LONG TERM CAN TRAPPING FOR POPULATION ANALYSES OF GROUND-SURFACE, ARID-LAND ARACHNIDS[1]

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ABSTRACT

This investigation was designed to estimate statistically the number of can traps required to study populations of ground-surface, arid-land arachnids. Data were obtained from 16 traps operated for 1 year in the pinyon-juniper life zone of the Pinos Altos Mountains in southwestern New Mexico. The formula $N = S^2/SE^2$ (where N = number of traps, S^2 = variance, and SE = standard error of the mean) was used to estimate the number of traps required for assigned precision limits of 10, 20, 30, and 50% of the mean ($\bar{x}$) number per trap. Only precision limits within 20% or less of the $\bar{x}$ are considered meaningful.

Thus, population studies on the local scorpion, *Vejovis coahuilae* Williams, would require 67 traps, whereas 25 traps would be sufficient for similar studies on local gross solpugid populations. *Mastigoproctus giganteus* Lucas populations might be estimated using only 21 traps per area. Finally, the number of traps per study area required for estimates of local, arid-land spider populations varied from 11 for the abundant cursorial gnaphosid, *Zelotes tuobus* Chamberlin, through 12 for the abundant web-building pholcid, *Psilochorus imitatus* Gertsch and Mulaik, to 22 for the abundant wolf spider, *Schizocosa* n. sp. (nr. *avida* Walckenaer). Data on less common species indicated that 20-70 traps per area might be required for study, even of male cursorial activity.

This evaluation of can trap population estimates suggests that a knowledge of the life cycle, food habits, ecological requirements, and behavior of target species, and the use of this and other methods of population estimation should be combined for valid population studies.

An investigation was designed to determine if long term operation of can traps of the type proposed by Muma (1970) could be utilized for quantitatively analyzing ground-surface, arid-land, non-acarine, arachnid populations (Williams 1968; Muma 1973, 1974). This report is concerned primarily with calculating the necessary number of traps per study area for the production of a repeatable mean number of specimens per trap, per year within certain limits of precision.

Baited and unbaited pitfall devices buried flush with the surface of the soil have been used as a qualitative survey tool by arthropod taxonomic specialists for many years. Fichter (1941) first suggested their use for quantitative research. His alcohol pitfall was large, expensive, and difficult to install and maintain. However, Muma and Muma (1949) discussed prairie

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spider populations on the basis of specimens collected in the Fichter pitfall, and Rhoades (1962) did the same with insect and spider populations in northwestern Florida. Other workers have utilized sheltered or unsheltered, sunken metal, glass, or plastic containers for both qualitative and quantitative studies (Southwood 1966). Reports have indicated considerable variation in trap size, killing-preserving agents, number used, time of operation, animals studied, and purpose of investigation. These variations for 12 recent studies are cited in Table 1.

Prior to presentation of the present research, it seems apropos to discuss the nomenclature of ground-surface arthropod trapping devices. As indicated in Table 1, 4 different names have been applied to such devices. The extra-large, 1 m-wide trap constructed to force arthropods into a much smaller alcohol-filled container (Fichter 1941; Muma and Muma 1949; Rhoades 1962) has consistently been referred to as an *alcohol pitfall.* Small, dry, similar-sized jars (Hensley et al. 1961; Duffey 1962; Mitchell 1963; Greenslade 1964; Hayes 1970) have also been referred to consistently as *pitfall traps.* Duffey hyphenated the term pitfall and Hensley et al. used a killing agent, but all workers applied the same name to essentially the same device. Variation in trap nomenclature has occurred among workers who utilized moderate to large-sized cans. Allred et al. (1965) referred to theirs, which they operated dry, as can pit-traps; although they and other workers later referred to them as can traps. Williams (1968 and 1970) referred to his, also operated dry, as pitfall traps, and Muma (1963, 1970, 1973, 1974) consistently referred to his, whether operated dry or with a killing-preserving agent, as can traps. Since the terms alcohol pitfall and pitfall trap have been consistently applied to similar devices, operated in a similar manner, a comparable name needs to be developed only for moderate to large cans operated dry and similar cans operated with a killing or killing-preserving agent. I suggest that large, dry cans be referred to as *pit traps,* a term used by Schmid et al. (1973), and large cans with a killing-preserving agent as *can traps.*

Two reviews (Southwood 1966, Turnbull 1973) have questioned the validity or reliability of such traps for quantitative evaluation of arthropod populations. Both reviews cited apparent reasons for this lack of efficiency and value. Several workers have taken the opposite position.

