EFFICIENCY OF SAMPLING TECHNIQUES IN THE STUDY OF SPIDER FAUNA OF AWKA, NIGERIA

[1]NWANKWO, Ogonna Daniel, [2]EWUIM, Sylvanus Chima and [3]OKOYE, Ebele Linda
[1]Department of Animal and Environmental Biology, Federal University, Oye-Ekiti, Ekiti State, Nigeria.
[2]Department of Zoology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
[3]Department of Microbiology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

Corresponding Author: Nwankwo, O. D. Department of Animal and Environmental Biology, Federal University, Oye-Ekiti, Ekiti State, Nigeria. **Email:** daniel.nwankwo@fuoye.edu.ng **Phone:** +234 8059938898

Received: *March 28, 2019* ***Revised:*** *May 14, 2019* ***Accepted:*** *May 23, 2019*

ABSTRACT

The use of different sampling protocols has been found to give a more reliable detail of the faunal composition of spider fauna of any given community. In the present study, pitfall trapping, sweep netting and jarring methods were used to sample spiders from three different sites within Nnamdi Azikiwe University, Awka, Nigeria. Sampling was done once every month for twelve months (April 2017 to March 2018). Out of the 680 individuals in 17 families caught, 63 % was by pitfall trap, 20 % and 17 % were respectively from sweep net and jarring method. At $p<0.05$, the sampling effort of pitfall trap was significantly better than the other two methods. Pitfall trap also recorded all taxonomic groups found in the study except Sparassidae and Uloboridae that were exclusively caught by sweep net and jarring methods respectively. Zodariidae, Ctenidae, Pisauridae, Pholcidae and Nesticidae were exclusively recorded by pitfall trap. There was a record of catch for all the three sampling techniques in all the twelve sampling attempts. Based on our finding, several sampling methods should be used in community survey for more reliable information on species richness, distribution and abundance.

Keywords: Spiders, Sampling methods, Pitfall trapping, Sweep netting, Jarring, Efficiency

INTRODUCTION

The increasing environmental and other forms of degradations have had and still having tremendous negative impact on the world's faunal composition. Laurance (2006) stated that various anthropogenic threats such as intensive agriculture, land fragmentation and deforestation have plagued the success of biodiversity with consequent limitations on the delivery of possible biodiversity benefits. Climate change as a result of global warming and habitat destructions due to the ever increasing world population are the major drivers of these anthropogenic activities that are now threatening the world's biodiversity. According to FAO (2005), estimates have shown that Nigeria has lost 55.7 % of its primary forest to anthropogenic activities such as logging, subsistence agriculture, collection of fuel wood etc. This information becomes more important when Myers *et al*. (2000) is considered; the high endemism of insects and other animal and plant taxa, coupled with the extent of threat to these endemic species confer the status of a global hotspot of biodiversity on the Nigerian rainforest and savannah vegetation zones. Arthropods are important components in most natural and transformed landscapes. They play crucial functional roles that ensure delivery of various ecosystem services which are important for some aspects of human livelihood such as agriculture, tourism, natural resources use, etc. (Tscharntke *et al*., 2005).

Over the last decades, many species have gone extinct, while many have been added to the list of vulnerable, endangered or threatened species. The very worst case is that some of these extinct species got lost even before it could be identified, described and named. So we were never privileged to document their existence before losing them. According to Hallmann *et al.* (2017), reported dramatic and alarming declines in insect populations in some areas in Germany, which could have far-reaching consequences on the world's crop production and natural ecosystems. The study reported that in Germany nature reserves, flying insect populations declined by 75 % over 27 year duration. Similarly, globally, more than 40 % of insect species have declined and a third is endangered. The rate of extinction of insects is eight times faster than that of mammals, birds and reptiles (Stork, 2010). The total mass of insects is falling by a precipitous 2.5 % a year, suggesting they could vanish within a century. The situation is almost the same if not worst for spiders, though like insects and many other invertebrates, spiders have traditionally suffered a lack of attention from conservation professionals and the general public. Like most terrestrial invertebrates, spiders are affected by anthropogenic and habitat alteration such as deforestation, agriculture, grazing and urbanization (Wells *et al.*, 1983).

