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THE LIFE HISTORY OF A TROPICAL FOREST CYPHOPHTHALMID FROM SIERRA LEONE (ARACHNIDA, OPILIONES).

Introduction

During a three year study of the litter, humus and soil in a secondary forest in Sierra Leone, West Africa, quantitative samples of the soil arthropods were taken. Amongst these was a new species of cyphophthalmid belonging to the genus *Parogovia* (Legg in press). As part of his Masters Thesis, E.B.Pabs-Garnon (1977) undertook a superficial study of the life-history of this species under the mistaken identity of *Ogovea grossa* Hansen & Sorenson. It is to this end that a fuller interpretation of the life-history has been made and presented in this paper.

The extensive sampling programme provided large numbers of individuals. This provided details of the number of instars, three, in the life history (Legg in press) and their seasonal quantitative variation, both in terms of gross numbers present, and their distribution within the three sub-sampled zones of the habitat (litter, humus, B-horizon of the soil). Since the rainfall, temperature, soil water content, pH, humidity, litter-fall and weight of litter per square metre were also recorded as part of the general forest study it has been possible to link annual population changes with changes in the relative abundance of the instars. These data are also presented here.

Study Site

The sampling site was located within the Botanical Reserve (Garden) of Fourah Bay College (University of Sierra Leone), a little south of the capital, Freetown. The Botanical Reserve is a continuation of the Forest Reserve of the Freetown Peninsula and occupies a valley with a stream and two hillsides. dominant tree species present include: *Carapa procera*, *Myrathus arboreus*, *Uapaca* spp, *Daniella thurifera*, *Terminalis superba* and *Piptadeniastrum africanum*. Within this Reserve a 100 metre square was selected for the sampling programme. The climate of this region consists of a distinct wet season and dry season with an annual rainfall of at least 3500 mm and mean daily temperature of 25.7°C.

Methods

Twenty-five monthly samples, each of 0.1 square metre, were taken from randomly chosen one metre grids within the study hectare from August 1972 to December 1974. For the purpose of this paper, the samples from January 1973 to December 1974 are presented and used in the life history interpretation. Modified Tullgren funnels (Gabbutt 1959) were used to extract the arthropods from selected subsamples of leaf litter (L), humus (H) and the B-horizon of the soil (B). Specimens were collected in 70% alcohol with added 5% glycerine.

Twenty small-litter ($<$ 250 mm long) samples were collected using 0.25 metre square litter traps made from polyethylene, suspended 1 m above the ground level. Temperature measurements were made continuously over the study period using a mechanical thermo-hydrograph. Monthly measurements of temperature and humidity were also made at various depths using a mercury thermometer and cobalt thiocynate paper. Soil pH was determined using fresh samples of soil/humus suspended in distilled water and a pH metre with a glass electrode. Soil water content was determined from samples air dried at 450°C to constant weight.

Annual changes in the litter, humus, soil environment

The relative humidity within the humus/soil was found not to fall below 90% throughout the year, and for a large part of the time the relative humidity was in excess of 99%. The soil water content (Figure 1), which is a function of the influx of rain, dew, run off from trees, the product of guttation, and flooding follows a similar, but far flatter curve than that of the overall rainfall (Figure 1) as measured at the weather station, at Kortright, about one kilometer to the north of the site.

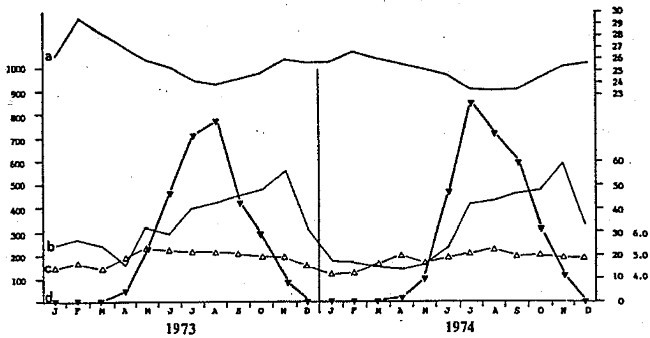

Figure 1. Seasonal variation in:

a) monthly mean temperature ^{o}C;

b) % soil water content;

c) soil pH;

d) monthly rainfall in mm.