Duffey (1962) concluded that small, dry pitfalls produced valid spider population data often comparable to those obtained by Tullgren aparatus processing of turf samples and by hand picking. Williams (1968, 1970) concluded that large, dry pitfalls produced numbers of scorpions comparable to those of the natural community observed with the ultraviolet light method. Schmoller (1971) believed that small, dry pitfalls produced good data on diurnal versus nocturnal ground-surface arthropods. Muma (1970, 1973, 1974, 1975) maintained that large pitfalls, despite numerous hypothetical objections, produced valid spider and solpugid population data. Gist and Crossley (1973) found small pitfall and hand sorting estimates of ground surface arthropods on isolated grids to be highly comparable. And finally, Uetz and Unzicker (in press) indicated that pitfall trapping is a valid, useful ecological method.

These differences of opinion concerning usefulness and validity of the pitfall principle in population studies may be reduced to 6 factors.

1. Large species may damage or devour small species. This is unquestionably true for dry pitfalls, but a killing-preserving agent (Fichter 1941;

TABLE 1. SIZE AND USE OF PITFALL DEVICES FOR ARTHROPOD STUDIES.

Worker and Citation	Trap Diameter	Killing Agent	Number Used	Time Operated	Name Applied	Arthropods Studied	Purpose of Study
Fichter (1941)	1 m	70% C_2H_2OH	3	9 mos.	Alcohol Pitfall	Misc. Arthropods	Long-grass prairie populations.
Hensley et al. (1961)	1 qt freezer jar	70% C_2H_5OH & Kerosene	2/plot	7 mos.	Pitfall Trap	Insects and Arachnids	Predaceous fauna, sugar cane fields.
Duffey (1962)	6.5 cm	None	23	14 mos.	Pit-fall Trap	Spiders	Limestone grassland populations and trap study.
Rhoades (1962)	1 m	70% C_2H_5OH	12	36 mos.	Alcohol Pitfall	Misc. Arthropods	Effects of heptachlor on populations.
Allred et al. (1963)	17.7 cm	None	Several 100	36 mos.	Can pit-trap	Misc. Animals	Biotic community surveys.
Whitcomb et al. (1963)	6-7 cm	70% C_2H_5OH	30	2.5 mos.	Pitfall Trap	Spiders	Comparison of populations.
Mitchell (1963)	6.5 cm	None	50 and 100	4 mos.	Pitfall Trap	Carabidae	Population make-up, density and activity
Greenslade (1964)	6.5 cm	None	21	2 mos.	Pitfall Trap	Carabidae	Trap evaluation.
Williams (1968)	15.3 cm	None	100	5 mos.	Pitfall Trap	Scorpions	Population make-up and density.
Hayes (1970)	6.0 cm	None	24	1 night	Pitfall Trap	Isopods	Trap evaluation.
Muma (1973)	9.5 cm	Alcohol & Glycol	16	48 mos.	Can trap	Spiders	Population make-up and density.
Muma (1974)	15.3 cm	Alcohol & Glycol	48	24 mos.	Can trap	Solpugida	Population make-up and density.

Hensley et al. 1961; Muma 1970, 1973; Schmid et al. 1973) prevents such activity.

