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Study on the abundance and diversity of ground dwelling insects using Pitfall trap in two different ecosystems of Kendujhar District, Odisha, India

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Abstract

The present study was undertaken to explore the diversity of ground dwelling insects from 2 different ecosystems of Kendujhar district, Odisha. A total of 25 different families belonging to 8 different orders were reported from these 2 ecosystems. Of them, family Formicidae belongs to the order Hymenoptera shares maximum number of species (142 from study site 1 and 88from study site 2) followed by Entomobryidae (131 and 72), Isotomidae (47 and 04) belongs to the order Collembola, Thripidae belongs to the order Thysanoptera (18 and 06) and so on. High percentage of ground dwelling insect diversity was observed in Formicidae family with 43% observed in woodland ecosystem followed by mixed vegetation ecosystem (34%). The present study was also conducted to determine the species richness, Simpson's Reciprocal Index and Shannon-Wiener index of insect fauna from different ecosystems. The Simpson's Reciprocal Index and Shannon-Wiener index are highest in mixed vegetation ecosystem (4.237 and 1.879) and lowest in woodland ecosystem (3.175 and 1.599). Graphical representation of the number of insects according to family by the heat map analysis using a warm to cool colour scheme in the form of hot and cold spots.

Key words : Ground-dwelling insects, pitfall trap, two different ecosystems, Kendujhar District, Odisha, India.

Barbil is a city and a municipal council in the Kendujhar district (also known as Iron city) of the state of Odisha, India. Arthropods are an important component of the diet for many species of wildlife, and wildlife researchers who work on insectivorous and omnivorous taxa often attempt to estimate relative abundance or species richness of arthropods for diet studies. Pitfall traps are the most frequently used method for sampling ground-dwelling arthropods[14,16,17,19]. This method estimates relative arthropod activity rather than absolute density, reflecting individual abundances of species and movement rates within a given habitat[12]. Current literature shows that pitfall traps can be used in a variety of ways: to evaluate the distribution of macro invertebrates in diverse ecosystems at different scales, to describe activity patterns, habitat associations as well as to establish relative species abundances, or the effects that disturbance can have on biodiversity[12,14,16]. In some cases, pitfall traps are the only method that is a realistic alternative, as is the case of studies covering large geographic areas in which the aims are to establish a qualitative inventory or to compare different assemblages[14,15]. Pitfall trap sampling has the advantage of being a quick and cheap method. Furthermore, it works even in the absence of an observer[16]. This latter fact contributes to the objectivity of the pitfall trapping method (*i.e.*, reduces bias due to factors such as observer fatigue or knowledge about the environment or the biology of the species) and makes Comparisons better (e.g., daily and seasonal dynamics of activity, etc.)[21].

Pitfall traps are used extensively to sample ground-dwelling arthropods for systematic and ecological studies. They are inexpensive and easy to use and can be operated for relatively long periods of time without maintenance. These traps can collect arthropods in numbers that are suitable for rigorous statistical analysis, although their efficiency is influenced by many biotic and abiotic variables[7,20]. Because of this, studies of ground-dwelling arthropods in habitats where soil is thin or lacking, or where digging is difficult, are left with no satisfactory alternatives to pitfall traps. The total capture of arthropods in pitfall traps depends on several factors. On one hand, the number of individuals crossing the sampling area, which is largely, determined by species surface activity and their relative population densities[11]. On the other hand, captures also depend on some trap features and the sampled environment. At least 18 factors that affect the pitfall-trap capture efficiency are known: size of the trap, shape[1,11,20], materials of construction[11], type of preservative[9,11,16,18], physical characteristics of the environment[7,10,12], time of activation and the quantity of traps deployed[9]. Changes to any of these factors can have a profound influence on the capture probability and consequently on the resulting number of arthropods collected. Still, there is no uniformity in protocols of pitfall trapping and sampling is largely based on the researchers past experience[16].

