Malaise Trap Catches and the Crisis in Neotropical Dipterology

Brian V. Brown

ABSTRACT: Diptera, or true flies, are extremely diverse but poorly known, especially in the Neotropical Region. Malaise trap catches from four sites are analyzed and found to contain mostly Diptera, with nematocerous families numerically dominant. Taxonomic activity, judged by the number of new species descriptions over the last 7 years, is extremely low for Neotropical taxa, probably because of grossly insufficient resources available to the few available researchers.

The Diptera (true flies) is one of the largest groups of insects, and thus forms one of the largest assemblages of organisms on the planet. There are currently more than 125,000 described species of flies (Brown, 2000; F. C. Thompson, personal communication), accounting for a relatively small fraction of the species that are actually present. An estimate by Hammond (1992) put the true number of flies at 1.6 million species. Regardless of the actual number of species, the Diptera is an important group that represents about 10% of the world's biodiversity.

Besides being rich in species, flies are extremely important to humans, from a negative standpoint (e.g., as vectors of disease) and from a positive standpoint (e.g., pollinators of various plants, biological control agents, and important decomposers in many habitats). They are diverse in all types of terrestrial and freshwater habitats, and therefore are of great potential use in bioinventory projects. It would repay society handsomely if we had a good knowledge of the types of flies present on our planet. Unfortunately, the flies are possibly the least studied of the megadiverse groups of insects—other megadiverse groups being the Coleoptera (beetles), Hymenoptera (ants, bees, wasps), and Lepidoptera (butterflies and moths). A telling sign of this obscurity is that the second-largest family of flies, the Tachinidae, a group of commonly encountered, large flies that is currently equal in species richness to birds (but is realistically far larger), does not even have a common name by which it is known to the public.

Like other organisms, fly species are not uniformly distributed around the world. There are few studies of dipteran biogeography, but one can generalize that there are more species of flies in the tropics than in colder parts of the world (although some families and other groups show the reverse relationship). Of the tropical regions, the New World tropics appear to be the most diverse of all, similar to the diversity patterns of birds and butterflies (Robbins and Opler, 1997) and many other groups. In addition to being diverse in the Neotropical Region, Diptera are extremely poorly known there. Certainly this is true of the Phoridae (humpbacked flies), the family that I study. For example, the ant-decapitating flies at La Selva Biological Station in Costa Rica (Brown, 2004) were only 10% known, suggesting that the ~1,000 described Neotropical phorid species (at the time of the most recent catalog; Borgmeier, 1968, 1971) are a pale representation of a much larger fauna of 10,000 or more.

Our knowledge of the Neotropical dipteran fauna is grossly deficient. The richness of various groups, the magnitude of the challenge of describing and understanding this diversity, and the special geographical areas most in need of study are all open questions. However, these are all areas of shocking neglect in our research programs.

Malaise Trap Catches

Flies are not difficult to capture. In fact, one of the most popular collecting methods to gather insects in tropical biodiversity surveys, the Malaise trap, gathers mostly flies. Even this most basic fact is barely documented in the literature (Hammond 1990, Penny and Arias, 1982). To investigate the Malaise-trap-susceptible fauna of the Neotropical Region, I studied and made counts of several Malaise trap catches from various parts of this region. The four samples I examined are as follows:

1. A large sample from a trap in a tree fall gap in primary forest at Tambopata Research Center, Peru, 16–22 July 2001.
2. A sample from the same tree fall gap, but from a suspended Malaise trap, the bottom of which touched a large, fallen log (i.e. the trap was not in contact with the leaf litter or the forest floor), 22–25 July 2001.
3. A sample from a forest edge, along which there was a large, recently cleared field, at Rios Paraisos, Puntarenas, Costa Rica, 15–17 February 2003. This edge was strongly sunlit, and considerably hotter and drier than the nearby forest interior.
4. A sample from an extremely degraded, relatively young second-growth forest near Rurrenabaque, Beni, Bolivia, 25 April 2003. This forest was frequently used by local people and their livestock.

For three of these samples (1–3) I noted all insects found in the sample (exclusive of Lepidoptera, which were discarded in the field), identifying each to Order (Fig. 1; unfortunately I do not have similar data for sample 4). Flies constituted 84, 81, and 64%, respectively, of the specimens in samples 1–3, followed in every case by Hymenoptera, Coleoptera, Homoptera, Collembola, and then a variety of other groups. Apparently the habitat in sample 3, a forest edge next to a large area of cleared land, was less hospitable to some groups of Diptera, probably because it was drier and hotter.