Basic biological, ecological and taxonomic information of spiders in Nigerian terrestrial and aquatic ecosystems is scanty, thus, these knowledge gaps have to be filled to guarantee successful conservation planning and action. The current trend of slow inventory of spider fauna in the nation may imply that several species may be lost and thus may not be ever accounted for. Nwankwo and Ewuim (2019) in their study noted that although Nigerian spider have been studied, still urgent action is needed to embark on extensive inventories that will lead to the discovery of new species as well as provide data on their distribution and abundance in the different vegetation zones within the country. Inventories aim to generate accurate species lists of given areas, but also providing reliable estimates of species abundance, which is a key factor for assemblage characterizations (Fisher, 1999; Cardoso, 2009; Tourinho *et al.*, 2014). Structured inventories normally use a combination of several sampling methods and have become an interesting alternative approach for monitoring arthropods or using arthropods as indicators of ecological change and ecosystem dynamics (de Souza *et al.*, 2012). The present study looked at the efficiency of the sampling methods employed in spider collections within the main campus of Nnamdi Azikiwe University Awka.

MATERIALS AND METHODS

The investigation was carried out for a period of 12 months (April 2017 to March 2018) within the main campus of Nnamdi Azikiwe University, Awka across three different sites. Awka is the capital of Anambra State of Nigeria and located in the lowland rain forest zone of southern Nigeria (Keay, 1961; Charter, 1970). Site one lies between point 4 and 5 in Figure 1 with coordinates, latitude 6°14'35.6"N and 7°7'28.1"E. Site two was directly behind site one (6°14'35.6"N and 7°7'26.9"E) and site three with coordinates 6°14'48.3"N and 7°6'55.6"E was located between points 24 and 25 in Figure 1.

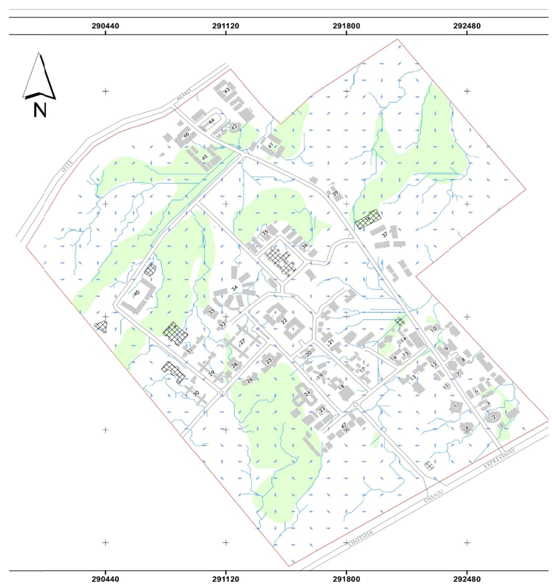

Figure 1: Map of Nnamdi Azikiwe University, Awka, showing the sampled sites (Source: UNIZIK, 2017)

Sampling Methods: Sampling was done using the pitfall trap, sweep net and mechanical knockdown (jarring) methods. The sampling was carried out in 12 sampling occasions within the three study sites.

Pitfall trapping: Eight pitfall traps (Figure 2a) made of white plastic containers, with mouth diameters of 12 cm and 13 cm deep were used on the three selected study sites on each sampling occasion. 70 % alcohol was used as both killing and preservation agent. The traps were filled to one-fifth with 70 % alcohol. The traps were collected after twenty-four hours, and the spiders caught were sorted, identified and counted. A total of eight traps were used for each site on every sampling period with spacing of about 5 – 10 meters apart.

Sweep netting: The sweep net (Figure 2b) with net made into bag and fitted into circular rod of mouth diameter of 30 cm, bag depth of 50 cm and a wooden handle of 1 m was used to sample the three sites.