Since conclusions drawn from samples are used to make hypotheses about populations as a whole, sampling procedure must be standardized to provide maximum information, within the experimental constraints of time, finance and manpower[21]. Therefore, to obtain reliable data on the structure of a community of ground dwelling arthropods in a determined area, it is recommended to improve site-specific settings of the pitfall sampling design. Preservation attributes, trap design, the fluid employed in traps, the number of traps deployed and time of activation, all affected the capture efficiency of the ground dwelling arthropod fauna in a. Area with mixed vegetation near Hotel Aadhar, Barbil, Odisha and b. Woodland area, Raeka, Odisha by pitfall trapping. During the present study it was observed that, a total of 25 families under 8 orders were recorded from the two selected study sites, out of which 19 families of insects which belongs to 7 orders were collected from study site 1 and on the other hand, 17 families of insects which belongs to 8 orders were collected from study site 2. Again, the family Thripidae which belongs to the order Thysanoptera, 2 families (Entomobryidae and Isotomidae) which belongs to the order Collembola, 2 families (Formicidae, Vespidae and Pompilidae) which belongs to the order Hymenoptera, 3 families (Drosophilidae, Muscidae and Tipulidae) which belongs to the order Diptera, 1 family Ptinidae which belongs to the order Coleoptera and 1 family Gryllidae which belongs to order Orthoptera were found in both locations. The result from the present study also showed that the highest number of families of insect species and Species richness (S) were observed in study site 1 (414 and 19), the lowest number of families of insect species and Species richness (S) were observed in study site 2 (204 and 17).

Site selection :

For this study, two sites of two different ecosystems of Barbil municipality of Odisha state of Eastern India were selected, one of which is mixed vegetation type, which is located near Hotel Aadhar (22.105742°N, 85.386876°S), and the other ecosystem is Raeka (22.097762, 85.409119) whose ecosystem is woodland (Fig. 1). Primarily, Woodland had many different types of short and tall trees, such as *Eupatorium odoratum*, *Elephantopus scabrai*, *Lagerstroemia parviflora* etc. and the mixed vegetation site has some large trees along with some smaller trees, such as *Mangifera indica*, *Aegle marmelos*, *Murraya paniculata* etc. which provide shade, while, the site with mixed vegetation has more crowd and traffic compared to Woodland site.

Trap setting and sampling :

A total of 162 pitfall traps were placed at these 2 study sites during the 3-day study period from 22nd January to 25th January, 2023. First, the pit is dug and the soil and rubbish are removed from the pit. Cups (8 cm

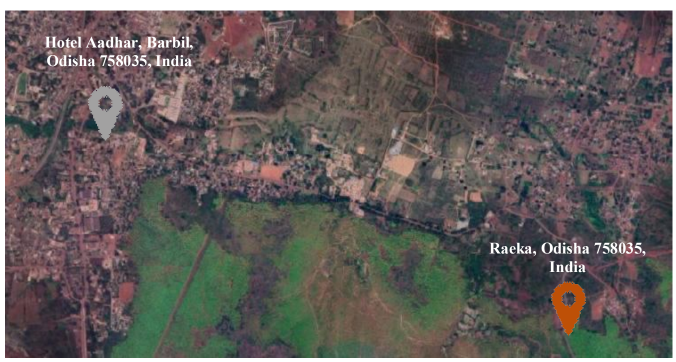

Fig. 1. Location of 2 study areas, a. Area of mixed vegetation ecosystem, near hotel Aadhar, Barbil, Odisha and b. Area with woodland ecosystem, Raeka, Odisha (https://www.google.com/maps/place/Hotel+Aadhar)

height and 6 cm diameter) were then placed inside these holes in such a way that the mouth of the cup was open and the edge was level with the ground, not above the ground. It must be ensured that the holes are equidistant from each other. ¼th of each cup was filled with soapy water, so that when the insects got inside the cup, they could not get out. A total of 54 cups for pitfall trap were placed daily and each cup was kept for 1 night. After that, insect samples are taken from each cup with the help of forceps. Thereafter, the sample of insects were washed and they were taken from each cup and preserved in tubes separately with a solution of 70% alcohol and each tube was labelled separately so that when the tubes were brought to the lab we can differentiate by that label. Then, in the lab each sample of insects is put into the Petri dish and identified following the classificatory scheme of Imm's[8] according to their order and family separately from pictures taken on the stereo binocular microscope. Thereafter, under the microscope, each insect is also counted according to their family.