Adding to our level of ignorance, no published studies enumerate the family composition of flies in Neotropical Malaise trap samples. Therefore, within the Diptera fraction of the Malaise trap samples, I identified each specimen to the family level (full data for each sample are available at www.phorid.net). Most samples (Fig. 2) were numerically dominated by the nematoceran families Cecidomyiidae (gall

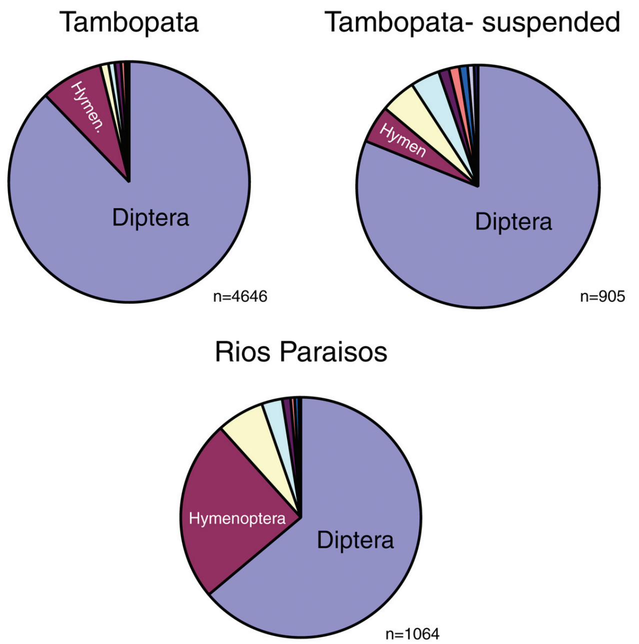

Fig. 1. Pie charts of dominant orders collected by Malaise traps 1-3 (Lepidoptera excluded)

midges), Sciaridae (black fungus gnats), Ceratopogonidae (biting midges), and Chironomidae (midges). Two exceptions were found in sample 3, the forest edge Rios Paraisos site, where Phoridae were most common, and in sample 4, where Sphaeroceridae (small dung flies) were abundant, undoubtedly because of the frequent presence of cattle and their droppings in the forest. In sample 2, from the suspended trap, the Phoridae were much less common, whereas other groups (Tipulidae, Sciaroidea), some of which are associated with decaying wood, were more prominent. Other sites for Malaise trapping would produce further variations in catch; for example, trapping near water would probably greatly increase the number of aquatic Diptera gathered, but these few samples give a general impression of a typical tropical rainforest sample.

Rates of Species Description

Malaise traps were used in large numbers, generating hundreds to thousands of samples, by the following studies funded by the National Science Foundation (NSF): the Arthropods of La Selva project (ALAS; Longino, 1994), the Colombia Arthropod Project initiated by Mike Sharkey and myself (www.uky.edu/~mjshar0), John Pickering's work in Panama, the PEET grant headed by Mike Irwin at the University of Illinois, the Carnegie Museum Dominican Republic survey, and by many other entomologists working on various projects. Based on this enumeration, there is no shortage of material for dipterists to study, and flies must be the most collected insects in Neotropical biodiversity surveys. The question therefore becomes whether this unprecedented collecting is fostering an equivalent increase in our knowledge of Diptera to any appreciable extent.

To assess activity in the taxonomy of Neotropical Diptera, I reviewed the records published by the *Zoological Record* for the past 7 years (volumes 133–139, 1997–2003). As a proxy for activity, I chose to count new species descriptions within each of the 22 largest families of Diptera for each biogeographical region. "Large family" is an arbitrary designation for those groups with more than 2,000 described species (see box, "Twenty-two Largest Families of Diptera). Together, these 22 families constitute ~77% of described Diptera species. Biogeographical regions were based on the coverage of the various Diptera catalogs, although for simplicity all Mexican species were considered Neotropical (biasing the results toward the Neotropical Region).