Figure 2: Pictures of pit fall trap (a) and sweep net (b) used in sampling spider species of Nnamdi Azikiwe University, Awka, Nigeria

On each sampling occasion, about twenty-five sweeps were made across the vegetation, with the bag emptied on plain white cloth; the catches were carefully examined for spiders after each sweep. The spiders caught were deposited into a well labeled container containing 70 % alcohol which serves as both killing and preserving agent.

Jarring: Few trees of relatively small (shakable) trunk were selected randomly in the farmland, fallow plot and the marshy plot for each sampling occasion. A one yard white cloth material was used under the trees during jarring for collection of spiders that fell of the trees. Each tree was jarred few times (by the trunk) on each sampling occasion before collection. The spiders 'knocked down' were then collected for counting and subsequent identification in the laboratory.

Sorting, Preservation and Identification of spiders: The sorting and preservation were done based on the site, method of collection and date of collection. Each sample bottle was properly labeled to reflect the location, method of collection, date of collection and name of the collector. African spiders, an identification manual by Dippnear-Schoeman and Jocque (1997) in addition to the World Spider Catalog provided the keys used for the identification.

Statistical Analysis: Data collected were analysed using for their central tendencies using descriptive statistics. The results were presented as Means ± Standard Error of Means (SEM) for the populations caught using each of the three sampling techniques. All data were statistically analysed using SPSS version 23. Furthermore, data were entered into Microsoft Excel, 2007 (Microsoft Corporation), and Bar and Pie Charts generated.

RESULTS AND DISCUSSION

A total of 17 families and 43 species were identified from 680 spiders caught during the sampling survey in Awka, using three different sampling methods. The summary of these spider fauna indicated the presence of 17 families; Araneidae, Clubionidae, Ctenidae, Eutichuridae, Gnaphosidae, Lycosidae, Nesticidae, Oxyopidae, Pholcidae, Pisauridae, Salticidae, Sparassidae, Tetragnathidae, Theridiidae, Thomisidae, Uloboridae and Zodariidae (Table 1).

Three hundred and ninety (390) spiders were caught by pitfall trap, 160 and 130 individuals from sweep net and jarring methods respectively. Pitfall trap recorded the highest percentage catch (63 %) (Figure 3) followed by sweep net (20 %) and jarring (17 %).

Table 1: Total number of spiders caught in Nnamdi Azikiwe University, Awka between April 2017 and March 2018

Family	*Genus*	Species	Population
Araneidae	*Cyrtophora*	*C. citricola*	42
	Gasteracantha	*G. sanguinolenta*	2
	Neoscona	*N. penicillipes*	3
	Argiope	*Argiope* sp.	2
	Prasonica	*P. nigrotaeniata*	3
	Indet		42
Clubionidae	*Clubiona*	*Clubiona* sp.	3
Ctenidae	Indet		6
Eutichuridae	*Cheiracanthium*	*C. aculeatum*	2
		C. kenyansis	11
		C. africanum	3
Gnaphosidae	*Zelotes*	*Z. scrutatus*	8
	Indet		12
Lycosidae	*Foveosa*	*F. infuscata*	77
	Hogna	*Hogna* sp.	35
	Arctosa	*Arctosa* sp.	18
	Trochosa	*Trochosa* sp.	28
	Pardosa	*P. injucunda*	76
	Hippasa	*H. lamtoensis*	6
		Hippasa sp.	11
	Ocyale	*Ocyale* sp.	3
	Auloniella	*Auloniella* sp.	5
	Indet		27
Nesticidae	*Nesticella*	*Nesticella* sp.	2
Oxyopidae	*Oxyopes*	*Oxyopes* sp.	38
	Peucetia	*Peucetia* sp.	21
Pisauridae	Indet		3
Pholcidae	*Crossopriza*	*C. lyoni*	9
	Indet		8
Salticidae	*Nigorella*	*N. albimana*	3
	Aelurillus	*A. russellsmithi*	6
	Pochyta	*Pochyta* sp.	1
	Evarcha	*E. dotata*	5
		Evarcha sp.	4
Pisauridae	Indet		15
Sparassidae	Indet		8
Tetragnathidae	*Leucauge*	*Leucauge* sp.	3
	Tetragnatha	*T. tellgreni*	12
		Tetragnatha sp.	4
Theridiidae	*Episinus*	*Episinus* sp.	3
	Argyrodes	*Argyrodes* sp.	26
	Steatoda	*S. erigonniformis*	10
	Theridion	*Theridion* sp.	4
Thomisidae	*Monaeses*	*M. pustulosus*	8
		Manaesus sp.	6
	Runcinia	*R. tropica*	4
		R. aethiops	1