Data analysis :

For the statistical analysis of the soil litter insect fauna recorded from the 2-study areas were analysed by using various diversity indices, which are as follows:

Numerical species richness (S) = number of species per specified number of individuals

Simpson's Reciprocal Index = $1/D = 1/\Sigma n_i(n_i-1)/N(N-1)$

Where, Σ = sum of (Total)

ni = the number of individuals of each different species

N = the total number of individuals of all the species

The Shannon-Wiener index (H)=- [Σ(ni/N) × ln(ni/N)]

Where, Σ = sum of (Total)

ni = the number of individuals of each different species

N = the total number of individuals of all the species

Mean (X) = the sum of the observations divided by the total number of observations Also, heat map analysis visualizes the number of insects by family in a graphical way in the form of hot and cold spots using a warm to cool colour scheme. Graphical representation was prepared by using MS - Excel software (Version, 2007).

Different types of insect orders and families which were collected during the present study by means of pitfall trapping procedure from two study sites of Barbil and the abundance of insect orders and families in the study areas has been listed in Table-1.

As perusal of Table-1 indicates that out of total 25 families, 19 families of insects which belongs to 7 orders were collected from study site 1 and on the other hand, 17 families of insects which belongs to 8 orders were collected from study site 2. Of those, family Thripidae which belongs to the order Thysanoptera, 2 families (Entomobryidae and Isotomidae) which belongs to the order Collembola, 2 families (Formicidae and Vespidae) which belongs to the order Hymenoptera, 3 families (Drosophilidae, Muscidae and Tipulidae) which belongs to the order Diptera, 1 family Ptinidae which belongs to the order Coleoptera, 1 family Cicadellidae which belongs to order Hemipteraand 1 family Gryllidae which belongs to order Orthoptera were found in both locations.

However, 1 family Pompilidae of order Hymenoptera; 5 families (Psychodidae, Tephritidae, Cecidomyiidae, Stratiomyidae and Syrphidae) of order Diptera and 2 families (Nitidulidae and Chrysomelidae) of order Coleoptera which were only found in study site 1 but not found in study site 2. On the other side, 2 families (Culicidae and Chironomidae) of order Diptera; 1 family Pentatomidae of order Hemiptera; 2 families (Carabidae and Staphylinidae) of order Coleoptera and 1 family Rhinotermitidae of order Isoptera were only found in study site 2 but not found in study site 1 (Fig 5 and Fig 6).

Table-1. Occurrence of Insects Order/Family wise from 2 different Ecosystems of Barbil

Order	Family	Number of insects (upto family)			
		Study site-1 (Mixed vegetation)	Total number of insects (According to order)	Study site-2 (Wood-land)	Total number of insects (According to order)
Thysanoptera	Thripidae	18	18	06	06
Collembola	Entomobryidae	131	178	72	76
	Isotomidae	47		04	
Hymenoptera	Formicidae	142	153	88	90
	Vespidae	09		02	
	Pompilidae	02			
Diptera	Drosophilidae	04	33	02	16
	Psychodidae	05			
	Tephritidae	05			
	Muscidae	13		05	
	Cecidomyiidae	01			
	Stratiomyidae	03			
	Syrphidae	01			
	Tipulidae	01		01	
	Culicidae			03	
	Chironomidae			05	
Hemiptera	Cicadellidae	10	10	01	02
	Pentatomidae			01	
Coleoptera	Ptinidae	07	18	03	06
	Nitidulidae	08			
	Chrysomelidae	03			
	Carabidae			02	
	Staphylinidae			01	
Orthoptera	Gryllidae	04	04	07	07
Isoptera	Rhinotermitidae			01	01
	Total		414		204

