

MILLIPEDE OUTBREAKS IN AKWA IBOM STATE, SOUTHEASTERN NIGERIA

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ABSTRACT

Several millipede outbreaks have been reported in Akwa Ibom State, southeastern Nigeria between 1990 and 2001. Studies which involved field surveys, oral interviews of farmers, on-farm and laboratory observations and field sampling in some reported locations of outbreaks were undertaken. Results showed that nine of the thirty-one Local Government Areas of the state were affected. All the arable crops on the farmland were destroyed particularly the cassava, *Manihot esculenta* Crantz; Yam, *Dioscorea rotundata* Poir; Cocoyam, *Colocasia esculenta* (L.) Schott; Fluted Pumpkin, *Telfairia occidentalis* Hook; Melon, *Colocynthis citrullus* Mill, Maize, *Zea mays* L. and Tomato, *Lycopersicon esculentum* Mill. Studies further revealed that the outbreaks occurred under two different agroecologies namely, homestead farms and open farmlands. A recently found small-sized millipede species identified as *Tibiomus* species (Diplopoda: Odontopygidae) was involved in outbreaks in homestead farms. Three large-sized millipede species, two of which were identified as *Spirostreptus assiniensis* (Diplopoda: Spirostreptidae) and *Peridontopyge* species (Diplopoda: Odontopygidae) were involved in outbreaks in open farmlands. The third species, which rarely occurred in non-outbreak periods and was non-destructive to crops was not identified. The millipede outbreaks were sporadic and unpredictable.

Keywords: Millipede Outbreaks; *Tibiomus* species *Spirostreptus assiniensis*; *Peridontopyge* species; Akwa Ibom State, Southeastern Nigeria.

INTRODUCTION

Millipedes are terrestrial arthropods, which have a single pair of antennae, elongated bodies and many legs. They usually have two pairs of legs per body segment except for the first 4-6 body segments with only a pair of legs each (Ewer and Hall, 1972; Webb et al., 1989).

Tian et al. (1995) reported that millipedes were useful in farm litter decomposition. However, they have been widely reported to cause damage to crops (Jones and Jones, 1974; Raheja, 1975; Davidson and Lyon, 1986; Akinlosotu et al., 1987; Wightman and Amin, 1988; Trabanino et al., 1990; Akele, 1991; Inyang, 1998).

The term, pest outbreak, is used to describe a population increase of pests of great magnitude causing extensive damage (Khoo, 1986). In Akwa Ibom State, southeastern Nigeria, millipedes were perceived to be innocuous and of insignificant relevance to the farmer. However, the sudden and repeated outbreaks of millipedes and the incidental damage to crops by this diplopod caused concern to farmers of the area. In May, 1990 several reports were received almost simultaneously of millipede outbreaks in the state. In 1991 and 1995, there were more reported cases of outbreak. In 1997 and 1998 there were other reports and in 2000 there was yet another report. Akwa Ibom State is in the rain

forest zone and lies between latitudes 4° and 6° North of the equator and longitudes 7° and 9° East of the meridian. Eshett (1993) reported that an annual rainfall of up to 3667mm had been recorded in the coastal areas of the state with a mean of 2385mm for the hinterland. The mean annual temperatures vary between 26°C and 28°C with annual maximum reaching 30°C and minimum of 25°C (Akwa Ibom State, 1989; AKADEP, 1994). This study is to report on findings made on these several millipede outbreaks in Akwa Ibom State, southeastern Nigeria.

MATERIALS AND METHODS

Following reports, which were always received late after onset of the outbreaks, field surveys of some of the affected areas were immediately conducted. The surveys involved farm visits where oral interviews of 10 farmers in each location of outbreak were conducted. Information was sought and obtained on previous experience of outbreaks, period and duration of outbreak, cropping history, land use pattern, agro-inputs used, host crop range, mode of damage, millipede ecology and control measures adopted. Outbreak areas were delineated and estimated by cutting traverses across the length and breadth of each area and summing up the values. Millipede

