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Population Dynamics of Two Millipedes in Alagarmalai Hills of Tamil Nadu

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Abstract: The population dynamics of millipede species, *Arthrosphaera magna* and *Harphaphe haydeniana* were examined during June 2010 to May 2011 in Alagarmalai Hills (10°0'-10°30' N and 75°55'-78°20'E) reserve forest of Madurai District. Monthly samples of larva, subadult and adult were collected from randomly selected quadrates of the study sites were counted, weighed and released in the respective quadrates. Population density and biomass of millipede, *A. mangna* was maximum (48/m^2; 104.58 g live wt/m^2) in December 2010 and minimum (4/m^2; 9.23g live wt/m^2) in May 2011. Similarly, higher (105/m^2; 38.32g live wt/m^2) and lower (6/m^2; 2.19g live wt/m^2) number and biomass of *H. haydeniana* was recorded in the month of December 2010 and March 2011, respectively. The metrological parameters such as rainfall and moisture were positively correlated but temperature was negatively correlated with density and biomass of the two millipede species.

Key words: Population dynamics · *Arthrosphaera magna* · *Harphaphe haydeniana* · Alagarmalai hills

INTRODUCTION

Millipedes are Arthropods that may be found all over the world except Antarctica [1]. Approximately, 11 thousand species/subspecies have been already recorded and they are allocated in more than 4,500 genera, 170 families and 15 orders [2]. Millipedes are one of the largest macro arthropods in forest ecosystem and play a role in enriching the soil fertility. Generally millipedes are detrivores, apparently affect nutrient cycling through the redistribution of organic material and consequently, the release of chemical elements such as nitrogen in the soil [3].

Studies on the distribution of diplopods started as early as 1884 [4]. Halkka [5] studied the life history and distribution of diplopod, *Schizophyllum sabulosum* through various instars in the litter of several kinds of forests in Central Europe and its population densities is subject to periodic fluctuations due to both phenology and environmental circumstances [6]. Millipede distribution is contagious and the maximum population record during 1975-1978 varied between 800-2400 per m^2 in different habitats [7]. Recently, Loranger-Mercciris, *et al*. [8] studied millipede abundance in semi-evergreen dry topical forest and related species richness and feeding preference on litter nitrogen content.

Role of climatic factors in the regulation of millipede population is equally important. Temperature influences millipede populations directly and indirectly both in nature and under experimental conditions [9, 10]. Temperature and humidity are the main factors influencing the structure of Diplopoda taxocoenoses [11, 12]. However, in forest habitats the millipede communities are influenced by humus type [13, 14]. Humidity and temperature also cause fluctuation in millipede populations [15]. Ashwini and Sridhar [16] found that millipede abundance and biomass were positively correlated with rainfall, soil moisture, soil Calcium content and soil temperature in forest of Southwest India.

Most millipede species easily cope with normal, annual periods of dryness using both behavioural and physiological mechanism and the basic behaviors are to take refuse in cavities or to burrow into the soil [17]. Physiological adaptations allow millipedes to survive those conditions for weeks or months [18, 19] and this is due to response to desiccation, which may protect the species during the dry seasons [20]. After exceptional drought in temperate forests, *Choredumatida* suffered significant population declines [21, 22]. The first-stadium juveniles of the glomerid, *Glomeris balcanica* die in large numbers during their first summer in Greece [23], which might worsen in particularly hot and dry years. In the present paper an attempt has been made to understand the role of environmental factors on the population dynamics of millipede *Arthrosphaera magna* and *Harphaphe haydeniana* in a Alagarmalai hills reserve forest.

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MATERIALS AND METHODS

Study Site: The study area, Algarmalai Hills is located in Madurai District, a part of the eastern plains of the Deccan plateau, has many minor discontinuous hill ranges and isolated iselbergs of the Eastern Ghats. Reserve forest of Alagarmalai hills (10°0'-10°30' N and 75°55'-78°20'E) are 20 km north-east of Madurai city. The study site, Peria aruvi Valley is located at the north-east of the Alagarmalai Hills. The Peria aruvi valley is rich in humus and during December to February there is heavy dew formation at nights and mornings. The maximum and minimum temperature varies from 25 to 37°C during December to April respectively. Four quadrates each, with an area of 1 m^2 in the four corners of each site were selected and demarcated with rope in Peria aruvi Valley. Field study was conducted monthly once from June 2010 to May 2011 and the mean data related to climatic factors such as temperature, Humidity and rainfall were obtained from the metrological station of the Agricultural College, Madurai, close to the study area.

