https://doi.org/10.30456/AVO.2023105

Avocetta 47: 2023F004

What species are being researched and why? A bibliometric analysis of breeding birds in Italy

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Abstract - The publication of updated works on the distribution, breeding and conservation status of Italian birds has stimulated an analysis of the factors that have so far guided the research. This was done through a bibliometric analysis of one of the largest scientific databases on the web. Two publication metrics were used, the total number of papers and the h-index. They express the quantity and the quality of research efforts through their impact on the scientific community. 791 articles concerning the 270 species reported in the Italian Atlas of Breeding Birds were selected and analysed by univariate statistics and negative binomial GLMs. Eight multilevel factors (origin of species, breeding phenology, main occupied habitat, population trends, degree of threat, national interest relative to population management, functional grouping and geographic range size) were used as potential predictors of species publication metrics. These 791 papers attracted 20,982 citations and had an overall h-index of 48. The publication years ranged from 1975 to 2023 with a significant increase in slope through time. The Barn Swallow leads the top ten of both publication metrics followed by the Lesser Kestrel and the Golden Eagle in the case of number of papers, while the Red-backed Shrike, and again the Lesser Kestrel follow the Barn Swallow in the first places of the h-index top ten. Main habitat, functional grouping and geographic range size are modelled as significant factors predicting a change in publication metrics, instead, the other five factors do not predict a significant change in both response variables. The lack of focus on research on species in numerical decline, threatened, or of national interest for population management reveals a main gap in Italian ornithological research. Another one is the skewed distribution of studies, with a not negligible 17% of breeding species that have never been the subject of a paper. These weaknesses are likely due to the low presence of ornithologists in local/national environmental and wildlife management bodies and to the uneven distribution of research groups among the Italian regions. Increasing the number of professional ornithologists and including them in local authorities and regional administrations is the best strategy to grow the levels of research and protection of Italian birds.

Keywords: Italian Breeding Bird Atlas, h-index, Italian ornithology, taxonomic chauvinism

INTRODUCTION

The Digital Revolution (Rifkin 2011) allows for computer-assisted scientific reviews that can identify and collect the vast majority of publications related to a certain topic or field, to discover emerging trends (Donthu et al. 2021). Not surprisingly, the number of reviews, comparative analyses and meta-analyses, referenced on scientific webs in ecology, evolution and conservation of terrestrial vertebrates is increasing with more or less steep slopes in the last 30 years (e.g. Fig. 1 in Ducatez & Lefebvre 2014). The research motivations for such bibliometric analyses are many and varied, but they all lead to one major conclusion: the unequal representation within the worldwide body of scientific research on living organisms.

Research is dominated by wealthy countries, while major research deficits occur in regions with disproportionately high biodiversity as well as with a large portion of threatened species. Similarly, core scientists work primarily in North America and Europe (Hendriks & Duarte 2008, Tydecks et al. 2018). In addition to this topical and geographic imbalance, the disparities in our knowledge of different organisms, and the greater or lesser focus they occupy in scientific research across a wide range of biological disciplines produce a taxonomic bias, also known as taxonomic chauvinism (Bonnet et al. 2002). Taxonomic bias is present at higher taxonomic scale, with some plant (e.g. Magnoliopsida, Liliopsida) and vertebrate (Aves, Mammalia, Actinopterygii, Amphibia) classes overrepresented in various scientific fields, more likely to raise funds, or considered more ecologically important than others (e.g. Insecta, Arachnida, Gastropoda, Agaricomycetes) (Troudet et al. 2017). But it also applies at intra-class or intra-order or even lower taxonomic levels (Troudet et al. 2017), for instance, it was found in Felidae (Brodie 2009), Rodentia (Amori & Gippoliti 2001), Carnivora (Brooke et al. 2014), and within the Amphibians (da Silva et al. 2020) and the Aves (Ducatez & Lefebvre 2014).

Taxonomic bias is pervasive and beyond biodiversity research because it has been noted in disparate fields. Reviews of parental care research on birds and mammals, for example, refer to a relatively narrow range of taxonomic groups (Stahlschmidt 2011), and this corresponds to the strongest overrepresentation among publications of behavioural research on endothermic vertebrates compared to arthropods (Rosenthal et al. 2017). Even a meta-analysis of LIFE animal projects on behalf of the Habitats Directive (92/43/EEC), revealed a taxonomic bias, as conservation effort is mainly explained by species popularity rather than extinction risk or body size (Mammola et al. 2020).

Taxonomic chauvinism in scientific research has long been known but the reasons for its existence are unclear. Certainly, several intrinsic reasons contribute to the fact that some taxonomic groups or regions are poorly studied. Populations of animals or plants that are rare and/or present in remote and expensive to explore areas contribute to this bias; as well as microscopic and or cryptic species and other animals whose identification requires the use of modern and specialized techniques (e.g. Blaxter 2004, Hebert et al. 2004).

However, these reasons are not enough to explain the unbalanced approach that scientists and conservation professionals have in choosing target species. The human dimension should also be taken into consideration because the cognitive biases of individuals guide the decision-making process (Catalano et al. 2018) and combine with social interests and emotional components to misrepresent the choice of study organisms (Stahlschmidt 2011, Troudet et al. 2017). For instance, flagship and iconic species such as the Peregrine Falcon (*Falco peregrinus*) or the White Stork (*Ciconia ciconia*) are among the most cited birds worldwide (2092 and 1526 publications respectively, in Ducatez & Lefebvre 2014). This occurs despite the robust framework already in place (e.g. Carignan & Villard 2002) for the selection of indicator species effective for the management of ecosystem integrity. It should be considered, however, that iconic species are often selected in response to widespread ecological illiteracy, because the keystone or other appropriate indicator species (see Carignan &

Villard 2002), may not necessarily be known or appreciated by the general public (Kronenberg et al. 2017).

Wildlife management and species conservation would certainly benefit from the recognition of intervention priorities (Master 1991) and the reasons for project failure (Catalano et al. 2018). Scientific research aware of these priorities and able to learn from the failures of a project will certainly be more effective in defending biodiversity (Sutherland et al. 2011; Catalano et al. 2019). This awareness would also make it possible to better channel the, often limited, resources dedicated to the conservation of species (Greggor et al. 2016).

In the face of the current global biodiversity crisis, with the current extinction rate tens to hundreds of times faster than the average over the last 10 million years (BirdLife International 2022), it is worth asking how to focus scientific research on the ecology and conservation of animal species on real emergencies.

Birds are among the best-studied living organisms and their populations have continued to decline worldwide with a faster rate of outright extinction since 1500 a. D. (Pimm et al. 2006, BirdLife International 2022). For that reason, scholars have reputed it important to identify what are the patterns and causes of taxonomic bias in ornithological research both on a global (e.g. Brito & Oprea 2009, Ducatez & Lefebvre 2014) and national scale (e.g. McKenzie & Robertson 2015).

The beginning of the 20s of this century is a key moment for the Italian ornithological community. The Italian Strategy on Biodiversity for 2030 (SNB 2030, www.mite.gov.it) arrives in correspondence with the publication of the new Atlas of Breeding Birds in Italy (Lardelli et al. 2022). Indeed, the latter comes together with the second European Breeding Bird Atlas (EBBA2, Keller et al. 2020) and the Eurasian African Bird Migration Atlas (Spina et al. 2022). Together, the three Atlases provide a formidable and up-to-date assessment tool for bird ecology, distribution and populations, which could underpin, if properly managed, Italian ambitious long-term plan to protect nature and reverse ecosystem degradation. A non-secondary asset for this turnaround is the National Recovery and Resilience Plan (NRRP) which entirely finances the National Biodiversity Future Centre (https://www.nbfc.it). A large network involving several universities, coordinated by the National Research Council (CNR), aimed at radically implementing the quality of biodiversity research in Italy (Morganti 2022). In this scenario, we all hope and expect that the professional importance of ornithologists and zoologists will increase in the coming years and thus contribute to a significant improvement in wildlife policy and management in our country (but see Morganti 2022).

The official list of breeding species in Italy (Lardelli et al. 2022) allowed me to analyse how they have been studied so far. The Italian ornithological reality is complex and the production of scientific articles is multifaceted. The regular production of articles in ISI journals that can be found on the Web of Science is accompanied by a large production not included in these databases (i.e. not-indexed). The collection of these bibliographic sources is certainly challenging and time-consuming, moreover, in these cases it would not be possible to use the h-index, but only the total number of papers.