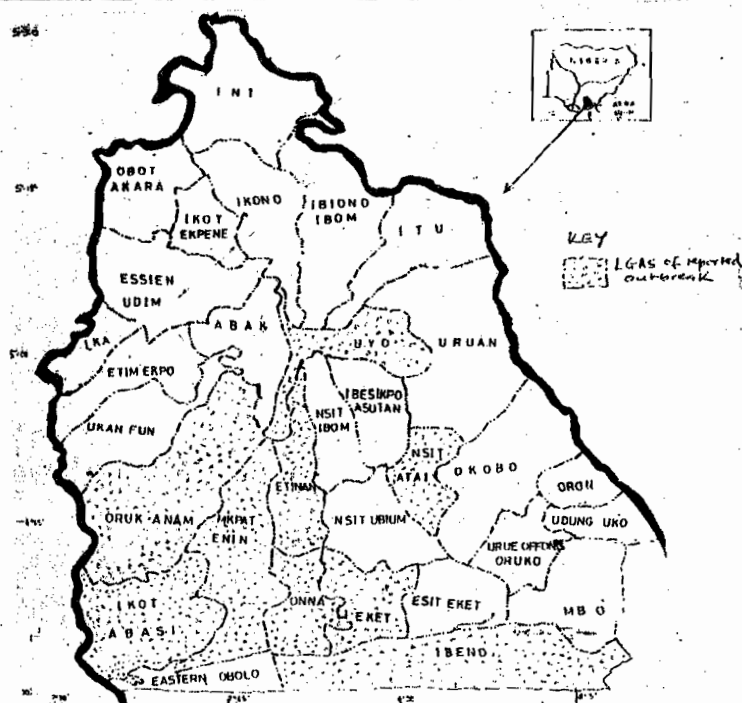


Fig. 1: Map of Akwa Ibom State, Southeastern Nigeria, showing Local Government Areas (LGAs) of reported millipede outbreaks namely: Eket, Etinan, Ibeno, Ikot Abasi, Mkpát Enin, Nsit Atai, Onna, Oruk Anam and Uyo.

density was determined through stratified random sampling in areas not treated with pesticides by the farmers. Observed difference in the habitats of the millipede species warranted different sampling approaches. Two habitats were observed namely: (i) Surroundings of living houses (ii) Forested areas.

Due to logistics problem, sampling was done in one location (LGA) per habitat per outbreak year. Sampling was also done in each habitat in non-outbreak year. Accordingly, sampling under habitat (i) were done at Federal Government College, Ikot Obio Itong, Mkpát Enin Local Government Area (LGA) in 1990 (outbreak year); Ndon Eyo, Onna LGA in 1991 (outbreak year); Itiam, Uyo LGA in 1998 (outbreak year), Itiam, Uyo LGA in 2001 (non-outbreak year). Samplings in habitat (ii) were done in Ikot Akam, Oruk Anam LGA in 1990 (outbreak year) and 1991 (non-outbreak year), Ikot Itong, Ekparakwa, Oruk Anam LGA 1995 (outbreak year) and Itiam, Uyo LGA 1997 (non-outbreak year). No sampling was done in 2000 since the outbreak report was received too late. However the economic losses caused by the outbreak on the farm families were evaluated.

Samplings under habitat (i) were done using Sharma and Lopez (1990) method. Millipede numbers counted per interval of time (one month) were used to deduce the population level for the month. A sampling area 900m^2 ($30\text{m} \times 30\text{m}$) was demarcated in each outbreak location. The area was stratified into four equal sub-plots of 225m^2

($15\text{m} \times 15\text{m}$) each. A 0.25m^2 area from which millipede counts were taken was thereafter randomly marked out and delimited with strong and durable pegs in each sub-plot. Four pieces of cassava roots each weighing approximately 50g were cut, soaked in cold water overnight to enhance putrefaction and half-buried randomly as baits in the 0.25m^2 areas. About two kilogram of guinea grass (*Panicum maximum* Jacq.) were heaped over the pieces of cassava roots, one week before counting commenced. The grasses were renewed after every three months, and the baits, monthly. Millipede numbers were counted in the second week of every month. The mean number of millipedes per number of days sampled was recorded for the month.

On each sampling day, the heaps of grasses were upturned in the morning hours between 6.00 am and 8.00 am Nigerian time and millipedes found under them counted. To enhance the sampling efficiency by preventing escape of the small-sized millipedes when disturbed during counting, a quadrat structure about 0.64m^2 ($0.8\text{m} \times 0.8\text{m}$) and 0.6m high with walls made of metal pan was nailed into the soil to a depth of about 0.05m round the four pegs before counting commenced. Inyang (1998) had reported that this small-sized millipede species was found in the upper layers of the soil. Trabanino et al. (1990) used the technique above to prevent escape of fast crawling insects and other arthropods while sampling for their presence in a cultivated field in Southern

Honduras.

A modified technique was used in habitat (ii) i.e. forested area. Five sampling units each measuring 5m x 5m were randomly marked out in each outbreak area to represent the centre, the North, the South, the East and the West of the outbreak area. Each 25m² unit was also delimited with strong pegs and 400 pieces of cassava roots half-buried randomly as baits and covered with about 200kg weight of guinea grass, renewed as in habitat (i). The millipedes found in the habitat were observed to bore deep holes into the soil where they remained during the day. The grass heaps were therefore upturned and baited areas sampled with spades. This involved burying full length of spade (30cm) into the soil and scooping out the soil to count the pest (millipedes) as reported by Robertson and Simpson (1989).