2. An alcohol preservative may repel species. Until comparative studies have been conducted with pitfall devices containing water, water and detergents, alcohol, and other preservatives, possible repellence can neither be assumed nor denied. However, the data of Muma (1973, 1974, 1975, this paper, and unpublished) indicate that many insect and arachnid arthropods are not repelled by an alcohol (ethyl or iso-propyl)-ethylene glycol mixtures. In fact, the common to prevalent collection of grasshoppers, ants, crickets, beetles, flies, spiders, and scorpions indicates a degree of attraction. The use of picric acid suggested by Southwood (1966) may be hazardous, since dry picric acid and its derivatives are known to be explosive, and Frank A. Enders (unpublished) has found picric acid to be less useful than ethylene glycol in a desert.

3. Trap and removal may reduce populations. Tretzel (1955), Greenslade (1964), Williams (1968), and Muma (1973, 1974, 1975) have found that this is not true, at least for spiders, carabids, scorpions, and solpugids.

4. Placement of traps may influence trap catches. The lip of the trap may be above ground-surface among dense grasses and herbs, above ground-surface in duff or leaf litter, and at ground-surface in natural or artificially cleared areas. As stated by Muma and Muma (1949), placement of traps should be based on a knowledge of the habits and life histories of the target animals.

5. Animal activity may influence trap catches. Activities vary from species to species, from habitat to habitat, from dry to night, with weather, temperature, and according to attractiveness of the trap to the target animals. Here again, quantitative analyses of trap records not guided by a knowledge of the biology of the species under study could be misleading.

6. Abundance of the study animal is the least influential factor. This may be true but such a generalization is subject to criticism, particularly since the influence of trap size, trap number, and duration of trap operation on the stability of the mean number of target animals collected is not known.

I have used (Muma 1974, 1975) and am presently using the large can trap proposed by Muma (1970), so only this trap is evaluated here.

METHODS

Sixteen can traps were emplaced in the pinyon-juniper life zone of the Pinos Altos Mountains in Grant County, New Mexico. Emplacement was in 3 transects; traps 1-5 oriented in an east-west line, spaced at 5 m intervals; traps 6-11 oriented in a north-south line at 5 m intervals, and traps 12-16 oriented in an east-west line at 10 m intervals. Transects 1-5 and 12-16 were separated by about 50 m.

The traps were operated from 1 April 1972 to 2 April 1973. Specimens were collected from the traps at 2-week intervals. To reduce evaporation, the killing-preserving agent used was 200 ml of a 1:1 mixture of 70% commercial grade isopropyl alcohol and commercial grade ethylene glycol. The killing-preserving agent was reconstituted at each visit with a 3:1 mixture of alcohol and glycol.

At each collection date, specimens were removed from each trap, sorted, identified, recorded, and maintained separately. Only adult specimens were identified to species. Sub-adults, when possible, were identified to genus and spiderlings (first, second, and third instars) to family. All immatures, with few exceptions, are reported here at the family level. A few adults could not be identified to species and are reported here at the generic level. Dr. Willis J. Gertsch, Portal, Arizona either identified or confirmed identifications of most of the spiders. Michael Soleglad, San Diego, California identified the scorpions.

The standard error of the mean was utilized in the formula $SE = S/\sqrt{n}$ or $n = S^2/SE^2$ to analyze the numbers of collected specimens of common species, those representing 1 or more percent of the total recorded specimens. In these formulas SE = standard error, S = standard deviation, n = number of traps and S^2 = variance. Variance was determined for precisions of 10, 20, 30, and 50% of the mean number of specimens per trap, per year. The mean ($\bar{x}$) number of specimens per trap, per year and the standard deviation (S) of the yearly trap totals and means were computed in the usual manner. Dr. Tom R. Ashley, ARS, USDA, Gainesville, Florida, and his associates examined accumulated raw data, and suggested this statistical treatment. Dr. Ashley also assisted in evaluating statistical review comments and suggestions.

RESULTS

Altogether 956 arachnid specimens, representing 4 orders and 15 families, were collected in the traps during the study. The Scorpionida was represented by 1 family and 1 species, the Pedipalpida by 1 family and 1 species, the Solpugida by 2 families and 6 species, and the Araneida by 11 families and 64 species. For taxonomic and zoogeographic purposes all species collected are listed in Table 2. The only statistical data presented in the table are those pertaining to families and species representing 1 or more percent of the total recorded arachnid population.