To be in line with the aforementioned research on taxonomic chauvinism, this article deals exclusively with the production of indexed ornithological literature in our country, trying to quantify the effort and impact of the research at the single species level and to investigate the macro-factors that best explain the differences between ornithological production. The first question is certainly that of establishing whether there is a taxonomic bias in this field and how it is structured. Are we, for example favouring or neglecting research on the most endangered species? Are there species that may play a key role in the functioning of ecosystems that we do not fully understand due to a lack of ecological data? These are some of the topics that this paper will try to investigate through the review of abstracts and citations of Italian ornithological papers indexed in the large Scopus database.

MATERIALS AND METHODS

270 avian species (in which *Corvus corone* and *C. cornix* are treated as separate taxonomic entities) classed as breeding by the Italian Breeding Bird Atlas (IBBA, Lardelli et al. 2022) were included in the bibliometric analysis dealing with the quantitative assessment of ornithological production in Italy. According to previous analyses (e.g. Ducatez & Lefebvre 2014, McKenzie & Robertson 2015), two pre-existing publication metrics were selected for use: a) total number of papers per species in the Elsevier Scopus (https://www.elsevier.com/solutions/scopus) zoological abstract and citation database (a measure of research effort); and b) species h-index (an indication of effort plus quality). Developed by Hirsch (2005) as a means of measuring the impact and sustainability of the scientific output of individual researchers (Malesios & Psarakis 2014), the h-index estimates papers which are regarded by fellow scientists as worthy of citation. The h-index was calculated as the largest number *h* such that *h* publications have at least *h* citations (Hirsch 2005). In our case, the h-index is used to assess the volume and impact of papers referring to Italian breeding bird species, using "individual species" in place of "individual researcher" (McKenzie & Robertson 2015). For example, if a species had four associated publications, cited 12, 10, 9 and 3 times, it would have an h-index of 3, as three papers attracted at least three citations.

The search was made for the scientific name of each species using Elsevier's Scopus (www.scopus.org, last accessed February 5, 2023), following their relevance using four main criteria: a) be the target species featured in the title, abstract or keyword; b) be the study carried out mainly in Italy; c) be primarily ecological and/or conservation-related; d) dealing directly with or referring specifically to free-living bird populations. Papers dealing solely with palaeontology, anatomy, genetics, parasitology and veterinary, or captive/laboratory animal studies were excluded, unless the authors directly related the observational data or laboratory experiments to the ecology or conservation of the populations of interest. This allowed for instance to include a few papers on Molecular Ecology.

Practically, birds breeding in Italy were searched (scientific name AND Italy) within the predefined "Article title, Abstract, Keyword" research domain, to select papers about the given species in the country. Results were refined by predefined Research Areas available on the Scopus page: "Source type" indicating journals, books and conference proceedings; "Source title", indicating the journal of publication; "Subject area" indicating the topic: "Zoology", "Environmental Sciences/Ecology" and "Biodiversity Conservation"; and Country/Territory ("Italy", "Sardinia", "Sicily", "Italian Alps", "Italian Apennines", etc.). The documents relating to national or local checklists and the reports of the Italian Ornithological Commission (COI) were eliminated at this stage. The cross-reference of the Research Areas allowed excluding articles in journals and Subject areas of "Parasitology", "Veterinary research", "Palaeontology" and "Genetics". The remaining records per species, including all publication information (e.g. title, abstract, authors, source, publication date), were then imported into Excel to generate the final checklist. In the majority of cases (> 80%), information already contained in the database (title, abstract, keyword, journal, authors) was sufficient to make these judgements. However, when this information was inadequate the full paper was sourced at the Publisher's site. All searches used the default timespan of the database (i.e. from 1975, the year of the first indexed article to 2023).

It is possible that by following this search strategy some relevant papers escaped the analysis (e.g. those which did not specify the scientific name of the target species in the title, abstract or keyword). To determine the extent of this issue, 157 species (57% of the total) were resampled and their specific lists were rechecked for relevance. It was found that 57.8% of the resampled species did not change the number of previously selected relevant papers, 21.4% of species lost a median of one paper (i.e. an article that was included in the first search and then excluded) and 20.8% of species gained a median of one paper (i.e. an article that got unnoticed/excluded in the first search and then included). Therefore, the original checklist of 791 papers extracted thanks to the sampling design was considered representative of the quantitative and qualitative ornithological production in Italy up to 5 February 2023. The total number of documents identified by the search and then validated expresses the total number of documents per species. These papers were then sorted by decreasing number of citations ("Times Cited") and the h-index was calculated.

A set of factors that were thought to influence species publication metrics were collated from the most updated sources (Gustin et al. 2019, Baccetti et al. 2021, BirdLife International 2021, Lardelli et al. 2022), transformed into discrete variables with two or more factor levels (Tab. 1) and entered into the database together with the publication metrics.

The basic question of the choice of these factors is knowing whether ornithological research in Italy has or has not followed specific logics, addressing emerging issues related to the conservation or management of species and their habitats. More specific questions investigated whether publication metrics of bird species breeding in Italy reflected a focus on: 1) origin of species (verify whether introduced species elicited more studies than native ones); 2) breeding phenology (verify whether migrant species elicited more studies than sedentary ones); 3) main occupied habitat (verify whether the research was mainly directed toward one or more of the six habitats listed in Tab. 1); 4) population trend in the previous 30 years stated by the 1979-1992 Atlas (verify whether declining species elicited more studies than stable or increasing ones); 5) degree of threat according to the national IUCN Red List (verify whether threatened species elicited more studies than least concern or not assessed ones); 6) national interest relative to population management (check whether protected species elicited more studies than not protected ones); 7) functional grouping (check whether the research mainly involved one or more of the 13 guilds listed in Tab. 1); 8) geographic range size (verify whether the research effort is determined by the geographical distribution, and therefore if the common species are studied differently from the rare ones).

The sum of UTM squares (probable, possible, confirmed) calculated by Lardelli et al. (2022) was used as a surrogate of the size of the geographic range of breeding species in Italy. The sum of UTM squares was firstly employed in an ordinary least square (OLS) regression with the number of papers and then with h-index to verify whether the quantity and quality of the ornithological research effort were connected or not with the ease of study of the species (i.e. the logistics and sampling for scientific research on a common species are thought to be simpler than those on a rare one). To comply with the OLS assumptions, the variables were linearized by transforming them into decimal logarithms (log N+1).

For exploratory purposes, simple univariate statistical comparisons (Kruskal Wallis test as the data were not normally distributed) were first made between the publication metrics and the selection of key factors listed in Tab. 1. In the case of geographic range size, five categories (from very rare to very common, see Tab. 1) were created by dividing the sum of UTM squares into frequency classes of 500 UTM squares. This new discrete variable and the other factors from Tab. 1, were subsequently entered as discrete predictors into generalized linear models (GLMs) with a log link function and a negative binomial distribution, to test their predictive effect on the two publication metrics for each species (response variables). The negative binomial distribution controls well the overdispersion that could be created by the high number of species with zero papers and h-index ($\text{Dispersion}_{\text{N papers}}$ = 1.127 and $\text{Dispersion}_{\text{h-index}}$ = 1.167).

Statistical significance was set in all analyses at $P < 0.05$. Statistics were computed using the 'glm.nb' function in the 'MASS' package (Zuur et al. 2009) of R (version 7.3-60) and PAST 4.11 (Hammer et al. 2001) software.

Table 1. List of key factors reputed influencing the publication metrics (total number of papers and h-index) of ornithological research in Italy.