Farm litters, stumps and plant roots were also excavated to about 30cm depth and the millipedes, which were far larger in size than those of habitat (i) were counted speedily and separated into different species with the assistance of paid scouting boys of the outbreak areas. Analysis of variance (ANOVA) and Least significant difference (LSD) were used to determine any difference in millipede numbers in outbreak and non-outbreak years.

Pictures were taken particularly during the 1995 outbreak of some of the scenes in the outbreak area of Ekparakwa, Oruk Anam LGA. Specimens of morphologically unidentical species were collected and caged separately in 25cm³ earthen pots covered with double layers of 2mm wire mesh for aeration in the laboratory. The body sizes of the millipedes were measured with the aid of magnifying glass and metre rule. Crops observed to be damaged in the field were introduced to the caged millipedes and observed daily for damage. Specimens of the millipede species, causing damage to crops, were sent to taxonomists at the International Institute of Tropical Agriculture (IITA), Ibadan, for identification.

During the 2000 outbreak, economic losses suffered by farm families in the outbreak areas were computed. This was done by estimating potential crop yields and prevailing prices of each major crop component in the crop mixtures cultivated by the farmers.

RESULTS

The millipede outbreaks were sporadic in nature and not predictable. Locations of reported millipede outbreaks are shown in Fig. 1. Out of the thirty-one LGAs of Akwa Ibom State, nine were affected namely Eket, Etinan, Ibeno, Ikot Abasi, Mkpato Enin, Nsit Atai, Onna, Oruk Anam

and Uyo. The two different habitats (agroecologies) of outbreaks were (i) Homestead farms where crops were cultivated all year round and residential buildings within the farms. (ii) Open farmlands cultivated every 5 years after bush fallow.

Outbreaks in homestead farms were reported in the premises of Federal Government College, Ikot Obio Itong, Mkpato Enin LGA (1990); Ndon Eyo village, Onna LGA (1991) and parts of Eket and Ibeno LGAs (1991); Ewet and Itiam, Uyo LGA (1997,1998). Outbreaks in open farmlands were reported in Ikot Akam and Ikot Inyang villages, Oruk Anam LGA (1990); Ikot Inyang, Anyam Effa, Ata Ikot Inyang, Awa Ntong and Ikot Akata villages, Etinan LGA (1990); Mbak Etoi and Mbiabong villages, Uyo LGA (1990). Reports of outbreaks were also received from Edemeya, Ikot Abasi LGA (1990); Ibakang, Ikot Ekpot and Odot villages, Nsit Atai LGA (1990). In the year 1995, outbreak report was received from Ikot Itung, Ekparakwa, Oruk Anam LGA and in 2000, report was received from Mbioto, Etinan LGA.

Estimated outbreak areas and duration of outbreak

Estimated outbreak farming areas in open farmlands decreased from 3100 hectares in 1990 to 2600 hectares in 1995 and 1750 hectares in 2000. Generally, where outbreak repeated in a LGA, there were shifts in spots of outbreak in succeeding years. However, in Ikot Itung, Oruk Anam LGA, farmers reported of a first outbreak in the same farming area in 1990 before they lodged a formal complaint in 1995 during a repeat outbreak.

In homestead farms, outbreaks occurred in patches, and affected smaller areas of less than twenty hectares in size.

Where outbreak landscape was sloppy, outbreaks occurred on the sloppy ends of such landscape. Unlike in open farmlands, outbreak in homestead farms repeated in similar locations over a number of years.

During outbreaks in open farmlands, crop damage lasted from seeding/planting in March to June when density of the millipedes peaked and dropped thereafter from July. During outbreaks in homestead farms, millipede damage persisted from seeding/planting time in March, almost right through the year except with significant decrease in millipede numbers ($P \leq 0.05$) and crop damage in June/July and December of the year (see fig.10)

Millipede ecology and density

At day, the millipedes were found under

damp farm litters, tree stumps, tree roots and rhizosphere of host crops. The large sized millipedes bored holes in soils under shaded areas and up to thirty individuals were commonly extracted from such holes. At night the millipedes were more active and came out in large numbers to cause damage. Table 1 shows millipede numbers as recorded during outbreaks in homestead farms at Ikot Obio Itong, Mkpat Enin LGA (1990), Ndon Eyo, Onna LGA (1991), Itiam, Uyo LGA (1998), and during non-outbreak year at Itiam, Uyo LGA (2001).

The data showed significant difference ($P \leq 0.05$) and higher ratio (9:1) of millipede numbers between the outbreak years and non-outbreak year. The population curve for both outbreak and non-outbreak years (Fig. 8) showed similar trend with two periods March to May and September to November corresponding with peak crop damage. A mean number of over 200 individual millipedes was recorded in a 0.25m² of sampling area during outbreak periods.

