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Robert W. Matthews
University of Georgia, Athens

Janice R. Matthews
University of Georgia, Athens

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THE MALAISE TRAP: ITS UTILITY AND POTENTIAL FOR SAMPLING INSECT POPULATIONS

Robert W. Matthews and Janice R. Matthews

Department of Entomology, University of Georgia, Athens, Georgia 30601

Slightly over three decades have elapsed since Malaise (1937) first published plans for the insect trap now bearing his name—a stationary mesh tent with open sides, a central baffle, and a top-mounted collecting apparatus (Fig. 1). A non-attractant device, the Malaise trap is based upon the observation that most flying insects hitting an obstacle respond by flying (or crawling) upward (and thus into captivity).

In recent years, the Malaise trap has become increasingly popular among insect taxonomists and collectors as a means of augmenting catch and collecting rare or ephemeral representatives. Many variations have been developed (e.g., Townes, 1962; Gressitt and Gressitt, 1962; Marston, 1965; Chanter, 1965; Butler, 1965), most aimed at making the trap more portable and/or efficient for collecting a particular insect group. To date, however, the Malaise trap has received little notice among other biologists, although it would appear to have considerable potential in almost any field study involving flying insects, and particularly in ecological investigations.

Total Malaise trap collections from four zoogeographic regions are recorded in the literature (Marston, 1965; Chanter, 1965; Moczar, 1967; Geijskes, 1968; Matthews & Matthews, 1970). When converted to a common format (Table 1), these data are representative of the proportionate occurrence of insect orders that can reasonably be expected in a Malaise sample. In each collection, Diptera, Hymenoptera, Hemiptera *sensu latu* and Lepidoptera comprise at least 90%. The Diptera vastly outnumber all other

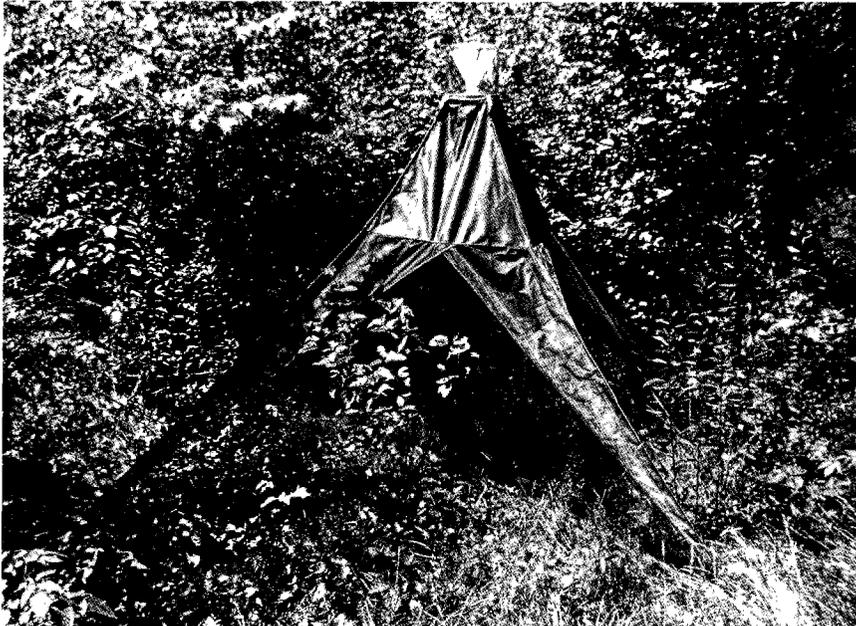


Fig. 1. Malaise trap used in this study: height to top of globe, 1.7 m; base length, center pole to corner stake, 1.2 m; base distance between stakes, 2 m; height of side openings, 1 m; color, gray-green. (Manufactured by Cornell Equipment Co., Inc., 1115 N. Rolling Rd., Baltimore, Md. 21228.)

Table 1. Total Malaise trap catch: comparison of percentage composition, by insect orders, from one tropical and three temperate localities. Chanter's (1965) catch was only a 24 hour sample and is not included here. Astericks represent values of less than 0.05%.

	<i>New York</i>	<i>Kansas</i>	<i>Hungary</i>	<i>Surinam</i>
Diptera	44.5%	66.3%	79.8%	58.0%
Plecoptera ¹	20.8			
Hymenoptera	14.7	12.3	10.7	19.0
Hemiptera	7.1	6.8	5.8	2.3
Lepidoptera	7.2	4.8	3.0	14.0
Coleoptera	2.4	5.6	0.3	4.6
Collembola	1.4	3.5		
Thysanoptera	0.9			
Trichoptera	0.7		*	
Psocoptera	0.2			0.1
Neuroptera	0.1	0.1	*	0.4
Odonata	*	0.1	0.2	*
Mecoptera	*		0.2	
Ephemeroptera	*		*	
Orthoptera	*	0.5	*	1.7
N	40,348	2,927	20,713	90,182
Dates of Study	2 June–31 Aug. 1967	6–13 June 1964	May–Oct. 1966	Sept. 1965– Dec. 1966
Source	Matthews & Matthews, 1970	Marston, 1965	Moczar, 1967	Geijskes, 1968

¹The abundance of Plecoptera in the New York sample was aberrant, a result of the mass emergence of *Nemoura albidipennis* Walker over a four week period from a small lake in close proximity to one trap.

orders, being 2.5-7.5 times as abundant as the second place order, typically Hymenoptera.

