Diversity of Thrips (Insecta: Thysanoptera) Fauna in a Protected Area: A Case Study of the Itanagar Wildlife Sanctuary, Arunachal Pradesh

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Abstract—*The diversity of thrips in the Itanagar Wildlife Sanctuary (IWS) has been studied during 2009 to 2014 by undertaking periodical survey in a total area of 140km^2 of IWS, Arunachal Pradesh. The study revealed the occurrence of 108 species of thrips (Insecta: Thysanoptera) belonging to 72 genera. Among them 47 species in 34 genera belong to the suborder, Terebrantia and the remaining 61 species in 38 genera come under the suborder Tubulifera. Among them 34 are endemic to India. On the basis of micro-niche that they occupy, 26 free living foliage inhabitants, 22 anthophilous forms, 17 fungal spore feeding litter dwellers, 15 gall inducers, 12 grass inhabiting thysanopterans, 5 pests and 3 predatory species have been collected from 58 plant species belonging to 31 families, for the first time from the biodiversity rich Itanagar Wildlife Sanctuary located between the latitude 26° 55' N to 28° 40' N and longitude 92° 40' E to 94° 21' E, which fall within the Eastern Himalaya Biodiversity hotspot region. By and large, abundance of thrips was found to be abysmally low during winter, appreciably more in summer and significantly high during spring and autumn. The smallest thrips among the tubuliferans, Preeriella formosana Okajima has been collected for the first time from Itanagar Wildlife Sanctuary, India. Therefore, it forms a new record for India and the predatory thrips, Mymarothrips garuda Ramakrishna & Margabandhu is the new record for North East India through the present study. The association of thrips with different plant hosts is discussed in terms of plant – insect relation by their phonological occurrence.*

1. INTRODUCTION

The order Thysanoptera (fringes on the wing) includes insect with appreciable economic importance, having an array of unique characters which distinguish them from other groups of insects. The wings bear fringes, their mouth parts are asymmetrical i.e., with well developed left mandible and vestigial right mandible, presence of a protrusible bladder at the tip of tarsi and a pre pupa stage between larva and pupa and the body size ranges from 0.5 to 15 mm in length. Although a majority of them are microscopic, their small size is compensated by rapid growth and fast breeding potential (Ananthakrishnan, 1969). They exhibit remarkable diversity in terms of habit and habitat. They possess piercing and sucking type of mouthparts with which the phytophagous forms suck the plant sap and contents of pollen grains, mycophgous thrips feed on fungal spore and mycelia and the predacious species devours soft bodied insect. Such feeding habits enable them to choose micro-habitats like flower, leaf sheath, bark, plant galls and leaf litters. The world record indicates the occurrence of nearly 6000 species of thrips (Website-Thrips wiki, assessed on 02/02/2015), of which nearly 700 are known from the Indian subcontinent (Sen, 1998) and 205 from NE India (Varatharajan, 2005). However, with respect to Arunachal Pradesh, attempts were made by Sen *et al*., (1988) with the collection of only 9 species, followed by Shyam *et al.* (2012) with 40 thrips species. As this state comes under one of the biodiversity rich sectors of the Eastern Himalayas, the present survey was undertaken to study the diversity of thrips of the "Itanagar Wildlife Sanctuary", Arunachal Pradesh.

2. MATERIALS AND METHODS

2.1 Study area

The study site - Itanagar Wildlife Sanctuary (IWS) in Arunachal Pradesh is located between the latitudes 26° 55' N to 28° 40' N and longitudes 92° 40' E to 94° 21' E, at an elevation ranging from 200-2000m ASL. This protected area was established in 1978 and is located in the Papum-Pare district of Arunachal Pradesh and covers an area of 140 km^2. The IWS has the geographical boundary as Pam River in the East, Pachin in the South, Neorochi on the North-East and Chingke stream on the North. The landscape has a rugged terrain with steep slope having meandering water canals and dense vegetation being typical of mixed forest (Srivastava and Choudhary, 2006).

2.2 Field survey and Sampling methods

Field survey was undertaken during 2009-2014 and periodical collections were made to cover as many areas of the sanctuary after obtaining permission from the forest officials of Arunachal Pradesh. Thrips were collected once in every season from diverse habitats by random sampling method and the specimens were extracted as far as possible in terms of unit

sample, wherein the unit represents number of thrips per 10 sweeps for grass inhabiting thrips or 10 flowers in case flower thrips; one collection funnel (tulgreen setup) for litter thrips; per foliage or yellow pan water trap for pest species; number of thrips per plant gall for gall makers (Lewis, 1973; Ananthakrishnan, 1984).