Table 2 shows millipede numbers

Table 1: Numbers of adult *Tibiomus* species (Diplopoda: Odontopygidae) sampled monthly from 0.25m² area of homestead farms in outbreak years (1990, 1991 and 1998) and non-outbreak year (2001).

Months/Numbers of *Tibiomus* sp., areas and years of sampling

Months	Number of <i>Tibiomus</i> sp., areas and years of sampling			
	Ikot Obio Itong, Mkpat Enin 1990	Ndon Eyo, Onna 1991	Itiam Etoi, Uyo 1998	Itiam Etoi, Uyo 2001
Jan	NA	89	45	7
Feb	NA	71	29	9
Mar	NA	256	117	19
April	NA	261	166	21
May	189	111	85	23
June	79	73	66	9
July	53	25	41	6
Aug	109	93	99	11
Sept	257	297	201	29
Oct	307	271	167	21
Nov	407	322	309	29
Dec	103	89	108	9
Σ	1504 ^b	1958 ^a	1431 ^b	203 ^c

Year totals followed by different letter are significantly different at the 0.05 level LSD.

Table 2 Numbers of adult millipede species sampled monthly from 25m² areas of open farmlands in outbreak years (1990, 1995) and non-outbreak year. Numbers of millipedes, locations and years of sampling.

MONTHS	Ikot Akam Oruk Anam outbreak year 1990			Ikot Akam Oruk Anam non-outbreak year 1991			Ikot Itung Oruk Anam outbreak year 1995			Itiam Etoi, Uyo non-outbreak year 1997		
	a	b	c	a	B	c	a	b	c	a	b	c
January	NA	NA	NA	5	0	0	NA	NA	NA	11	0	0
February	NA	NA	NA	9	0	0	NA	NA	NA	8	0	0
March	NA	NA	NA	31	4	0	NA	NA	NA	27	0	0
April	NA	NA	NA	31	9	0	NA	NA	NA	41	3	0
May	397	16	5	51	11	3	490	39	11	59	2	0
June	211	9	6	27	4	3	357	17	9	19	0	0
July	67	8	3	11	0	0	81	11	6	8	0	0
August	33	6	6	7	0	0	17	10	11	11	0	0
September	74	4	2	21	0	0	97	13	12	16	0	0
October	53	0	0	13	2	0	103	9	3	21	0	0
November	67	0	0	19	0	0	116	0	0	33	0	0
December	6	0	0	4	0	0	17	0	0	7	0	0
Σ	908	43	22	232	30	6	1278	99	52	261	5	0

Year totals followed by different letter are significantly different at the 0.05 level LSD.

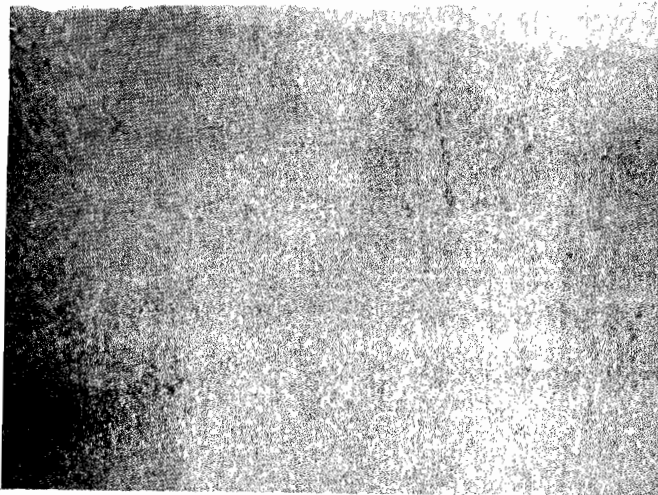


Fig. 2(a): The scene of a farming area devastated by millipedes during the 1995 outbreak. The farm was intercropped with cassava, yam/cocoyam/mnize/melon/fluted pumpkin in zafly. (Ekparakwa, Oruk Anam L.G.A, May, 1995)



Fig. 4: *Spirostrepus assiniensis* (circled) and *Peridontopyge* sp. (uncircled)



Fig. 2(b): Heaps of cassava cuttings awaiting planting completely debarked and rendered useless by millipedes during the 1995 outbreak. (Ekparakwa, Oruk Anam L.G.A, 1995)



Fig. 5: The unidentified species mating (Ekparakwa, Oruk Anam L.G.A, May 1995)



Fig. 3: *Tibiomys* species (Diplopoda: Odontopygidae)

