A Comparison of Methods for Sampling Ants (Hymenoptera, Formicidae) in Savannas[1]

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ABSTRACT

Hand collecting of ants, sampling all ants in a specific area, and collection with pitfall traps baited with meat, tuna, honey, or with unbaited traps were compared with respect to efficiency in assessing species diversity and abundance in eight different localities in the Venezuelan Llanos. Hand collecting for over 8 hr was the most time-efficient and reliable technique for estimating the number of species. Intensive sampling of ants in a small area proved to be the least efficient method. Each of the techniques sampled a somewhat different set of ant species. The best results were obtained by a combination of hand collecting and pitfall traps. Abundance was better measured by the number of collection sites where the species occurred rather than by the number of individuals collected.

RELIABLE SAMPLING OF INSECTS has always been difficult; sampling of ants is no exception. Though varying procedures for trapping ants have been described (*e.g.*, Wheeler 1910, British Museum 1974), five methods commonly are used. Ants are collected by hand whenever they are seen (*e.g.*, Kusnezov 1943, Brown 1973, Bennet & Humphries 1976, Jaffe *et al.* 1987). Ants are collected by fogging trees with insecticides (Lubin 1977). Ants are extracted from collected leaf litter using a Berlese funnel (Levings 1983). Ants are collected with pitfall traps (*e.g.*, Torres 1984, Carroll & Janzen 1973, Lubin 1977). Ants are collected when encountered in quadrates (a defined small area) (Levieux 1969, Room 1975, Reznikova & Samoshilova 1981). The efficiency of the different methods of collection depends mainly on the habitat in question. There is no direct way of comparing the different collection procedures. The difficulty of making a quantitative estimate of abundance in the case of social insects is furthered by debate over which unit to count: some count colonies (*e.g.*, Bernstein & Gobbel 1979); others count individuals (*e.g.*, Fillman *et al.* 1983). We tested the efficiency of three trapping procedures in assessing the quantity and diversity of ants in savannas.

METHODS AND STUDY SITES

SAMPLING PROCEDURES.—Direct sampling: The collectors moved to different places more than 100 m apart, a distance greater than the mean linear foraging distance of workers of most species for which this information is available (see for example Bernstein & Gobbel 1979), and sampled all ants found in their visual sphere. A minimum of 10 different collection places at each site was used. At each place, the observers walked randomly through the savanna, using a pair of forceps and a bucal aspirator to collect all ants seen (Kusnezov 1943). Unless stated otherwise, each site was sampled for a total of four hours, at different times of day and night. Two persons collected data for this work. Each had general knowledge of the ants' habits and was also trained to be patient, as any brusque movement triggered the cryptic reaction of certain species, making them practically invisible for up to 10–15 min.

Intensive sampling: We marked an area of 5 × 1.5 m and explored the soil surface inside that area during the day. Plants were removed and the soil excavated for ant-nests: any ant found was collected with forceps and a bucal aspirator during the approximately four-hour search period. Three such areas were explored at each site.

Pitfall traps: A 120-ml plastic beaker was filled to a third of its volume with 3 percent formol. In the center of the beaker, a metal wire resting on the bottom of the beaker emerged from the solution, holding a 1 cm^2 plastic bait board on which different attractants could be placed. The beaker was placed into a close-fitting second beaker, buried until the rim was level with the soil surface. At each site, 6 traps were baited with honey, 7 with meat, 7 with tuna fish, and in some sites 2 traps were left unbaited. Traps were collected by removing the upper beaker and replacing a new one into the buried beaker every 12 hr during 48 hr (at 6:00 to 6:30 and 18:00 to 18:30 hr), so that night and day collections could be differentiated.

