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Research Note

Qualitative and quantitative aspects of recent research on helminth parasites

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Abstract

Relationships between the species diversity of different taxa, the mean number of articles published per year on each taxon, and the mean impact factor of the journals in which they appear, were examined across six taxa of helminths: Nematomorpha, Acanthocephala, Monogenea, Trematoda, Cestoda and Nematoda, the latter including only animal parasitic nematodes. The mean annual output of scientific articles per taxon was not related to the species diversity of these taxa or, at least, not significantly. Thus, the large volume of publications on nematodes is not merely a reflection of their estimated diversity. There were significant differences among taxa in the mean impact factor of the journals in which papers on each taxon appeared, with nematodes having the highest mean score, followed by trematodes and cestodes. In addition, across the six taxa, the mean journal impact factor correlated positively and significantly with the mean annual number of papers published: not only are there more papers published on nematodes and trematodes than on nematomorphs or acanthocephalans, but they are also generally published in higher-ranking journals. These results suggest that there is an increasing gap in the quantity and general importance of the research carried out on different helminth taxa.

Many authors have deplored the state of our knowledge of certain parasite taxa. It is common to see comments such as 'little known' or 'poorly studied' or something similar in reference to the smaller parasitic taxa (e.g. Roberts & Janovy, 1996; Bush *et al.*, 2001). How much truth is there in these statements? Differences in the quantity or quality (i.e. general importance) of research reported on various helminth taxa may only be artefacts. For instance, if twice as many research articles are published per year on taxon A than on taxon B, and if taxon A also includes twice as many species as taxon B, then the proportional research effort, on a per-species basis, is the same for the two taxa. From the perspective of the broad interest or general importance of the research, we would expect that taxon A would generate more articles in high-profile multidisciplinary journals than taxon B, but once again it should not be the absolute numbers that matter, but the relative numbers with respect to the species diversity of the two taxa. To rigorously assess the state of our knowledge on parasites, we need a comparative analysis that takes these issues into account.

If the quantity and quality of research on parasites is equally shared among taxa or at least a reflection of their respective species diversity, we can make two predictions that can serve as null hypotheses. Firstly, although there might be more papers published on certain taxa, the average quality of these research articles should be the same across taxa. In other words, the frequency distribution of quality measures of published articles on different parasite taxa should be the same across taxa, irrespective of how many articles are published in total on these taxa. Secondly, the number of papers published annually on different taxa should correlate with the

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species diversity of these taxa, but not with the average quality of the papers. If the quantity and quality of research go hand-in-hand, then there will be severe biases in our knowledge of different parasite taxa. Here, I will test these hypotheses using data on six taxa of helminth parasites.

All papers published in 1999, 2000 and 2001 on Nematomorpha, Acanthocephala, Monogenea, Trematoda and Cestoda were found by searching the Web of Science database (www.webofscience.com). The Nematoda were treated differently. Each paper listed was examined individually to determine whether it was on animal-parasitic nematodes or not; all papers on plant-parasitic or free-living nematodes were excluded (not surprisingly, many were on *Caenorhabditis elegans*). Because the number of papers published on nematodes is much larger than for other helminth taxa, a random subsample of 500 per year was examined instead of the total in the database and, from this subsample, the total annual number of papers on animal-parasitic nematodes was extrapolated. The random subsample was taken as the first 500 papers listed in the search results.

The impact factor of the journal in which each of the papers was published was used as a measure of journal quality. Impact factors are computed for each journal as the average number of times an article published in that journal over the previous two years was cited in the target year, here being 2000. They were obtained from the Journal Citation Report of the Institute of Scientific Information (www.jcr.isihost.com). It can be argued that the overall quality (including design, replication, execution and statistical significance of the results) or general importance (such as its relevance to many subdisciplines) of a study usually determines where it will be submitted and eventually published (e.g. Murtaugh, 2002). Thus high-profile, oft-cited journals will contain more articles of broad importance than lower-profile journals, and their impact factors can be used as a measure of overall journal quality.

Estimates of total species richness for each of the six helminth taxa were also obtained from other sources (Rohde, 1996; Poulin & Morand, 2000). These estimates include undiscovered species believed to exist, and are roughly proportional to numbers of currently known species.