Estimation of Population Density and Biomass: The juveniles and adults of *A. magna* and *H. haydeniana* from the selected quadrates of the study area were collected. The average number of individuals in the four quadrates of the four study area was recorded. The mean of four such censuses collected in each month was considered the mean density of the population and expressed as number of individuals/m^2. Population biomass during different months was calculated as the sum of the products of the number of individuals and expressed as g/live weight/m^2.

RESULTS

The data obtained from the present study revealed that Pill millipedes *A. Magna* was predominantly found in the study area. The juveniles are dark olive green color and will be seen during November - January. The head of the adult is yellow-brown or olive - brown or olive - green; second segment, colum and other segment are dark - brown with black band bordered with light - yellow colour, forming a narrow stripe. The average weight of an adult individual is 2.49g (n=10; range 1.5 to 3.5g), measures 4.7 cm and long (n=10; range 3.5 to 6 cm) and mid segment width 2.0 cm (n=10; range 1.5 to 2.5 cm). Number of body segment is 12 (Plate 1).

Plate 1:

Plate 2:

The other millipede species, *H. haydeniana* (which is also called as yellow-spotted millipede, almond-scented millipede or cyanide millipede) is also found in the moist area of study area. The average weight of an adult individual is 0.36g (n=10; range 0.2 to 0.5g), measures 3.5 cm and long (n=10; range 2.7 to 5.5cm) and mid segment width 0.41 (n=10; range 0.3 to 0.5 cm). The body is black and is distinctively marked along the sides with patches of a yellowish colour. *H. haydeniana* has approximately twenty body segments (Plate 2).

Population density of millipede, *A. mangna* was higher (48/m^2) in December 2010 and lower (4/m^2) in June 2010 and May 2011 (Table 1). Maximum (105/m^2) and minimum (6/m^2) number of *H. haydeniana* was recorded in the month of December 2010 and March 2011, respectively. The biomass of millipede, *A.magna* and *H.haydeniana* was higher (104.58 and 38.32g live wt/m^2) in December 2010 and minimum (9.23 and 2.19g live wt/m^2 in May 2011 and March 2011, respectively (Table 1). Temperature fluctuated between 24°C in December 2011 and 38°C in May 2011 (Fig. 1a). Maximum humidity was recorded (95%) in December 2011 and minimum humidity (69%) was recorded in July 2010 and May 2011respectively (Fig. 1b). The highest rainfall was observed during in December 2011 (580mm) (Fig. 1c). The metrological parameters such as rainfall, moisture and temperature were significantly altered population

Table 1: The density and biomass of *A.magna* and *H. haydeniana* in the study area during 2010-2011. Density (N/m^2) and biomass (g live weight/m^2) are represented the mean (X±SD) of four quadrates in study area

	Millipede species			
	A. magna		*H. haydeniana*	
Months	Density	Biomass	Density	Biomass
Jun, 2010	4±0.3	9.96±0.7	18±1.4	6.57±0.5
Jul	12±1.0	29.88±2.6	34±3.0	12.27±1.1
Aug	24±1.9	40.69±3.2	49±3.9	17.77±1.4
Sep	31±3.5	60.54±5.4	76±6.0	27.24±2.4
Oct	33±2.9	82.17±7.3	92±8.2	33.58±2.6
Nov	42±2.8	61.62±5.5	98±8.8	35.77±3.2
Dec	48±3.3	104.58±9.4	105±9.4	38.32±3.4
Jan, 2011	26±2.3	64.74±5.1	24±2.1	8.76±0.7
Feb	12±1.0	29.80±2.3	13±1.1	4.74±0.4
Mar	6±0.4	14.94±1.3	6±0.4	2.19±0.1
Apr	5±0.4	12.45±0.9	10±0.9	3.65±0.3
May	4±0.3	9.23±0.7	8±0.6	2.92±0.2