Twenty-two Largest Families of Diptera

Tipulidae (*sensu lato*)	Muscidae
Tachinidae	Agromyzidae
Syrphidae	Empididae
Asilidae	Phoridae
Ceratopogonidae	Culicidae
Dolichopodidae	Tabanidae
Chironomidae	Drosophilidae
Cecidomyiidae	Psychodidae
Bombyliidae	Sarcophagidae
Sciaroidea (minus Sciaridae)	Stratiomyidae
Tephritidae	Chloropidae

A quick assessment of Fig. 3 shows the striking fact that most families have a species description rate of <20 species per year. This is in spite of the fact that flies are among the most diverse groups of insects, are the most collected group of insects, and that there are tens of thousands of undescribed species in the New World tropics. Peaks >20 species per year in this graph represent the contribution of infrequent monographic research papers, such as that of Grimaldi and Nguyen (1999). Examining the underlying data shows that the average number of species described per year in these largest groups of flies is only 7.6 (Table 1), with only four families reaching double digits. With these rates of species description, the goal of inventorying the Neotropical Diptera is far off indeed.

In terms of overall number of Diptera species described per year in these largest groups, the Neotropical Region finishes third behind the Palearctic Region and the Oriental Region (Table 3). These two areas are currently being vigorously investigated, and the fauna described, largely by workers in China and Russia. The number of new species described in North America, at an average of 40 per year, is astonishingly low.

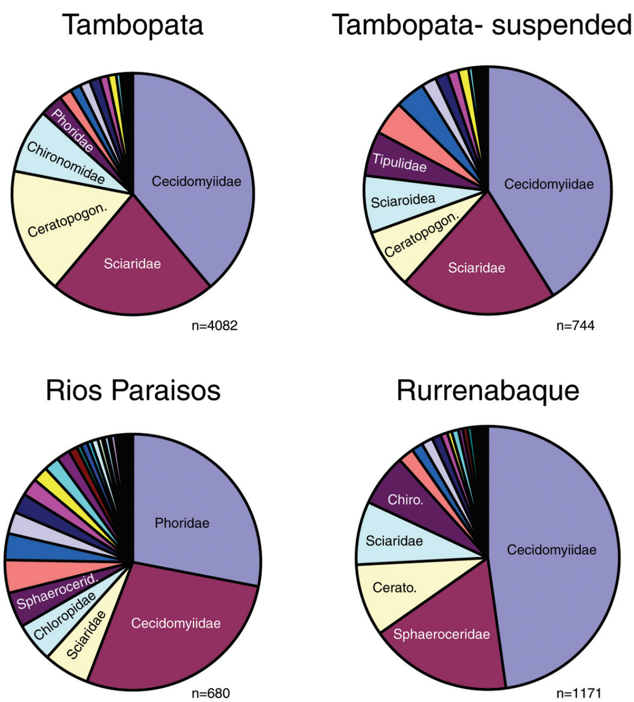

Fig. 2. Pie charts of families of Diptera collected by Malaise traps 1-4 (only 5 most numerous families labeled).

Table 2. Number of new extant Neotropical species per year in largest families of Diptera, as recorded in the Zoological Record, volumes 133–139 (1997-2003). Overall average = 7.6. species /family /year.

	Volume no.							
Neotropcial species	133	134	135	136	137	138	139	Mean no./year
Tipulidae (s.l.)	0	0	0	0	0	3	4	1
Tachinidae	0	0	1	5	0	24	2	4.6
Syrphidae	3	3	0	10	6	0	6	4
Asilidae	4	5	10	1	1	0	30	7.3
Ceratopogonidae	3	6	16	15	5	5	9	8.4
Dolichopodidae	0	10	0	0	9	12	39	10
Chironomidae	37	6	2	15	3	30	14	15.3
Bombyliidae	0	0	1	0	0	4	1	0.9
Cecidomyiidae	6	1	2	0	25	0	7	5.9
Tephritidae	0	11	2	8	1	5	0	3.9
Muscidae	7	1	10	1	1	3	5	4
Agromyzidae	1	4	11	0	0	0	9	3.6
Empididae	0	0	1	0	1	4	3	1.3
Phoridae	15	46	2	60	8	22	51	29.1
Culicidae	1	2	1	1	7	1	2	2.1
Sciaroidea	22	7	0	0	0	0	0	4.1
Tabanidae	6	1	1	24	22	5	0	8.4
Drosophilidae	1	0	0	118	5	1	13	19.7
Psychodidae	12	87	5	49	8	19	16	28
Sarcophagidae	1	0	2	15	4	4	1	3.9
Stratiomyidae	0	0	0	0	4	0	1	0.7
Chloropidae	2	0	0	0	0	0	1	0.4

Current rates of species description in Diptera average ~1,200 species per year, worldwide. At this rate, it will take us more than 1,000 years to document all 1.6 million species of Diptera. Even to treat the Diptera of Costa Rica, a fauna on the order of 20,000–35,000 species (depending on how large you think the Cecidomyiidae might be), is a task well beyond our current means.