Linked with the annual cycle of rainfall is the seasonal loss of leaves from many of the trees (Figure 2). The forest is a semi-deciduous rainforest and litter fall is continuous, with a single peak between February and April and reaching a maximum of over 1000 gm per square metre in April, at the end of the dry season. The total litter fall is over 7.8 tonnes per hectare per year, which is comparable with similar litter falls given in Proctor 1983. With the beginning of the rains there is a net increase in the quantity of litter which accumulates, indicating that the activity of decomposers is at a minimum during this time. This decrease in activity is not only reflected in the quantity of litter present on the ground but also in the overall reduction in the litter-fall. At the end of the wet season with the decreasing rainfall and soil water content, there is an increase in litter fall, but even greater increase in the decomposition of the litter, with a net result of less litter per square metre. Soil pH also shows season changes which appear to be linked with soil water content and the

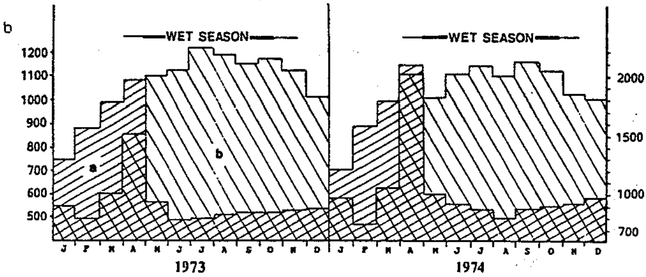

Figure 2. a) Weight of litter per square metre in grams;
b) Weight of small-litter fall per square metre in grams.

accumulation of litter in the wet season. During the wet season, there is a reduction in litter fall and a greater accumulation of litter. Increased biological activity at the end of the wet season results in a decrease in pH (increased acidity), possibly reflecting greater quantities of humic acids produced by the activities of decomposers.

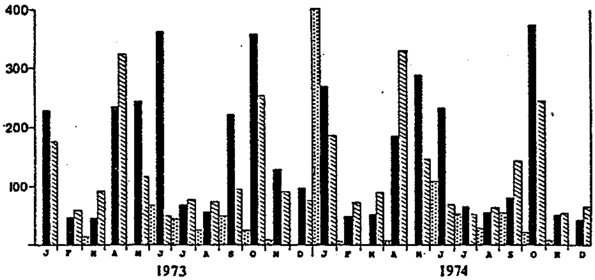

Figure 3. Combined total number of instars per square metre in the litter (solid), humus (cross-hatched) and B-horizon of the soil (dotted).

/------------------ dry season ----------------/

2. Adult LWS - protonymph - deutonymph - tritonymph - adult LDS instar duration greatly in excess of one month in the dry season.

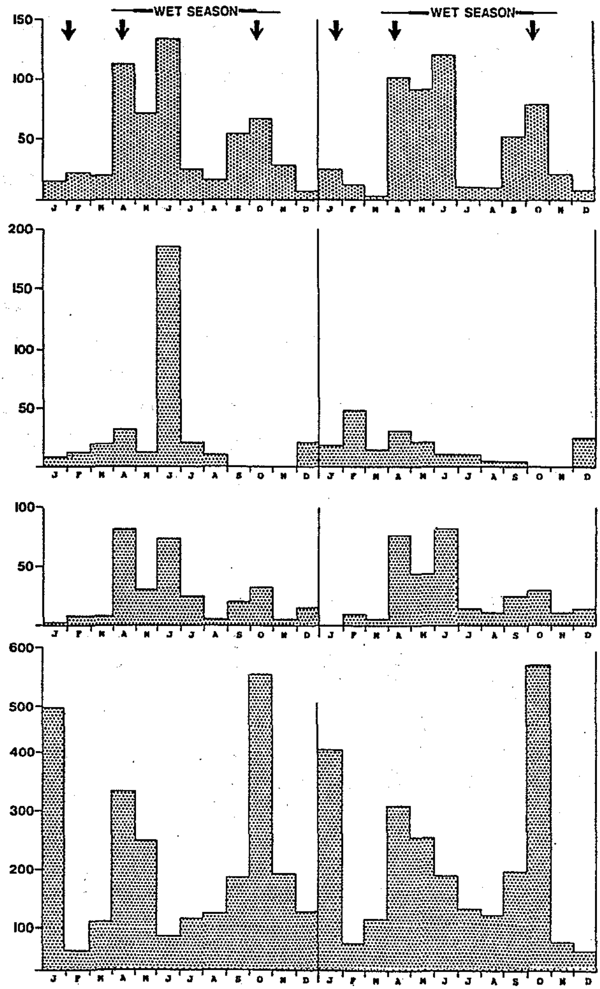

Figure 4. Total numbers of each instar per month.
a) protonymphs; b) deutonymphs;
c) tritonymphs; d) adults.

Phenology

All life stages were collected throughout the year, however, as would be expected in a region with a distinctly seasonal climate, variations occurred in the proportions of each of the instars present in each month (Figure 4). Variations also occurred in the distribution of the different instars within the L, H and B horizons of the soil (Figure 3).