	Thomisus	*Thomisus* sp.	2
	Indet		33
Uloboridae	*Philoponella*	*P. angolensis*	3
Zodariidae	*Diores*	*Diores* sp.	13
	Dusmadiores	*D. katelijinae*	680

Indet = juvenile/immature spiders or morphologically damaged spiders that could not be identified beyond family level

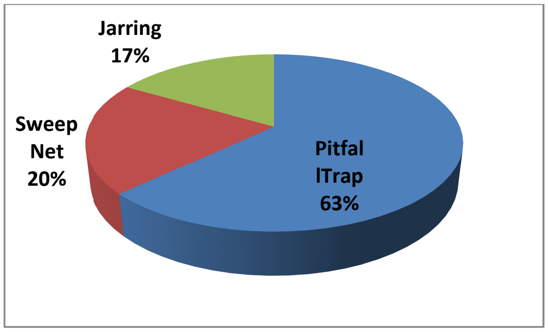

Figure 3: Percentage of spider caught by each of the sampling method employed during the study

According to Pluess *et al*. (2010), high numbers of individuals and species are usually caught by pitfall trap. The heterogeneity of the spider species and the increased number of the catches by the pitfall trap is not unconnected with their interception efficiency and capture rate of the wandering species which were surface-active forms at the various habitats. These wandering spiders dominate the entire population from this study. The three sampling methods recorded catch in all the months of the study period. De Souza *et al*. (2012) stated that structured inventories normally use a combination of several sampling methods and have become an interesting alternative approach for monitoring arthropods or using arthropods as indicators of ecological change and ecosystem dynamics. The commonly used sampling methods include pitfall traps, sweep net, litter sifting or extraction, suction sampling and virtual/active search. The pitfall trapping was more efficient in all the months of the study except in the month of December were it came second to sweep netting (Figure 4). The sampling effort of pitfall trap was significantly higher than both the sweep net and jarring at $p<0.05$. The high efficiency of the pitfall efforts in sampling of spiders shown in Figure 5 indicated that the trap was superior to both the sweep net and jarring. Though the effort of sweep net was slightly better than that of the jarring but there was no significant different from the two.

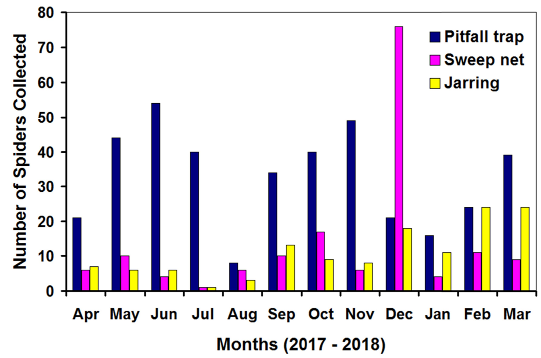

Figure 4: Monthly distribution of spiders as collected by the three sampling method

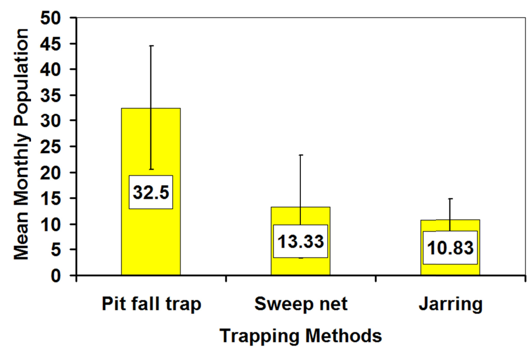

Figure 5: Distribution of spider base of number caught by each of the three sampling methods