Fig. 2 shows that have the darkest colours to determine which families have the highest number of species and also have the lowest colours to determine which families have the lowest. Formicidae was the richest family in the 2 study areas that comprised (142 and 34%) and (88 and 43%) species of insects followed by Entomobryidae with (131 and 32%) and (72 and 35%) species. In the study site 1, 3 families (Cecidomyiidae, Syrphidae and Tipulidae) among 19 families were the lowest with (1 and 0%) species respectively each as indicated in (Fig. 3) and in the study site 2, 4 families (Tipulidae, Cicadellidae, Pentatomidae and Staphylinidae) among 17 families were the lowest with (1 and 0%) species respectively each as indicated in (Fig. 4).

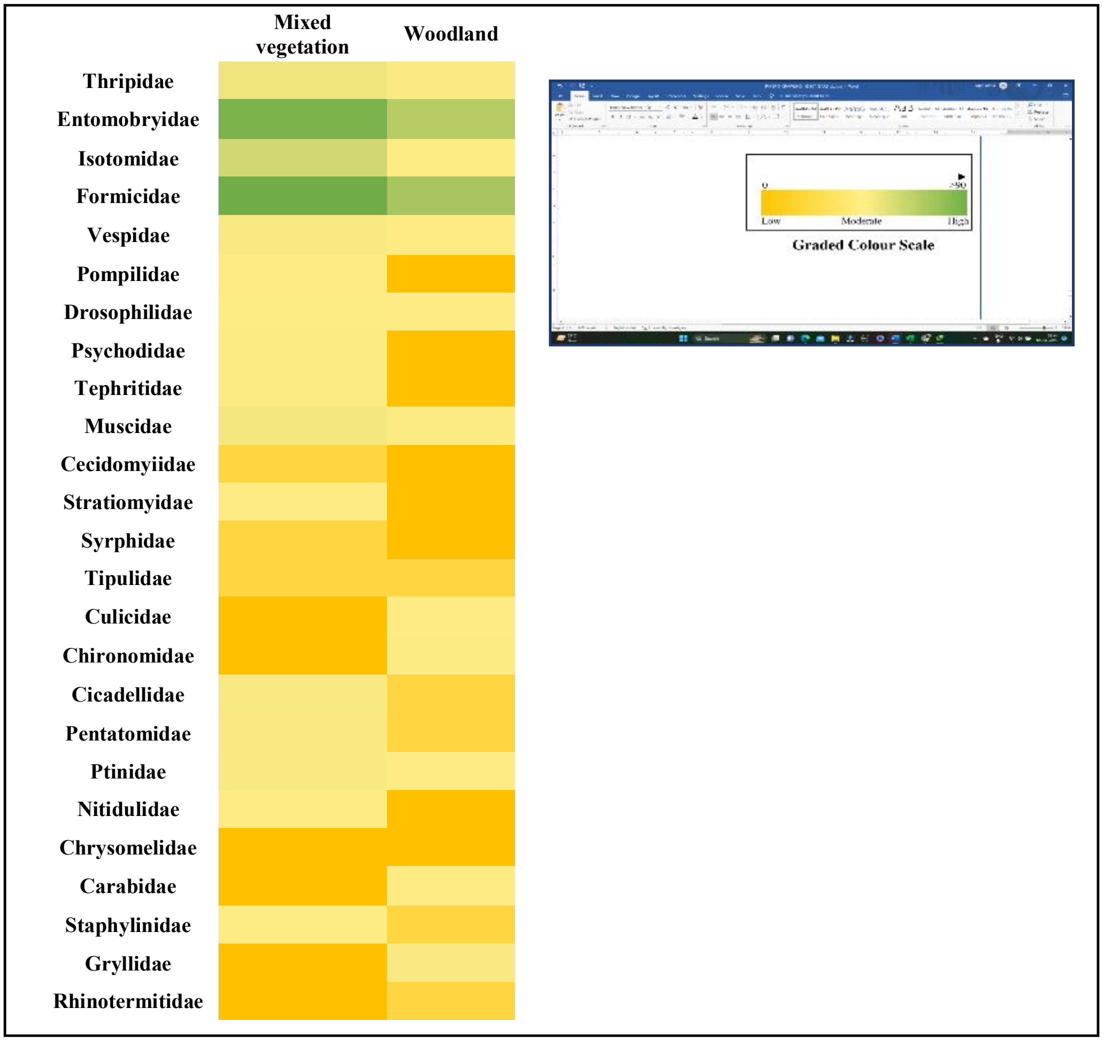