The statistical approach used indicated that large series of traps are required at each study station if a sampling precision within 10% of the mean is desired for most of the local common arachnid forms representing less than 20% of the total studied population. On the other hand, if less sampling precision is tolerable, a few traps can be operated on each study area to produce meaningful population data for most common southwestern New Mexico arachnids collected during this study.

No differences were detected between the arachnids trapped in the east-west and north-south transects, so the tabulated figures represent the totals for 16 traps.

DISCUSSION AND CONCLUSIONS

Many of the arachnids collected by the can traps were not true, ground-surface cursorial forms. For instance, most Pholcidae, Agelenidae, Dictynidae, Theridiidae, and Linyphiidae are web-builders. They stay on their snares to capture prey that vibrate or become entangled in the silken strands. Further, most of the misumenine Thomisidae are known to be ambush predators (Gertsch 1949). Regular occurrence of such sedentary forms in can traps is difficult to explain in some cases and relatively easy in others.

TABLE 2. ARACHNIDA COLLECTED IN 16 CAN TRAPS IN THE PINYON-JUNIPER LIFE ZONE OF THE PINOS ALTOS MOUNTAINS AT SILVER CITY, NEW MEXICO BETWEEN 1 APRIL 1972 AND 2 APRIL 1973. COMMON FORMS, THOSE REPRESENTING 1.0% OR MORE OF THE POPULATION, ARE STATISTICALLY EVALUATED FOR THE NUMBER OF TRAPS (N) REQUIRED FOR SAMPLING PRECISION WITHIN 10, 20, 30, AND 50% OF THE MEAN ($\bar{X}$).

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}\pm SE$/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Scorpionida							
Vejovidae							
Vejovis coahuilae Williams	14	1.5	0.88±0.34	265	62	22	10
Pedipalpida							
Thelyphonidae							
Mastigoproctus giganteus Lucas	26	2.7	1.63±0.38	87	21	10	4
Solpugida							
Eremobatidae (Juveniles, young and adults)	29 9	3.0	1.81±0.45	97	25	11	4
Eremobates n. sp. (*palpisetulosus*-group)	2						
Eremobates pallipes (Say)	3						
Eremochelis sp. (*imperialis*-group)	1						
Hemerotrecha fruitana Muma	3						
Hemerotrecha sp. (*banksi*-group)	1						
Ammotrechida (juveniles, young and adults)	1						
Ammotrechula peninsulana (Banks) (young)	1						

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Araneida							
Pholcidae (immatures and adults)	144	15.1	9.00±2.04	83	21	10	4
Psilochorus imitatus Gertsch and Mulaik	99	10.3	6.19±1.07	48	12	6	2
Lycosidae (immatures and adults)	284	29.7	17.75±1.90	19	5	3	1
Allocosa sp. (immature)	1						
Hesperocosa unica (Gertsch and Wallace)	4						
Lycosa coloradensis Banks	4						
Lycosa n. sp. (nr. *coloradensis*)	5						
Lycosa n. sp.	12	1.3	0.75±0.27	227	52	23	9
Pardosa sp. (*lapidicina*-group)	1						
Pardosa sternalis (Thorell)	3						
Schizocosa n. sp. (nr. *avida* Walckenaer	67	7.0	4.19±0.96	87	22	10	4
Schizocosa mimula Gertsch	22	2.3	1.38±0.32	84	21	10	4
Tarentula kochi Keyserling	24	2.5	1.19±0.33	127	32	14	5
Gnaphosidae (immatures and adults)	239	25.0	14.94±1.61	19	5	3	1
Callilepis gosoga Chamberlin and Gertsch	1						
Drassodes celes Chamberlin	1						
Drassodes gosiutus Chamberlin	2						
Drassodes robinsoni Chamberlin	5						
Drassyllus mephisto Chamberlin	13	1.4	0.81±0.26	183	43	19	7