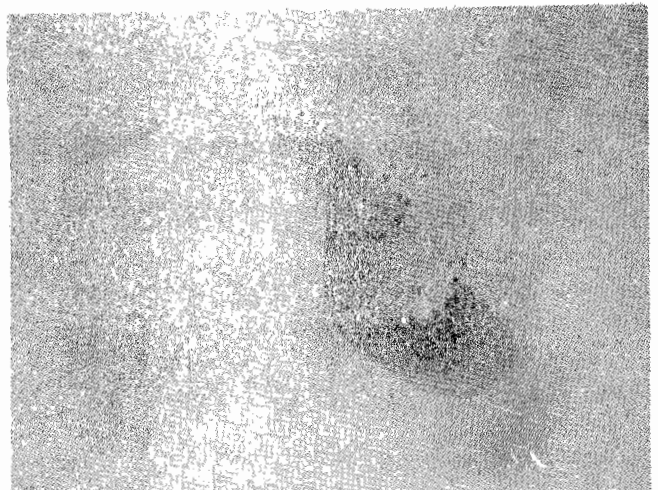


Fig. 6: *Spirostrepus assiniensis* (Diplopoda: Spirostreptidae). The most prevalent millipede species in Akwa Ibom State, Southeastern Nigeria.



Fig. 7: Carcasses of burnt millipedes. Farmers controlled the millipedes by collecting them in heaps and burning with fire.

sampled during outbreaks in open farmlands in Ikot Akam, Oruk Anam LGA (1990), Ikot Itung, Oruk Anam LGA (1995) and during non-outbreak in Ikot Akam, Oruk Anam LGA (1991) and Itiam, Uyo LGA (1997). Data was not available in the beginning months of outbreak years as outbreak reports were always received late. There was significant difference ($P \leq 0.05$) and higher ratio (7:1) of millipede numbers between outbreak and non-outbreak years. The curves for both outbreak and non-outbreak years (Fig. 9) also showed a common trend. A mean number of over 300 individual millipedes were sampled from a 25m² area during outbreak period. In both agroecologies, the millipedes caused no significant crop damage in non-outbreak years.

Millipede types and identification

Outbreaks in homestead farms involved a small-sized millipede, dark in colour with dorsal medium yellow stripes with mean body length of

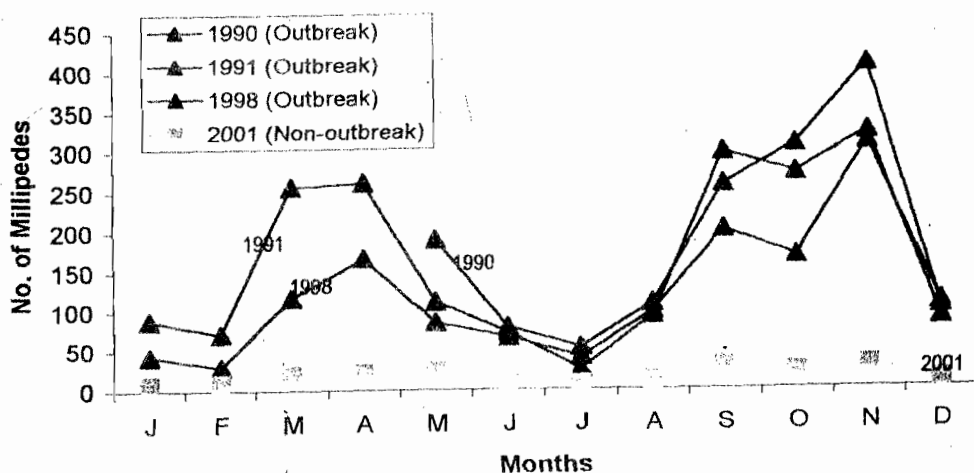


Fig. 8: Population curves of *Tibiomus* sp. (Diplopoda: Odontopygidae) during outbreak and non-outbreak years in Akwa Ibom State, Southeastern Nigeria.

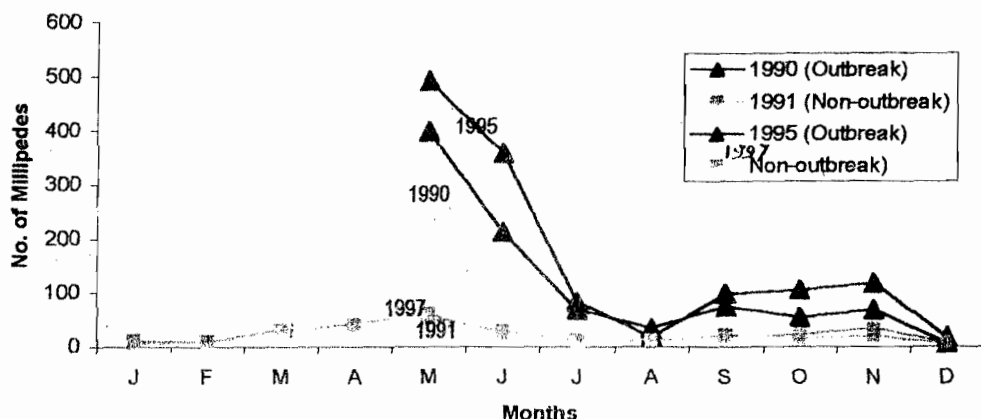


Fig. 9: Population curves of *Spirostreptus assiniensis* (Diplopoda: Spirostreptidae) during outbreak and non-outbreak years in Akwa Ibom State, Southeastern Nigeria.