Factor	Factor coding	Factor Levels	Source
Origin of species	N = native, I = introduced	2	Baccetti et al. 2021, Lardelli et al. 2022
Phenology of breeding	SED = mostly sedentary, MIG = mostly migrant	2	Baccetti et al. 2021, Lardelli et al. 2022
Main habitat occupied for breeding in Italy	AGR = agricultural area, FOR = forest, GEN = generalist, MON = mountain, SEA = marine, WET = Wetlands	6	Lardelli et al. 2022
Population trend respect to the previous Atlas (1979-1992)	INC = increase, STA = stable, DEC = decline	3	Keller et al. 2020*, Lardelli et al. 2022
Degree of threat according to the IUCN Red List of birds breeding in Italy	THR = Threatened (if assessed as CR, EN, VU), LC = Least concern (if assessed as NT, LC) NA = Not assessed (if assessed as NA or DD)	3	Gustin et al. 2019, BirdLife International 2021
National interest relative to population management	P = protected (if species subject to national Action Plans, and/or included in Annex 1 of the Birds Directive 2009/147/EC and/or protected by the national law on hunting, L. 157/92); NP = Not protected (if it is not included in the previous sources and allowed hunting for L.157/92).	2	For Annex 1 Birds Directive see http://www.minambiente.it; For National law on hunting see https://www.gazzettaufficiale.it; For National Action Plan see https://www.naturaitalia.it
Functional grouping	gamebird (12 spp.), ducks/geese (17 spp.), herons/egrets/storks/pelicans (19 spp.), birds of prey (24 spp.), seabirds (15 spp.), doves/pigeons (6 spp.), grebes/rails (11 spp.), waders (14 spp.), owls/nightjars (10 spp.), crows (9 spp.), passerines (113 spp.), woodpeckers (9 spp.), and others (11 spp.).	13	Baccetti et al. 2021, Lardelli et al. 2022
Geographic range size	VR = Very Rare (1 < n UTM < 500); R = Rare (501 < n UTM < 1000); U = Uncommon (1001 < n UTM < 1500); C = Common (1501 < n UTM <2000); VC = Very common (2001 < n UTM < 3500);	5	Lardelli et al. 2022

* population trend for 7 marginal species in Italy

RESULTS

After searching the 270 bird species reported as breeding in the IBBA, 791 articles downloaded from Scopus were considered valid based on the chosen criteria. 1,212 relevant scientific references were identified based on these 791 publications (some articles referred to more than one species; on average 1.53 species). The publication years of these papers ranged from 1975 to 2023 with a significant increase of slope through time ($F_{1,46}$ = 138.31; P < 0.001) fitted (AICc = 1229.6, R^2 = 0.860) by a 2nd order polynomial (Fig. S1). Together these 1,212 references attracted 20,982 citations and had an overall h-index of 48. The total number of papers for the 270 species (mean ± SD = 4.49 ± 5.06) ranged from 0 papers for 47 species (17.4% of total) to 36 for 1 species (0.4%), while h-indices (mean ± SD = 2.81 ± 2.77) ranged from 0 in the case of 56 species (20.7%) to 19 for 1 species (0.4%) (Tab. 2).

The Shapiro-Wilk's W test showed that both the number of papers (W = 0.780; p < 0.001) and the h-index (W = 0.849; p < 0.001) are not normally distributed. As expected, the two metrics are strongly correlated (Pearson r = 0.92; P < 0.001). The histogram

Table 2. Distribution of publication metrics among the 270 birds breeding in Italy according to the predictive variables (factors) listed in Table 1.

Factor	Factor level	N	Total no. papers		h-index	
			Mean	SE	Mean	SE
Total species		270	4.489	0.308	2.815	0.168
Origin	I	14	3.214	1.223	1.714	0.559
	N	256	4.559	0.318	2.875	0.174
Phenology	SED	132	5.144	0.422	3.288	0.236
	MIG	138	3.862	0.442	2.362	0.235
Main habitat	AGR	81	5.469	0.721	3.358	0.374
	FOR	47	3.617	0.689	2.277	0.392
	MON	13	5.385	1.651	3.231	0.652
	WET	81	3.827	0.416	2.321	0.227
	GEN	41	4.512	0.634	3.098	0.419
	SEA	7	4.857	1.738	3.429	1.288
Population trend	DEC	91	4.527	0.557	2.967	0.320
	INC	97	4.887	0.553	2.856	0.268
	STA	82	3.976	0.469	2.598	0.287
Degree of threat	NA	34	2.941	0.699	1.706	0.331
	THR	63	3.190	0.446	2.175	0.291
	LC	173	5.266	0.421	3.266	0.225
Population management interest	NO	163	4.037	0.359	2.577	0.195
	YES	107	5.178	0.547	3.178	0.302
Functional group	gamebirds	12	4.667	1.089	3.250	0.566
	ducks&geese	17	1.294	0.513	1.059	0.441
	grebes&rails	11	3.909	1.224	2.727	0.675
	herons/egrets/others	19	4.947	0.984	2.737	0.483
	doves&pigeons	6	3.667	2.512	2.167	1.276
	owls&nightjars	10	8.700	2.135	6.400	1.392
	other	11	4.000	0.953	2.545	0.608
	seabirds	15	4.267	0.978	2.733	0.707
	medium/small waders	14	3.929	1.013	2.071	0.518
	diurnal raptors	24	8.792	1.565	4.458	0.686
	woodpeckers	9	2.000	0.527	1.556	0.475
	passerines	113	3.823	0.451	2.469	0.247
	crows	9	7.111	1.419	5.111	0.696
Geographic range size	VC	28	8.036	1.466	4.536	0.737
	C	22	5.364	0.934	3.909	0.599
	U	23	5.130	1.043	3.261	0.580
	R	30	5.967	1.054	3.600	0.566
	VR	167	3.425	0.312	2.180	0.174

of the distribution of the two publication metrics for individual species is reported in Fig. 1. About 69% of the publications in the database were produced by universities and public research institutions, 17% from nature associations, foundations and private research bodies, 5% from naturalistic museums, and finally about 2% from parks and reserves (Fig. 2).

The complete list of species along with their publication metrics ranked per the total number of papers is shown in Tab. 3. The Barn Swallow *Hirundo rustica* holds the top position with 36 papers followed by the Lesser Kestrel *Falco naumanni* with 30 papers and by the Golden Eagle *Aquila chrysaetos* with 22 papers. The Rock Dove *Columba livia* completes the top ten list with 16 papers.

Regarding the h-index, the top ten list is quite similar. The Barn Swallow still maintains first place with an h-index of 19. However, the Red-backed Shrike *Lanius collurio* takes second place with an h-index of 12, followed by the Lesser Kestrel (h-index = 11), while the Hooded Crow *Corvus cornix* (h-index = 9) secures the tenth position on this h-index list (Tab. 3).

Golden Eagle, Italian Sparrow *Passer italiae* and Rock Dove with a relatively higher number of papers have a lower h-index and are excluded from the top ten of the h-index ranking. In contrast, three species (Scopoli's Shearwater *Calonectris diomedea*, Western Barn Owl *Tyto alba* and Eurasian Eagle-Owl *Bubo bubo*) have a relatively higher h-index score relative to the total number of papers and are excluded from the top ten.

After being linearized by logarithmic transformation both publication metrics respect the OLS assumptions, and they are also positively and significantly correlated with the total number of UTM squares; in detail, the total number of papers has a correlation value r = 0.359 (t_{268} = 6.296; p = 0.0001), and h-index has r = 0.365 (t_{268} = 6.424; p = 0.0001) with the geographic range size. Details of OLS regressions are reported in Fig. S2.

Univariate statistical comparisons (Tab. S1) revealed that a homogeneous group of factors explained the two publication metrics. In detail, the various levels of factors such as the origin of the birds, their main occupied habitat, population trends and interest in population management do not produce differences in the two publication metrics. Instead, the reproductive phenology is important, because the sedentary species have attracted more papers with a higher h-index than the migrating ones. The same occurs with the degree of threat because the threatened species have attracted more papers with a higher h-index than the species of least concern or not assessed (data deficiency, DD and not available, NA species).

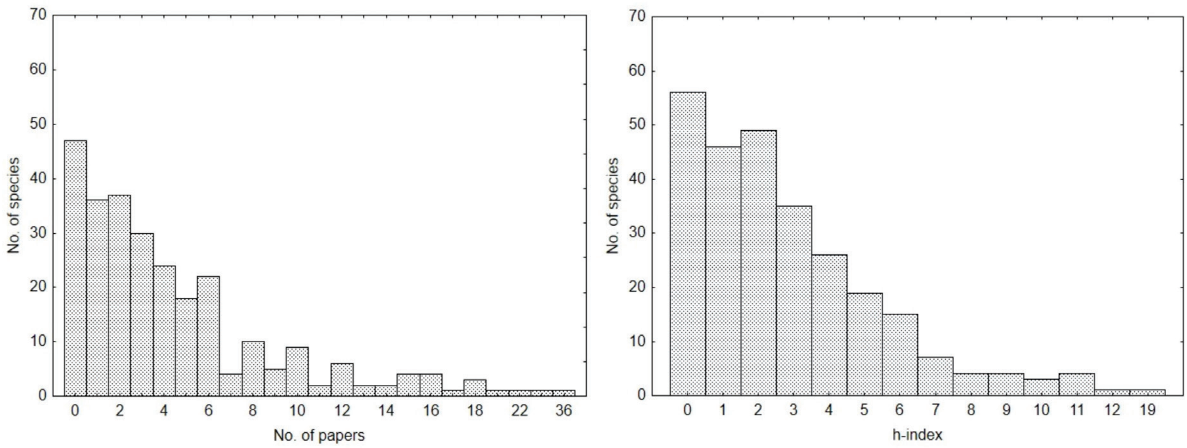

Figure 1. Histograms of the distribution of the total number of papers (left) and h-index (right) for the 270 species breeding in Italy.