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}\pm$SE/ trap/year	No. traps (n) needed for sampling precision within:			
				$10\%\bar{x}$	$20\%\bar{x}$	$30\%\bar{x}$	$50\%\bar{x}$
Drassyllus mormon Chamberlin	6						
Drassyllus orgilus Chamberlin	1						
Gnaphosa sericata (L. Koch)	4						
Haplodrassus sp. (nr. *signifer* Koch)	13	1.4	0.81±0.33	295	68	30	11
Herpyllus propinquus Keyserling	2						
Herpyllus sp. (nr. *hesperolus* Chamberlin	2						
Micaria sp. #1	4						
Micaria sp. #2	2						
Micaria sp. #3	5						
Micaria sp. #4	1						
Micaria sp. #5	1						
Poecilochroa pananus Chamberlin	2						
Zelotes n. sp. (large)	32	3.3	2.00±0.60	144	36	16	6
Zelotes tuobus Chamberlin	82	8.6	5.13±0.84	43	11	5	2
Anyphaenidae (immatures and adults)	7						
Anyphaena coloradensis Banks	3						
Clubionidae (immatures and adults)	21	2.2	1.31±0.30	85	22	10	4
Agroeca trivittata Keyserling	1						
Castianeira variata Gertsch	1						
Corinna bicalcarata Simon	2						
Piabuna n. sp.	3						

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}\pm$SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Phrurotimpus borealis (Emerton)	1						
Phrurotimpus mormon Chamberlin and Gertsch)	1						
Scotinella schwarzi (Gertsch)	5						
Agelenidae (immatures and adults)	15	1.6	0.99±0.34	225	52	23	9
Agelenopsis longistylus (Banks)	1						
Cicurina nr. *varians* Gertsch and Mulaik	9						
Dictynidae (immatures and adults)	17	1.8	1.06±0.36	189	48	21	8
Dictyna n. sp. (nr. *saltona* Chamberlin and Gertsch)	1						
Dictyna cholla Chamberlin and Gertsch	2						
Dictyna oasa Ivie	3						
Dictyna personata Gertsch and Mulaik	5						
Tricholathys n. sp.	3						
Theridiidae (immatures and adults)	15	1.6	0.94±0.19	74	17	8	3
Euryopis sp. (small light female)	1						
Euryopis scriptipes Banks	8						
Steatoda medialis Banks	2						
Linyphiidae (immatures and adults)	16	1.7	1.00±0.29	135	34	15	6
Cochembolus sp.	1						

TABLE 2—*Continued.*

Arachnids Collected	No. Spms. Trapped	% of Population	$\bar{x}$±SE/ trap/year	No. traps (n) needed for sampling precision within:			
				10%$\bar{x}$	20%$\bar{x}$	30%$\bar{x}$	50%$\bar{x}$
Eperigone eschatologica Crosby	3						
Erigone sp. (poss. *blaesa* Crosby and Bishop)	2						
Meioneta sp.	4						
Tennesseellum formicum (Emerton)	3						
Thomisidae (immatures and adults)	118	12.3	7.38±0.89	24	6	3	1
Apollophanes margareta (Lowrie and Gertsch)	1						
Apollophanes texanus (Banks)	4						
Ebo pepinensis Gertsch	1						
Thanatus sp. (nr. *coloradensis* Keyserling)	2						
Tibellus sp. (immature)	1						
Xysticus aprilinus Bryant	1						
Xysticus cunctator Thorell	64	6.7	4.00±0.95	91	23	11	4
Xysticus lassanus Chamberlin	13	1.4	0.81±0.32	273	63	28	10
Xysticus locuples Keyserling	1						
Xysticus paiutus Gertsch	1						
Salticidae (immatures and adults)	11	1.2	0.69±0.18	126	27	12	5
Metaphidippus sp.	1						
Pellenes sp. (nr. *wrighti* Lowrie and Gertsch)	1						
Phidippus n. sp. (nr. *coccineus* Peckham)	2						

Common occurrence of misumenine crab spiders in can traps primarily represents sexual cursorial activity of males searching for females (Muma and Muma 1949). In this study 83% of the collected misumenines were males, whereas only 60% of the cursorial philodromine crab spiders were males. Other explanations are needed for the regular occurrence of web-building species.