Overall seasonal population variation

The various instars show three peaks (Figures 1,3): early dry season, January (EDS), early wet season, April, May, June (EWS) and late wet season, September, October (LWS). In the LDS adults produce eggs which contribute to peak EWS protonymphs and later deutonymphs and tritonymphs and ultimately LWS adults. The LWS adults are also made up of adults which have survived the wet season and are breeding again. LWS breeding gives rise to LWS protonymphs, the dry season deutonymphs peak and then to LDS tritonymphs and LDS adults. An apparent problem arises with the presence of a very large number of deutonymphs in the EWS and very low numbers in the LWS, which might be a function of the sampling technique. edtraction technique (Gabbutt 1969) and sampling timing.

Eggs laid in the LWS go more slowly through to tritonymphs, the main component of the dry season. This means that protonymphs, deutonymphs, tritonymphs and adults of the EWS are all of the same generation, whereas protonymphs, tritonymphs and adults of the LWS are not. Instead, the protonymphs are from the LWS generation and the tritonymphs the EWS generation.

Rather than continuous breeding, it would appear that there are two flushes:

/----------------- wet season ---------------/

1. Adult LDS - protonymph - deutonymph - tritonymph - adult LWS instar duration probably about one month or less (too rapid for the sampling frequency).

Annual vertical migration

Mortality of all stages both in mid-dry season and mid-wet season is heavy and about the same, probably resulting from the extremes of soil water content: too dry (desiccation) and too wet (water-logging), rather than annual changes in temperature which are only slight (2.5°C). Within the litter, humus, soil continuum there is vertical migration to reduce dry season mortality, when conditions closer to the surface are less favourable. Migration might also be linked with the activity of the prey species upon which the cyphophthalmid feeds. Laboratory studies (Pabs-Garnon pers. comm.) indicate that these are small arthropods which feed either directly upon the raw organic matter or the fungi associated with their decay. During the wet season greater litter activity occurs, with associated increase in the acidity of the habitat through the release of humic acids. At this time migration into the litter would be favourable in terms of humidity/soil-water content and availability of food. During decay sugars are released which lead to the formation of humic acids. Like many soil predators, including millipedes (Sakwa 1973) it is probable that this species has a similar gustatory ability as its prey, in a manner similarly occurring in pseudoscorpions (Caplin 1974) thus it is capable of locating the environment where the prey is found. In this way it would be possible for the cyphophthalmid to move into the soil where the greatest levels of sugars and humic acids are, together with its prey species.

Towards the end of the wet season, fewer individuals are found in the litter, the humus and soil being increasingly favoured. Of all the instars, deutonymphs appear to be the least adventurous, rarely occurring in the litter; whilst adults occur in this layer throughout the year. The species as a whole appears to favour the humus layer.

Conclusion

Most of the work on soil arthropods has concentrated on temperate habitats, with little work being done on tropical systems. Soils of tropical forests are noted for their thinness and rapid loss once the habitat has been disturbed for agriculture (eg Trenbarth 1984). Studies have chiefly been concerned with leaf-fall and aspects of the nutrient cycling, chemistry and physics of the soils. Relatively little work has centred on the soil fauna associated with the rapid cycling of nutrients in this habitat. To understand the roles that the various members of the soil fauna have, and how these organisms live, will contribute to our overall understanding of the functioning of the soil and the forest as a whole. This would lead, hopefully, to better and successful management of this highly at-risk habitat.

Acknowledgements

We extend our grateful thanks to Mr. J.G. Blower and Dr. P.D. Gabbutt of the University of Manchester for their comments and suggestions.

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Jocqué: Considering the fact that the litter layer in tropical forests is very thin, is there room for a vertical migration of the organisms you studied?
Legg: The animals were not only found in the litterlayer but also in the underlying humus and gravel layers. There is statistical evidence that the organisms migrate from one layer to another and prefer one of the three at particular stages and for particular periods.

Juberthie: What is the number of eggs laid by females and the type of reproductive strategy of Paragonia in tropical forest? How long is the adult life?
Legg: Laboratory studies indicate 5 - 10 eggs per female; it is more 'K' strategy. Individuals live one to two years.
In conclusion, it seems that the reproductive strategy and life cycle of this tropical forest species of Cyphophthalmi differ strongly from those of the temperate Cyphophthalmi (Siro); it is more or less 'K'.

Deeleman: What is the reason you chose this particular species to study the life history?
Legg: It was studied because it is found in large numbers together with other arachnids and was a hitherto undescribed species. My research student was interested in studying the morphology and life history of the species - hence the study.