Recently, concern has been raised over the existence of obvious taxonomic biases in contemporary literature on ecology, evolution, and conservation biology (Bonnet et al. 2002, Stein et al. 2002, Clark and May 2002a, 2002b). For example, Bonnet and colleagues (2002) show that that an apparent, albeit subliminal, bias toward homeothermic (endothermic) fauna affords research on these groups greater publication success relative to “unpopular” poikilotherms (ectotherms). There is no doubt that such a trend is undesirable. Although the use of model organisms is an effective approach to start with, as the discipline advances, looking beyond a small set of popular homeotherms such as birds and small mammals is essential for greater generality in theoretical as well as applied ecology and evolutionary biology. For instance, Lawton and colleagues (1998) give an empirical demonstration of the need for a multitauxon approach in conservation biology, a discipline that clearly suffers from taxonomic bias (Clark and May 2002b). Focusing attention on charismatic organisms such as eagles and tigers may attract public support and funds for conservation, but such an approach often underrepresents the vast majority of species, many of which are at great risk of extinction (Stein et al. 2002).

To these concerns I would like to add another. Scientific proclivity is also influenced by taxon-specific limitations that render certain biotic groups more difficult to work with than others. Biases such as editorial chauvinism against certain organisms may develop inadvertently (Bonnet et al. 2002), but the fact that inherent differences between groups make some more difficult to study than others must not be ignored while searching for the roots of such predilections. Rather than ectothermy or endothermy alone, these limitations are governed by the overall life history of each biotic group.

These group-specific difficulties can be as fundamental as taxonomy and sampling methodology. Poor standardization of taxonomy, for instance, can result in unreliable taxon identification, and poor standardization of sampling methodology can result in inefficient or inappropriate field sampling methods. Ultimately, a prevalence of such problems in certain biota may discourage research on them. Methodological problems often undermine the deductive power and reliability of research seriously. For example, if the species diversity of a biotic group in an area is to be sampled, lack of a standardized sampling protocol can make it difficult to obtain reliable richness–abundance estimates efficiently, thereby increasing the effort required to obtain adequate samples. This can have two obvious consequences. First, resource limitations will tend to polarize research toward “easy” biotic groups. Second, in groups that tend to have poorly standardized research methodology, low-investment studies will be at a distinct disadvantage, leading to a disproportionately low representation of such studies on those groups.

In the case of the cash-strapped field of tropical biology (James et al. 2001), the importance of these factors is intensified because limited time and material resources restrict research efforts. This is a serious problem, because the increasingly frequent need for urgent conservation attention in tropical regions worldwide makes short-term studies crucial for quick assays.

Methodological problems and taxonomic bias

Methodological handicaps also contribute to the taxonomic bias apparent in the scientific literature. This can result from several factors that are difficult to isolate: reluctance on the part of field biologists to undertake studies on such groups at the outset, manuscript failures at the presubmission stage (results go unreported because they are weak or insignificant), and postsubmission manuscript rejections attributable to weak or unreliable results. If methodological hurdles really do influence the success of research on certain biota, and if success is gauged by publication of study results in a peer-reviewed journal, published literature on such biota will be skewed away from lower-investment studies because of the limitations associated with such research.

How can these trends be gauged from the literature? One measure of investment in biological field research is study duration; in general, studies with long periods of fieldwork involve greater investment than shorter ones. In other

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words, relatively short-term (and hence low-investment) studies will fail (for the reasons mentioned above) with disproportionate frequency for biotic groups that are “methodologically challenged,” forcing scientists to invest more in improving the reliability of data. Likewise, the study durations of groups with fewer methodological problems (e.g., those that are easier to sample) should be skewed toward shorter periods within the distribution of this measure of investment. To examine these predictions, I tested the null hypothesis that the distribution of field study duration will approximate a normal distribution irrespective of taxonomic group.