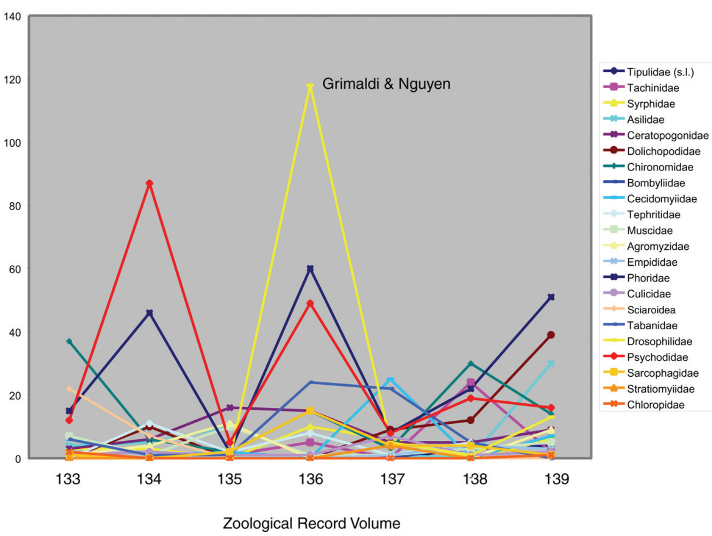

Fig. 3. Number of new species per year (top 22 families of Diptera) as described in the *Zoological Record,* volumes 133–139 (1997–2003) for the Neotropical region.

Table 3. Number of new extant species of Diptera (top 22 families) per year for each world region, as recorded in the *Zoological Record*, volumes 133–139 (1997–2003).

	Volume no.							
Region	133	134	135	136	137	138	139	Mean no./year
Nearctic	43	25	41	28	7	79	57	40
Neotropical	121	190	67	322	110	142	214	166.6
Palearctic	314	307	368	481	340	363	276	349.9
Oriental	201	221	142	260	145	214	249	204.6
Afrotropical	30	122	86	161	60	81	102	91.7
Australasian	111	69	60	96	61	7	104	72.6
Total	820	934	764	1348	723	886	1002	925.3

Reasons for the Crisis

I can offer several reasons why rates of species description are so low, especially for the diverse Neotropical Region. The major reason is of course the small number of taxonomists. Particularly in Latin America, there are few fly taxonomists other than those who are investigating groups with direct economic impact. In North America, there are many taxa for which only one person is an expert, and a few for which there are no experts, e.g. Sciaridae and Psychodidae). Other problems exist; for instance, the most commonly collected flies in Malaise traps are Cecidomyiidae, the majority of which no workers will identify because the taxonomy of the largest group is based on biological associations with host plants, and Malaise trap material is not conducive to their research programs. Regardless, there are more Diptera taxonomists here in North America than anywhere else in the world, and our hemisphere is still not being properly inventoried.

Even when workers are present to deal with a group, their work is often not highly valued or well supported. Taxonomy is an important discipline that provides the intellectual framework for ecological, phylogenetic, and conservation studies, yet many workers are expected to do this vital work in their spare time with little funding and few support staff. Research results from computer-generated phylogenetic studies are more highly valued by many administrators and colleagues, and the few hours available for research are often of necessity filled with working on these and other electronic products (such as databases). All of these tasks have their places and are valuable, but taxonomy has been the field to suffer in the past few decades.

When doing large-scale work, taxonomists need the support of technicians, which is often in short supply. A useful model that can be integrated into grant proposals is to surround a taxonomist who is working on a large group of species with an illustrator, a technician (to sort, mount, and label material), a scientific assistant (to share the load by dealing with the common species and easy problems), and, optimally, a student to learn from the expert. For even better results, the scientific assistant could be an INBio-type parataxonomist, who would seek out the organisms in the field on an ongoing basis.