The paucity of Coleoptera is especially notable in view of the fact that beetles constitute the largest insect order. Their poor representation is due in part to their tendency to drop (and thereby escape) upon encountering obstacles in flight. A series of pans filled with detergent water and placed beneath the trap baffles would no doubt increase the number of beetles (and certain other groups) obtained.

TRAP PLACEMENT

Since the Malaise trap samples only those insects which happen to fly through a relatively small area, trap placement becomes a matter of utmost significance. As Gressitt and Gressitt (1962) point out, greatest quantity results when traps are set where insect flight tends to be concentrated by "local circumstances of topography, density or lack of vegetation, relation to wind, water and such aspects." During the summer of 1967, we had identical Malaise traps operating continuously for thirteen weeks in four locations within 500 m of each other in a mesic forest habitat southwest of Albany, New York (see Matthews & Matthews, 1970, for additional habitat details). The most productive trap averaged 259 insects per day (range, 36-749) and obtained 59% of the entire summer collection. Even at the ordinal level, variation between the traps' catches was striking. For example, Diptera, the best collected group, comprised from 14.7% to 54.4% of the total season's catch in the different traps, with even greater fluctuations over shorter time intervals.

At the level of the species, the basic unit in any community study, the data are even more graphic. For example, analysis of the combined collections of sawflies (Hymenoptera: Symphyta) from three continuously operating traps reveals that 1824 individuals belonging to 115 species were taken. A single trap obtained 95 of these species (82.5%); only 15 species were taken by all three traps. About two-thirds of the species were represented by five or fewer individuals, and 42 species were represented by single individuals. Of these 42 unique species, 25 were taken in the same trap. Thus, the addition of two more traps in the study area resulted in an increase of nearly 40% in the number of unique species obtained, a particularly significant increment if one is calculating species diversity indices for a given habitat. It should be clear that if one hopes to adequately sample the flying insect fauna of an area or wishes to minimize catch biases reflecting trap placement, several traps should be in operation simultaneously.

RELATIVE COLLECTING EFFICIENCY

The performance of Malaise traps relative to various other sampling methods has yet to be rigorously investigated. To our knowledge, only one study has included Malaise traps in comparisons with other non-attractant traps for flying insects. Juillet (1963) found the Malaise trap to be superior to window pane and sticky traps, and only slightly less reliable and versatile than the rotary trap. For all orders except Coleoptera, the Malaise trap was also second only to the rotary trap in numbers of insects captured per cubic yard per hour. This study needs confirmation, however, as Juillet did not replicate his samples nor make allowance for trap placement, regarding the study area as a "uniform environment" although the single Malaise trap was situated across a path while the other traps were placed nearby in the interior of the woodlot.

As a supplement to other sampling techniques, Evans and Owen (1965) noted that Malaise trap collections added significantly to the number of species recorded from an old field community. Similarly, Breeland and Pickard (1965) found that of 29 species of mosquitoes known to occur in their study area, Malaise traps collected 27, compared to 19, 16 and 13 species by three conventional methods. In another study (Gunstream and Chew, 1967) which utilized both Malaise and light traps over a six week period in California alfalfa fields, both trap methods captured the same 7 mosquito species, but in very different proportion and reproductive condition; they concluded that the relative representation of each species and the proportions of population classes within species from the Malaise trap collections were likely to more nearly represent the actual situation. Similarly, Owen (1969) noted that Malaise traps captured roughly equal numbers of each sex of sphingid moth species, whereas light trap collections of the same species were typically biased toward one sex or the other. In addition, the two methods yielded quite different frequencies of the various species.

Traditionally, the most commonly used sampling technique in ecological studies has been sweeping—a method with many shortcomings (see Southwood, 1966). To date, no studies have directly compared sweep net samples to Malaise collections made concurrently in the same habitat. In an attempt to provide a rough indication of the relative performance of the two methods, Table 2 compares our New York Malaise collections with a selected subsample of one particularly comprehensive sweep sample study, Whittaker's (1952) investigation of foliage insect communities from the Smoky Mountains of eastern Tennessee. The two methods yielded most similar percentages in those orders containing predominantly active fliers, such as Hymenoptera and, to a lesser extent, Diptera. Lepidoptera appear to be more adequately sampled by the Malaise trap, perhaps due to a more complete representation of nocturnal species. Sweep samples appear, however, to be more satisfactory for Coleoptera and Hemiptera, which typically exhibit less tendency toward free flight and greater tendency to drop when disturbed.