After scanning 302 articles in 25 journals on ecology and conservation biology from 1970 to the present (Institute for Scientific Information [ISI] impact factor > 1, taxon-restricted journals excluded), data were scored on study duration for research on three poikilothermic groups (amphibians and reptiles, lepidoptera, and coleoptera) and two homeothermic groups (small mammals and birds). Although amphibians and reptiles are two distinct phylogenetic groups, they were pooled together because a significant number of articles included both in the same study. Relevant articles were identified after searching the ISI Web of Knowledge application and manually browsing journals, after which each article was scanned for a mention of the period over which the fieldwork was conducted. If the study duration was not specified in the article, the article was dropped from the data or further information was solicited from corresponding authors. Frequency distributions of study duration were plotted separately for each faunal group. Data were square-root transformed before plotting and trimmed by excluding the upper 5 percent for each group to eliminate unusually long-term studies. The removal of these extreme outliers served to evenly remove studies that were long-running projects that tended to include intermittent fieldwork periods.

Because methodological problems are particularly challenging in the biologically rich but poorly documented tropics, only research between approximately 23° north and 23° south of the equator was considered. As this article attempts to draw inferences about methodological issues that may underlie observed trends in the scientific literature, the data collection had to be restricted to subsets of studies that had similar research objectives. First, different habitats are likely to have very characteristic fieldwork regimes and thus different modes of fieldwork duration. To reduce the chances of such multimodality in the data set, studies from arid, desert, wetland, and high-altitude biomes were dropped, leaving only those in habitats ranging from tropical to subtropical, dry to moist, broadleaf forest types (see Olson et al. 2001). Second, only synecology or community ecology studies (for the purposes of this article, defined as covering four or more taxa) were considered, because studies on one or two species ask fundamentally different questions from those asked in multiple-species studies, which require a very different approach toward research design and sampling.

Are some groups more difficult than others?
The sample sizes and distributions of study duration for the five groups are plotted in figure 1. It is interesting that all the significant differences in mean study periods are between the vertebrate and invertebrate groups, with coleoptera and lepidoptera studies taking a much shorter time on average than the three vertebrate groups (figure 1). That there are only between 40 and 100 studies in each group indicates the paucity of multispecies biodiversity research in tropical forest habitats. Also, a few studies had to be dropped from the analyses because unambiguous data on study duration could not be obtained.

Nevertheless, the analyses show very clear trends and strongly indicate that studies on each taxonomic group are influenced by inherent factors that ultimately influence their appearance in the literature (figure 2). An inordinately high number of studies on beetles (figure 2a) and butterflies and moths (figure 2b) have short durations (1 to 4 months), although the upper limit of study duration is comparable with that of other groups (2 to 5 years). Apparently development in methodology allows minimal yet efficient allocation of effort in terms of sampling time (mean 7.04 and 9.69 months, respectively) for invertebrates such as beetles and butterflies. In contrast, amphibian and reptile studies (figure 2c) have a much higher mean duration (13.17 months) and a second mode at a very long duration (2 to 5 years), indicating that short-term studies on these groups are perhaps at a disadvantage and that research is pushed toward longer durations. Only in small mammals (figure 2d) and birds (figure 2e), to which considerable research effort is devoted (mean duration 12.77 and 13.78 months, respectively), is the expected normal distribution seen, indicating an unbiased appearance in the literature and a relatively unambiguous methodology.

Figure 1. Distribution of study periods for (a) coleoptera, (b) lepidoptera, (c) amphibians–reptiles, (d) small mammals, and (e) birds. Sample sizes are in parentheses; mean values are next to boxes. Mann-Whitney U statistic is significant (p > 0.05, two-tailed) for coleoptera versus small mammals, lepidoptera versus small mammals, coleoptera versus birds, coleoptera versus amphibians–reptiles, lepidoptera versus small mammals, and lepidoptera versus amphibians–reptiles.
An important fact that these results do not reflect is that difficult taxonomy can also have a delaying effect \textit{after} fieldwork, because it calls for greater investment of person-hours for reliable identification (Oliver and Beattie 1996). For instance, though beetle studies may have short sampling durations, taxonomic segregation and identification of samples can take a lot of effort for this extremely diverse and poorly studied group (Erwin 1995, Lawton et al. 1998). However, the results do unambiguously demonstrate that publication of relatively economical, short-term work is possible even in taxonomically problematic groups such as beetles, probably because of advances in sampling methodology. That both of the “economical” groups are poikilotherms indicates that biological traits other than poikilothermy or homeothermy can determine the suitability of a faunal group for research.

