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ON A COLLECTION OF BRACONIDAE FROM THREE RICE GROWING ZONES OF TAMIL NADU

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ABSTRACT

Surveys were conducted to explore the braconid fauna in rice ecosystems of Tamil Nadu during 2015-16 in three different rice growing zones viz., western zone, Cauvery delta zone and high rainfall zone. A total of 574 braconids with 18 species under 8 subfamilies were collected. Alpha and beta diversity were computed for the three zones. The diversity indices (Simpson's index, Shannon-Wiener index, Pielou's index) revealed that high rainfall zone is the most diverse zone, with Cauvery delta zone being the least diverse. *Macrocentrus philippinensis* was the dominant braconid with a relative abundance of 19.3%. On comparing the species similarities using the Jaccard's index in three zones taken in pairs, it was observed that 53% similarity existed between western and Cauvery delta zones, it was 44% between the high rainfall and Cauvery delta zones, and 50% as regards the high rainfall and western zones.

Key words: Diversity, indices, parasitoids, Braconidae, rice ecosystem, Jaccard's index, similarity

Rice (*Oryza sativa* L.), is an annual grass native to Asia. Rice fields have been in existence since the beginning of organized agriculture. Since then a rich biodiversity has become associated with rice fields. It is an ecosystem that sustains not only the people whose staple diet is rice but also a diverse assemblage of insects that have made rice fields their niche. (Edirisinghe and Bambaradeniya, 2006). In India, rice is not just a food stuff, but a culture. Tamil Nadu, one of the leading rice growing states in India, has been cultivating rice from time immemorial as this state is endowed with all favourable climatic conditions suitable for growing rice. Rice fields harbour a rich and varied fauna than any other agricultural crop. Rice fields have unique characteristics that make them ideal grounds for diverse biological organisms (Heckman, 1979; Fritz et al., 2011). Insect pests are reported as the major threat to its production.

More than 800 species of insects are known to infest rice, of which about 20 species are of economic importance. The overall losses due to insect pest damage in rice are estimated at 25% (Pathak and Dhaliwal, 1981; Dale, 1994). Farmers generally rely on insecticides to combat pest problems of rice. Indiscriminate use of insecticides results in the loss of biodiversity of beneficial organisms like parasitic hymenopterans (Dudley et al., 2005). Reducing the mortality of parasitic hymenopterans caused by insecticides is essential for greater sustainability in rice pest management (Heong and Hardy, 2009; Gurr et al., 2011). Parasitic hymenopterans especially braconids are the best alternatives to pesticides. They show greater stability to the ecosystem than any group of natural enemies of insect pests because these are capable of living and interacting at lower host population level. To aid this means of pest control, it is essential that the diversity of parasitoids needs to be studied first (Dey et al., 1999).

Braconidae is one of the largest and taxonomically difficult families of Ichneumonoidea and are primary or secondary parasitoids attacking a large range of insect orders in their various stages of development, thereby playing a pivotal role in the control of insect pests in nature. All braconids are parasitic, but they do not attack Mecoptera, Siphonaptera, and Strepsiptera. Larvae, pupae, and immatures in cocoons are preferred. Adults are often associated with moist habitats and extensive ground cover (Matthews, 1974; van Achterberg, 1984). The diversity of braconids associated with rice ecosystem is poorly studied especially in Tamil Nadu. Any additional knowledge in diversity, taxonomy and biology is of potential practical value. In this context, the present study was undertaken to explore the diversity of braconid fauna in rice ecosystems of Tamil Nadu.

MATERIALS AND METHODS

The field survey was carried out in the rice fields during 2015-16 in three agroclimatic zones of Tamil Nadu viz., western zone (District representation: Coimbatore at, Paddy Breeding Station, Coimbatore (427 masl, 10°59'43.24''N, 76°54'59.22''E), Cauvery delta zone (District representation: Thiruvarur at, Krishi Vigyan Kendra, Needamangalam (26 masl, 10°46'23.93'' N, 79°25'0.96'' E) and high rainfall zone (District representation: Kanyakumari at Agricultural Research Station, Thirupathisaram, 17 masl, 8°12'16.70''N, 77°26'57.84''E). Collections were made for 20 consecutive days in each zone to give equal weightage and to minimize chances of variations. The time of sampling in each zone was decided by the rice growing season and the stage of the crop i.e., 20 days during August- September, 2015 in western zone, October- November, 2015 in high rainfall zone and December, 2015 - January 2016, in Cauvery delta zone. Sweep net, yellow pan trap kept at ground level and yellow pan trap erected at canopy levels were employed.