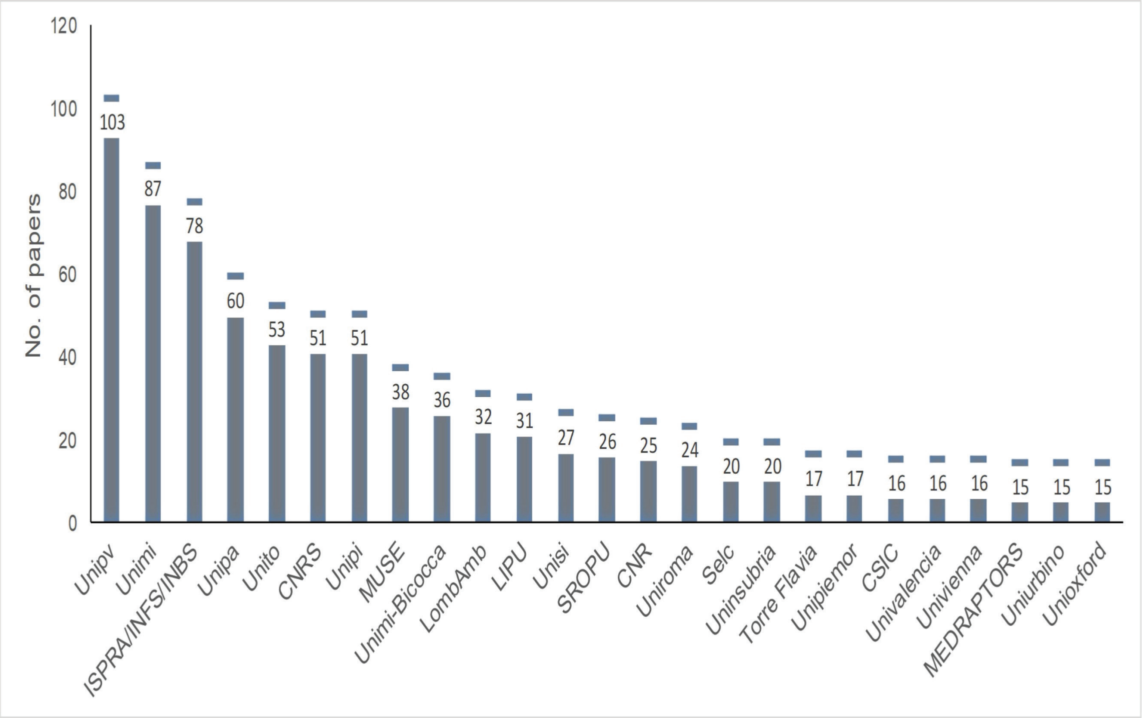

Figure 2. Histogram of the distribution of the total number of papers for the 25 most productive research institutions, which together comprise 63% of the ornithological references analysed.

This also applies after removing the not assessed level from the test and comparing directly the two groups of threatened versus least concern. Functional group and geographic range size also attracted a higher total number of papers and had a higher h-index. In this case, multilevel factors were explored by multiple comparisons of mean ranks for all groups. For functional groups, all pairwise comparisons were not statistically significant, except for 'ducks and geese' which were studied much less compared to 'owls and nightjars' (Z = 3.82, P = 0.01), 'diurnal birds of prey' (Z = 4.78, P = 0.0001), and 'crows' (Z = 4.09, P = 0.003), similarly 'ducks and geese' had papers with a lower h-index than those of 'owls and nightjars' (Z = 4.01, P = 0.004), 'diurnal birds of prey' (Z = 4.15, P = 0.003) and 'crows' (Z = 4.35, P = 0.003). Even in the case of geographic range size, all pairwise comparisons were not statistically significant, except for very common species which attracted a larger total number of papers than the very rare ones (Z = 3.78, P = 0.001). While the very common (Z = 3.76, P = 0.002) and common (Z = 3.12, P = 0.02) species had papers with a higher h-index than the very rare species.

The statistically significant factors and their levels with the estimates ± SE, Z-value and P-value of the negative binomial GLMs for the two publication metrics are reported in Tab. 4. The results of the negative binomial GLMs using the number of total papers and the h-index are very similar to each other and predict less significant factors than univariate tests (compare Tab. 2 and 4). Indeed, the GLM using the h-index has a slightly better overall fit (AIC = 1131.5) than the one with the number of papers (AIC = 1358.5).

Although the native and sedentary species are the subject of slightly more papers with higher h-index than the introduced and migratory ones (Tab. 2), the origin and breeding phenology of the species do not predict a significant change of both response

Table 3. Publication metrics ranking for Italian breeding birds: total number of papers (a measure of research quantity) and h-index (a measure of research effort plus quality). The Spearman rank-order correlation between the h-index and the number of papers up to the threshold of 10 papers (n = 37 species) is statistically significant (r = 0.562; P = 0.0003).

Common name	Scientific name	N papers	h-index
Barn Swallow	*Hirundo rustica*	36	19
Lesser Kestrel	*Falco naumanni*	30	11
Golden Eagle	*Aquila chrysaetos*	22	5
Tawny Owl	*Strix aluco*	20	11
Red-backed Shrike	*Lanius collurio*	18	12
Common Kestrel	*Falco tinnunculus*	18	10
Italian Sparrow	*Passer italiae*	18	6
Hooded Crow	*Corvus cornix*	17	9
Long-eared Owl	*Asio otus*	16	11
Rock Dove	*Columba livia*	16	8
Lanner Falcon	*Falco biarmicus*	16	8
Short-toed Snake Eagle	*Circaetus gallicus*	16	7
Scopoli's Shearwater	*Calonectris diomedea*	15	11
Eurasian Skylark	*Alauda arvensis*	15	8
Red-legged Partridge	*Alectoris rufa*	15	6
Little Egret	*Egretta garzetta*	15	6
Common Buzzard	*Buteo buteo*	14	9
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	14	6
Western Barn Owl	*Tyto alba*	13	10
Peregrine Falcon	*Falco peregrinus*	13	7
Eurasian Eagle-Owl	*Bubo bubo*	12	10
Black Kite	*Milvus migrans*	12	9
European Honey Buzzard	*Pernis apivorus*	12	7
Eurasian Coot	*Fulica atra*	12	6
Eurasian Stone-curlew	*Burhinus oedicnemus*	12	5
European Robin	*Erithacus rubecula*	12	5
Great Reed Warbler	*Acrocephalus arundinaceus*	11	6
Black-crowned Night Heron	*Nycticorax nycticorax*	11	5
Little Owl	*Athene noctua*	10	9
Eurasian Bittern	*Botaurus stellaris*	10	8
Common Moorhen	*Gallinula chloropus*	10	6
Yellow-legged Gull	*Larus michahellis*	10	6
Great Tit	*Parus major*	10	6
Great Cormorant	*Phalacrocorax carbo*	10	5
Rose-ringed Parakeet	*Psittacula krameri*	10	5
Eurasian Blackcap	*Sylvia atricapilla*	10	5

Grey Heron	*Ardea cinerea*	10	4
Eurasian Scops Owl	*Otus scops*	9	7
Carrion Crow	*Corvus corone*	9	7
Eurasian Blue Tit	*Cyanistes caeruleus*	9	5
Eurasian Woodcock	*Scolopax rusticola*	9	4
Griffon Vulture	*Gyps fulvus*	9	4
Subalpine Warbler	*Sylvia cantillans*	8	7
Pallid Swift	*Apus pallidus*	8	6
Alpine Chough	*Pyrrhocorax graculus*	8	6
Common Starling	*Sturnus vulgaris*	8	6
Water Pipit	*Anthus spinoletta*	8	6
Eurasian Nuthatch	*Sitta europaea*	8	5
House Sparrow	*Passer domesticus*	8	5
Common Chaffinch	*Fringilla coelebs*	8	5
Kentish Plover	*Charadrius alexandrinus*	8	4
Eurasian Magpie	*Pica pica*	8	3
Grey Partridge	*Perdix perdix*	7	7
Eurasian Teal	*Anas crecca*	7	6
Bearded Reedling	*Panurus biarmicus*	7	4
Cetti's Warbler	*Cettia cetti*	7	3
Red-billed Chough	*Pyrrhocorax pyrrhocorax*	6	6
Mallard	*Anas platyrhynchos*	6	5
Common Swift	*Apus apus*	6	5
Eurasian Oystercatcher	*Haematopus ostralegus*	6	5
Western Marsh Harrier	*Circus aeruginosus*	6	5
Garden Warbler	*Sylvia borin*	6	5
Rock Partridge	*Alectoris graeca*	6	4
Common Pheasant	*Phasianus colchicus*	6	4
Greater Flamingo	*Phoenicopterus roseus*	6	4
Corn Crake	*Crex crex*	6	4
Little Tern	*Sternula albifrons*	6	4
Bearded Vulture	*Gypaetus barbatus*	6	4
Marsh Tit	*Poecile palustris*	6	4
Sedge Warbler	*Acrocephalus schoenobaenus*	6	4
Short-toed Treecreeper	*Certhia brachydactyla*	6	4
Purple Heron	*Ardea purpurea*	6	3
Black-winged Stilt	*Himantopus himantopus*	6	3
Bonelli's Eagle	*Aquila fasciata*	6	3
Monk Parakeet	*Myiopsitta monachus*	6	3