STUDY SITES.—We chose eight sites on haciendas of the mainland savannas in the Venezuelan Llanos, which cover an area of 180,000 km^2. Chaguaramas (Estado Monagas) and La Leona (Edo. Anzoategui), in the eastern Llanos, are sandy and dry. Calabozo (Edo. Guarico), Masaguaral

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TABLE 1. *Mean percentage (% spp. + SD) of the species collected at 8 different localities in the Venezuelan Llanos using different collecting techniques.* E *gives the percentage of species collected exclusively during the night or the day. The mean of the total number of species in each site (No. spp.) is also given.*

Technique	Day collection % spp.	*E*	Night collection % spp.	*E*	Total % spp.
Direct	59 ± 13	—	—	—	59 ± 13
Intensive	36 ± 14	—	—	—	36 ± 14
All traps	69 ± 13	17	65 ± 9	13	82 ± 11
Meat traps	56 ± 17	24	43 ± 12	11	67 ± 15
Tuna traps	49 ± 12	15	49 ± 9	15	64 ± 11
Honey traps	44 ± 16	16	41 ± 11	13	57 ± 15
Unbaited traps	24 ± 8	10	19 ± 9	5	29 ± 8
Tuna + honey	60 ± 15	10	57 ± 13	7	67 ± 12
Meat + honey	63 ± 17	21	54 ± 11	12	75 ± 13
Tuna + meat	67 ± 12	24	55 ± 6	12	79 ± 11
No. spp.	18 ± 7	10	16 ± 5	8	26 ± 8

(Edo. Guarico), and Jabillal (Edo. Cojedes), in the central Llanos, have heavier soils and higher vegetation. Banco de Morrones (Edo. Portuguesa) and Pueblo Nuevo (Edo. Barinas), in the western Llanos, have experienced different kinds of agricultural intervention. Mantecal (Edo. Apure) suffers the annual inundations characteristic of the southern Llanos. All collections were carried out in the wet season (July through September) of 1985.

RESULTS AND DISCUSSION

Table 1 shows the relative efficiency in trapping numbers of species of the various techniques. The percentage of species trapped in relation to the total number of species collected using all the sampling techniques is presented. Pitfall traps were the most efficient if 20 traps were used for 4 days. Second in efficiency was 4 hours of hand collecting, and least efficient was intensive sampling. Among the traps, those baited with meat were the most efficient, although tuna baits captured a few more species at night. It is interesting to note that the increase in efficiency of the meat traps seemed to rely on an increased efficiency in trapping species with exclusively diurnal habits (E = 24 in Table 1). The efficiency of nocturnal collections with pitfall traps was practically independent of the bait used, but that of diurnal collections varied around 15 percent according to the bait used. Unbaited traps collected a surprising 29 percent of the species of a chosen site.

If the collections at the different sites are pooled, direct sampling techniques are comparable to collections from pitfall traps (Table 2). Here we compare a hand collection effort of 32 hr with that of collecting with 160 traps during 4 days. The two techniques together accounted for 97 percent of all the species sampled, indicating that intensive sampling did not add any significant number of species collected.

TABLE 2. *Percent of the total number of species collected (92 spp.), trapped by each collecting technique.*

Technique	% collected	% never collected by other techniques
Direct	75	14
Intensive	51	3
Traps	77	16
Traps + direct	97	49
Traps + intensive	86	25
Direct + intensive	84	23

Figure 1 shows the efficiency in terms of time of the various collecting techniques. Direct sampling required the least amount of time to obtain a fixed number of species. Pitfall traps baited with meat were second in efficiency, and least efficient was intensive sampling. Each technique, after successive application, levels off at a different value of diversity and with a different set of ant species (Table 2).

For more diverse habitats, pitfall traps are less efficient than direct sampling in trapping ants. The absolute number of species collected with direct sampling correlated significantly ($P < 0.05$, linear regression analysis) with the total number of plant species present in each site ($r = 0.66$), whereas pitfall trap captures were not correlated with the plant diversity ($r = -0.14$). The number of species captured with both methods did not correlate with each other ($r = -0.03$).