The sweep net employed for collecting was essentially similar to an ordinary insect net with 673 mm mouth dia and a 1076 mm long aluminum handle. The frame can be fitted to one end of the handle. This facilitates easy separation of the frame. The long handle allows the net to be used as far as possible making the sweeping easier and effective. The net bag was made up of thin cotton cloth. It measures about 600 mm in length and has a well- rounded bottom. The top of the bag which fits around the frame was made up of a canvas. The canvas was folded over the frame and sewed in position. Sweeping of vegetation was as random as possible from ground level to the height of the crop. Sweeping was done in early morning and late evening hours for about half an hour per day which involved 30 sweeps. One to and fro motion of the sweep net was considered as one sweep.

Yellow pan traps kept at ground level are shallow trays of 133 x 195 mm and 48 mm deep and were of bright yellow, with twenty yellow numbers installed on the bunds. These are half- filled with water containing a few drops of commercially available detergent (to break the surface tension) and a pinch of salt (to reduce the rate of evaporation and to prevent rotting of trapped insects). The spacing between traps was standardized as 1.5 m. The traps were set for a period of 24 hr (Example: traps set at 10 a.m. on one day was serviced at 10 a.m. on the following day). These same yellow pan traps were installed at the crop canopy by means of polyvinyl chloride pipes fitted below, with a screw attachment and were installed in 10/ site.

The parasitoids thus collected were preserved in 70% ethyl alcohol, later dried, mounted on triangular cards and identified using taxonomic keys under a Stemi (Zeiss) 2000-C and photographed under Leica M205A stereozoom microscopes. These identified specimens were deposited in the Insect Biosystematics Laboratory, Tamil Nadu Agricultural University, Coimbatore. The diversity indices viz., relative Density (%) = (No. of individuals of one species / no. of individuals of all species) x 100; and alpha diversity quantified using Simpson's diversity index (*SDI*), Shannon-Wiener Index (*H'*), Margalef Index (α) and Pielou's Evenness Index (*E1*).

Simpson's diversity index $D = \Sigma n\ (n-1)/\ N(N-1)$ where n = total number of organisms of a particular species and N = total number of organisms of all species (Simpson 1949). Subtracting the value of Simpson's diversity index from 1, gives Simpson's Index of Diversity (SID). The value of the index ranges from 0 to 1, the greater the value the greater the sample diversity. Shannon-Wiener index Shannon-Wiener index $H' = -\Sigma\ Pi \ln(Pi)$, where $Pi = S / N$; S = number of individuals of one species, N = total number of all individuals in the sample, *ln* = logarithm to base e (Shannon & Wiener 1949). Margalef index $\alpha = (S - 1) / \ln (N)$; S = total number of species, N = total number of individuals in the sample (Margalef 1958). Pielou's evenness index $E1 = H' / \ln(S)$; H' = Shannon-Wiener diversity index, S = total number of species in the sample (Pielou 1966; (Magurran 1988). Beta diversity, the most widely used being Jaccard Index (JI) (Jaccard 1912)- JI (for two sites) $= j / (a+b-j)$, where j = the number of species common to both sites A and B, a = the number of species in site A and b = the number of species in site B. It is assumed the data to be normally distributed and adopted parametric statistics for comparing the sites.

The ANOVA was also used to check the differences between the three zones, for which the data were transformed into x+0.5 square root before statistical analysis. The mean individuals caught from three different zones were analyzed adopting Randomized block design (RBD) to find least significant difference (LSD). Critical difference (CD) values were calculated at p = 0.05. All these statistical analyses were done using Microsoft Excel 2016 version and Agres software version 3.01.

RESULTS AND DISCUSSION

In the present study, a total of 574 braconid individuals were collected from rice ecosystem that represents 18 species under 8 subfamilies. Under the subfamily Braconinae, species such as *Bracon brevicornis* (Wesmael), two indetermined species of *Bracon, Amyosoma chinensis* (Szepligeti), *Stenobracon nicevillei* (Bingham) and *Tropobracon luteus* Cameron were collected. Under Cheloninae subfamily, two species viz., *Chelonus formosanus* Sonan and *Phanerotoma* sp. were collected. Three species viz., *Rinamba* sp., *Spathius agrili* Yang and *Spathius* sp. were collected under the subfamily Doryctinae. Only one species *Macrocentrus philippinensis* Ashmead was collected under the subfamily Macrocentrinae. Under Microgastrinae, species such as *Apanteles colemani* Viereck and *Cotesia falvipes* Cameron were collected. An indetermined species of the *Opius* was collected under the subfamily Opiinae. Under the subfamily Horminae, *Parahormius* sp. and one indetermined species were collected. One indetermined species under the subfamily Cardiochilinae was also collected. From western, Cauvery delta and high rainfall zones the number of species caught were 12, 11 and 15 respectively. Table 1 reveals that *M. philippinensis* was the most dominant in rice ecosystem with a relative density of 19.3%. The ANOVA indicated that, the p-value of species such as *Bracon* sp.1, *C. formosanus, Cotesia flavipes, M. chinensis, Phanerotoma* sp. *S. nicevillei*, two indetermined species of subfamily Horminae and Cardiochilinae were >0.05 and so it is evident that there was significant difference between the zones (Table 1).