Among all the groups, amphibian and reptile studies from Asia are exceptionally underrepresented (8 of 59, or 13.6\%) in the data (figure 3). Moreover, six of these eight Asian studies have durations exceeding 1 year (toward the second mode indicating long study duration). This strengthens the conjecture that the high frequency of longer study periods in literature on amphibians and reptiles is at least partly a result of methodological problems; tropical Asia is a region with notoriously low rain-forest amphibian and reptile abundance (May 1980) and a relatively young and controversial herpetological taxonomy. Neotropical amphibian–reptile studies, on the other hand, not only are well represented (36 studies) but are more evenly represented in terms of study duration. It is interesting that, on average, studies of amphibians

![Figure 2. Frequency distributions of study duration (months) of ecological studies for five taxonomic groups. The expected curve (dotted line) is the hypothesized normal distribution fitted around the mean and standard deviations of each of the five observed frequency distributions. Each observed curve (solid line) was fitted to the actual data with a distribution-specific polynomial function ranging between third and fifth orders, such that the overall pattern in the data set was adequately represented. The normality of each data set was tested by the Kolmogorov–Smirnov one-sample test, with Lilliefors probabilities for significance. The number of studies is shown on the y-axes; the study period (square root of months) is shown on the x-axes.](image-url)
and reptiles in the Old World tropics (Australasia and Africa–Madagascar) focus on more than double the number of species (mean = 44.41, n = 22) than do Neotropical studies (mean 17.21, n = 28; Mann-Whitney U, p < 0.00001). This is surprising, considering that the phenomenon of low abundance so often encountered in the Old World tropical forests, combined with the region’s relatively young herpetological taxonomy, should discourage scientists there from taking on larger, presumably unmanageable sets of taxa that ostensibly have disparate methodological requirements.

As figure 3 shows, synecological studies from the Neotropics appear to dominate all groups except small mammals, where the Australasian tropics have a slight edge. The Afro tropics are poorly represented throughout, except in amphibian and reptile studies, where they overtake Australasian studies.

**Overcoming taxonomic bias**

In general, these results strongly indicate not only that there are taxon-specific differences in research methodology but also that some groups clearly have an advantage in terms of the level of investment (as suggested by study duration) required for effective research. This level of investment is ostensibly influenced by the degree of methodological development of research protocol. It is obvious that scientists and funding agencies, especially in the field of tropical biology, have to take into consideration the level of investment that studying a particular group entails. Thus, poorly developed research methodology can easily reduce the popularity of a faunal group as a study subject, a factor that adds to the taxonomic bias apparent in scientific literature.

There is no doubt that taxonomic chauvinism exists and that it is a serious problem in applied as well as theoretical ecology and evolutionary biology. However, biases arising from innate properties of biota can only be eliminated by applying biological insights. For instance, the fact that herpetologists, especially in Asia, do come up against methodological problems is evident from the common practice of using multiple techniques in conjunction to improve reliability of sampling. In such situations, biologists must objectively choose manageable subsets of their study group to ensure an optimal investment of research effort (more intensive sampling using fewer methods) rather than taking on entire sets of taxa.

At the same time, despite the obvious advantages that some poikilotherms have as study organisms, the continued polarization of research toward a small set of biota suggests that traditional homeothermic perspectives do play their part in this inequity. Scientists of the biologically rich tropical world are well placed to overthrow this traditional hegemony. However, in most cases the tropical world is also the developing world, and an upheaval of scientific traditions (Shine 1994) is possible only with greater material and intellectual investment (Barnard 1995).

Keeping the grim status of tropical ecology in mind, taxonomic and perhaps area-specific problems with methodology must be reviewed and dealt with so that the limited resources at the disposal of tropical biologists are well allocated to a wider range of biological diversity and geographic regions. The unique biology of certain faunal groups precludes extrapolation from other, better known ones, and every fresh, innovative step in the methodological development of these groups will bring their study onto a more even footing with more popular organisms.

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