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ORIGINAL PAPER

Discovery of potent, unsuspected sampling disparities for Malaise and Möricke traps, as shown for Neotropical Cryptini (Hymenoptera, Ichneumonidae)

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Abstract Malaise and Möricke traps, universally used mostly to sample wasps and flies, are compared for the first time at genus level, focusing on Cryptini, one of the most diverse parasitoid taxa. Conclusions are supported by 10,706 man-hours of activities, 5,569 specimens from 20 Atlantic Forest and Amazon Forest localities, 4.81 Malaise trap-years and 89.09 Möricke trap-years. Substantial taxonomic and sexual biases were detected and quantified for Cryptini and for each of its studied genera. Möricke captured a proportion of Cryptini to other Ichenumonidae almost four times greater than Malaise. Most genera were captured mostly or exclusively by one of the traps only. Generally, Malaise collected 2.4 times more males than females, and 20% more species for males than females; Möricke yielded 2.4 times more females, and 2–4 times more species for females than males. The study scrutinizes and reaches beyond an allegedly known, but widely neglected problem. Data interpretation strongly suggests the necessity of sampling with both traps at once, under the risk that biodiversity investigations might otherwise continue to generate grossly biased results. Trap equivalence is discussed and quantified.

Keywords Behaviour · Gender · Sex-ratio · Yellow pan trap · Flight interception trap

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Introduction

In order to furnish sound templates of species richness and abundance as a basis for conservation assessment and management, confidence in the results from different sampling methods is vital. In such context, undetected sampling biases can be quite serious, as they may lead to equivocal recommendations with far-reaching implications for conservation. This is particularly critical with insects, because most insect species can only be efficiently detected or quantified with traps.

Even so, there has been a great and unquestioned reliance in recent decades on Malaise traps for collecting Hymenoptera and estimating their biodiversity. The number of authors using this trap jumped from a steady average of 21.0 citations per year from 1989–1994, to 39.4 citations per year from I.2000 to IV.2007 (CAB Abstracts 1989–1998, Biological Abstracts 1999–2007), an 88% increase, for over 100 publications. Current biodiversity projects with Hymenoptera also tend to rely heavily on the use of Malaise traps, e.g. 150 and 40 Malaise trap-years of sampling effort in Hanson and Gauld (1995) and Azevedo and Helmer (1999), respectively.

Not surprisingly, Malaise traps have been the single or major trap choice for studies with Ichneumonoidea in 28 of 47 (60%) papers about these wasps which involved collecting trips, in the past 18 years (CAB and Biological Abstracts *op. cit.*, and informal sources). In contrast, for the same period, barely five articles (11%) explicitly mention the use of Möricke traps for targeting Ichneumonoidea, and only two of these studies (Guerra and Penteado-Dias 2002; Chay-Hernandez et al. 2006) were specifically aimed at biodiversity studies of that group. Henry Townes himself, perhaps the most influential ichneumonid specialist, was one of the greatest promoters of Malaise traps (e.g. Townes

1972), and specialists today still heavily rely on and recommend Malaise traps for targeting Ichneumonoidea.

Some comparative studies suggest Möricke traps can outperform other traps, including Malaise, for collecting Hymenoptera (e.g., Noyes 1989, in part; García 2003), but a generalized preference for Malaise might not be surprising, either for Ichneumonoidea or for any other Hymenoptera taxon, because of the lack of published, specific challenging information. In fact, only a few works deal with lower taxonomic levels; most studies are instead focused on comparisons at family-level or even higher taxonomic ranks (e.g. Noyes 1989; García 2003; Bartholomew and Prowell 2005). Furthermore, in spite of their generalized use, and several published studies investigating or proposing improvements on their collecting efficiency, no differences seem to ever have been formally investigated for Malaise or Möricke traps in terms of sex-bias, trap equivalence or relative importance for more specific taxa. This work is apparently the first to venture on all these aspects and to address them through the most specific and in-depth investigation ever conducted for Malaise versus Möricke trap efficiency.

This study is focused on a dominant taxon of Ichneumonoidea, the Cryptini. With over 3,000 species, the Cryptini are likely the most diverse insect tribe and, in tropical regions, "the most conspicuous of all ichneumonids" (Townes 1970). Species of Cryptini are mostly parasitoids of pupae and prepupae of Lepidoptera, Coleoptera and Hymenoptera (Gauld 2006).