Fig. 2: Heatmap showing the abundance of different families of insect species in 2 different ecosystems of Barbil during the study period (from 22nd January to 25th January, 2023).

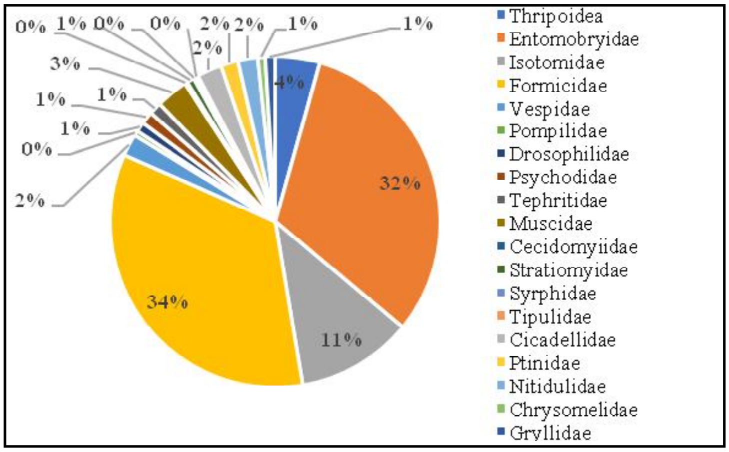

Fig. 3: Family wise percentage composition of the species of insects in the study site 1

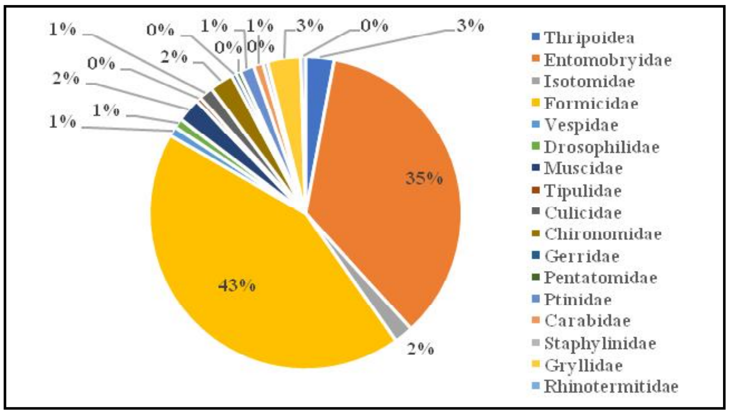

Fig. 4: Family wise percentage composition of the species of insects in the study site 2

The diversity of the families of insect species observed in the study area is presented in (Table 2). The result showed that the highest number of families of insect species and Species richness (S) were observed in study site 1 (414 and 19), the lowest number of families of insect species and Species richness(S) were observed in study site 2 (204 and 17).