Mean number of braconids collected/ day from western zone was 9.00 ± 1.69, while it was 8.15 ± 2.07 from Cauvery delta zone and 11.55 ± 2.99 from high rainfall zone. Simpson's index of diversity is highest for high rainfall (0.89) followed by western (0.88) and Cauvery delta zone (0.89). Daniel et al. (2017) obtained similar results on the diversity of pteromalids of rice ecosystems in Tamil Nadu. The species composition among elevational zones can indicate how community structure changes with biotic and abiotic environmental pressures (Shmida and Wilson 1985; Condit et al., 2002). Studies on the effect of elevation on species diversity of taxa such as spiders (Sebastian et al., 2005), moths (Axmacher and Fiedler, 2008), paper wasps (Kumar et al. 2008) and ants (Smith et al., 2014) reported that species diversity decreased with increase in altitude. However, according to Janzen (1976), diversity of parasitic Hymenoptera is not as proportionately reduced

Table 1. Braconids- from three rice growing zones of Tamil Nadu

Species	Zones						Total			
	Western		Cauvery Delta		High Rainfall					
	No.	%	No.	%	No.	%	No.	%	F	P
Amyosoma chinensis	11	6.1	0	0.0	19	8.2	30	5.2	3.24	0.04
Apanteles colemani	0	0.0	11	6.7	13	5.6	24	4.2	2.27	0.11
Bracon brevicornis	0	0.0	19	11.7	20	8.7	39	6.8	1.81	0.17
Bracon sp. 1	4	2.2	0	0.0	18	7.8	22	3.8	3.48	0.03
Bracon sp. 2	0	0.0	0	0.0	4	1.7	4	0.7	2.92	0.06
Cardiochilinae	18	10.0	0	0.0	8	3.5	26	4.5	3.48	0.03
Chelonus formosanus	23	12.8	28	17.2	0	0.0	51	8.9	3.46	0.03
Cotesia falvipes	0	0.0	0	0.0	27	11.7	27	4.7	8.00	0.00
Horminae	0	0.0	0	0.0	21	9.1	21	3.7	5.58	0.00
Macrocentrus philippinensis	9	5.0	46	28.2	56	24.2	111	19.3	2.32	0.10
Opius sp.	7	3.9	5	3.1	4	1.7	16	2.8	0.19	0.82
Parahormius sp.	2	1.1	9	5.5	7	3.0	18	3.1	1.11	0.33
Phanerotoma sp.	16	8.9	2	1.2	1	0.4	19	3.3	3.45	0.03
Rinamba sp.	41	22.8	22	13.5	0	0.0	63	11.0	3.00	0.05
Spathius agrili	24	13.3	0	0.0	16	6.9	40	7.0	2.41	0.09
Spathius sp.	8	4.4	14	8.6	5	2.2	27	4.7	1.13	0.32
Stenobracon nicevillei	0	0.0	5	3.1	12	5.2	17	3.0	3.18	0.04
Tropobracon luteus	17	9.4	2	1.2	0	0.0	19	3.3	2.84	0.06
Total No. collected	180	-	163	-	231	-	574	-		
Species No.	12	-	11	-	15	-	18	-		-

%- Relative Density, No.- Total number of individuals collected, F-Value, P-Value

Table 2. Diversity indices (Braconidae)- three rice growing zones- Tamil Nadu

Zones	No. of Braconidae collected/day	Std. Error	SID	*H'*	α	*E1*	β %
Western	9.00 (2.85)	± 1.69	0.88	0.98	2.11	0.39	W and C - 53
Cauvery Delta	8.15 (2.58)	± 2.07	0.84	0.89	1.96	0.37	C and H - 44
High Rainfall	11.55 (2.99)	± 2.99	0.89	1.04	2.57	0.38	H and W-50
S.ED	0.46	-	-	-	-	-	-
CD (p=0.05)	0.93	-	-	-	-	-	-

Figures in parentheses square root transformed values; In a column, means followed by a common letter(s) not significantly different by LSD (p=0.05).; SID- Simpson's Index of Diversity, *H'*- Shannon-Wiener Index, α- Margalef index, *E1*- Pielou's index, β-Beta diversity (Jaccard Index); W- Western Zone, C- Cauvery Delta Zone, H- High Rainfall Zone

by elevation as in other insect groups, a fact that is in support of our results. A similar study conducted by Shweta and Rajmohana (2016) to assess the diversity of members belonging to the subfamily Scelioninae also declared that the elevation did not have any major effect.