Methods

This study is based on data generated from specimens collected in the Brazilian Atlantic Forest and Amazon Forest, from four major projects. In all cases, the following traps were used: Townes style Malaise traps (Townes 1972) of both coarse and fine mesh sizes, and yellow Möricke traps, made from 15 cm diameter by 7 cm deep plastic bowls. Möricke are cheap and easy to set in relation to Malaise, a reason why they are always used in much greater numbers than the latter. A summary description of each project follows. (1) Biota/FAPESP: a multi-institutional project which sampled the Atlantic Forest in 17 nearly equidistant localities, extending from northern (07°08′25.0″S) to southern (26°19′25.6″S) Brazil, between XII.2000 and XI.2002, with a total effort of 1,020 Malaise trap-days (MaTD) and 10,200 Möricke trap-days (MöTD); specimens in the *Museu de Zoologia da USP* (MZSP), Brazil. (2) São Paulo, Estação Biológica Boracéia (23°38′S, 45°53′W): a 16,450 ha area of pristine Atlantic Forest; four collecting trips between VI.2002 and I.2003, adding to 139 MaTD and 2,738 MöTD; specimens in MZSP. (3) Pará, Reserva Caxiuanã (1°46′S 51°37′W): a 33,000 ha area of pristine Amazon Forest, sampled from 13 to 27.XI.2003, with 146 MaTD and 10,860 MöTD; specimens in the *Museu Paraense Emílio Goeldi*, and in the Entomological Collection of the *Universidade Federal do Espírito Santo* (UFES). (4) Espírito Santo, Reserva Biológica de Duas Bocas (from 20°18′05″–20°19′08″S to 40°28′06″–40°32′28″W): a 2,910 ha area of Atlantic Forest; two collecting trips, in primary (20.X–05.XI.2005) and secondary (24.IV–03.V.2005) forests, with 450 MaTD and 8,720 MöTD; specimens in MZSP and UFES. Both trap types were used concurrently in all collecting events.

Sorting and identification of all Cryptini were performed by the authors or by supervised students of one of us (APA), first at MZSP (2003–2005), then at UFES (2006–2007). A total of 5,569 Cryptini specimens were examined, most determined to genus-level and all sorted to morpho-species. Table 1 does not include data from project 1 because the respective number of non-Cryptini Ichneumonidae was not checked (unsorted material, stored in several institutions; also nonessential to the purposes of Table 1). Some genus-level determinations performed at MZSP were later considered doubtful, and the respective information is not used here. Tables 1 and 5 are populated with data from 3,167 and 2,920 Cryptini specimens, respectively, which is extensively representative for the group. Tables 2, 3 and 4 summarize information for all examined specimens and morpho-species. Since over 60% of the examined species are undescribed taxa or are currently being revised, reliable

Table 1 Number of specimens of Cryptini and other Ichneumonidae collected by Malaise and Möricke traps in two major ecosystems in Brazil

Project [ecosystem]	Malaise traps			Möricke traps		
	Cryptini	Non-Cryptini	%C	Cryptini	Non-Cryptini	%C
Caxiuanã [AM]	107	198	35.1	1,583	666	70.4
Duas Bocas, primary forest [AF]	394	2,954	11.8	796	1,419	35.9
Duas Bocas, secondary forest [AF]	24	178	11.9	263	233	53.0
Total	525	3,330	13.6	2,642	2,318	53.3

AM Amazon Forest, *AF* Atlantic Forest, *%C* percentage of Cryptini in relation to the total number of specimens (Cryptini + Non-Cryptini) in each area

Table 2 Number and percentage of Cryptini specimens, by sex, collected with *Malaise* traps in two major ecosystems in Brazil

Project [Ecosystem]	Females	Males	Total	%f	%m	f/m	Trap-days	Spm/td
Caxiuanã [AM]	31	76	107	29.0	**71.0**	0.41	146	0.7329
Biota/FAPESP [AF]	251	483	734	34.2	**65.8**	0.52	1,159	0.6333
Duas Bocas, primary forest [AF]	78	316	394	19.8	**80.2**	0.25	294	1.3401
Duas Bocas, secondary forest [AF]	15	9	24	**62.5**	37.5	1.67	156	0.1538
Total	375	884	1,259	29.8	**70.2**	0.42	1,755	0.7174