Our preliminary analyses of concurrent Malaise and sweep samples have indicated that, while the total ordinal percentages may be similar, within a given order the species composition is often quite different. Gross comparison of the hymenopterous taxa in Whittaker's and our samples (Table 2) also suggest this. For example, the proportion of

Chalcidoidea and Proctotrupeoidea was much greater in the sweep subsample, while Symphyta and Apoidea were more abundant in the Malaise collection. While these differences may in part be geographic and/or seasonal, they nevertheless indicate the desirability of utilizing a variety of sampling techniques when attempting a comprehensive sample of the insect fauna of an area, as Evans and Murdoch (1968) have done.

Table 2. Comparison of selected mesic forest Malaise trap and sweep net collections. Malaise trap subsample obtained by omitting Plecoptera from eastern New York totals (Matthews and Matthews, 1970). Sweep net subsample derived by summing data from eastern Tennessee cove communities judged most similar to the above (Whittaker, 1952, localities A, B, E, L, L', M, N).

	Percentage composition by order		Composition of hymenopterous taxa		
	sweep net	Malaise trap		sweep net	Malaise trap
Diptera	40.1%	56.2%	Symphyta	2.7%	35.2%
Hymenoptera	16.5	18.6	Ichneumonoidea	44.9	47.7
Homoptera	20.1	8.7	Chalcidoidea	22.8	5.7
Coleoptera	11.2	3.0	Proctotrupeoidea	23.7	3.6
Heteroptera	3.1	0.3	Cynipoidea	3.3	1.0
Lepidoptera	2.7	9.0	Formicoidea	0.2	0.3
Other orders	5.4	4.2	Apoidea	0.9	4.5
			Other Aculeata	1.5	4.8
N	18,252	31,950	N	3,013	5,931

OPERATIONAL STRENGTHS AND WEAKNESSES

Inherent in the Malaise trap design and mode of action are several advantages which make it particularly well suited for insect community studies. It can be operated continuously in any weather, with only occasional or a predetermined schedule of attendance. As many replications as desired may be made simultaneously at various locations within a study area. Because the Malaise trap functions without bait, the catch is primarily of local origin. In addition, cost of materials needed to construct a trap is nominal, usually less than \$25, and recently at least two commercially manufactured traps have become available.

In contrast to those obtained by sweep nets, Malaise samples are "clean"—the collection bottle contains only whole insects, perfectly preserved, a tremendous saving on technicians' time (and temper). Malaise samples could also be expected to contain a higher (and no doubt more truly representative) proportion of the very small Hymenoptera and Diptera species, whereas these often either escape through the relatively coarse mesh of the average sweep net or become lost in the crushed and sodden vegetation which typically characterizes sweep net collections. Finally, because Malaise-caught insects generally make excellent museum specimens, taxonomists are usually more willing to make identifications of this material.

Various physical factors may well influence the efficiency of Malaise trap operation. Temperature, precipitation and air movement are apparently of considerable importance, largest catches generally occurring on hot, clear, still days following rain. A more subtle, but nevertheless real, climatic influence was noted by Townes (1962), who points out that insects generally fly closer to the ground in the spring because of warmer air there, and thus are likely to enter the traps in greater numbers at this season. Height of surrounding vegetation and location of a trap in shade or sun can also materially alter

trap performance and efficiency. Time of year will, of course, also be reflected in catch composition and quantity, as many groups (e.g., sawflies, spittlebugs, see Matthews and Matthews, 1970) have decidedly seasonal occurrence.

For comparative studies between localities or seasons, standardization of trap design obviously becomes an important consideration, for area sampled by the trap, trap shape and color, net mesh gauge (or replacement by plastic film, e.g., Marston, 1965), and form and nature of collecting apparatus are but a few of the more important design variables which have been observed to affect catch size and composition. A carefully designed investigation into the relative importance of such parameters would be welcomed. Control of differences due to trap placement could be minimized by a long term study utilizing a regular rotation schedule.

SUMMARY

The popularity of Malaise traps seems destined to grow, if for no other reason than because they are amenable to an almost infinite variety of modifications. For example, in an investigation of stream insect migration, Roos (1957) adapted a trap to collect from each side separately. DeFoliart and Morris (1967) utilized a Malaise-like trap made of acetate sheets and baited with dry ice for seasonality studies of pest species of hematophagous Diptera. Fresh flowers and/or honey might be used to augment Hymenoptera, Diptera and Lepidoptera collections. Baiting traps with pheromones, as was done recently with light traps by Howland, et al. (1969), could open a range of new possibilities.

In conclusion, Malaise traps as non-attractant samplers of insect populations offer a rather efficient and economical means for obtaining large quantities of data with minimal effort. Diptera, Hymenoptera and Lepidoptera are the most adequately sampled orders, but modifications could augment catches of various groups. With replications of standardized traps, comparable data from different habitats or even different zoogeographic regions would be relatively easy to obtain. Malaise traps could have additional valuable applications in long term faunal composition and seasonality studies, species diversity analyses, and many other ecologically oriented investigations.

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