When we repeatedly sampled with pitfall traps on the same site, the number of new species collected diminished with time (Fig. 1) and the number of individual ants collected also decreased. On the first day, 47 ± 23 percent of all individuals captured fell into the traps; the following days only 18 ± 6, 20 ± 20, and 15 ± 12 percent respectively could be captured. These results indicated a depletion of the foraging workers of the site similar to the "Digging-in effect" shown by Greenslade (1973).

The number of individuals collected was not a good indication for the abundance of a given species (Fig. 2). The frequency of occurrence seemed to give a more comprehensive picture of the most common species in a site. *Labidus coecus,* for example, was collected only a few times, although each time thousands of individuals filled the pitfall traps. On the other hand, *Atta* workers were trapped in very small numbers, but a single trapped worker indicated the presence of huge nests of these fungus-growing ants.

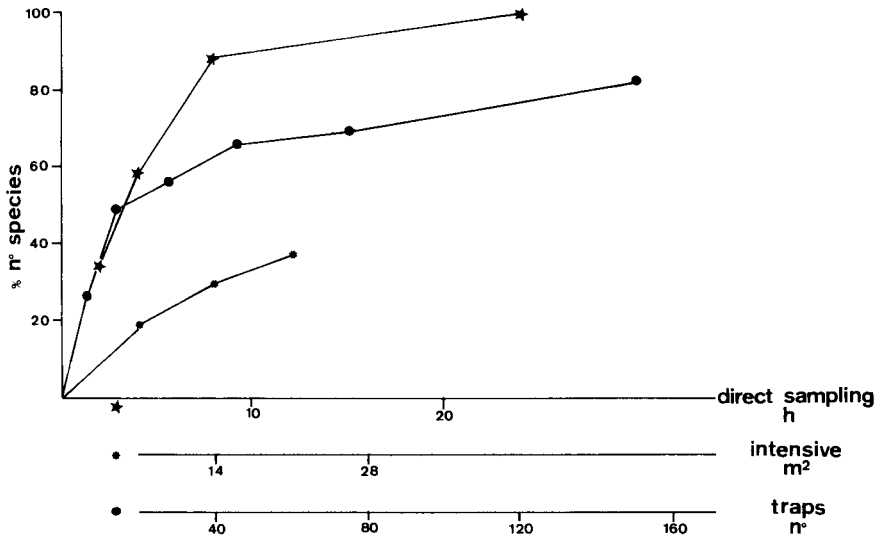

FIGURE 1. Percentage of species of a site captured in relation to collection effort using different collecting techniques. The collection efforts of the different techniques have been estimated in person-hours of field work. Standard error is less than 2 percent of the means.

CONCLUSIONS

Our results show that the number of individuals collected is a poor measure of their abundance, at least for social species (see also Hughes 1986). The number of nests is also a poor indicator of abundance. The number of colonies present is difficult to estimate in the examples of *Monomorium* spp. or *Azteca* spp., but is relatively easy in the examples of *Atta* spp. or *Monacis* spp. Thus, no reasonable inter-species comparison regarding abundance can be made using only nest-density data. Community surveys need to be based on approximately equivalent units. Frequency of capture, a parameter that can be easily obtained with any sampling technique, is an indication of the probability of finding an ant (or ant colony), and is independent of the forager density of the species if sufficiently large sampling areas are chosen. The probability of finding workers of any species should be independent of forager density and colony size, but dependent on how common the species is (how widely distributed in the ecosystem it is) if relatively large sampling areas are used, and only the presence of the species in that area is recorded. Frequency of capture is more independent of the foraging habits and colony size of the different species and thus more appropriate for interspecific comparisons. Frequency of capture can be correlated with biomass, colony number, number of foragers, etc., if the mean colony size and density, foraging worker population, and biomass of individual workers for each species are known (Levieux 1973). Frequency of capture may allow comparisons among ant faunas of different ecosystems (Room 1975).

Our results show that the three techniques evaluated differ significantly in their efficiencies and reliability for assessing species diversity in an ecosystem. Each technique samples different sets of ant species and consequently the interpretation of the collection data is specific only for the particular collecting technique.