Highest percentages of each area in boldface

AM Amazon Forest, *AF* Atlantic Forest, *f/m* number of females by the number of males, *Spm/td* number of specimens collected per trap-day

Table 3 Number and percentage of Cryptini specimens, by sex, collected with *Möricke* traps in two major ecosystems in Brazil

Project [Ecosystem]	Females	Males	Total	%f	%m	f/m	Trap-days	Spm/td
Caxiuanã [AM]	1,162	421	1,583	**73.4**	26.6	2.76	10,860	0.1458
Biota/FAPESP [AF]	1,130	534	1,664	**67.9**	32.1	2.12	12,938	0.1286
Duas Bocas, primary forest [AF]	495	305	800	**61.9**	38.1	1.62	4,840	0.1653
Duas Bocas, secondary forest [AF]	242	21	263	**92.0**	8.0	11.52	3,880	0.0678
Total	3,029	1,281	4,310	**70.3**	29.7	2.36	32,518	0.1325

Highest percentages of each area in boldface

AM Amazon Forest, *AF* Atlantic Forest, *f/m* number of females by the number of males, *Spm/td* number of specimens collected per trap-day

Table 4 Collecting efficiency of Malaise and Möricke traps in two major ecosystems in Brazil, for Cryptini

Project [Ecosystem]	Malaise traps			Möricke traps			Mö/Ma		
	Spm/td *f*	Spm/td *m*	Ratio	Spm/td *f*	Spm/td *m*	Ratio	*f*	*m*	*f* and *m*
Caxiuanã [AM]	0.2123	0.5205	2.5	0.1070	0.0388	2.8	2.0	13.4	5.0
Biota/FAPESP [AF]	0.2166	0.4167	1.9	0.0873	0.0413	2.1	2.5	10.1	4.9
Duas Bocas, primary forest [AF]	0.2653	1.0748	4.1	0.1023	0.0630	1.6	2.6	17.1	8.1
Duas Bocas, secondary forest [AF]	0.0962	0.0577	0.6	0.0624	0.0054	11.5	1.5	10.7	2.3
Total	0.2137	0.5037	2.4	0.0931	0.0394	2.4	2.3	12.8	5.4

AF Atlantic Forest, *AM* Amazon Forest, *f* females, *m* males, *Mö/Ma* number of Möricke traps necessary to collect the same number of specimens as one Malaise trap (values for *Mö/Ma f&m* calculated from Tables 2 and 3), *Ratio* number of times the Spm/td for one sex is larger than the other (*m/f* for Malaise; *f/m* for Möricke), *Spm/td* number of specimens per trap-day

associations of males and females were not possible in many cases, and the number of species had to be treated separately for each sex. Because this situation prevents in-depth discussions, analyses at the species level were reduced to complementary information. Accordingly, it is not the aim of this work to compare trap efficiency in terms of species richness or diversity.

Analyses

The equivalence between traps in terms of specimens (Tables 4, 5) and species (Table 6) are expressed as *Mö/Ma*, the average number of Möricke traps or Möricke trap-days, necessary to collect the same number of specimens (or species) as one Malaise trap or as one Malaise trap-day. It was calculated as $(a/b)/(c/d)$, were $a =$ number of specimens, or species, collected by Malaise traps; $b =$ number of Malaise trap-days; $c/d =$ same data, for Möricke traps. Statistical significance tests have not been performed because only obvious differences were considered. Fittingly, when referring to Table 5, the items "Results", "Discussion" and "Conclusions" are focused on genera with 10 or more specimens collected with at least one trap type.

Results

The total collecting effort for this work was of 1,755 Malaise trap-days (4.8 trap-years; Table 2) and 32,518 Möricke trap-days (89.1 trap-years; Table 3).