Common Chiffchaff	*Phylloscopus collybita*	6	3
Northern Wheatear	*Oenanthe oenanthe*	6	3
Egyptian Vulture	*Neophron percnopterus*	6	2
Eurasian Jay	*Garrulus glandarius*	5	5
Moltoni’s Warbler	*Sylvia subalpina*	5	5
European Greenfinch	*Chloris chloris*	5	5
Great Crested Grebe	*Podiceps cristatus*	5	4
Western Osprey	*Pandion haliaetus*	5	4
Eurasian Hobby	*Falco subbuteo*	5	4
Spotted Flycatcher	*Muscicapa striata*	5	4
Spanish Sparrow	*Passer hispaniolensis*	5	4
Yelkouan Shearwater	*Puffinus yelkouan*	5	3
Woodlark	*Lullula arborea*	5	3
Song Thrush	*Turdus philomelos*	5	3
Common Blackbird	*Turdus merula*	5	3
Common Nightingale	*Luscinia megarhynchos*	5	3
Eurasian Tree Sparrow	*Passer montanus*	5	3
European Goldfinch	*Carduelis carduelis*	5	3
Western Cattle Egret	*Bubulcus ibis*	5	2
Montagu’s Harrier	*Circus pygargus*	5	2
Common Reed Bunting	*Emberiza schoeniclus*	5	2
Rock Ptarmigan	*Lagopus muta*	4	4
Black Grouse	*Lyrurus tetrix*	4	4
Water Rail	*Rallus aquaticus*	4	4
Western Jackdaw	*Coloeus monedula*	4	4
White-throated Dipper	*Cinclus cinclus*	4	4
White-winged Snowfinch	*Montifringilla nivalis*	4	4
Corn Bunting	*Emberiza calandra*	4	4
Barbary Partridge	*Alectoris barbara*	4	3
Pied Avocet	*Recurvirostra avosetta*	4	3
Black-headed Gull	*Chroicocephalus ridibundus*	4	3
Audouin’s Gull	*Ichthyaetus audouinii*	4	3
Lesser Spotted Woodpecker	*Dryobates minor*	4	3
Great Spotted Woodpecker	*Dendrocopos major*	4	3
Spotted Nutcracker	*Nucifraga caryocatactes*	4	3
Marsh Warbler	*Acrocephalus palustris*	4	3
Common House Martin	*Delichon urbicum*	4	3
Long-tailed Tit	*Aegithalos caudatus*	4	3
Tree Pipit	*Anthus trivialis*	4	3
Ortolan Bunting	*Emberiza hortulana*	4	3

Squacco Heron	*Ardeola ralloides*	4	2
Eurasian Curlew	*Numenius arquata*	4	2
Gull-billed Tern	*Gelochelidon nilotica*	4	2
Red-footed Falcon	*Falco vespertinus*	4	2
Eurasian Penduline Tit	*Remiz pendulinus*	4	2
Little Grebe	*Tachybaptus ruficollis*	3	3
Common Wood Pigeon	*Columba palumbus*	3	3
Eurasian Wryneck	*Jynx torquilla*	3	3
Black Woodpecker	*Dryocopus martius*	3	3
Northern Raven	*Corvus corax*	3	3
Red-billed Leiothrix	*Leiothrix lutea*	3	3
Common Redstart	*Phoenicurus phoenicurus*	3	3
Rock Sparrow	*Petronia petronia*	3	3
Common Quail	*Coturnix coturnix*	3	2
European Nightjar	*Caprimulgus europaeus*	3	2
European Storm Petrel	*Hydrobates pelagicus*	3	2
Black Stork	*Ciconia nigra*	3	2
White Stork	*Ciconia ciconia*	3	2
Sandwich Tern	*Thalasseus sandvicensis*	3	2
Northern Goshawk	*Accipiter gentilis*	3	2
Eurasian Hoopoe	*Upupa epops*	3	2
European Bee-eater	*Merops apiaster*	3	2
Common Kingfisher	*Alcedo atthis*	3	2
Eleonora's Falcon	*Falco eleonorae*	3	2
Lesser Grey Shrike	*Lanius minor*	3	2
Woodchat Shrike	*Lanius senator*	3	2
Crested Lark	*Galerida cristata*	3	2
Moustached Warbler	*Acrocephalus melanopogon*	3	2
Sand Martin	*Riparia riparia*	3	2
Common Whitethroat	*Sylvia communis*	3	2
Black Redstart	*Phoenicurus ochruros*	3	2
Chukar Partridge	*Alectoris chukar*	3	1
Common Cuckoo	*Cuculus canorus*	3	1
Common Tern	*Sterna hirundo*	3	1
Whinchat	*Saxicola rubetra*	3	1
Western Capercaillie	*Tetrao urogallus*	2	2
Garganey	*Spatula querquedula*	2	2
Northern Shoveler	*Spatula clypeata*	2	2
European Turtle Dove	*Streptopelia turtur*	2	2
Little Bittern	*Ixobrychus minutus*	2	2

Great Egret	*Ardea alba*	2	2
Northern Gannet	*Morus bassanus*	2	2
Common Redshank	*Tringa totanus*	2	2
Eurasian Pygmy Owl	*Glaucidium passerinum*	2	2
Boreal Owl (Tengmlam's Owl)	*Aegolius funereus*	2	2
European Roller	*Coracias garrulus*	2	2
Savi's Warbler	*Locustella luscinioides*	2	2
Wood Warbler	*Phylloscopus sibilatrix*	2	2
Sardinian Warbler	*Sylvia melanocephala*	2	2
Dartford Warbler	*Sylvia undata*	2	2
Eurasian Treecreeper	*Certhia familiaris*	2	2
Bluethroat	*Luscinia svecica*	2	2
Dunnock	*Prunella modularis*	2	2
Grey Wagtail	*Motacilla cinerea*	2	2
Citril Finch	*Carduelis citrinella*	2	2
European Serin	*Serinus serinus*	2	2
Cirl Bunting	*Emberiza cirlus*	2	2
Common Merganser (Goosander)	*Mergus merganser*	2	1
European Shag	*Phalacrocorax aristotelis*	2	1
Common Sandpiper	*Actitis hypoleucos*	2	1
Slender-billed Gull	*Chroicocephalus genei*	2	1
Mediterranean Gull	*Ichthyaetus melanocephalus*	2	1
Whiskered Tern	*Chlidonias hybrida*	2	1
White-backed Woodpecker	*Dendrocopos leucotos*	2	1
Calandra Lark	*Melanocorypha calandra*	2	1
Greater Short-toed Lark	*Calandrella brachydactyla*	2	1
Spectacled Warbler	*Sylvia conspicillata*	2	1
Marmora's Warbler	*Sylvia sarda*	2	1
Mistle Thrush	*Turdus viscivorus*	2	1
Blue Rock Thrush	*Monticola solitarius*	2	1
Goldcrest	*Regulus regulus*	2	1
Eurasian Siskin	*Spinus spinus*	2	1
Northern Bobwhite	*Colinus virginianus*	1	1
Hazel Grouse	*Tetrastes bonasia*	1	1
Common Pochard	*Aythya ferina*	1	1
Gadwall	*Mareca strepera*	1	1
Black-necked Grebe	*Podiceps nigricollis*	1	1
Western Swamphen	*Porphyrio porphyrio*	1	1
Little Bustard	*Tetrax tetrax*	1	1
Eurasian Spoonbill	*Platalea leucorodia*	1	1