For analyses, impact factors were log-transformed because of their general skewed distributions. An ANOVA was used to assess differences in impact factors of journals in which papers on the six helminth taxa are published. This was first performed using all papers, and then repeated using only the top 50% in each helminth taxon, i.e. the top half of the papers once they had been ranked by journal impact factors for each taxon. Correlations across the six taxa between the mean number of papers published per year and either estimated species richness or mean impact factor of journals in which the papers were published, were evaluated using Spearman's rank correlation coefficient.

The papers found by searching the Web of Science database came from more than 300 different scientific journals, spanning a wide range of disciplines. There were clearly more papers published annually on nematodes than on other helminth taxa; trematodes and cestodes were distant second and third, respectively (table 1). There were also significant differences in the mean journal impact factors among papers published on the six helminth taxa ($F_{5,2008} = 9.857$, $P = 0.0001$), with nematodes being the only group with a mean journal impact factor greater than 1.0 (table 1). This can be seen in the frequency distributions of journal impact factors for the six taxa, where there are proportionally more articles in high-impact journals for nematodes than in other taxa (fig. 1). The difference is even more pronounced when using only the top 50% of articles ($F_{5,1000} = 14.361$, $P = 0.0001$), with nematodes having a mean impact factor (back-transformed from the average of log-transformed data) of 2.2, and other taxa having a mean impact factor of 1.73 or less.

There were positive, but non-significant, correlations between the mean number of papers published per year on the different taxa and either their estimated species diversity ($r_s = 0.600$, $N = 6$, $P = 0.1797$) or their mean journal impact factor ($r_s = 0.667$, $N = 6$, $P = 0.1360$). There was, however, a significant positive relationship between the mean number of papers published per year on the different taxa and the mean journal impact factor of the top 50% of articles ($r_s = 0.886$, $N = 6$, $P = 0.0476$). In other words, not only are there more papers published on nematodes and trematodes than on nematomorphs or acanthocephalans, but they are also generally published in higher-ranking journals.

Table 1. Summary data on the estimated species richness and research published on six helminth taxa.

	Estimated no. living species*	Mean no. papers per year	Mean journal impact factor
Nematomorpha	350	8	0.778
Acanthocephala	1200	66	0.724
Monogenea	20000	79	0.871
Cestoda	5000	156	0.755
Trematoda	15000	237	0.871
Nematoda	10500	584	1.119

Mean journal impact factor is the geometric mean, i.e. back-transformed average of log-transformed data.
*Sources: Rohde (1996) and Poulin & Morand (2000).