Table 5 Number of specimens, per sex, for each identified Cryptini genus collected with Malaise and with Möricke taps in two major ecosystems in Brazil

Genus	Malaise Traps				Möricke Traps				Best results		
	f	*m*	%*m*	Mö/Ma *f*	*f*	*m*	%*f*	Ma for *m*	Mö for *f*	Ma	Mö
Hercana	0	0	–	Mö	2	0	100.0				
Hylophasma	0	0	–	Mö	1	0	100.0				
Prosthoporus	0	0	–	Mö	3	0	100.0				✔
Trihapsis	0	0	–	Mö	1	0	100.0				
Acerastes	9	5	35.7	11.9	14	1	**93.3**		✔		
Acorystus	3	0	0.0	4.6	12	1	**92.3**		✔		
Baltazaria	1	0	0.0	**1.3**	14	11	**56.0**				✔
Baryceros	1	168	**99.4**	**0.9**	21	13	**61.8**	✔	✔		
Basileucus	1	0	0.0	18.5	1	0	100.0				
Bathyzonus	4	24	**85.7**	–	0	1	0.0	✔		✔	
Chromocryptus	2	2	50.0	3.7	10	1	**90.9**		✔		
Cryptanura	2	8	**80.0**	**1.1**	35	5	**87.5**		✔		
Debilos	18	0	0.0	**1.2**	281	22	**92.7**		✔		
Diapetimorpha	35	150	**81.1**	**1.1**	617	137	**81.8**	✔	✔		✔
Digonocryptus	9	5	35.7	**1.8**	92	64	**59.0**				✔
Diplohimas	4	3	42.9	2.9	26	0	**100.0**		✔		
Dismodix	3	4	57.1	27.8	2	0	100.0			✔	
Glodianus	2	6	75.0	2.9	13	0	**100.0**	✔	✔		
Harpura	5	1	16.7	Mö	50	0	**100.0**		✔		
Lamprocryptus	1	4	80.0	Mö	43	0	**100.0**		✔		
Leptharthron	0	1	100.0	1/4	39	2	**95.1**		✔		✔
Loxopus	2	6	75.0	0.8	46	5	**90.2**		✔		✔
Lymeon	16	33	**67.3**	0.9	332	55	**85.8**		✔		
Melanocryptus	2	7	80.0	7.4	5	1	83.3	✔		?	
Mesostenus	2	0	0.0	0.5	74	0	**100.0**		✔		
Messatoporus	11	8	42.1	29.1	7	0	100.0				
Polycyrtus	11	21	**65.6**	1.3	152	70	**68.5**		✔		
Polyphrix	1	0	0.0	6.2	3	0	100.0				
Rhinium	1	0	0.0	0.1	153	2	**98.7**		✔		✔
Toechorychus	7	3	30.0	25.9	5	0	100.0			?	
Tricentrum	3	3	50.0	2.6	21	6	**77.8**		✔		
Whymperia	7	0	0.0	3.3	39	0	**100.0**		?		
Agonocryptus	2	0	0.0	Ma	0	0	–				
Distictus	0	1	100.0	Ma	0	0	–				
Golbachiella	1	2	66.7	Ma	0	0	–				
Lamprocryptidea	1	16	**94.1**	Ma	0	0	–	✔		✔	
Mallochia	1	0	0.0	Ma	0	0	–				
Photocryptus	1	2	66.7	Ma	0	0	–				
Total	170	483	74.0	1.5	2,114	397	84.2				

Sampled areas and collecting effort as in Tables 2 and 3. Male or female percentages equal or superior to 50%, for genera with 10 or more specimens collected by the respective trap, are marked in boldface

f Females, *m* males, *Ma* Malaise trap, or "collected only in Malaise traps", *Mö* Möricke trap, or "collected only in Möricke traps", *Mö/Ma f* number of Möricke traps necessary to match the number of female specimens collected by one Malaise trap. "Best results" were selected when *Mö/Ma f* values were greater than average (2.3), or %*m* or %*f* were greater than 70% with 10 or more specimens collected, or taxon is rare and two or more specimens were collected by one trap type only

Table 6 Number of Cryptini morph-species, per sex, collected with Malaise and with Möricke traps in two major ecosystems in Brazil

