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Staphylinidae family inhabiting rice agro-ecosystem at Ernakulam district

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Abstract
Rice fields are wetland ecosystems with a high degree of environmental heterogeneity that harbors varied fauna. The present study was carried out in agro-ecosystem at Ernakulam district to document the biodiversity of inhabiting *Staphylinidae* family during three different stages of rice cultivation, namely Pre-harvesting, Harvesting and Post harvesting. A total of 10,039 *Staphylinidae* beetles, belonging to five subfamilies *viz*, Oxytelinae, Staphylininae, Paederinae, Aleocharinae, Tachyporinae were collected from the study site during a 2-year period. The subfamilies, Staphylininae, Aleocharinae, Oxytelinae, Paederinae were recorded in all three stages of rice cultivation. The collected species have been observed to follow a uniform pattern of seasonal colonisation and succession. The biodiversity of irrigated rice is of concern to both agroecologists and conservation biologists. Integrated efforts can therefore result in the creation of biodiversity-based strategies as an organising principle for the sustainable management of the agro-ecosystem.

Keywords: *Staphylinidae*, agro-ecosystem, rice field, beetle, biodiversity, crop management

Introduction

Rice is the primary food crop of Kerala accounting for about 28 percent of the total harvested area and for more than 99 % of the production of cereal in the state. Rice is considered a good source of protein as well as a staple food in many parts of the world. Rice cultivation is thought to be one of the oldest forms of rigorous agriculture by man [3]. And there is historical evidence that rice was considered as the staple food and the first cultivated crop in Asia [5]. Rice cultivation has increased to nearly 158 million ha in all over the world with approximately 90% of the production in developing countries [10]. According to 2011 statistical data, China was the largest producer followed by India. According to the USDA report, India was the world's largest exporter of rice with 9.75 million tons.

Staphylinidae is an ancient family of beetles primarily distinguished by their short elytra (wing covering) that leave more than half of their abdomen exposed. These beetles are called a rove beetles and they belong to the suborder Polyphaga of order Coleoptera. And this group is the second largest family of beetles after the Cuculionidae (the true weevils). However more than 58,000 scientifically described species are present worldwide and probably over 75% of the tropical species still undescribed [12]. Linnaeus was the first who use the name Staphylinus. The family is distributed worldwide and found practically in all types of ecosystem. Mainly they are seen under stones, under tree bark, near streams, in leaf litter and in dung [1, 8]. But, about half of the species are found to be present in soil and litter [12].

Rice feed insects are dynamic and their relative importance is changing. With time due to changes in rice production methods, climate, yields and varieties-and in many cases due to undetermined factors. The infestation of the rice crop by different species is related to the growth stage of the plant. Insects feed on all areas of the rice plant throughout the rice-growing regions of the world. The fauna of Kerala's *Staphylinidae* has been studied quite poorly so far though Iran is a wide country and includes a number of geographical regions. This study deals with the fauna of this taxon in rice fields of Ernakulam district. Our objective is to provide the information about the biodiversity of rice field inhabiting *Staphylinidae* family beetle during three different stages of rice cultivation, namely Pre-harvesting, Harvesting and Post harvesting. Our results can assist in the experimental design of further studies in the area.

Materials and methods

1. Study area

The study was conducted during the pre-harvesting, harvesting, post-harvesting stages of paddy cultivation in a village of Udayamperoor, Ernakulam district, Kerala, India for the period of 2 years. It is located in the 9º57' North latitude and 76 º15' East longitude with an area of 2407 sq. km. There are three methods selected for the collection of beetles they are light traps, floatation method and baited pitfall traps. Sampling was conducted during paddy crop cultivation during 2017 and 2018 respectively. Five plots were randomly selected for each time of sampling. Different sample collection method opted for the collection of the *Staphylinidae* group.

Two to six-hour old fresh cow dung pats were collected early in the morning. It can be easily differentiated by its green colour, smell, and physical appearance. Thirty dung pats, having the weight of 250 g each was placed in different sites. The distance between pats was maintained as 10 meters. After 3days, dung pats were collected from each site and analyzed. Beetles were extracted from the pat by floatation method (Moore, 1954) and preserved in 70% ethyl alcohol. Vials tagged with labels providing information about the site, location, time and date. In the light trap's method, light traps were placed in the paddy field with soap solution from 6pm to 11pm. Due to the presence of light, beetles were attracted and falls into the

solution and these beetles were collected and preserved in 70% ethyl alcohol for further work. Baited pitfall trap was also used for collection. The bait is used to attract the insects which will finally fall into the trap containing soapy water. The trap is placed with their top at the ground level. Samples are collected are stored in labelled vials.

Collected rove beetles were examined and sorted under Stereo Zoom Trinocular Microscope (LABOMED- 200 MAR, CODE- ZM 45 TM) and adult organisms were identified to species level according to the abundance using keys [2, 7] and by taking the photographs of the entire body of the rove beetles using an image processing system (NIKON D 90 –DSLR CAMERA). Once the identification was done beetles were removed and placed in a small vial containing 70% ethyl alcohol. After the identification of beetles, they were sorted on the basis of the taxon and transferred beetles of the same taxon into a common vial. Each vial containing a clearly displayed label containing information about all the sites, location, number and collection date, taxon name and preservation date. The count of each category of beetles was entered.