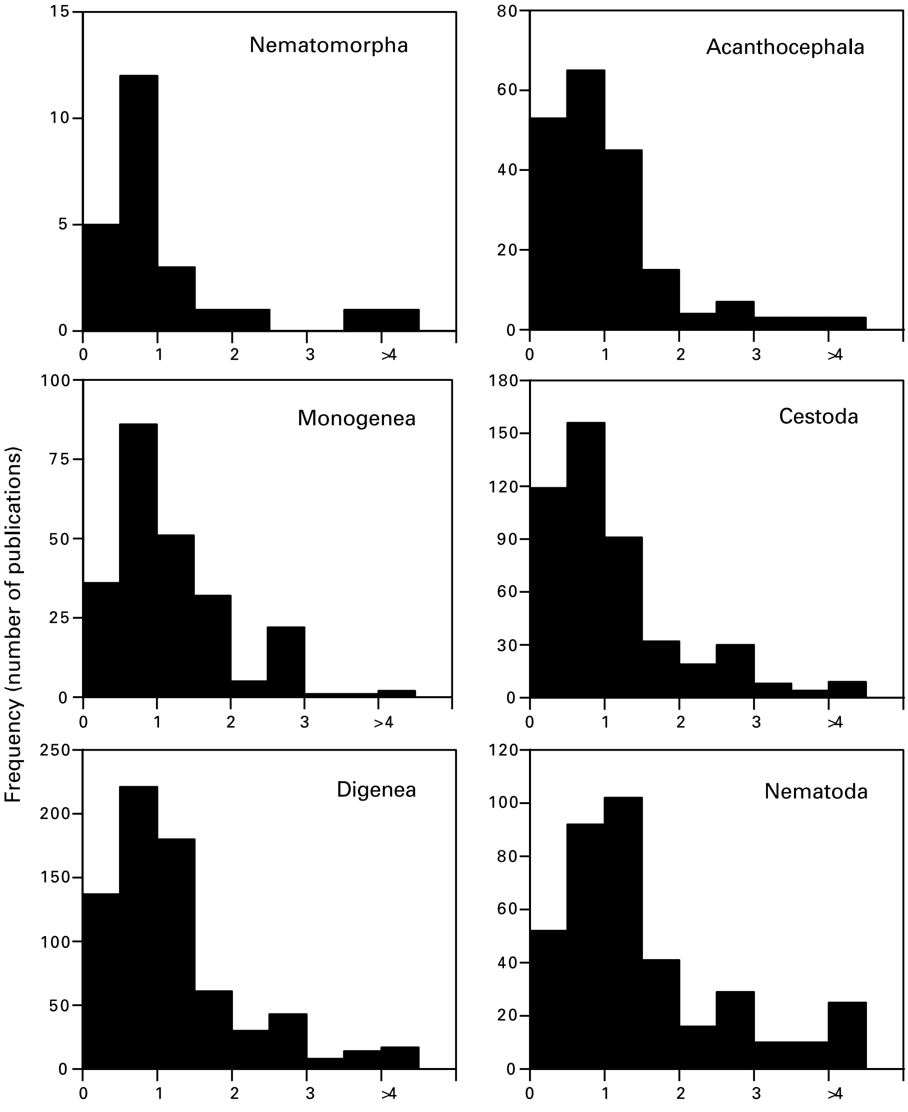

Fig. 1. Frequency distributions of impact factors of journals in which publications on six helminth groups were published over the past three years. Each publication is counted separately, so that certain journals are represented several times in the data set. The last column in each histogram includes all values greater than 4.0.

Our knowledge of parasitic helminths is therefore not equally shared among taxa. From a quantitative perspective, more articles are published on certain taxa than on others, and this is not a simple reflection of the relative species diversity of the different taxa. In terms of quality (i.e. general importance as measured by citation rates), the same biases are also apparent, with research on nematodes, and to a lesser extent also on trematodes and cestodes, being published in generally higher-profile journals. The quality of a journal and, by extension, that of the articles it contains, is obviously very subjective, and cannot be captured entirely by a simple measure such as the impact factor. Journals which publish more review articles or methodological papers usually achieve higher impact factors, regardless of how meticulously and rigorously these articles are prepared. There is, however, general agreement that frequent citations imply scholarly acceptance, and that the prestige of a journal is only derived from the usefulness of the articles it publishes, the latter being directly measurable by citation rates (Christenson & Sigelman, 1985). Therefore, if the null hypothesis is that the general importance of the research performed on helminths does not vary among the six groups, we should expect mean journal impact factors of papers published on the six helminth taxa not to differ significantly. The results obtained here are thus indicative of real biases.

This is not necessarily surprising. There are more species of medical or veterinary importance among nematodes, cestodes and trematodes than among monogeneans, acanthocephalans and nematomorphs. There is therefore a greater incentive, reflected no doubt in funding priorities, for research into the biology of the former groups than research on the latter groups. This has the potential to create an increasing gap in our knowledge of parasitic helminths. In the present survey, most reports published in journals of low impact factor (< 1.0) appeared to be species descriptions or natural history observations of limited importance to science in general, such as data on the prevalence of particular helminth species in local populations of a host species. In contrast, most articles in higher-impact journals (>1.5) reported findings of broader relevance to one or more major discipline, often hypothesis-driven and addressing general questions of potential relevance to many other researchers. These higher-profile studies often deal with the ecology, genetics, immunology, physiology, or applied medical or veterinary aspects of the host–parasite association. The biology of the neglected groups of helminths is known only through the work on a few individual researchers, who have carried out detailed investigations of a limited number of species within these groups; whether these are valid 'model' species that are representative of the whole taxon, i.e. whether findings on them can be extrapolated to other species within their group, is unknown.

A research bias favouring certain helminth groups over others has been suspected before. Here, I present the first quantitative demonstration that there is indeed more, and arguably higher-profile, research being carried out on nematodes, and to a lesser extent on trematodes and cestodes, than on other helminth groups, regardless of their respective species diversity. As science funding shifts increasingly toward research with near-future applications, it will prove a growing challenge to expand our knowledge of the low-profile helminth taxa, which is already noticeably falling behind that of the high-profile worms.

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