Project [Ecosystem]	Malaise			Möricke			Mö/Ma	
	f	*m*	*m*/*f*	*f*	*m*	*f*/*m*	*f*	*m*
Caxiuanã [AM]	19	22	**1.2**	71	27	**2.6**	19.9	60.6
Biota/FAPESP [AF]	116	125	**1.1**	160	96	**1.7**	8.1	14.5
DB primary [AF]	41	53	**1.3**	88	49	**1.8**	7.7	17.8
DB secondary [AF]	16	11	0.7	47	12	**3.9**	8.5	22.8

Sampled areas and collecting effort as in Tables 2 and 3. Sex ratios superior to 1.0 marked in boldface. Full total values are not presented because species-level data from Biota/FAPESP could not be precisely matched with other results (see item "Methods")

f females, *m* males, *Mö/Ma* average number of Möricke trap (or trap-days), necessary to collect the same number of species than one Malaise trap (or trap-day)

Trap efficiency for Cryptini

Although variable, the proportion of Cryptini in relation to other Ichneumonidae was generally high, from 11.8 to 70.4% (Table 1). However, the proportion of Cryptini in the total number of Ichneumonidae collected was drastically higher in Möricke (average 53.3%) than in Malaise (13.6%), in all localities. In two instances, Möricke traps yielded 1.13 and 2.38 times more Cryptini than all other ichneumonids combined. Both traps yielded their highest proportion of Cryptini in the Amazon Forest area (Table 1).

Sex-bias

A strong sex-bias was detected for both traps. On average, 70.2% of the Cryptini collected by Malaise traps were males (Table 2). Möricke traps, in contrast, always collected much more females (average 70.3%), reaching up to 92.0% in one case (Table 3). The proportion of females, however, was always highest in a secondary vegetation area of the Atlantic Forest (Tables 2, 3, "Duas Bocas, secondary forest"); this locality was the only one where Malaise traps collected more females (62.5%) than males.

Such proportions are also reflected in the markedly different trap efficiency for each sex. In terms of number of specimens collected per trap-day (Spm/td), the efficiency of Malaise traps was, on average, 2.4 times greater for males (Spm/td = 0.5037) than for females (0.2137); its efficiency in collecting females was better than for males only in the area of secondary vegetation in the Atlantic Forest (Table 4). Möricke traps, however, collected, on average, 2.4 times more *females* per trap-day (Spm/td = 0.0931) than males (0.0394); its efficiency was nearly always much superior for females (Table 4).

The equivalence of each trap type in collecting each sex was therefore highly distinct (Table 4). On average, 2.3 Möricke traps collected as many female Cryptini as one Malaise trap, and this value did not prove to be much variable, ranging only between 1.5 and 2.6. For capturing males, however, an average of 12.8 yellow Möricke traps were necessary to trap the same number of specimens collected by a single Malaise; the variation here was much higher, ranging between 10.1 and 19.3 Möricke traps per Malaise (Table 4), but always much superior than the equivalent values for the females.

Considering all specimens, 5.4 Möricke traps were necessary to catch as many Cryptini as one Malaise trap; this general value ranged 2.3–8.1, depending on the sampled area (Table 4).

Results for the genera, per sex

A group of four genera, mostly rare or uncommon taxa, listed at the top in Table 5, were collected exclusively in Möricke traps; for all of these, only females were collected. Another six genera, listed at the bottom of Table 5, were collected only with Malaise traps; of these, *Agonocryptus* and *Mallochia* were represented only by female specimens, and the remaining genera mostly by males; *Lamprocryptidea* was the only well-represented genus here, with 16 males and 1 female.

Of 28 genera collected in both traps, 11 had mostly or exclusively males in Malaise traps, while females were mostly or exclusively obtained with Möricke traps. For other 15 genera, sex-bias was evident on one trap type only, with either more than 75% of males in Malaise or 75% females in Möricke; none had more males in Möricke traps *and* more females in Malaise traps, though less drastic differences showed by *Digonocryptus* and *Baltazaria* suggest that for these taxa females and males are probably captured with similar efficiency, at least in Möricke traps. Note that naturally disparate sex-ratios might be common for parasitoids (see item "Discussion"), but this does not compromise the detected differences, or similarities, in trap efficiency—they remain factual.

