators, Crustacean-Prey, Insect-Predators, Insect-Prey, Mammalian-Predators, Mammalian-Prey, Molluscan-Prey, Piscean-Prey, Predation-, Predators-, Prey-, Reptilian-Predators, Reptilian-Prey.

G - Physiology
Biochemical-Techniques, Biochemical-Variation, Biochemistry-, Blood-, Blood-and-Serum-Proteins, Blood-Cells, Blood-Sucking, Body-Temperature, Carbohydrate-Metabolism, Colour-Pigments, Cytochemical-Techniques, Chemoreception-, Chromatography-Techniques, Defaecation-, Development-, Developmental-Disorders, Developmental-Stages, Dietary-Deficiency, Digestion-, Drinking-, Embryo-Development, Endocrinology-, Energy-Budget, Energy-Expenditure, Energy-Intake, Energy-Requirements, Energy-Utilization, Enzymes-, Excretory-Functions, Excretory-Products, External-Ph, Faecal-Analysis, Faeces-, Food-

Conversion-Efficiency, Growth-, Growth-Rate, Gut-Content, Gut-Microorganisms, Haematological-Techniques, Haemodynamics-, Heart-Beat, Hibernation-, Hipoxia, Histological-Techniques, Hormones-, Injuries-, Intermediary-Metabolism, Ion-and-Water-Relations, Ionic-Relations, Lipid-and-Fatty-Acid-Content, Lipid-and-Fatty-Acid-Metabolism, Lipids-, Mechanoreception-, Metabolic-Rate, Metabolism-Measurement, Mimicry-, Moulting-, Mummification-, Nervous-Electrophysiology, Nervous-System, Nervous-System-and-Behaviour, Neurons-, Neurotransmitters-, Nutrition-, Osmotic-Relations, Ossification-, Oxygen-Consumption, Photoreception-, Physiological-and-Biochemical-Sex-Differences, Physiological-Condition, Physiological-Techniques, Plasma-, Pressure-Receptors, Protein-Content, Proteins-, Reflexes-, Regurgitation-, Reproductive-Condition, Reproductive-Techniques, Respiration-, Respiratory-Function, Respiratory-Gas-Exchange, Respiratory-Gas-Transport, Respiratory-Passages, Respiratory-Quotient, Respiratory-Rate, Respiratory-Regulatory-Mechanisms, Sensory-Reception, Sex-Determination, Sexual-Maturation, Sexual-Reproduction, Sleep-, Spermatogenesis-, Steroids-, Tactile-Receptors, Taxis-, Temperature-, Temperature-Relationships, Thermal-Tolerance, Thermoregulation-, Tissue-Storage, Torpor-, Toxins-and-Venoms, Visual-Acuity-and-Discrimination, Visual-Pigments, Water-, Water-Movements, Water-Relations, Whole-Animal-Physiology.

H - Foraging, nutrition and diet

Carnivorous-Feeding, Diet-, Feeding-, Feeding-Analysis-Techniques, Feeding-On-Specific-Substances, Feeding-Rate, Fishing-and-Fisheries, Food-Availability, Food-Capture, Food-Carrying, Food-Handling, Food-Pellets, Food-Plants, Food-Preferences, Food-Robbing, Food-Sharing, Food-Storing, Foraging-, Grazing-, Herbivorous-Feeding, Honeydew-Eating, Ingestion-, Omnivorous-Feeding, Quantity-Of-Food-Consumed, Scavenging-, Seed-Dispersal, Starvation-, Trophic-Structure.

I - Habitat Selection

Associations-, Community-, Community-Comparisons, Community-Structure, Competitive-Exclusion, Dispersal-, Dispersal-Patterns, Distribution-Patterns, Distribution-Within-Habitat, Ecological-Mapping, Ecological-Niche, Geographical-Variation, Habitat-, Habitat-Colonization, Habitat-Exploitation, Habitat-Modification, Habitat-Preference, Habitat-Utilization, Horizontal-Distribution, Relative-Abundance, Seasonal-Abundance, Seasonal-Distribution-Within-Habitat, Spatial-Environment, Succession-In-Habitats, Zoogeography-.

J - Morphology and biometry

Adenohypophysis-, Adrenal-Cortex, Adrenal-Gland, Adrenal-Medulla, Air-Sacs, Albinism-, Asymmetry-, Autonomic-Nervous-System, Bill-, Biomass-, Biomechanics-, Biometrical-Techniques, Biometrics-, Bog-, Bone-, Brain-, Central-Nervous-System, Circulatory-System, Cloaca-, Colour-, Colour-Aberrancies, Colour-Change, Colour-Variation, Colour-Variety, Cornea-, Dermal-Skeleton, Digestive-System, Diving-, Ducts-Of-Female, Excretory-Glands, Eye-, Feathers-, Flight-, Forelimb-Skeleton, Forelimbs-, Functioning-Of-Eye, Ganglia-, General-Morphology, Gonad-, Gynandromorphism-, Head-, Hindlimb-Skeleton, Hindlimbs-, Integument-, Integumentary-Glands, Intestine-, Jaws-, Kidney-, Liver-, Locomotion-, Lungs-, Measurements-, Morphological-Sex-Differences, Morphological-Variation, Muscle-Arrangement-and-Gross-Muscle-Anatomy, Musculature-, Nervous-System, Ovary-, Pineal-Organ, Plumage-, Posture-, Proventriculus-, Reproductive-System, Respiratory-System, Retina-, Running-, Sexing-Techniques, Sexual-Dimorphism, Size-, Size-Variation, Skeletal-Musculature, Skeleton-, Skin-, Skull-, Striated-Muscle, Structures-Associated-With-Eye, Swimming-, Symmetry-, Tail-, Tendons-, Testis-, Thyroid-Gland, Tongue-, Trachea-, Volume-, Walking-, Weight-.