Only two out of the seventeen families recorded in the study was not caught by pitfall trap. These two families were Sparassidae and Uloboridae. Sparassidae was exclusively caught by sweep net while Uloboridae was caught by jarring. Every other family caught, either by sweep net or jarring was also caught by pitfall trap showing the superior efficiency of pitfall trap in spider collection. Zodariidae, Ctenidae, Pisauridae, Pholcidae and Nesticidae were exclusively captured by pitfall trap. Gnaphosidae, Corinnidae, Tetragnathidae and

Clubionidae were also caught by sweep net as well as pitfall trap.

From the study, the three sampling methods shared six families in common; and the families include Lycosidae, Salticidae, Araneidae, Thomisidae, Theridiidae and Oxyopidae. Gnaphosidae, Tetragnathidae and Clubionidae were families shared in common by pitfall trap and sweep net. There was no family in common between sweep net and jarring, and also between pitfall trap and jarring. This suggests the need of using varied methods of sampling in other to capture all representatives of the spiders species in the locality studied. The pitfall trap was the most effective and efficient method for collecting spiders in comparison with sweep net and jarring methods. Sweep net method with eleven families was the second most efficient method for sampling spiders. The combination of the three sampling techniques; pitfall trapping, sweep netting and jarring increased both the population and species diversity of the spiders collected. Coddington *et al.* (1991) stated that the use of several sampling methods is often required to produce a reliable estimation of species richness and composition. For spiders, different sampling methods target certain vegetative strata and/or behaviours, and therefore produce a sampling bias across taxa (Uetz and Unzicker, 1976; Churchill, 1993; Edwards, 1993; Coddington *et al*., 1996; Isaia *et al*., 2006). To obtain statistically and ecologically meaningful data, and to maximize the fauna sampled for biodiversity assessments, a range of methods are best standardized and integrated. However, spider taxonomists exploit specific methods to quickly find preferred taxa.

Conclusion: Spiders are found almost on every available terrestrial habitat because of its predatory role on the other arthropods. Inventories tend to reveal the general distribution and relative abundance of species across different sites studied. Pitfall trap caught the highest number of spiders as well as had the greatest diversity, making it the most efficient spider sampling equipment in this study. The records of various unique taxa by the three sampling methods showed that the use of several sampling techniques in the survey of spider fauna of a particular locations give a more reliable estimate of the spider fauna of such place and as such recommended.

ACKNOWLEDGEMENTS

We wish to thank all the volunteers who helped in the collections, particularly, Agozie Dan-Nwankwo, Amaka Nwankwo, Kingsley Uba, Chikodili Chinweze and Amuche Nnadozie. Thank you for your efforts during the field studies. We also thank Hannah Wood, Dana DeRoche and Tom Nguyen (Entomology Department, National Museum of Natural History, Washington DC, USA), for their support during the taxonomic identification of spiders in this study. This study was sponsored with Tertiary Education Trust Fund (TETFund) of the National University Commission (NUC), Abuja, Nigeria.

REFERENCES

CARDOSO, P. (2009). Standardization and optimization of arthropod inventories – the case of Iberian spiders. *Biodiversity and Conservation*, 18(14): 3949 – 3962.

CHARTER, J. R. (1970). *Vegetation Ecological Zones*. Federal Department of Forest Research, Ibadan. Nigeria.

CHURCHILL, T. B. (1993). Effects of sampling methodology on the composition of a Tasmanian coastal heathland spider community. Pages 475 – 481. *In:* RAVEN, A. J. (Ed.). *Proceedings of the XIIth International Congress of Arachnology,* Brisbane.

CODDINGTON, J. A., YOUNG, L. H. and COYLE, F. A. (1996). Estimating spider species richness in a southern Appalachian cove hardwood forest. *Journal of Arachnology*, 24: 111 – 128.