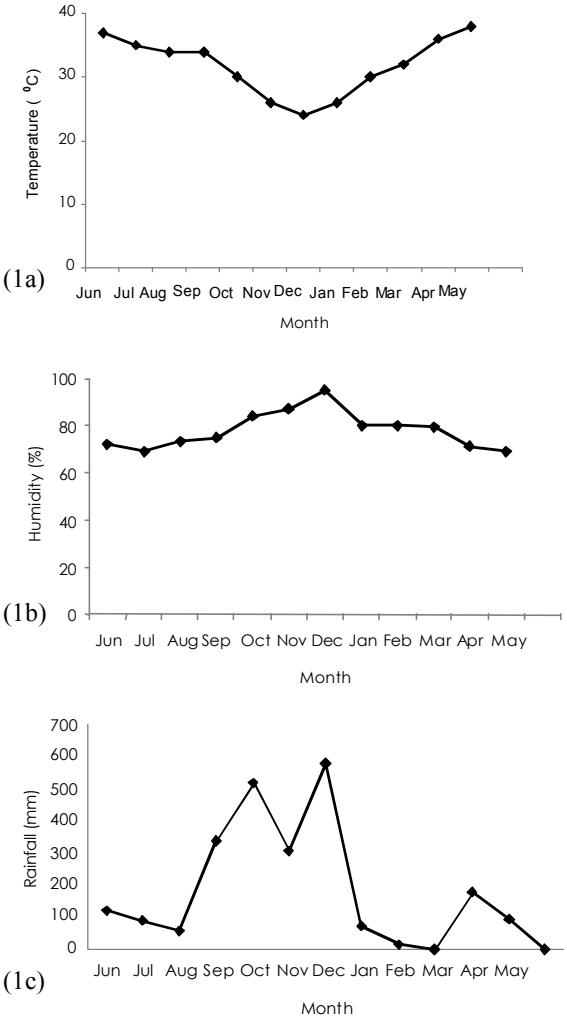

Fig. 1a,b,c: Temperature, Humidity and Rainfall in the study area

dynamic of millipede. The rainfall and moisture were positively (r=0.9861; P<0.05) correlated but temperature was (r=-0.9464; P<0.05) negatively correlated with density and biomass of the two millipede species.

DISCUSSION

Arthropods such as millipedes and woodlice are important components in forest ecosystem. In some tropical regions millipedes are more important than earthworms in what it concerns to soil recycling once when they feed on decomposing plant material eating fungi, bacteria and the material they have already torn in pieces [3]. The present study revealed that the sampling season are the most important factors, affecting the population density of millipede [24], for the soil invertebrates like Lumbricidae, Isopoda, Diplopoda, Chilopoda and Formicidae.

Diplopods are mesophilous and hygrophilous animals that generally present nocturnal habits. They are always escaping from the sunlight and therefore are found hidden in humid and dark places, such as under litter, mosses, stones or pieces of wood, inside rotten trunks or on the soil surface [25]. David,and Couret [26] found an estimated population density of *Polyzonium germanicum* was 820 individual/ m^2 of this species alone in the forest of Orleans in strongly acid moder. Shinohara,and Niijima [27] reported that adult density of *P. laminate armigera* was 160-200 individuals/ m^2 at the time of swarming at Yanagisawa Patch, Yamanashi Prefecture. They observed more than 300/m^2 in a spot area. Saito [28] observed more 165/m^2 for pre-adult and 107/m^2 for adults as a maximum density of *P. laminate laminate* at Mt Kiyosumi, Chiba Prefecture.

Millipede abundance is a highly variable characteristic. In the present study the average of *A. magna* ranges from 4 to 48 individual/m^2 and *H. haydeniana* ranges from 4 to 105 individual/m^2 in Algarmalai hills. Comparing our result with those of Lokain [29], the vast East European, or Russian, plan on the average of millipede ranges from 7 to 30 individual/m^2 in the taiga, from 35 to 75 individual/m^2 in the belt of mixed coniferous-broadleaved forest and up to 133 individual/m^2 in broadleaved forests. Further to the South, the numbers reach up to 30-80 individual/m2 in the steppe and down to 2 individual/m^2 in dry steppe [30].