3.10cm and body width of 0.07cm and identified as *Tibiomus* species (Diplopoda: Odontopygidae) (Fig. 3). Outbreaks in open farmlands involved three different species of large sized millipedes. These had shades of dark and brown colours with body length range of 8.50cm to 15.50cm and body width range of 0.75cm to 1.25cm. Two of the species (Fig. 4), which caused severe damage to crops, were identified as *Spirostreptus*

assiniensis (Diplopoda: Spirostreptidae) and *Peridontopyge* species (Diplopoda: Odontopygidae). The third species (Fig. 5), which fed only on dead and decaying plant materials in the laboratory was not yet identified. *S. assiniensis* was the most prevalent millipede species and was about 91% of the species composition. *Peridontopyge* sp. was about 6% and the unidentified species about 3%. Species composition during non-outbreak period, did not differ significantly (Fig 11) *S. assiniensis* co-existed in the homestead farms with *Tibiomus* sp.

Millipede nuisance and economic losses

The initial fright by many farmers following the outbreaks was that it was a curse by the gods. The outbreaks in homestead farms caused a lot of nuisance to homes. Apart from damage to growing crops and those in storage, the millipedes invaded residential houses in large numbers. They were seen climbing wet walls and they contaminated improperly covered food and water. They ate practically everything including papers and textile materials. They crawled inside improperly protected houses and were seen even in bedrooms and were often found aggregated

under damp materials.

Outbreaks in open farmlands caused high economic losses and starvation in all farming communities. Losses per family was put at over ₦42,000.00 per outbreak.

DISCUSSION

Farmers in millipede-outbreak-areas agreed that under normal conditions millipede numbers were below economic threshold, hence they did not cause significant damage to crops. Crop damage was therefore a direct result of millipede abundance during the outbreak periods. The assertion by Hardin *et al.* (1995) that crop damage did not necessarily indicate an increase in pest species is fallacious with the millipede outbreak. Pest outbreaks usually result from the disturbance of a stable ecosystem, resulting in deregulation of the natural control processes (Berryman, 1982). It would therefore appear that millipede populations in the outbreak areas in this study escaped the influence of population controlling factors and erupted to high densities, which caused massive destruction of crops.

Outbreaks were sporadic and unpredictable. Jones and Jones (1974) made similar observations about millipede outbreaks. In this study however, outbreaks were restricted to nine LGAs.

In this study, *Tibiomus* sp. was rare in open cultivated land but was more confined to homestead farms. *S. assiniensis* co-existed with *Tibiomus* sp. but was more confined to forested areas and open farmland, with *Peridontopyge* sp.

Khoo (1986) attributed pest outbreaks in the tropics to conversion of forests for agriculture, particularly to frequent clearing of stabilized