Another eight genera were apparently sampled with similar sex-ratio efficiency by both traps (Table 5), with four of them sampled in nearly identical way in both traps (i.e., no sex-ratio discrepancy), and four sampled with slight sex-ratio bias (1.3–7.7 percentage points). However, below average values of Mö/Ma for females (0.1–1.8) show that Möricke was the best trap for collecting *Debilos*, *Digonocryptus*, *Mesostenus* and *Rhinium*.

For taxa with 10 or more specimens collected per trap type (see "Methods"), males were clearly more efficiently collected with Malaise traps for *Baryceros*, *Bathyzonus*, *Cryptanura*, *Diapetimorpha*, and *Lamprocryptidea*, and maybe also *Lymeon*, *Melanocryptus*, and *Polycyrtus*. The obvious lack of efficacy or the high number of Möricke traps necessary to produce an equivalent sample with Malaise (see Mö/Ma values in Table 5), also helps to suggest that some genera (10 or more specimens) were also generally more efficiently collected by Malaise traps: *Bathyzonus*, *Lamprocryptidea*, *Messatoporus* and *Toechorychus*, while also possibly *Acerastes*, *Basileucus*, *Dismodix*, and all other genera collected exclusively by this trap (bottom of Table 5). These tendencies match also personal observations and unpublished results from many small collecting trips in the Atlantic Forest with Malaise traps. For 26 genera (68.4% of the total), no males at all (21 genera) or only one male (5) were collected in Möricke traps, and for 7 genera (18.4%), no females at all, or only a single female of 15 (*Baltazaria*) were collected in Malaise traps.

Möricke traps, on the other hand, proved clearly more efficient in collecting females for most genera, yielding over 85% of the collected female specimens for 21 genera (55.3%), with 27 genera (71.1%) with Mö/Ma fewer than 8.0.

Trap equivalence for number of species

Analyses here are complementary information only. Results in Table 6 might seem suggestive that Malaise traps collect the greatest proportion of species per specimens, but this cannot be confirmed. It seems to be the case because Mö/Ma values between Tables 4 and 6 indicate that generally many more Möricke per Malaise are needed to match Malaise results with number of species (12.3–31.6) than with number of specimens (2.3–12.8). This interpretation is however incorrect, because the number of specimens rises linearly with sampling effort, while the number of species quickly increases exponentially before approaching an asymptote; a rarefaction index would have to be calculated, but this is beyond the aim of this work.

Although species-level results were not investigated separately for each genus, it seems reasonable to expect many differences at this level too. At the same time, however, the average number of species per trap, collected with Malaise traps, as represented by males (see sex association difficulties in the item "Methods") was usually somewhat superior (0.7–1.3, but mostly 1.2) to the average number of species per trap as represented by females. This relationship was the opposite with Möricke traps, which collected 1.7–3.9 times more species represented by females than those recognized for male specimens.

Discussion

The used traps are not linearly comparable because "one Malaise" and "one Möricke" are not fixed units. Size, for example, plays an important role: small Möricke traps seem to work better than large ones (Masner and García 2003), but a small Malaise is inefficient (Perioto 1991), while design and mesh size will also modify its effectiveness (Darling and Packer 1988). Even so, efficient decision-making and precise data analysis may depend on comparing the numbers of specimens or species collected per taxon per trap.

It is generally accepted that Malaise works best for active, flying insects which are negatively geotropic (e.g., Bethylidae, collected hundreds or thousands of times more in Malaise than in Möricke; C. O. Azevedo, personal communication), while Möricke seems to work for most Hymenoptera families, catching proportionally more small wasps or less-powerful flyers than Malaise does. The nature and extent of such differences, however, are virtually unknown. Yet, the intensity of responses reported here signal the possibility that trap biases are much more drastic and compromising than generally suspected.

It might be relevant to note that any trap sex-bias is best discussed comparatively between traps, but hardly in relation to the real (natural) sex-ratio. This is because sex-ratio is not constant among species, and the extent of departure from 1:1 will vary across species, and even locally within species, according to circumstance. Some of the Cryptini species collected only as females, for example, can be thelytokous. Sex-bias differences *between traps*, however, remain both real and relevant from a practical point of view.