K - Behaviour

Abnormal-Behaviour, Acoustic-Signals, Activity-Patterns, Aggregating-Behaviour, Aggressive-Behaviour, Agonistic-Behaviour, Altruistic-Behaviour, Avoidance-Behaviour, Bathing-, Behaviour-, Behavioural-Interactions, Behavioural-Sex-Differences, Behavioural-Techniques, Behavioural-Variation, Circadian-Activity, Comfort-Behaviour, Communication-, Conditioning-, Cooperative-Behaviour, Courtship-, Courtship-Display, Crepuscular-Activity, Deceptive-Actions, Defensive-Behaviour, Display-, Diurnal-Activity, Echolocation, Experience-, Feeding-Behaviour, Flocking-, Gregariousness-, Grooming-, Group-Behaviour, Imprinting-, Interspecific-Competition, Intraspecific-Competition, Learning-, Lunar-Rhythm, Mating-, Mating-Call, Memory-, Mobbing-, Movements-, Nocturnal-Activity, Over-Wintering, Pair-Formation, Parent-Young-Interaction, Play-, Preening-, Reflex-Behaviour, Reproductive-Behaviour, Resting-, Roosting-, Seasonal-Activity, Seasonal-Functions, Social-Behaviour, Social-Hierarchy, Social-Organization, Sonographic-Techniques, Sound-, Sound-Characteristics, Sound-Reception, Sound-Recording-Techniques, Territoriality-, Tool-Using, Visual-Signals, Vocalizations, Warning-Behaviour.

L - Biological Conservation and Wildlife Management
Accidental-Damage, Accidental-Entrapment, Aerial-Nets, Animals-and-Man, Animals-As-Sport, Animals-As-Tools, Bird-Strike, Breeding-Programmes, Breeding-Techniques, Captive-Breeding-and-Rearing-Records, Captive-Breeding-Records, Captive-Rearing-Records, Care-Of-Eggs, Care-Of-Young, Censusing-Techniques, Commercial-Activities, Conservation-, Conservation-Measures, Control-, Damage-Caused-By-Animals, Damage-To-Crops, Damage-To-Livestock, Damage-To-Man-Made-Objects, Diet-In-Captivity, Dietary-Requirements, Dispersal-By-Man, Disturbance-By-Man, Education-and-Entertainment, Endangered-Species, Endangered-Status, Extinction, Extinction-, Farming-and-Agriculture, Food-For-Man, Habitat-Management, Habitat-Preservation, Hand-Rearing, Home-Range, Housing-Techniques, Impact-On-Habitat, Inbreeding-, Industrial-Activity, Industry-, Introduction-, Legislation-, Leisure-and-Sport, Marking-Techniques, Markings-, National-Parks, National-Parks-and-Reserves, Nature-Reserves, Netting-, Population-Censuses, Protection-Of-Endangered-Species, Radar-Tracking, Radio-Telemetry, Radio-Tracking, Rearing-Techniques, Release-and-Relocation-Programmes, Ringing-and-Tagging-Reports, Ringing-Recoveries, Ringing-Report, Tagging-, Telemetry, Tracking-Techniques, Trade-In-Animals, Trapping-, Wildlife-Management, Zoological-Gardens, Zoos-and-Wildlife-Parks.

M - Reproduction and breeding biology
Animal-Constructions, Breeding-Habits, Breeding-Place, Breeding-Population, Breeding-Programmes, Breeding-Season, Breeding-Site, Breeding-Success, Breeding-Synchronization, Breeding-Techniques, Broods-, Captive-Breeding-and-Rearing-Records, Captive-Breeding-Records, Care-Of-Eggs, Care-Of-Young, Clutches-, Colonial-Breeding, Cooperative-Breeding, Copulation-, Egg-, Egg-Laying, Egg-Number, Fertilization-, Fledgeing-Success, Fledgling-, Hatching-, Hatching-Success, Lek-, Monogamy-, Nest-and-Burrow-Fauna, Nest-and-Roost-Boxes, Nest-Building, Nest-Parasitism, Nest-Parasitism-Hosts, Nest-Parasitism-Parasites, Nest-Sharing, Nest-Usurpation, Nesting-, Nesting-Period, Nesting-Site, Nestling-, Nests-, Parental-Care, Parental-Condition-Effect-On-Progeny, Polygamy-, Productivity-, Sex, Young-, Young-Development.

N - Population dynamics
Age-, Age-Class-Distribution, Age-Determination, Ageing-, Censusing-Techniques, Emigration-, Fecundity-, Fertility-, Life-Cycle, Life-Cycle-and-Development, Life-Cycle-Stages, Life-Habit, Life-Tables, Longevity-, Mortality-, Natality-, Population-Censuses, Population-Changes, Population-Density, Population-Density-Measurement, Population-Dynamics, Population-Energetics, Population-Genetics, Population-Regulation, Population-Sampling, Population-Sex-Ratio, Population-Size, Population-Structure, Population-Study, Recruitment-, Reproduction-, Reproductive-Productivity, Survival-.