All assemblage parameters in this study were calculated based on the average density of *Staphylinidae* in each harvesting time. The Shannon-Wiener Index (H'), Pielou's evenness index (J') and Simpson's diversity function (D) were used to determine the diversity among *Staphylinidae* in each level of harvesting time. High numbers on H' signify high diversity, whereas low values on D indicate high diversity [14]. Non-parametric test, Kruskal Wallis was used to analyze the seasonal and collecting variations of *Staphylinidae* [13]. All diversity estimation was done with PRISM software [6]. The inspections of *Staphylinidae* per rice plot fitted to distributions, which would be expected if these family of beetles are randomly spread (Poisson distribution) or aggregated (negative binomial distribution). The distribution pattern of beetles was statistically classified by calculating the Variance-to-mean ration (S_2/X). For the distribution pattern, the value is higher than 1.0 (>1.0) shows aggregated form, the values are equal to 1.0 (=1.0) indicates random form whereas the values lower than 1.0 (<1.0) it means a regular pattern of *Staphylinidae*.

Results & Discussion

A list of the collected beetles from different harvesting time for 2 years was summarized in Table 1. A total of 10,039 *Staphylinidae* beetles, belonging to the five subfamilies *viz*, Oxytelinae, Staphylininae, Paederinae, Aleocharinae, Tachyporinae were collected from the study site during the entire study period. Of all beetles, Oxytelinae was the most abundant subfamily and Tachyporinae was the least abundant subfamily among collected *Staphylinidae* beetles for the first year. Staphylininae, Aleocharinae, Oxytelinae, Paederinae were recorded in all three stages of rice cultivation. During the initial year study, on the seasonal comparison, the highest diversity of Staphylindae family was recorded in the post harvesting (H'=1.6) period during 2017. Oxytelinae recorded the highest diversity in harvesting (H'=2.1). Staphylininae, Paederinae, Aleocharinae and Tachyporinae were recorded highest diversity during Post harvesting. Two tribes of Staphylininae were recorded namely Staphylinini and Xantholini. Subfamily Paederinae contains a single tribe Paederini with genus include Paederus, Scopaeus, Thinocharis, Lathrobium, Scimbalium, Sclerochiton, Acanthoglossa and Cryptobium. Subfamily Aleocharinae contains three tribes namely Pronomaeini, Oligotini, and Myllaeinini. All the collected species showed significant variation in abundance between different seasons (Table 1).

Among the estimated diversity indices, the Shannon-Wiener index (H') for all Staphylininae beetles was high for different stages of paddy cultivation. During the first year the H' range was 1.5 to 1.6 with high evenness (J'=0.99). And the dominance by the Simpson index was high for pre-harvesting time (D=0.80). During the second year, high diversity was noticed during harvesting and post harvesting period, the Shannon-Wiener index (H') was 1.6 with high evenness (J'= 0.99). However, the dominance by the Simpson index was high for all harvesting period (D= 0.79). All species indices are presented in Table 2. Moreover, significant differences in the species diversity indices of rice harvesting stages were detected ($p<0.05$) in all comparisons. For the spatial distribution pattern of *Staphylinidae*, the distribution indices Variance-to-mean ratio (S^2/X) was 0.99 indicates there is very evenly spread across all stages of paddy cultivation throughout the study period.

1. Discussion

Rice is the main cereal crop in the developing world and is the staple food of more than half of the world's population. The results clearly depict that the irrigated rice field is an agro-ecosystem that retains a high *Staphylinidae* family richness in the selected study site. The rice plant is the perfect host for a wide variety of insect species. All parts of the plant, from the root to the growing grains, are affected by various organisms. There are about 800 insect species in the world that can damage rice in the field or in storage, but most of the species that feed on rice are of minor importance. In addition, the distribution and abundance of species varies between the rice ecosystems within a given area as well as climate [4]. High abundance of *Staphylinidae* beetles from the study site is mainly due to the moist or humid condition and presence of marshy lands. The high abundance in the post harvesting stage is mainly due to the presence of a large amount of decaying matter and moisture conditions of the paddy field after harvesting. In post harvesting stage, increase of decaying matter and the animal materials like dung make suitable habitat for them. The documentation of rice field biodiversity represented in terms of species richness was made possible by a variety of methods targeting different classes.

The value of staphylinid predation on pests has been repeatedly demonstrated in the literature. Populations of pest insects and mites are subdued in a wide variety of crops (agricultural, horticultural and forest entomology) and biting flies (including mosquitoes) and fleas (medical and veterinary entomology). Their presence in the carrion gives them a role to play in forensic entomology. *Staphylinidae* form a substantial part of the world's biodiversity. The results revealed that such biodiversity parameters as richness, diversity and composition of these beetles differ during various rice cultivation for two years. All indices also exhibited relatively high values. Based on the obtained

results, it may be concluded that the distribution form beetles obtained in this study revealed mostly even spread.

Table 1: Total number of Staphylininae beetles recovered during paddy cultivation in the period of 2017 to 2018

Season	Subfamily	1st Year (2017)	2nd Year (2018)
Pre-harvesting	Oxytelinae	403	327
	Staphylininae	314	305
	Paederinae	412	350
	Aleocharinae	326	335
	Tachyporiae	463	480
Harvesting	Oxytelinae	630	300
	Staphylininae	325	330
	Paederinae	314	301
	Aleocharinae	259	320
	Tachyporiae	369	431
Post harvesting	Oxytelinae	106	320
	Staphylininae	230	341
	Paederinae	212	315
	Aleocharinae	303	319
	Tachyporiae	368	388

Table 2: *Staphylinidae* diversity in different stages of paddy cultivation during 2017 and 2018. Hmax= Maximum species diversity; H'= Shannon Wiener index of diversity; J'= Pielou's evenness index; D= Simpson's index; d= Margalef species richness

Cultivation time	Hmax		H'		J'		D		D	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Preharvesting	1.5	0.99	1.6	1.5	0.99	0.98	0.79	0.7	0.66	0.53
Harvesting	1	1	1.5	1.6	0.99	0.99	0.77	0.79	0.66	0.53
Postharvesting	1		1.5	1.6	0.93	0.99	0.77	0.79	0.6	0.53

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