All of this costs money, of course, but the research products of the group would be of such a higher quality and quantity that the investment would be extremely fruitful. Funding is available in the United States, via the NSF Revisionary Syntheses in Systematics program, as well as the Biodiversity Surveys and Inventories program and the much larger Planetary Biodiversity Inventory initiative. Hopefully, Diptera taxonomists can compete successfully for more of these grants, allowing them to pursue this desperately needed science. The alternative is to continue scratching at the surface of diversity, without being able to make significant inroads.

Twenty years ago, Dan Janzen (1985) made an impassioned plea for big thinking in North American taxonomic entomology. He urged us to dedicate ourselves to collecting, preserving, describing, and naming the Neotropical fauna before it is largely extinguished through human activity. Janzen's concerns are equally relevant today. Collections remain inadequate to understand the fauna, the number of researchers capable of working on the fauna probably has decreased, and the rate of new species description remains low. Meanwhile, the clearing of tropical forests has been busily pursued, and our last opportunities to sample and understand the dipteran fauna of large areas are being erased. What is called for is an equal effort on our part to dramatically increase our knowledge of Neotropical Diptera by asking for funding that will allow us to accomplish our dream: a comprehensive knowledge of the diversity, phylogenetic relationships, and biological roles of the true flies.

Acknowledgments

I thank Art Borkent, Steve Gaimari, Martin Hauser, Mathias Jaschhof, and Mike Sharkey for their comments on an earlier version of this paper, and Peter Cranston, who provided thoughtful comments on an orally presented version. I am also grateful to Lisa Gonzalez and Giar-Ann Kung for helping with gathering the data. This work was supported in part by NSF grants DEB-0090031 and 0315271.

References Cited

Borgmeier, T. 1968. A catalogue of the Phoridae of the World (Diptera, Phoridae). Studia Entomologica 11: 1–367.

Borgmeier, T. 1971. Supplement to a catalogue of the Phoridae of the World (Diptera, Phoridae). Studia Entomologica 14: 177–224.

Brown, B. V. 2000. Diversity of flies, gnats and mosquitoes, pp. 815–826. *In* S. A. Levin [Ed.]. Encyclopedia of biodiversity, vol. 2. Academic Press, New York.

Brown, B. V. 2004. Diversity of ant-decapitating flies (Diptera: Phoridae: *Apocephalus*) from the ALAS project: new results and projections. Sociobiology 44: 683–688.

Grimaldi, D., and T. Nguyen. 1999. Monograph on the spittlebug flies, genus Cladochaeta (Diptera: Drosophilidae: *Cladochaetini*). Bul. Am. Mus. Nat. Hist. 241.

Hammond, P. M. 1990. Insect abundance and diversity in the Dumoga-Bone National Park, N. Sulawesi, with special reference to the beetle fauna of lowland rain forest in the Toraut region, pp. 197–254. *In* W. J. Knight and J. D. Holloway [Eds.]. Insects and the Rain Forests of South East Asia (Wallacea). Royal Entomological Society of London.

Hammond, P. M. 1992. Uncharted realms of species richness, pp. 26–39. *In* B. Groombridge [Ed.]. Global Biodiversity: Status of the Earth's Living Resources. World Conservation Monitoring Centre, Chapman and Hall, London.

Janzen, D. H. 1985. Degradation of tropical forests: a dialogue. Bull. Entomol. Soc. Am. 31: 10–11.

Longino, J. T. 1994. How to measure arthropod diversity in a tropical rainforest. Biol. Int. 28: 3–13.

Penny, N. D., and J. R. Arias. 1982. Insects of an Amazon Forest. Columbia University Press, New York.

Robbins, R. K., and P. A. Opler. 1997. Butterfly diversity and a preliminary comparison with bird and mammal diversity, pp. 69–82 in M. L. Reaka-Kudla, D. E. Wilson, and E. O. Wilson [Eds.]. Biodiversity II: Understanding and Protecting our Biological Resources. Joseph Henry Press, Washington, DC.

Brian V. Brown is Curator of Entomology at the Natural History Museum of Los Angeles County, and an expert in the systematics of phorid flies. He can be reached at bbrown@nhm.org.