A similar trend was observed in Shannon-Wiener index also with 1.04, 0.98 and 0.89 for high rainfall western and for Cauvery delta zones, respectively. Margalef index was maximum for maximum rainfall zone (2.57) followed by western zone (2.11) and Cauvery delta zone (1.96). The species evenness was the highest for western zone (0.39) followed by high rainfall zone (0.38) and Cauvery delta zone (0.37). The elevational diversity gradient (EDG) in ecology proposes that species richness tends to increase as elevation increases, up to a certain point creating "diversity bulge" at moderate elevations (McCain and Grytnes, 2010). The elevation dealt with in this work ranged from 17-427 m which was not very high. Taking into account the scale and extent of elevational gradients, it can be said that species diversity and richness did not show any correlation i.e. specie diversity and richness were not proportional with that of elevation. Daniel and Ramaraju (2017) assessed the diversity of Chalcididae among three rice growing tracts of Tamil Nadu and concluded that there was no correlation between elevation and species richness.

Studies on the altitudinal variation of parasitic Hymenoptera assemblages in an Australian subtropical rainforest by Hall et al. (2015) did not record any distinct assemblage at each altitude, at the morphospecies level, even though there was a clear separation between 'upland' and 'lowland' assemblages. To detect minute changes in species assemblages, species level sorting is found to give the best result (Grimbacher et al., 2008). The area under cultivation turns out to be a very

Table 3. Braconids collected and their hosts

Parasitoid	Host	Reference
Amyosoma chinensis (Szepligeti)	*Scirpophaga excerptalis* and *Sesamia inferens*	Quicke, 1987
Apanteles colemani Viereck	*Orgya postica*	Ayyar, 1927
Bracon brevicornis (Wesmael)	Crambidae	Khan and Murthy, 1954
Bracon sp. 1	*Cnaphalocrocis medinalis*	Rao et al., 1970
Bracon sp. 2	*Cnaphalocrocis medinalis*	Rao et al., 1970
Cardiochilinae	Pyralidae and Noctuidae	Huddleston and Walker, 1998
Chelonus formosanus Sonan	*Spodoptera* sp.	Ananathanarayanan and Ayyar, 1937
Cotesia falvipes Cameron	*Cnaphalocrocis medinalis*	Mohammad Ali and Prasad, 1958
Horminae	Crambidae	Dale, 1994
Macrocentrus philippinensis Ashmead	*Cnaphalocrocis medinalis*	Talgeri and Dalaya, 1971
Opius sp.	*Hydrellia* sp.	Nanadakumar and Pramod, 1998
Parahormius sp.	*Hydrellia* sp.	Dale, 1994
Phanerotoma sp.	*Scirpophaga* sp	Dale, 1994
Rinamba sp.	Crambidae	Dale, 1994
Spathius agrili Yang	*Chilo suppressalis*	Rao et al., 1970
Spathius sp.	*Chilo suppressalis*	Rao et al., 1970
Stenobracon niceviellei (Bingham)	*Scirpophaga incertulas*	Narayanan, 1938
Tropobracon luteus Cameron	*S. incertulas, Sesamia inferens, Chilo suppressalis*	Ayyar and Ananthanarayanan, 1937


1. *Amyosoma chinensis*


2. *Apanteles colemani*


3. *Bracon brevicornis*


4. *Bracon* sp.1


5. *Bracon* sp.2


6. *Cardiochilinae*


7. *Chelonus formosanus*


8. *Cotesia falvipes*


9. Horminae


10. *Macrocentrus philippinensis*


11. *Opius* sp.


12. *Parahormius sp.*


13. *Phanerotoma* sp.


14. *Rinamba sp.*


15. *Spathius agrili*


16. *Spathius* sp.


17. *Stenobracon nicevillei*


18. *Tropobracon luteus*

Fig. 1 - 18. Braconidae collected from rice growing zones of Tamil Nadu

important factor with respect to abundance and species density in rice fields (Wilby et al., 2006). The number of species in a habitat increases with increase in area (Gotelli and Graves, 1996).

On comparing the species similarities using the Jaccard's index in between the three zones taken in pairs, it was found that 53% similarity existed between western and Cauvery delta zones and 44% similarity between high rainfall and Cauvery delta zones and 50% similarity was between high rainfall and western zones (Table 2). Details regarding the hosts of collected braconids are presented in Table 3.

This study reveals the diversity of braconids of three different rice ecosystems of Tamil Nadu, where the the High rainfall zone is the most diverse and the Cauvery delta zone being the least. The reasons for the significant changes in diversity of parasitoids and their host insects are to be further studied. There is much scope for research to be take on these aspects

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