African Sacred Ibis	*Threskiornis aethiopicus*	1	1
Black Tern	*Chlidonias niger*	1	1
European Green Woodpecker	*Picus viridis*	1	1
Eurasian Golden Oriole	*Oriolus oriolus*	1	1
Coal Tit	*Periparus ater*	1	1
African Blue Tit	*Cyanistes teneriffae*	1	1
Zitting Cisticola	*Cisticola juncidis*	1	1
Barred Warbler	*Sylvia nisoria*	1	1
Lesser Whitethroat	*Sylvia curruca*	1	1
Eurasian Wren	*Troglodytes troglodytes*	1	1
Common Rock Thrush	*Monticola saxatilis*	1	1
Black-eared Wheatear	*Oenanthe hispanica*	1	1
Alpine Accentor	*Prunella collaris*	1	1
Tawny Pipit	*Anthus campestris*	1	1
Western Yellow Wagtail	*Motacilla flava*	1	1
Common Linnet	*Linaria cannabina*	1	1
Corsican Finch	*Carduelis corsicana*	1	1
Black-headed Bunting	*Emberiza melanocephala*	1	1
Yellowhammer	*Emberiza citrinella*	1	1
Common Eider	*Somateria mollissima*	1	0
Eurasian Collared Dove	*Streptopelia decaocto*	1	0
Pygmy Cormorant	*Microcarbo pygmaeus*	1	0
Little Ringed Plover	*Charadrius dubius*	1	0
Northern Lapwing	*Vanellus vanellus*	1	0
Middle Spotted Woodpecker	*Leiopicus medius*	1	0
European Crested Tit	*Lophophanes cristatus*	1	0
Spotless Starling	*Sturnus unicolor*	1	0
Eurasian Bullfinch	*Pyrrhula pyrrhula*	1	0
Black Swan	*Cygnus atratus*	0	0
Mute Swan	*Cygnus olor*	0	0
Greylag Goose	*Anser anser*	0	0
Egyptian Goose	*Alopochen aegyptiaca*	0	0
Common Shelduck	*Tadorna tadorna*	0	0
Marbled Duck	*Marmaronetta angustirostris*	0	0
Red-crested Pochard	*Netta rufina*	0	0
Ferruginous Duck	*Aythya nyroca*	0	0
Tufted Duck	*Aythya fuligula*	0	0
Stock Dove	*Columba oenas*	0	0
Laughing Dove	*Spilopelia senegalensis*	0	0
Alpine Swift	*Tachymarptis melba*	0	0

Great Spotted Cuckoo	*Clamator glandarius*	0	0
Little Crake	*Zapornia parva*	0	0
Spotted Crake	*Porzana porzana*	0	0
Glossy Ibis	*Plegadis falcinellus*	0	0
Eurasian Dotterel	*Charadrius morinellus*	0	0
Black-tailed Godwit	*Limosa limosa*	0	0
Collared Pratincole	*Glareola pratincola*	0	0
White-winged Tern	*Chlidonias leucopterus*	0	0
Ural Owl	*Strix uralensis*	0	0
Booted Eagle	*Hieraaetus pennatus*	0	0
Eurasian Sparrowhawk	*Accipiter nisus*	0	0
Red Kite	*Milvus milvus*	0	0
Long-legged Buzzard	*Buteo rufinus*	0	0
Grey-headed Woodpecker	*Picus canus*	0	0
Eurasian Three-toed Woodpecker	*Picoides tridactylus*	0	0
Willow Tit	*Poecile montanus*	0	0
Melodious Warbler	*Hippolais polyglotta*	0	0
Red-rumped Swallow	*Cecropis daurica*	0	0
Eurasian Crag Martin	*Ptyonoprogne rupestris*	0	0
Western Bonelli’s Warbler	*Phylloscopus bonelli*	0	0
Western Orphean Warbler	*Sylvia hortensis*	0	0
Ashy-throat/Vinous-throated parrotbill	*Sinosuthora webbiana/alphonsiana*	0	0
Wallcreeper	*Tichodroma muraria*	0	0
Fieldfare	*Turdus pilaris*	0	0
Ring Ouzel	*Turdus torquatus*	0	0
Collared Flycatcher	*Ficedula albicollis*	0	0
European Stonechat	*Saxicola torquatus*	0	0
Common Firecrest	*Regulus ignicapilla*	0	0
Red Avadavat	*Amandava amandava*	0	0
White Wagtail	*Motacilla alba*	0	0
Hawfinch	*Coccothraustes coccothraustes*	0	0
Common Rosefinch	*Carpodacus erythrinus*	0	0
Common Redpoll	*Acanthis flammea*	0	0
Red Crossbill	*Loxia curvirostra*	0	0
Rock Bunting	*Emberiza cia*	0	0

variables (Tab. 4). The same happens for population trends and for those species in which there is a national interest related to population management.

Conversely, main habitat, functional grouping, and geographic range size are statistically significant factors predicting a change of publication metrics (Tab. 4). About the habitat factor, the forest (FOR) and generalist (GEN) species have a lower number of papers than species in the other habitats, and again the forest species have lower h-index than species in the other habitats. The negative estimates of the functional groups reported in Tab. 4 assess that ducks and geese, doves and pigeons, and passerines are significantly less studied, i.e. they have lower output on both publication metrics, compared to other groups. As for the h-index, the woodpeckers' group also has a negative estimate. The group of very rare species (VR) is the least studied and cited with a statistically significant difference with the other species, whether they are common, frequent or relatively rare.

DISCUSSION

Italian ornithology is at a turning point thanks to the release of updated works on the distribution, breeding and conservation status of the country's bird species (Gustin et al. 2019; Baccetti et al. 2021; Lardelli et al. 2022) and it seemed appropriate to analyse the factors that have so far guided the research. This was done through a bibliometric analysis of one of the largest databases on the web. For this purpose, two publication metrics were used, the total number of papers and the h-index. They are highly correlated to each other and express the results in purely quantitative (total number of papers) and quali-quantitative (h-index, number of papers plus number of citations) terms. Despite some limitations of the h-index as a reference metric for defining research quality (e.g. Costas & Bordons 2007), the main one being the lower score of recent articles, which obviously tend to have fewer citations than older ones, this index has gained popularity and is widely used today. In this analysis, the two publication metrics had interchangeable results but just with slightly better significant results, i.e. lower P-values, for the h-index.

The results showed that Italian ornithological production is affected by taxonomic chauvinism, a productivity bias that afflicts all global scientific production on animal and conservation ecology (Bonnet et al. 2002, Troudet et al. 2017). Similarly, to what was found in other bibliometric analyses on birds (e.g. Brito & Oprea 2009, McKenzie & Robertson 2015), some groups receive more attention than others. In the Italian case, the gamebirds, owls, and diurnal raptors are statistically more studied than average and the papers produced have a greater impact, i.e. h-index, on the scientific community; while conversely passerines, ducks and geese, doves and pigeons and woodpeckers are statistically less studied and with less impact. Several reasons may have led to this imbalance between the various groups. Surely, diurnal and nocturnal birds of prey include iconic and apical species important to study, also because many have threatened populations in our country. Management approaches may have contributed to the preponderance of studies for gamebirds, most of which live in alpine habitats and therefore are also affected by management for mountain tourism as well. Strangely, this is not the case for ducks and geese, another group of interest in hunting management. There is an average production of 4.7 papers for the 12 gamebird species compared to almost four times lower values (1.3) for the 17 ducks and geese. In the latter case, the restricted geographical range could be the reason for the underrepresentation of publication metrics in an otherwise interesting group to study, due to the presence of several threatened (Common Eider *Somateria mollissima,* Tufted Duck *Aythya fuligula,* Ferruginous Duck *A. nyroca,* Red-crested Pochard *Netta rufina*, etc.) or introduced species (Mute Swan *Cignus olor,* Black Swan *C. atratus,* Egyptian Goose *Alopochen aegyptiaca,* Greylag Goose *Anser anser*). Instead, the large number of passerines, the richest group of breeding species (n = 122) among those reported in the IBBA (Lardelli et al. 2022), could be the reason why this group is understudied. Indeed, among the passerines, almost a third of the species

Table 4. Output from GLM with a negative binomial distribution and Log link function of the statistically significant factors and levels predicting the number of paper and h-index publication metrics.