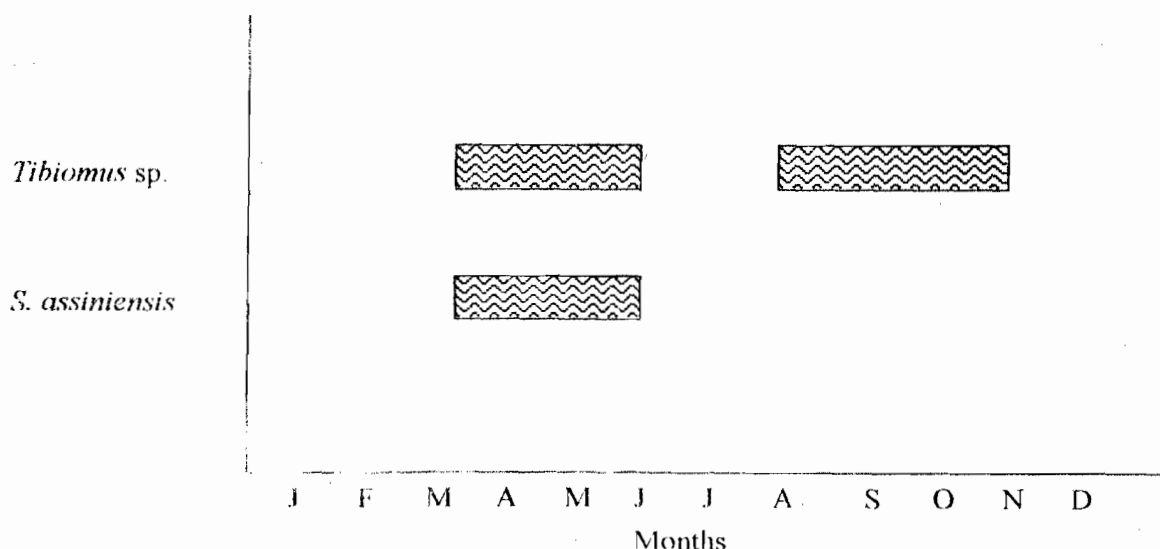


Fig. 10: Periods of peak crop damage by two predominant millipede species during outbreaks in Akwa Ibom State, Southeastern Nigeria.

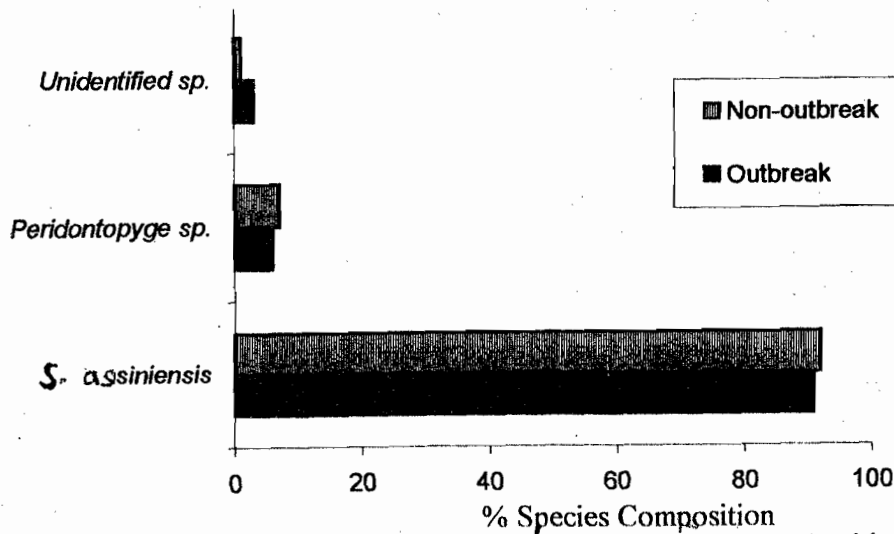


Fig. 11: Grouped bar graph showing the percentage composition of three millipede species found in open farmlands during outbreak and non-outbreak periods in Akwa Ibom State, Southeastern Nigeria.

forests for replanting with either the same or new crop plants. This contention appears to hold true in the observations made in the outbreaks under discussion. A reduction in the bush fallow period led to more frequent clearing of forests. Each of the outbreaks occurred following land clearing and seeding. The decreasing total hectares of outbreak areas might be due to a gradual return to a more or less stable physical environment.

Trabanino et al. (1990) had observed that millipede population in Honduras were higher in slash-and-burn than slash-and-mulch fields. The slash-and-burn culture practised by farmers in Akwa Ibom State might therefore increase risk of build-up of millipede populations. This might also account for the sustenance of crop damage in the field for up to three months in open farmlands and longer periods in homestead farms. Generally, pest outbreaks occur over a relatively short period of time (Berryman, 1987). A further explanation might be the conducive climatic condition for reproduction and survival of the millipedes within the period of crop damage. Earlier studies of millipede in Nigeria by Toye (1967) showed that they had mean short life cycles of about 28 days. Therefore, the first generation of millipedes at the outset of outbreaks could produce succeeding generations which would continue reproduction and damage within the moist conducive condition of March to June.

By July, when the numbers of the millipede and crop damage subsided, the moisture content of the soils are usually very high leading to high mortalities of soil inhabiting arthropods. The month of July is the highest rainfall month of the study area (AKADEP, 1994). This study confirms earlier studies by Inyang and

Emosairue (2001) that *Tibiomus* sp. was usually abundant and destructive in infested areas between the months of September and November as well as between March and May. The bimodal nature of the population and crop damage by this millipede species is also attributable to the effect of excessive moisture of June/July. The population of this species built up again after "August break" and continued damage until impaired again by the usual excessive drought of December, which caused high mortalities.