Relevance of the discoveries for biodiversity studies

This work presents knowledge with direct implications for studies on ecology and systematics, such as biodiversity assessments or taxonomic revisions. Just to set an example, only one specimen of *Rhinium* was collected by Malaise traps, but this genus was the 6th most common in Möricke samples, with 155 specimens. If the respective collecting efforts are considered, the data suggests that a single Möricke trap collects, on average, as many *Rhinium* specimens as nine Malaise traps combined (Mö/Ma = 0.11, Table 5). A quite similar situation was registered for *Digonocryptus* and *Debilos*. In a biodiversity study performed only or mostly with Malaise traps, these three genera would very likely appear to be uncommon. On the other hand, seven genera were collected only by Malaise traps, including *Bathyzonus*—reported as the most common genus of Cryptinae in Costa Rica, after extensive Malaise trapping, by Hanson and Gauld (1995). Möricke-based sampling in this case would obviously lead to a much different result. Striking performance differences between such highly different traps are indeed generally assumed *a priori* by researchers; and yet, their drastic biases are nearly always ignored, either in the definition of sampling protocols or in the resulting publications. At the same time, mitigating approaches or solutions have never been proposed, while the real extension of such differences has apparently not even been clearly registered or discussed before.

It is also relevant to stress that female specimens are by far the most important sex for Ichneumonidae recognition, taxonomy, and phylogenetic studies, males being usually less characteristic and more difficult to study because of character-reduction and variations associated with their generally small size in relation to females. It seems therefore clear that any sampling effort for Cryptini and groups with similar biology or behaviour, must rely on the combined use of Möricke and Malaise traps. As can be learned from the Mö/Ma values in Table 5 even a single Möricke per Malaise would already yield relevant results, while about 30 Möricke traps set for each Malaise seems minimal to yield female representatives for the corresponding genera represented only or mostly by males in Malaise, and vice versa. The importance of Möricke traps is reinforced by the results of García (2003), in Venezuela, which show this trap as the most effective (Malaise, FIT and sweep-netting were also tested), collecting 75% of the specimens and 76% of the total number of sampled Hymenoptera species. It is important to note, however, that while Möricke trap efficiency is higher than Malaise for Cryptini, it is conversely lower than Malaise for other Ichneumonidae: the overall Mö/Ma index for all Ichneumonidae was 25.5, but it jumps to 47.2 if the Cryptini are excluded. Möricke efficiency, however, also varies for other Ichneumonidae tribes and subfamilies, and some are possibly best sampled by this trap also.

If such differences are not addressed, Hymenoptera biodiversity studies will suffer both in accuracy and lack of representative material to work. And it will remain quite difficult to propose, with a minimum degree of confidence, which wasp taxa are truly common or rare, or which area is or is not a hotspot. For a practical example, even the abundance rankings provided in the colossal study by Hanson and Gauld (1995), for the genera of Cryptinae in Costa Rica, are probably largely imprecise, because sampling was based on Malaise trapping only. Taxa which are not collected either by Möricke or Malaise also makes for another important concern, but this demands a separate investigation.

Conclusions

1. Möricke excels at yielding Cryptini in relation to other Ichneumonidae, with an average of 53.3% of the specimens, vs. 13.6% for Malaise;
2. Möricke traps are generally 2.4 times more efficient than Malaise traps, and perhaps the most efficient trap known, for collecting *female* specimens of Cryptini; Malaise traps are generally 2.4 times more efficient than Möricke traps for collecting *male* specimens for most Cryptini taxa;
3. At genus-level, males for about half the taxa are obtained chiefly or exclusively with Malaise; females for about 40% of the collected genera are obtained chiefly or exclusively with Möricke;
4. To improve sampling of female Cryptini specimens even one Möricke per Malaise can already yield relevant results, while about 30 Möricke traps set for each Malaise seems minimal to generate equivalent genus-level female representativeness;
5. The most efficient proportion of Möricke to Malaise traps for sampling a representative number of sexes, specimens, and taxa is particular for each Cryptini genus; recommendations (Table 5) should be consulted if more specific collecting efforts are intended;
6. The importance of Möricke in complementing Malaise, and vice versa, is paramount for sampling Cryptini and, possibly, other Hymenoptera; if this fact is ignored, trap collections will generate under-represented samples for taxonomic studies, and grossly biased results for biodiversity or ecological investigations.

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