Table-2. Comparing Biodiversity Indices of 2 different ecosystems at Barbil (according to different families)

Location	Species richness (S)	Simpson's reciprocal index (D)	Shannon-Wiener index (H)
Mixed vegetation	19	4.237	1.879
Woodland	17	3.175	1.599

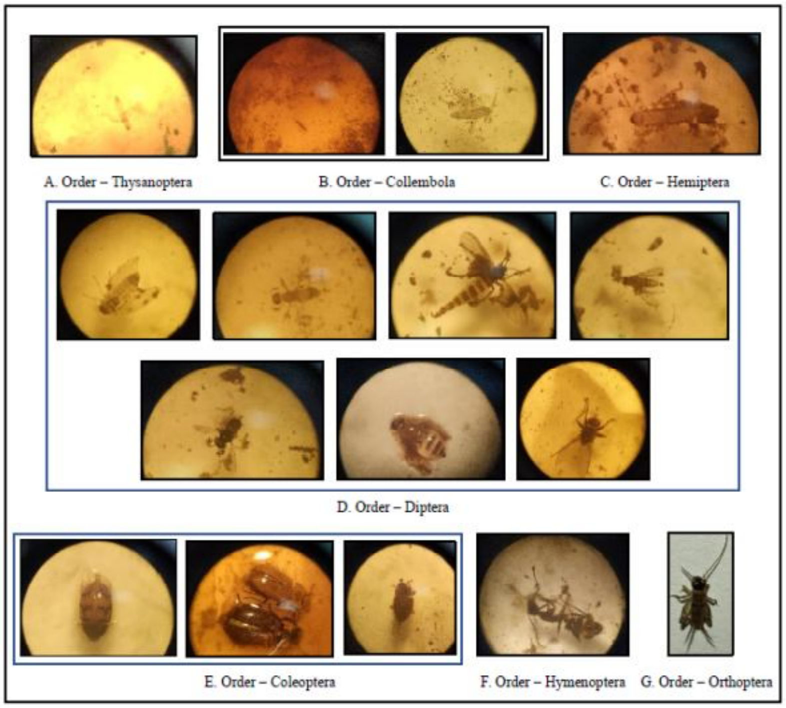

Fig. 5: Pictures of few insects collected in study site 1 during the study period

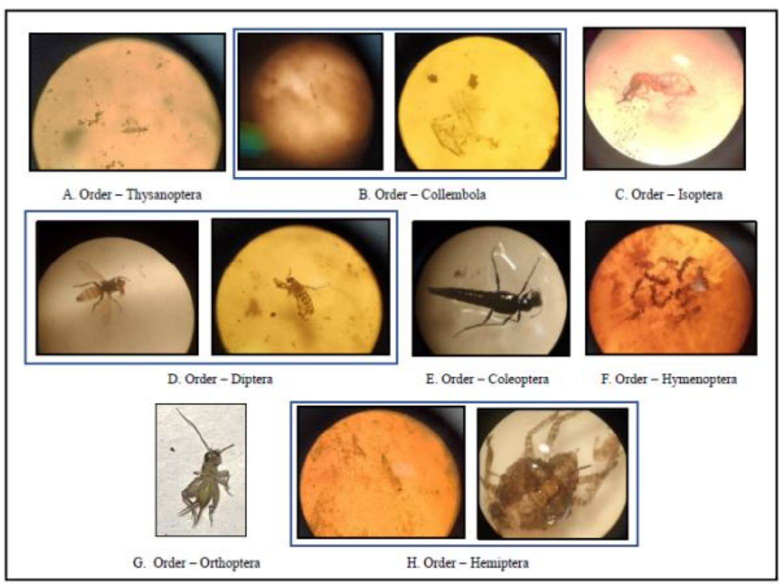

Fig. 6: Pictures of few insects collected in study site 2 during the study period

As is known that, in case of Simpson reciprocal index (1/D), the lowest value for this index is 1 and the highest value is equal to the number of species. The higher the value for this index, the greater the diversity of the species. During the present study, in case of study site 1, there are 19 different families of insect species then the maximum value for this index would be 19 and in case of study site 2, there are 17 different families of insect species then the maximum value for this index would be 17. As the number of different families of insect species in the study site 1 is higher than the study site 2. So, study site 1 is more diverse than the study site 2. Also know that, as species richness (S) increases, so diversity increases, that means species richness is directly proportional to diversity. So, study site 1 is more diverse than study site 2.