Seasonal fluctuations of soil fauna have been related to physical factors, such as temperature, moisture content and rainfall [31]. Borlow [32] suggested that humidity exerts the greatest influence on the distribution of millipedes. Humidity is one of the principal characteristics that influence the distribution of soil macroarthropods, because their survival can be negatively affected by both low and high soil humidity values [33]. The effect of humidity is closely related with temperature. At higher temperatures, soils are more likely to desiccate because of faster evaporation, leading to soil drought that may have adverse effects on soil fauna. Higher temperatures may also enhance the adverse effect of flooding on soil fauna because of reduced oxygen solubility and availability in water [34]. In many tropical and subtropical regions of the world, high seasonal differences in rainfall (and associated water level fluctuations) may result in occasional soil flooding that can have considerable influence on soil fauna [35].

As the cuticle of the vast majority of millipede species is devoid of a protective layer that could prevent them from excessive water losses, diplopods are quite sensitive to air humidity. They largely prefer to live in such moist substrates as leaf litter, rotten wood, stumps and the uppermost soil, crevices under the bark and stones, tree logs, anthills, bird nests, rodent and earthworm burrows tec. At higher rates of air humidity, for example in summer in the southern part of promorsky province, millipedes can appear on the ground surface, when the level of relative air humidity is close to 100%, yet with the sun hidden behind the clouds [36]. In contrast, the activity breaks at low or too high temperature or in a too dry soil belong to the second form of rest. In the temperate belt, most of the Diplopodd maintain activity during the entire period of vegetation. The feeding activity of these millipedes is mainly regulated by temperature.

The present study also indicates that the population density of millipedes were higher in rainy season and similar findings revealed that soil fauna population in many temperature regions are generally highest during the spring and rainfall [31, 32]. Furthermore, Wallwork [37] recorded definite pattern of population fluctuation with peak during rainy season followed by winter and in the hot and dry summer month. During high temperature the population density is lower. According to Edwards, [38] who have recorded lower density during the summer months, this may be explained by the migration of organisms downwards in the soil profile during the hot summer months, preventing them from being caughtly by the pitfall traps. Physiological adaptation allow millipedes to survive those conditions for weeks or months like burrowing into the soil, moulting etc. [39]. Bird *et al.* [40] noted that many temperate polydesmoids over-wintered partially or entirely as adults while adults in tropical regions die shortly after the rainy season and the larvae diapause in spherical moulting chambers during the dry season. O'Neill [41] found that *Narceus americanus* hibernated at very low temperature and that high temperature may be detrimental to the animal. Shaw [42] found that in New York the millipede, *Narceus annularis* moved into the litter from its summer locations, most of population being active by winter seasons. Millipedes on the forest floor are very susceptible to desiccation and are found only in humid and moist conditions [43].

The population density and biomass of millipede *A. magna and H. haydeniana* decrease in dry season (March to June) due to increase in temperature. Density and biomass of millipedes increased in rainy season (October to January) due to lower temperature and high rainfall and moisture. Assimilation is variable, depending on food quality, animal condition and weather. During a dry period, assimilation is decreased. Low coefficients of specific assimilation are usual in species that don not accomplish feeding in the summer for a considerable time. In contrast, the highest coefficient of specific assimilation are revealed in species that stop feeding over a hot dry season and settled under the litter and stones. Millipedes show two main forms of rest, or dormancy, i.e. physiological and physical [44]. The former is an adaptation to periodically un-favourable condition and it is genetically determined. The latter form of rest depends on a direct impact of unsuitable conditions. A summer diapauses in diplopods in the arid regions belongs to the first type of rest. For instance, aestivation in millipede, *Amblyiulus continentalis* (Attems) in the Lenkoran region

of Azerbaijan coincides in time both in nature and in the laboratory regardless of temperature of the environment [45]. The beginning of winter physiological rest is observed in many species, when the temperature drops below the lower limit of their feeding and locomotor activity [44]. Such early preparations allow to surviving cold periods. The metrological parameters such as rainfall, moisture and temperature were significantly contribute the millipede species dynamics [46]. Hajdar and Mihallaq [47] revealed that the spread of Diplopode fauna depends in the combination of several factors where the values of temperature, rain and moisture have an important role in their proliferation, particularly in their active period during the year.

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