Factor	Level of Factor	Estimate	SE	z	P
a) Model: no. of papers					
	Intercept	2.799	0.547	5.120	< 0.001
Main habitat	FOR	-0.453	0.193	-2.351	0.019
	GEN	-0.461	0.185	-2.488	0.013
Functional grouping	ducks &geese	-1.371	0.465	-2.949	0.003
	doves & pigeons	-0.985	0.496	-1.985	0.047
	passerines	-0.635	0.306	-2.079	0.038
Geographic range size	VR	-0.835	0.226	-3.690	< 0.001
b) Model: h-index					
	Intercept	2.229	0.496	4.497	< 0.001
Main habitat	FOR	-0.435	0.177	-2.462	0.014
Functional grouping	ducks & geese	-1.256	0.418	-3.008	0.003
	doves & pigeons	-0.983	0.442	-2.223	0.026
	woodpeckers	-0.880	0.428	-2.059	0.039
	passerines	-0.724	0.257	-2.820	0.005
Geographic range size	VR	-0.764	0.199	-3.832	< 0.001

have 0 or 1 paper (and 0-1 h-index), but there are several much-studied species, such as the Barn Swallow and the Italian Sparrow which fall into the top-ten, and also some reed warblers (Great Reed Warbler *Acrocephalus arundinaceus*, Eurasian Reed Warbler *A. scirpaceus*), the Eurasian Skylark *Alauda arvensis*, the Great Tit *Parus major*, the European Robin *Erithacus rubecula*, the Eurasian Blackcap *Sylvia atricapilla* and others all have a total number of papers ≥ 10, and h-index ≥ 5. Perhaps to study such a large group with an equivalent effort, more researchers would be necessary than those currently available in the context of Italian ornithology.

The scientific production is divided more or less equally between the species that live in wetlands, agricultural areas, and mountains, except for the statistically significant smallest number of papers and with a minor impact of forest and generalist species.

Most of the previously published research on bird conservation is oriented towards non-threatened species, albeit with considerable variation between Orders (Brito & Oprea 2009). McKenzie & Robertson (2015) also complain of a similar bias for England, with more scientific production and impact on non-threatened species than on threatened ones. The results of both the univariate statistics and the GLMs would indicate that also the Italian ornithologists follow the general trend observed by Brito & Oprea (2009) and McKenzie & Robertson (2015) and do not focus their research on species in numerical decline compared to those with stable or increasing populations, as well as pay more attention (see the results of the Kruskal-Wallis test) on species of least concern instead of threatened ones. Furthermore, judging by the statistical analysis used, not even the population management of species of national interest (according to the lists of the National Hunting Law, the National Action Plans and Annex 1 of the Birds Directive) seems to be a criterion of choice in the selection of target species on which to research and write scientific articles.

This generalized decoupling between scientific research and the threat or population status of Italian bird species is certainly an important limitation. This knowledge gap could have important implications for the effective protection and management of birds and their habitats. This perhaps corresponds to the scarce dialogue between research bodies and local/national bodies of wildlife management, to the very limited implementation of administrative instruments such as the National Action Plans or the management plans of the Natura 2000 network, and in general to the scarce presence of ornithologists (and zoologists) in wildlife management policies in Italy (Morganti 2022).

Furthermore, a second main gap in Italian ornithological research seems to be the uneven distribution of studies among the 270 breeding species. Indeed, only 18% of the species are relatively well studied, while there is a large part (69%) with limited production (1-9 papers) and a not negligible 17% of species has never been the subject of a paper. This certainly corresponds to an uneven distribution of research groups among the Italian regions, as represented by the data in Fig. 2, in which 13 of the 25 most productive agencies come from northern Italy, 6 from abroad, 5 from central Italy and only 1 from southern Italy. Therefore, the enlargement of the audience and the regional diffusion of professional ornithologists appears once again to be fundamental for meeting the challenges of the two 2030 Strategic Objectives of the SNB: A (Build a coherent network of protected areas terrestrial and marine), and B (Restore terrestrial and marine ecosystems, with the specific objective “Species, Habitats and Ecosystems”).

Another non-secondary aspect revealed by this bibliometric analysis and which would be desirable to resolve shortly is certainly the scarce research effort on introduced species.

Assuming that the number of UTM cells adequately expresses, as happens elsewhere (e.g. McKenzie & Robertson 2015), the frequency and abundance of a species in the national territory, it can be stated that the attention of Italian ornithologists is directed above all to the more common species compared to the rarer ones. This stems from both the positive correlation between the two publication metrics and the number of UTM cells and from the selection of the ‘very rare’ variable as a significant factor level in the GLM (where the number of UTM cells has been transformed into a discrete variable expressing the size of the geographic range).

The common species are certainly easier to reach and can more easily allow the formulation of robust and representative sample designs from an ecological and territorial point of view. In the case of impacts, the information provided by common species is useful to study because it can reveal the geographic scale of the effects, or even reveal responses in other species, or taxonomic groups. These aspects are not trivial because it means that our scientific community favours species with the attributes of good bioindicators, i.e. those abundant in all parts of a studied area, easy to sample and identify and which potentially represent relationships with other biological groups of interest, or provide early warning to environmental impacts (Noss 1990, Caro & Doherty 1999, Carignan & Villard 2002).

Most of the top-ten species of the two published metrics are apical predators (Golden Eagle, Short-toed Snake Eagle *Circaetus gallicus*), insectivores (Barn Swallow, Lesser Kestrel, Red-backed Shrike), or eat mainly rodents (the four owl species), and marine animals (Scopoli’s Shearwater), thus feeding upon an array of prey species that make them good potential indicators of contamination, habitat loss and environmental change. Indeed, the common species and their variations in distribution and population are currently the subject of long-term studies to verify environmental changes, such as the well-known

Farmland Bird Index (FBI, Rete Rurale Nazionale & Lipu 2020). So it is probably no coincidence that some of the species in moderate or steep decline (Barn Swallow, Italian Sparrow, Red-backed Shrike) according to the FBI, are featured in the top ten of the two publication metrics.

Nevertheless, according to Lambeck (1997), the most suitable focal species are those that are quite rare (and therefore selective), but not too much (as to collect a reliable sample size and avoid bias due to pure stochasticity, Haila 1985). In addition, rare, small or uncharismatic species do play pivotal functions in ecosystems (e.g. Lawler et al. 2003, Mouillot et al. 2013). Rare and uncommon species are quite studied, as well as very common ones. Since the results of the model have identified a negative selection only for the group of very rare species, it can be stated that there is a positive basic selection of species with the size of the geographic range coinciding with that of the useful ecological indicators.

The present bibliometric analysis was possible thanks to the presence of a database on the web which allows rapid and reliable selections of publications by species. More than two-thirds of the publications in the database were produced by universities and public research bodies that need the feedback provided by the Web of Science. The presence of foreign university institutions (about 23% of the quota of papers produced by universities), certifies the vitality and interconnection between Italian and foreign research centres (but also the so-called ‘brain drain’, e.g. https://lab24.ilsole24ore.com/cervelli-in-fuga-trappola-talenti-europea).

A substantial one-third of the research present on the Web of Science is produced by ONG naturalistic associations, foundations and private research bodies, or by naturalistic museums, parks and reserves. This share is important and represents the tip of the iceberg formed by agencies, associations and all those groups that do not strictly need to publish in indexed journals. There are national (e.g. Rivista Italiana di Ornitologia, Alula, Uccelli d’Italia) and regional (e.g. Aves Ichnusae, Naturalista siciliano, Tichodroma, Bollettino Ornitologico Lombardo, etc.) journals that regularly publish non-indexed scientific articles. Besides, all the information produced outside of traditional publishing and distribution channels, i.e. the ‘grey literature’ that includes reports, working papers, newsletters, government documents, etc., should be mentioned. Grey literature is an important source of information (e.g. Battisti & Fanelli 2022). Besides, the papers that are used to inform policy are not necessarily the ones that are highly cited within the academic world, because the quality evidenced by the h-index is important in the academic arena, but it is perhaps less critical in terms of management and conservation policies and actions (Haddaway & Bayliss 2015). The impossibility of rapid collection, selection and analysis of these products is certainly the major limitation that prevented their inclusion in this study and contributes to the ‘academia-management divide’ (e.g. Shah et al. 2007, Arlettaz et al. 2010). An analysis based on as many sources as possible would therefore be interesting and desirable to understand and quantify the non-ISI journals and grey literature production as well, exploring the ‘dark side of the moon’ which could provide more congruous results of the phenomenon and full indication of the general interest for the bird species in our country.

Acknowledgements

I thank Stefano Anile, Corrado Battisti and Flavio Ferlini (reviewer) for their positive and useful comments and their support in the final draft of the paper. Work supported by NBFC to University of Palermo, funded by the Italian Ministry of University and Research, PNRR, Missione 4 Componente 2, “Dalla ricerca all’impresa”, Investimento 1.4, Project CN00000033.

REFERENCES

Amori G. & Gippoliti S., 2001. Identifying priority ecoregions for rodent conservation at the genus level. Oryx 35: 158-165.