Among the theridiids, females were 4 times as numerous as males. They may have been trapped either while changing web sites (Turnbull 1964) or while repelling intruders (Riechert 1973). Also conceivably some theridiids could be cursorial species taxonomically classified among web-builders.

In this study, the most prevalent species was *Psilochorus imitatus* Gertsch and Mulaik, a pholcid. Abundance of pholcids probably was due to the spiders' use of the can traps as web-building sites. This species and other southwestern pholcids normally use mammal, especially rodent, burrows, hollow yucca "logs", and crevices in and under other ground-surface debris as web-building sites. It can be assumed that the sunken cans merely added additional micro-habitats to the environment. Since more than 1 male of this species often live in the web of 1 female under natural conditions, it is not surprising that 64% of the collected adults were males. Some males also may have been trapped while searching for females.

The common occurrence of agelenid, dictynid, and linyphiid spiders in the can traps cannot presently be explained, especially since nearly equal proportions of the sexes of each species were collected. Many linyphiids also have been taken in other studies (Barnes 1953; Walker 1969). As stated by Muma and Muma (1949), behavioral and life history studies must be conducted on local, arid-land species before their cursorial activity can be explained.

The above discussions suggest biological reasons for the occurrence of non-cursorial forms in the can traps. In addition, surprisingly, analyses of trapped specimens indicate that such traps may be useful in comparative population studies on such species. This is especially true for the abundant *P. imitatus,* whose populations may be investigated to a precision within 20% of the mean, using 12 traps per study area. To a limited extent, the same is true for the ambush predator, *Xysticus cunctator* Thorell, if precision limits are extended to 30% of the mean and deductions and conclusions are confined largely to activity of the male population.

Among the true cursorial spiders collected during the study, the Lycosidae and Gnaphosidae were by far the most abundant. In fact, the only common cursorial spiders taken in the traps were representatives of these families. The cursorial Anyphaenidae were uncommon and the Clubionidae and Salticidae were common only as families. Therefore, in any local, arid-land studies involving populations of running or jumping spiders, deductions and conclusions should be confined to the family level for precision within 20% of the mean using 27 traps per study area.

The most common cursorial spider taken in the can traps was *Zelotes tuobus* Chamberlin. It was more than twice as abundant as the next three most common gnaphosid, a large undescribed *Zelotes,* and more than 6 times as numerous as *Drassyllus mephisto* Chamberlin and a species of *Haplodrassus* near *signifer* C. L. Koch. Although the wolf spiders as a family were more numerous than the wandering gnaphosids, the most common lycosid, *Schizocosa* n. sp., was distinctly less abundant than *Z. tuobus.* However, it was 3 times as numerous as either *Schizocosa mimula* Gertsch or *Tarentula kochi* Keyserling and 5 times as abundant as *Lycosa* n. sp., the other 3 common wolf spiders.

Although only 5 traps per study area would be required to obtain precision within 20% of the mean for evaluation of local lycosid and gnaphosid populations at the family level, the number of traps would have to be increased to 30 to obtain precision within 30% of the mean if analyses of common local species populations were desired.