Direct sampling of worker ants, although an old technique, is not popular for quantitative ecological studies. In spite of this, it seems to be more efficient for assessing ant species diversity in a given environment compared to the other two methods. For ant collections on the Solomon Islands, using hand collection, baits, and funnel extraction of soil samples (Greenslade & Greenslade 1977), a similar conclusion may be reached if the data are analyzed in terms of species numbers instead of number of individuals. For ecosystems such as forests or bushland, direct sampling may be regarded as a even more useful method for finding the ant species present. Direct sampling techniques give accurate quantitative data on species abundance if frequency of occurrence (*i.e.*, frequency of sampling in standard area units) is measured. The pitfall traps have been a popular collection technique because of its easy implementation, the apparent constancy of the fauna sampled, and the possibility of obtaining quantitative data. In spite of these apparent advantages, pitfall traps collect only a certain group of ant species. Quantitative data from pitfall traps present the same problems as other methods in relating numbers of individuals to species frequency.

Intensive sampling, if quadrate size is increased, becomes equivalent to direct sampling but supposes a greater intensity with which a certain area is searched for ants.

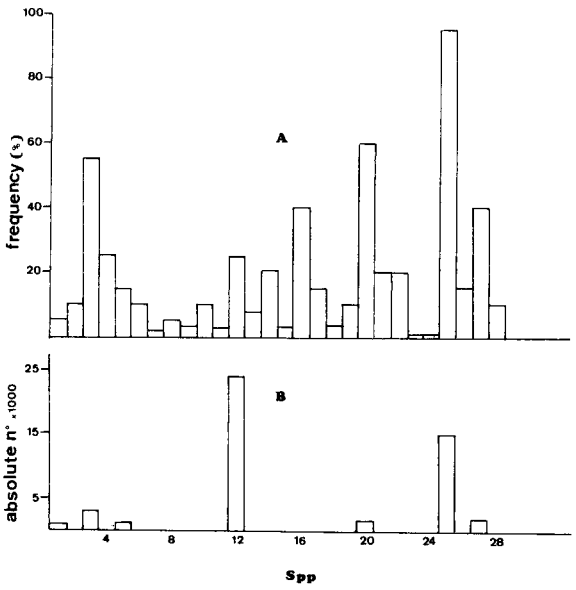

FIGURE 2. Ant species abundance (spp. only Formicinae, Dolichoderinae, and Dorylinae of the Venezuelan Llanos) given as A: Frequency (number of traps) in which each species was found, and B: Number of specimens collected per species. The numbers on the x axis correspond to the species listed in the appendix.

Accuracy of this method depends on the observation capability of the collector in the same degree as in direct sampling. In the case of ants, intensive sampling does not help to augment efficiency in the assessment of variability.

In conclusion, a combination of direct sampling with pitfall traps seems to be the optimal collection method for savanna ants. If time is a limiting factor, a one-day collecting effort per site (>8 hr) should be sufficient to assess more than 75 percent of the collectable species and to provide reliable information about their frequency. Pitfall traps alone should be used only for specific ecological studies on inter-site comparisons or in studies involving only a selected group of ant species. The results of pitfall trap collections should be confined to those particular studies and should not be used for comparisons with data obtained by different collectors at different geographical localities.

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Appendix

Some of the Formicinae, Dorylinae, and Dolichoderinae found in the Venezuelan Llanos. The numbers correspond to those in Figure 2.

Formicinae:	
Camponotus abdominalis	1
Camponotus renggeri	2
Camponotus lingidi	3
Camponotus spp.	4–8
Paratrechina spp.	9–11
Dorylinae:	
Labidus coecus	12
Eciton burchelli	13
Dolichoderinae:	
Tapinoma spp.	14–17
Monacis bispinosa	18
Azteca spp.	19–23
Conomyrma spp.	24–26
Iridomyrmex spp.	27–28
Hypoclinea spp.	29–30