Arlettaz R., Schaub M., Fournier J., Reichlin T.S., [...] & Braunisch V., 2010. From publications to public actions: when conservation biologists bridge the gap between research and implementation. BioScience 60(10): 835-842.

Baccetti N., Fracasso N. & C.O.I., 2021. CISO-COI Check-list of Italian birds - 2020. Avocetta 45: 21-85.

Battisti C. & Fanelli G., 2022. Foraging diet of the two commonest non-native parakeets (Aves, Psittaciformes) in Italy: assessing their impact on ornamental and commercial plants. Rendiconti Lincei, Scienze Fisiche e Naturali 33(2): 431-439.

BirdLife International, 2021. European Red List of Birds. Publications Office of the European Union, Luxembourg.

BirdLife International, 2022. State of the World's Birds 2022: Insights and solutions for the biodiversity crisis. BirdLife International, Cambridge, UK.

Blaxter M.L., 2004. The promise of a DNA taxonomy. Philosophical Transactions Royal Society B Biological Sciences 359: 669–679.

Bonnet X., Shine R. & Lourdais O., 2002. Taxonomic chauvinism. Trends Ecology Evolution 17: 1–3.

Brito D. & Oprea M., 2009. Mismatch of research effort and threat in avian conservation biology. Tropical Conservation Science 2(3): 353-362.

Brodie J.F., 2009. Is research effort allocated efficiently for conservation? Felidae as a global case study. Biodiversity Conservation 18: 2927–2939.

Brooke Z.M., Bielby J., Nambiar K. & Carbone C., 2014. Correlates of Research Effort in Carnivores: Body Size, Range Size and Diet Matter. PLoS ONE 9(4): e93195.

Catalano A.S., Redford K., Margoulis R. & Knight A.T., 2018. Black swans, cognition, and the power of learning from failure. Conservation Biology 32: 584–596.

Catalano A.S., Lyons-White J., Mills M.M. & Knight A.T., 2019. Learning from published project failures in conservation. Biological Conservation 238: 108223.

Carignan V. & Villard M.A., 2002. Selecting indicator species to monitor ecological integrity: a review. Environmental Monitoring and Assessment 78(1): 45–61.

Caro A.T.M. & Doherty G.O., 1999. On the Use of Surrogate Species in Conservation Biology. Conservation Biology 13: 805-814.

Costas R. & Bordons M., 2007. The H-index: Advantages, limitations and its relation with other bibliometric indicators at the micro level. Journal of Informetrics. 1:193-203.

da Silva A.F., Malhado A.C.M., Correia R.A., Ladle R.J., Vital M.V.C. & Mott T., 2020. Taxonomic bias in amphibian research: Are researchers responding to conservation need? Journal for Nature Conservation 56: 125829.

Donthu N., Kumar S., Mukherjee D., Pandey N. & Lim W.M. 2021. How to conduct a bibliometric analysis: an overview and guidelines. Journal Business Research 133: 285-296.

Ducatez S. & Lefebvre L., 2014. Patterns of Research Effort in Birds. PLoS ONE 9(2): e89955.

Greggor A.L., Berger-Tal O., Blumstein D.T., Angeloni L., [...] & Goldenberg S.Z., 2016. Research priorities from animal behaviour for maximising conservation progress. Trends Ecology Evolution 31: 953964.

Gustin M., Nardelli R., Brichetti P., Battistoni A., Rondinini C. & Teofili C., 2019. Lista Rossa IUCN degli uccelli nidificanti in Italia 2019. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Roma, Italia.

Haddaway N.R. & Bayliss H.R., 2015. Shades of grey: two forms of grey literature important for reviews in conservation. Biological Conservation 191: 827-829.

Haila Y. 1985. Birds as a tool in reserve planning. Ornis Fennica 62: 96-100.

Hammer Ø., Harper D.A.T. & Ryan P.D., 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4: 1-9.

Hebert P.D.N, Penton E.H., Burns J.M., Janzen D.H. & Hallwachs W., 2004. Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*. Proceedings National Academy Sciences USA 101: 14812–14817.

Hendriks I.E. & Duarte C.M., 2008. Allocation of effort and imbalances in biodiversity research, Journal of Experimental Marine Biology Ecology 360 (1): 15-20.

Hirsch J.E., 2005. An index to quantify an individual's scientific research output. PNAS; 102: 16569–16572.

Keller V., Herrando S., Voříšek P., Franch M., [...] & Foppen R.P.B., 2020. European Breeding Bird Atlas 2: Distribution, Abundance and Change. European Bird Census Council & Lynx Edicions, Barcelona, Spain.

Kronenberg J., Andersson E. & Tryjanowski P., 2017. Connecting the social and the ecological in the focal species concept: case study of White Stork. Nature Conservation 22: 79–105.

Lambeck R. J. 1997. Focal Species: A Multi-Species Umbrella for Nature Conservation. Conservation Biology 11(4): 849-856.

Lardelli R., Bogliani G., Brichetti P., Caprio E., [...] & Brambilla M., 2022. Atlante degli Uccelli nidificanti in Italia. Edizioni Belvedere, Latina, Italia.

Lawler J., White D., Sifneos J. & Master L., 2003. Rare species and the use of indicator groups for conservation planning. Conservation Biology 17: 875-882.

Malesios C. & Psarakis S., 2014. Comparison of the h-index for different fields of research using bootstrap methodology. Quality & Quantity 48: 521-545.

Mammola S., Riccardi N., Prié V., Correia R., [...] & Sousa R., 2020. Towards a taxonomically unbiased European Union biodiversity strategy for 2030. Proceedings Royal Society B Biological Sciences 287: 20202166.

Master L.L., 1991. Assessing threats and setting priorities for conservation. Conservation Biology 5: 559-563.

McKenzie A.J. & Robertson P.A., 2015. Which Species Are We Researching and Why? A Case Study of the Ecology of British Breeding Birds. PLoS ONE 10(7): e0131004.

Morganti M., 2022. Italy at a turning point in its ecological research world (or not?). Avocetta 46: 73-76.

Mouillot D., Bellwood D.R., Baraloto C., Chave J., [...] Thuiller W, 2013. Rare Species Support Vulnerable

Functions in High-Diversity Ecosystems. PLoS Biology 11(5): e1001569.
Noss R.F., 1990. Indicators for Monitoring Biodiversity: A Hierarchical Approach. Conservation Biology 12: 822-835.
Pimm S.L., Raven P., Peterson A., Sekercioglu Ç. H. & Ehrlich P.H., 2006. Human impacts on the rates of recent, present, and future bird extinctions. Proceedings National Academy of Sciences USA 103: 10941-10946.
Rete Rurale Nazionale & Lipu 2020. Common breeding farmland birds in Italy. Update of population trends and Farmland Bird Indicator for National Rural Network 2000-2020. www.reterurale.it/farmlandbirdindex.
Rifkin J., 2011. The Third Industrial Revolution; How Lateral Power is Transforming Energy, the Economy, and the World. Palgrave Macmillan Press, London, UK.
Rosenthal M.F., Gertler M., Hamilton A.D., Prasad S. & Andrade M.C.B., 2017. Taxonomic bias in animal behaviour publications. Animal Behaviour 127: 83-89.
Shah A., Treby E., May V. & Walsh P., 2007. Bridging the divide between academia and practitioners: training coastal zone managers. Ocean & Coastal Management 50(11-12): 859-871.
Spina F., Baillie S.R., Bairlein F., Fiedler W. & Thorup K., 2022. Eurasian African Bird Migration Atlas. EURING/CMS.
Stahlschmidt Z., 2011. Taxonomic chauvinism revisited: insight from parental care research. PLoS ONE 6: e24192.
Sutherland W.J., Fleishman E., Mascia M.B., Pretty J. & Rudd M.A., 2011. Methods for collaboratively identifying research priorities and emerging issues in science and policy. Methods Ecology Evolution 2: 238-247.
Troudet J., Grandcolas P., Blin A., Vignes-Lebbe R. & Legendre F., 2017. Taxonomic bias in biodiversity data and societal preferences. Scientific Report 7: 9132.
Tydecks L., Jeschke J.M., Wolf M., Singer G. & Tockner K., 2018. Spatial and topical imbalances in biodiversity research. PLoS ONE 13(7): e0199327.
Zuur A.F., Ieno E.N., Walker N., Saveliev A.A. & Smith G. M. 2009. Mixed Effects Models and Extensions in Ecology with R. Springer, New York, NY.

Received: 17 April 2023
First response: 19 June 2023
Final acceptance: 27 July 2023
7 September 2023
Editor: Roberto Ambrosini