CODDINGTON, J. A., GRISWOLD, C. E., SILVA, D., PENARANDA, D. and LARCHER, S. (1991). Designing and testing sampling protocols to estimate biodiversity in tropical ecosystems. Pages 44 – 60. *In:* DUDLEY, E. D. (Ed.). *Proceedings of the Fourth International Congress of*

Systematic and Evolutionary Biology. The Unity of Evolutionary Biology, Dioscorides Press, Portland.

DIPPNEAR-SCHOEMAN, A. S. and JOCQUE, R. (1997). *African Spiders: An Identification Manual*. Plant Protection Research Institute, Pretoria, South Africa.

EDWARDS, R. L. (1993). Can the species richness of spiders richness of spiders be determine? *Psyche*, 100: 185 – 208.

FISHER, B. L. (1999). Improving inventory efficiency: a case study of leaf-litter ant diversity in Madagascar. *Ecological Applications*, 9(2): 714 – 731.

FAO (2005). *Towards Sustainable Forest Management*. Food and Agricultural Organization (FAO), Geneva. Available from www.monogabay.com. Accessed August 20, 2012.

HALLMANN, C. A., SORG, M., JONGEJANS, E., SIEPEL, H. and HOFLAND, N. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLOS One*, 12(10): e0185809. https://doi.org/10.1371/journal.pone.0185809

ISAIA, M., BONA, F. and BADINO, G. (2006). Influence of landscape diversity and agricultural practices on spider assemblage in Italian vineyards of Langa Astigiana (Northwest Italy). *Environmental Entomology*, 35(2): 297 – 307.

KEAY, R. W. J. (1961). *An Outline of Nigerian Vegetation.* Federal Ministry of Information, Lagos, Nigeria.

LAURANCE, W. F. (2006). Have we overstated the tropical biodiversity crisis? *Trends in Ecology and Evolution,* 22: 65 – 70.

MYERS, N., MITTERMEIER, R. A., MITTERMEIER, C. G., DA FONSECA, G. A. and KENT, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403(6772): 853 – 858.

NWANKWO, O. D. and EWUIM, S. C. (2019). The first national inventory of spiders (Araneae) in Nigeria. *Animal Research International*, 16(1): 3247 – 3254.

PLUESS, T., OPATOVSKY, I., GAVISH-REGEV, E., LUBIN, Y. and SCHMIDT-ENTLING, M. H. (2010). Non-crop habitats in the landscape enhance spider diversity in wheat fields of a desert agroecosystem. *Agriculture, Ecosystems and Environment*, 137(1-2): 68 – 74.

DE SOUZA, J. L. P., BACCARO, F. B., LANDEIRO, V. L., FRANKLIN, E. and MAGNUSSON, W. E. (2012). Trade-offs between complementarity and redundancy in the use of different sampling techniques for ground-dwelling ant assemblages. *Applied Soil Ecology*, 56: 63 – 73.

STORK, N. E. (2010). Re-assessing current extinction rates. *Biodiversity and Conservation*, 19(2): 357 – 371.

TOURINHO, A. L., DE SOUZA LANÇA, L., BACCARO, F. B. and DIAS, S. C. (2014). Complementarity among sampling methods for harvestman assemblages. *Pedobiologia*, 57(1): 37 – 45.

TSCHARNTKE, T., KLEIN, A. M., KRUESS, A., STEFFAN-DEWENTER, I. and THIES, C. (2005). Landscape perspectives on agricultural intensification and biodiversity; an ecosystem service management. *Ecology Letters*, 8(8): 857 – 874.

UETZ, G. W. and UNZICKER, J. D. (1976). Pitfall trapping in ecological studies of wandering spiders. *Journal of Arachnology,* 3: 101 – 111.

UNIZIK (2017). *Map of Nnamdi Azikiwe University, Awka, Showing Major Building and Road Network*. https://unizik.edu.ng Accessed April 12, 2017.

WELLS, S. M., PYLE, R. M. and COLLINS, N. M. (1983). *The IUCN Invertebrate Red Data Book*. IUCN, Switzerland.