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Global ant (Hymenoptera: Formicidae) biodiversity and biogeography – a new database and its possibilities

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Abstract

Despite several centuries of research, the global patterns of species diversity, individual abundance and community composition and their drivers and subtleties remain poorly resolved. We have developed a global database for the diversity of ants, perhaps the best-studied of ecologically important insect taxa. We describe the database and aspects of its limitations and, at more length, possibilities. The database offers the possibility of testing general macroecological theory with an ecologically important group of insects. The database will also allow us to understand ways in which the global diversity, distribution and biogeography of ants differs from the more often studied vertebrates and plants and some of the consequences of those differences.

Key words: Biodiversity, macroecology, distribution, Formicidae, database, biogeography.

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Introduction

Nearly all analyses of patterns of diversity, abundance or composition of ecological communities have been confined to regions, or, at best, continents. Global scale analyses offer the hope of adding additional nuance to biogeographic and macroecological questions, in large part because global datasets allow comparisons among continents and biogeographic regions (GASTON 2000, GASTON & al. 2003, TURNER 2004, LAMOREUX & al. 2006). Such comparisons allow very general tests of putative patterns and mechanism. One approach to generating global diversity datasets is to combine the results of the many community and diversity studies done around the world. This approach has recently been used for birds (PAUTASSO & GASTON 2005), but ideally one would like to be able to compare results for birds with those of other taxa more representative of the global fauna, which consists primarily of insects.

Ants represent an ideal group for which to compile a global database. Ants are ecologically important in nearly every terrestrial biome. In addition, ants run the spectrum in terms of abundance and distribution. Ants are overly represented as global introduced and invasive species (MCG

Box 1: Here we highlight some of the kinds of questions our global database will be able to address.

- Recent reviews (HAWKINS & al. 2003) have indicated the central importance of both solar energy and water availability as fundamental drivers of diversity gradients. But via what mechanism? Is it simply that energy limits abundance which in turn mediates extinction rates (SRIVASTAVA & LAWTON 1998), or alternatively does energy drive speciation rates (ALLEN & al. 2002, KIER & al. 2005)?

- Metabolic and food web theories (e.g., BROWN & al. 2004) predict that higher trophic levels increase in diversity disproportionately with increases

How exhaustive is the database to date?

Our database includes > 90 % of papers on ant communities retrieved using the search term "Formicidae + Pitfall" and more than 95 % of those papers retrieved using "Winkler + Formicidae as of February, 2007". See "Adding data" in the Discussion for more about papers not yet in the database. Although the lead PI's on the project have an English language bias, we do not suspect that this bias is strong in most regions. For example, if we search on Formicidae and "trampa de caida" (pitfall trap) in Google Scholar we find only twelve studies, all of which were retrieved when the search was performed in English. However, in Europe and Asia, our English language bias has undoubtedly led us to miss some studies that could be usefully included in the overall database. We are in the process of additional searches in Korean, Japanese, Swedish, Bulgarian, French and several other languages to supplement our sampling from Europe and Asia.

Certainly studies exist that we might have overlooked (if you know of any obscure ones, please contact the lead author, rob_dunn@ncsu.edu). A full list of studies included in the database as of the publication of this paper is available online at:

http://www4.ncsu.edu/~rrdunn/AntMacroecology.html

Missing regions

To consider the relative completeness of sampling of different continents, we tabulated the number of sites in the study from different continents. Overall, North and South + Central America and Australia have been much better sampled than Asia and Africa and Europe (Tab. 1, Fig. 1). Europe is better represented in the full database than it is represented for the sampling methods considered here be-

Fig. 2: Distribution of sampling points across temperature by rainfall space. Points are overlaid on a diagram showing the major biomes from WHITTAKER (1975). Note that most temperature by rainfall space is well sampled, exceptions being temperate rainforests, tundra, the hottest subtropical deserts and to a lesser extent taiga. Importantly, the areas that are most poorly sampled (really hot, really cold) are those thought based on nonstandardized sampling to be the most species poor (HEATWOLE 1991, 1996). Temperate woodland/shrubland (red), temperate deciduous forests (forest green) and tropical seasonal forests (lime green), on the other hand, are very well sampled.

tion plots on WHITTAKER's (1975) biome map to understand to which biomes these missing conditions correspond. We found no quantitative studies of ant communities from the Tundra and few from the driest desert conditions (Fig. 2). In part, these omissions may, we suspect, represent the relative scarcity of ants under these conditions. Few researchers desire to sample ants where they will not find many or where it is easier to simply search for the one or two species known to occur. Nonetheless, quantitative samples from these regions would contribute disproportionately to our understanding of the drivers of ant community diversity and composition.

Broad patterns of diversity

We will consider patterns of diversity in much more detail in subsequent analyses. However, it is useful to consider at least the broadest patterns here. For example, ant diversity at the landscape grain (pooled across sites with in a study) appears to be highest in those biomes with high temperatures, as has been shown elsewhere for other datasets (BRÜHL & al. 1999, KASPARI & al. 2003, SANDERS & al. 2003, KASPARI & al. 2004, SANDERS & al. in press) which are a subset of our global dataset. In contrast, there appears to be very little relationship between annual rainfall and total species richness in our dataset (Fig. 3).

Issues with sampling completeness

for temperate forest sites, there is a correlation between the number of Winkler samples taken and the number of species collected. Comparison of small samples from tropical and temperate forest sites could lead to erroneous conclusions about the relative diversity of communities in those two biomes. However, once 15 or 20 Winkler samples have been taken for tropical sites, the increase in diversity sample number slows. These results compare well with one of the most detailed studies of sampling at a single site to date (LEPONCE

BRÜHL, C.A., MOHAMED, M. & LINSENMAIR, K.E. 1999: Altitudinal distribution of leaf litter ants along a transect in primary