The Shannon-Wiener index (H) is an index that seeks to measure the diversity of species, considering their uniformity. The higher the value of H, the higher the diversity of species in a particular community. Shannon-Weiner index was higher in study site 1 (mixed vegetation ecosystem), that is 1.879 which is higher than the study site 2 (woodland ecosystem), that is 1.599. So, the ecosystem of mixed vegetation is more diverse than the woodland ecosystem (Fig. 7).

Past investigators have used pitfall traps more than any other technique to measure arthropod abundance or biomass and the use of pitfall traps has increased over time. Brown and Matthews[3] proposed a standardized pitfall trap design, which, if embraced by the wildlife community, would help future researchers to produce data that would allow more synthetic analyses.

During the present study in 2 different ecosystems of Kendujhar district, Odisha different ground dwelling insect orders and families were collected. The occurrence of 25

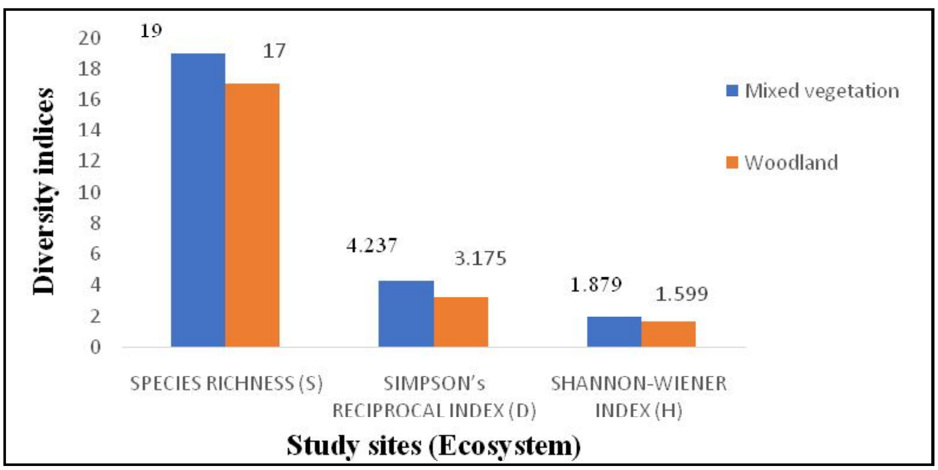

Fig. 7: Bar diagram showing Diversity indices like Species richness (S), Simpson's Reciprocal index (1/D), Shannon-Weiner index (H). Index at Study site 1: Mixed vegetation, Study site 2: Woodland

families of insects belonging to 8 orders reveals during examination of the collected specimens. Of them, 10 families belong to the order Diptera; 5 families belong to the order Coleoptera; 3 families belong to the order Hymenoptera; 2 families each belong to order Hemiptera and order Collembola and 1 family each belongs to the order Thysanoptera, Orthoptera and Isoptera.

Cleary, the use of pitfall traps with distinct efficiency will give a different impression of species richness and abundance in a community. It is well appreciated that capture rates of pitfall traps depend on trapping efficiency, species activity and species density[5]. Because of these distortions many authors concluded that this trapping method is of limited value for quantitative estimations of population sizes or for the comparison of communities[2,7]. Still, there is an extensive use of pitfall traps. The high numbers of species recorded in pitfall traps, coupled with the continuous nature of their sampling, would argue in favour of their use[2]. Litter faunabelonging to ten orders belonging to three classes, Insecta (Hymenoptera, Coleoptera, Orthoptera, Diptera, Dermaptera, Hemiptera), Crustacea (Amphipoda and Isopoda) and Arachnida (Araneae and Opiliones) were recorded using wet pitfall traps in different ecosystems in Taralu estate area[6]. Mouhoubi, Djenidi and Bounechada[13] study to assess entomofauna biodiversity at three saline wetlands, located in Setif region, North-eastern Algeria.

In any case, an environment specific testing that considers the influences of preservation attributes and sampling efficiency as presented here should be carried out prior to any extensive sampling.

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