As discussed above for the non-cursorial spiders, other factors must also be considered in the comparative estimation of arid-land, cursorial, spider populations with can traps. For instance, increased confidence in the mean number of wandering gnaphosids trapped apparently is somewhat related to the abundance of the several species under investigation. Only 11 traps are required to obtain precision within 20% of the mean for the very abundant *Z. tuobus.* A much larger number of traps is required for the less common gnaphosids. Furthermore, the sex ratios of trapped common gnaphosids varied from only 31% males for *D. mephisto* to only 63% males for *Z. tuobus* which indicates that both gnaphosid sexes are cursorially active. The same is not true for the lycosids. In the first place, increased confidence in the mean number of lycosids trapped is not related to the abundance of the investigated species. More traps were required to obtain the same level of confidence for the abundant undescribed species of *Schizocosa* than for the much less common *S. mimula.* Since the sex ratios of trapped wolf spiders varied from 73% males for *Schizocosa* n. sp. to 86% males for *S. mimula,* the occurrence of wolf spiders in can traps must be assumed to be largely an expression of male sexual cursorial activity (Hollander 1967). These data show that can trap evaluation of wolf spider populations should be combined with careful biological and behavioral studies prior to the drawing of specific conclusions.

Among the other orders of arachnids trapped, the data on the scorpion, *Vejovis coahuilae* Williams, perhaps are the most interesting since Williams (1968, 1970) has collected and published data on a closely related species, *Vejovis spinigerus* Wood. In his first study, Williams (1968) operated 100 pit traps in a desert valley and concluded that *V. spinigerus* was not sufficiently abundant to determine the effects of trap cover and the trap and removal method. Habitat data collected by Williams (1970), using 20 pit traps per habitat, corroborated his 1968 findings by demonstrating that *V. spinigerus* was primarily a rocky, habitat species.

Present data also confirm Williams' conclusions since *V. coahuilae* is closely related to *V. spinigerus* and was the only scorpion collected in can traps in the rocky, pinyon-juniper life zone of the Pinos Altos Mountains. The limited number of specimens recorded here indicate that either Williams' pit traps were more efficient in collecting scorpions than can traps or, as indicated by Beatty (1961) and Frank A. Enders (unpublished), the scorpion population during the present study was much smaller than that sampled by Williams. In either case it appears that use of fewer than 62 can traps per study area will invalidate such traps for the study of local scorpion populations. Further, current studies (Muma 1975, and unpublished) indicate that scorpions are highly discontinuous in distribution and "colonies" should perhaps be located before trapping is attempted.

Data on *Mastigoproctus giganteus* Lucas, the only pedipalpid trapped during the present study, indicate that local populations of this whip-scorpion can be studied with as few as 21 traps per station. Current studies (Muma, unpublished) indicate that this whip-scorpion may also be highly discontinuous in distribution and "colonies" should perhaps be located before trapping is attempted.

The data on solpugids were somewhat disappointing. Although the family Eremobatidae represented 3% of the total, trapped, arachnid population, the Ammotrechidae were not common, and none of the 6 recorded solpugid species achieved common status. Even analyzed at the family level, the data indicate that use of fewer than 25 can traps per plot greatly decreases the sampling precision of such traps for estimating local solpugid populations. For instance, local, gross solpugid populations can be compared only to a precision within 30% of the mean, using 11 can traps per study area. Since a single field worker cannot effectively operate 25 traps per study area, additional methods studies are required for analyzing solpugid populations. Muma (1974) indicated the need for such studies for *Eremochelis bilobatus* (Muma).

Several conclusions can be drawn concerning the use of can traps, and possibly also alcohol pitfalls, pitfall traps, and pit traps, for the estimation of ground-surface and cursorial arachnid populations. Prior to trapping, an investigation should be made to determine whether or not the species or group to be studied is subject to collection by the pitfall principle. During this study, absence of Loxoscelidae, Diguetidae, Sparassidae, and Oxyopidae and collection of relatively few Salticidae indicate that all ground-surface forms may not be susceptible to collection by pitfalls. After susceptibility to can trap collection has been determined, habitats with low population levels should be investigated with perhaps more can traps than were utilized here to determine the sexual activity and precision limits of the mean number of individuals trapped. Finally, can traps apparently can produce only data on community or habitat species composition, relative data on abundance, and some information on seasonal adult incidence and activity. Therefore, can trap population data should be considered complementary and supplementary to other population estimates and to a knowledge of the biology and behavior of the forms under study.

LITERATURE CITED

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