TECHNICAL COMMENTS

Journal of the Lepidopterists' Society
46(4), 1992, 298–300

COMPARISON OF BUTTERFLY DIVERSITY IN THE NEOTROPICAL AND ORIENTAL REGIONS

Heppner (1991) admirably compiled and tabulated an immense amount of Lepidopteran diversity data that potentially will be of interest to biologists and conservation policy makers. For example, he concluded that the Oriental Region has more species of Lepidoptera per unit area than the Neotropical Region and stated "... figures of species richness and diversity per unit of land area give a more meaningful understanding of the average loss to be anticipated as each section of land is deforested. ..." The purpose of this note is to alert conservationists and others that the conclusions and numbers in Heppner's paper need to be viewed with caution. Errors range from technical (he used 1.67 to convert mi^2 to km^2 [2.59 is the correct factor]) to logical (see below). Specifically, I show that the variable "species/area," as calculated by Heppner, is not valid for comparing different sized areas, that the numbers of butterflies tabulated in his paper are inconsistent with other published work, and that the Neotropical Region has more than twice the butterfly species for a given area than does the Oriental Region.

Is Heppner's Argument Logical?

Heppner's argument is simple. The Neotropical Region has 46,313 Lepidoptera species and an area of 7.202 million mi^2 (=18.65 million km^2), whereas the Oriental Region has 26,794 Lepidoptera and an area of 3.934 million mi^2 (=10.19 million km^2). Dividing, the Neotropics have 6434 species/million mi^2, and the Orient has 6782 species/million mi^2. From these numbers, Heppner concluded that the Oriental Region has a higher species diversity of Lepidoptera. Using Heppner's method and data for just butterflies, the Neotropical Region is barely more diverse than the Oriental Region (1101 vs. 1057 species/million mi^2).

I use a *reductio ad absurdum* argument to show that it is illogical to use "species/area" to compare different sized regions. Approximately 113 species are recorded in Massachusetts (21,386 km^2) while there are about 3130 species in Brazil (8,483,571 km^2) (Opler & Krizek 1984, Brown 1991). Following Heppner's method of comparison, the average diversity of butterflies per unit area in Massachusetts (5.3 species/thousand km^2) is more than 14 times greater than that of Brazil (0.4 species/thousand km^2), which has the highest (or just about the highest) number of butterfly species in the world (Brown 1991).

It is reasonably well-established that species number within a region is a power function of area with the exponent usually in the 0.1–0.4 range (MacArthur & Wilson 1967, Legg 1978, Gilbert 1984). As a result, "species/area" is inversely correlated with area; the larger the area within a region, the smaller the ratio "species/area." Comparisons between areas in different regions depend upon both size and species richness of the two areas. If the sizes are different, the comparison is invalid. This is the case for the example with Massachusetts and Brazil, as it is for Heppner's comparison of the Orient with the much larger Neotropics. A valid comparison requires assessing species number as a function of area within each region (see below).

Comparison of Heppner's Tables With Other Published Sources

To assess the accuracy of Heppner's tables, I examined his species numbers for butterflies. They appear to be biased. His 19,238 butterfly species in the world is 11% higher than the corresponding figure in Shields (1989), 7% higher than that in Brown (1991), and above the range given in Robbins (1982) for described and undescribed species. His figure for butterflies without Hesperiidae is greater than the interval in Ehrlich and Raven