This study has also confirmed findings by other workers (Toye, 1967, Jones and Jones 1974, Akiniosotu et al 1987) that millipedes are nocturnal and polyphagous in feeding habit. However, they fed on crops uncommonly reported as their hosts, such as cocoyam, yam, maize, melon, fluted pumpkin, tomato, African spinach and sweet potato. Furthermore, contrary to the observation by Taylor (1977) that millipedes were secondary pests of crops, they caused primary damage to crops during the outbreaks. This they did by scrapping barks of cassava cuttings with preference to the bud points. They ate germinating points, bored into tissues, defoliated the crops and caused stunting, wilting and death. Millipedes thrive best under moist conditions (Davidson and Lyon 1986; Trabanino et al, 1990) and live in leaf litter or burrow in the soil (Ewer and Hall, 1972). They were found in these ecologies during the outbreaks under study. However, the very high numbers caused many of them to invade nearby residential houses, perhaps in dispersal effort to less competitive areas.

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REFERENCES

- Akele, S. A., 1991. Use of Chemicals in controlling millipede attack on Cassava stem. Nig. J. Crop & For 1:111-112.
- Akinlosotu, T. A., Omidiji, M. D. And Oyedokun, J. B., 1987. On the occurrence of a millipede *S. assiniensis* on cassava. J. Root Crops 13 (1): 41-45
- Akwa Ibom Agricultural Development Project, 1994. Swamp rice Study Stage I Report Vol. 4, Annex III: Rainfall and Hydrological Data. pp 1-12
- Akwa Ibom State, 1989. Physical background, soils, land use and ecological problems. Technical report of the Task force on soils and land use survey. The Government Printer, Uyo. 602 pp.
- Berryman, A. A., 1982. Biological control, thresholds and pest outbreaks. *Environmental Entomology* 11: 514-549.
- Berryman, A. A., 1987. The theory and classification of outbreak In Barbosa, P. and Schultz, J. C. (Eds.) *Insect Outbreaks* pp. 3-27. Academic Press Inc., London.
- Davidson, R. H. And Lyon, W. F., 1986. *Insect pests of farm, Garden and Orchard* 8th Ed. John Wiley, New York. 640 pp.
- Eshett, E. T., 1993. The wetland soils of Nigeria: Properties, classification and traditional land use properties, In *Wetlands and Ecotones: Studies on Land water interaction*. International Scientific Publications, New Delhi, pp. 227-244.
- Ewer, W. W. and Hall, J. B., 1972. *Ecological Biology 1: Organisms and their environments*. Longman Group Limited London, pp. 207-215
- Hardin M. R., Benrey, B., Coll, M., Lamp, W. O., Roderick, G. K. and Barbosa, P., 1995. Arthropod pest resurgence. An Overview of potential mechanisms. *Crop Protection* 14 (1): 5-18.
- Inyang, U. E., 1998. Pest status of two millipede species in Akwa Ibom State, Southeastern Nigeria. M. Sc. Thesis, University of Uyo, Uyo Nigeria, 74 pp.
- Inyang, U. E. And Emosairue, S. O., 2001. *Tibiomus* species (Diplopoda: Odontopygidae), a new pest in Akwa Ibom State. In print: *Annals of agricultural sciences*.
- Jones, F. G. W. and Jones, M. G., 1974. *Pest of Field Crops* (2nd ed.) Edward Arnold, London. 448 pp.
- Khoo, S. G., 1986. Pest Outbreaks in the Tropics. *Journal of plant protection in the tropics* 3 (1): 13-24
- Raheja, A. K., 1975. Millipedes on Groundnut (*Arachis hypogaea*) *Nigerian Journal of Plant Protection*. 1(1): 91-92.
- Robertson, L. N. and Simpson, G. B., 1989. The Use of germinating seed baits to detect soil insect pests before crop sowing. *Australian Journal of Experimental Agriculture* 29: 403-7.
- Sharma, H. C. and Lopez, V. F., 1990. Biology and population dynamics of sorghum head bugs (Hemiptera: Miridae) *Crop Protection* 9: 164-173.
- Taylor, T. A., 1977. *Crop Pests and Diseases: Studies in the development of African resources* 4. Oxford University Press, Ibadan. 70 PP.
- Tian, G., Brussaard, L. and Kang, B. T., 1995. Breakdown of plant residues with contrasting chemical compositions under humid tropical conditions: effect of earthworms and millipedes. *Soil Biology Biochem* 27 (3): 227-280
- Toye, S. A. 1967. Observations on the biology of three species of Nigerian millipedes. *J. Zool London* 152:67-78.
- Trabanino, C. R., Pitre, H. N., Andrews, K. L. And Meckenstock D. H., 1990. Soil inhabiting phytophagous arthropod pest in intercropped sorghum and maize in Southern Honduras. *Turrialba* 40 (2): 172-183.
- Webb, J. E., Wallwork, J. S. and Elgood, J. H., 1989. *Guide to invertebrate animals* 2nd Ed. Macmillan Education Ltd., London. Pp 159-161.
- Wightman, J. A. and Amin, P. W., 1988. Groundnut pests and their control in semi-arid tropics. *Tropical pest management* 34(2): 218-226