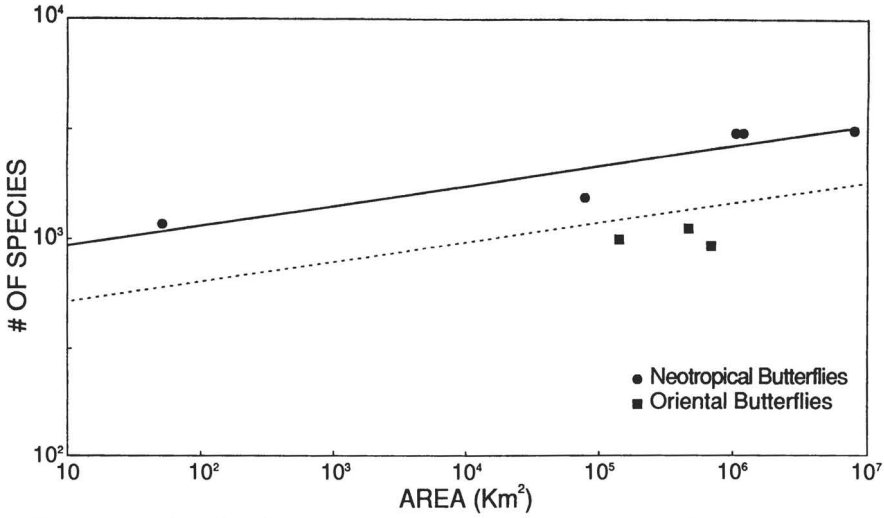

FIG. 1. Log-log plot of species richness in the Neotropics (from left to right, Tambopata, Panama, Colombia, Peru, Brazil) and in the Orient (from left to right, Malay Peninsula, Thailand, Borneo). See text for sources. Solid regression line calculated from Neotropical data. Dotted line represents half the species richness expected in a Neotropical region, showing that Oriental species richness is less than half that of the Neotropics for equal-sized areas.

(1965). Numbers in the table are uniformly higher for families than those in Shields. Heppner's figure for Neotropical Nymphalidae is 42% (almost 850 species) higher than the 2019 species in the Atlas of Neotropical Lepidoptera checklist (Lamas in prep.). Unless documentation is forthcoming for the apparent high bias in Heppner's tables, the butterfly parts should not be used for diversity studies.

NEOTROPICAL VS. ORIENTAL BUTTERFLY DIVERSITY

A comparison of species richness in the Neotropical and Oriental Regions is of biological and conservation interest. Since Heppner's data are insufficient for a valid comparison, I compare these regions using butterflies, for which there are reasonably accurate data. For the Neotropics, I use species richness of the Tambopata Reserve in southeastern Peru (Lamas 1985, Lamas et al. 1991), Panama (Robbins 1982), and Colombia, Peru, and Brazil (Brown 1991). These areas comprise a large portion of the Neotropics, including desert, grassland, scrub forest, rain forest, cloud forest, and paramo habitats. For the Oriental Region, I use diversity in Thailand (Pinratana 1988), the Malay Peninsula (Corbet & Pendlebury 1978), and Borneo (Otsuka 1988, Maruyama 1991, Seki et al. 1991). I do not know of any other reasonably complete, recently published butterfly data from these regions. I plot data on a log-log graph (Fig. 1) and draw a regression line through the points for the Neotropics. Legg (1978) performed a similar analysis, but much of his data differs markedly from that in the publications cited above.

Neotropical butterfly richness is more than twice as great as that in the Orient (Fig. 1), in contrast to the slight difference in Heppner's paper. Extrapolating from the regression line, for example, a Neotropical country the size of Thailand would have 2.2 times the number of species that occur in Thailand. Single collecting sites in the Neotropics (Emmel & Austin 1990; Fig. 1) may have more species than the entire Malay Peninsula or Borneo. In lieu of more complete published data—with which the validity of the power function model could be tested—the Neotropics are richer than the Orient for butterflies, in accord with previous comparisons using less data (Robbins 1982, DeVries 1987). The Neotropics

also appear to be richer for vertebrates and canopy tree species (Gentry 1988). Whether this pattern also holds for other Lepidoptera is unknown, but Sphingidae and Saturniidae are probably the only groups that are sufficiently well-known for a valid comparison.

This note is contribution no. 24, Biological Diversity in Latin America (BIOLAT) Project, Smithsonian Institution. I thank G. Lamas for graciously allowing me to use data from his unpublished checklist.

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Received for publication 26 January 1992; revised and accepted 13 March 1992.