2.3 Preparation of permanent slide

Preparation of permanent slide becomes a pre-requisite to enable to identity the specimen besides preserving the specimen for years together. To begin with, the specimen was macerated and bleached in 10% NaOH solution followed by dehydration in alcohol grade from 50 > 70 > 90 > 100%. Subsequently, the specimen was cleared in terpineol and mounted in canadabalsm. These slides were kept in the oven for a week at 35^0C till they became completely dried. The balsam mounted specimens were identified by conventional morpho-taxonomic method based on the key available for thrips of India (Ananthakrishnan and Sen, 1980) and also by referring specialized books & monographs (Wilson, 1975; Palmer *et al.*, 1989; Bhatti, 1990) and later confirmed with reference slides for some species. One set of permanent slides is in the Insect Museum, Department of Life Sciences, Manipur University and another set was deposited in Indian Agricultural Research Institute (IARI), New Delhi and kept along with PUSA National collections.

3. RESULTS AND DISCUSSION

The present work has revealed the occurrence of 108 species of thrips, belonging to 72 genera (Table- 1). Among them 34 genera constitute members of the suborder, Terebrantia and the rest 38 being yet another suborder Tubulifera. The former group was represented by a genus & a species under the family Aeolothripidae and 33 genera under Thripidae. Members of the thripids include 22 genera in the subfamily Thripinae with 32 species and 11 genera having 14 species under Panchaetothripinae. With respect to 61 tubuliferans, the collected specimens were grouped into 2 subfamilies viz., Phlaeothripinae and Idolothripinae with 51 and 10 species. While comparing the two suborders, the total collection exposed the occurrence of 47 terebrantians and 61 tubuliferans indicating the latter suborder being represented by more species than by the former. This trend is in tune with the recorded number of thrips of the world checklist, which highlights that the number of tubuliferans (3500 species) is greater than the terebrantians (2500 species) (Website-Thrips wiki). Similar pattern was also reported by Ananthakrishnan and Sen (1980) stating presence of 260 terebrantians and 387 tubuliferans from the collections of Indian subcontinent. Of the total 72 genera of thrips, the genera such as *Thrips,*

Table 1: Thysanoptera Fauna of Itanagar Wildlife Sanctuary, Arunachal Pradesh

No. of Species	No. of Genera	Suborder: Terebrantia	S1	S2	S3	S4	Habit & Habitat
		Family : Aeolothripidae					
1.	1	Mymarothrips garuda Ramak. and Marg., 1931			+		Predator
		Family: Thripidae (Subfamily: Thripinae)					
2.	2	Anaphothrips sudanensis Trybom, 1911	+	+	+	+	Grass
3.	3	Ayyaria chaetophora Karny, 1926	+	+	+		Flower
4.	4	Bolacothrips indicus (Ananthakrishnan, 1966)		+		+	Grass
5.	5	Dendrothripoides innoxius (Karny, 1914)	+				Leaf
6.	6	Dendrothrips. stannardi (Ananthakrishnan, 1957)	+				Leaf
7.	7	Dichromothrips nakahari Mound, 1976	+	+	+		Flower
8.		D. smithi (Zimmerman,1900)	+	+	+		Flower
9.	8	Frankliniella intonsa (Trybom, 1895)	+	+	+		Flower
10.		F. schultzei (Trybom, 1910)		+	+		Flower
11.	9	Fulmeikiola serrata (Kobus, 1893)			+		Leaf
12.	10	Hydatothrips aureus Bhatti, 1973	+	+			Grass
13.	11	Lefroyothrips lefroyi (Bagnall, 1913)	+		+		Flower
14.	12	Megalurothrips distalis(Karny, 1913)	+	+	+	+	Flower
15.		M. peculiaris(Bagnall, 1918)	+		+		Flower
16.		M. typicus Bagnall, 1915	+		+		Flower
17.	13	Microcephalothrips abdominalis(Crawford, 1910)	+	+	+	+	Flower
18.	14	Mycterothrips consociatus (Targioni-Tozzetti,1887)			+	+	Leaf
19.	15	Neohydatothrips samayunkur Kudo, 1995	+		+		Flower
20.	16	Organothrips indicus Bhatti 1974	+	+	+	+	Aquatic weed
21.	17	Parabaliothrips coluckus (Kudo, 1977)	+		+		Leaf
22.	18	Rhamphothrips parviceps Hood, 1919			+		Grass
23.	19	Sciothrips cardamomi (Ramakrishna, 1935)	+	+	+		Pest
24.	20	Scirtothrips dorsalis Hood, 1919		+	+		Pest

25.	21	Stenchaetothrips biformis(Bagnall, 1913)	+	+	+		Leaf
26.	22	Thrips flavus Shrank, 1776	+				Flower
27.		T. formasanus Priesner, 1934	+	+			Flower
28.		T. hawaiiensis (Morgan, 1913)	+	+	+	+	Flower
29.		T.(Isothrips) orientalis (Bagnall,1915)	+	+	+	+	Flower
30.		T. andrewsi (Bagnall, 1921)		+			Flower
31.		T. palmi Karny, 1925	+		+		Pest
32.		T. tabaci Lindeman, 1889	+	+			Pest
33.	23	Trichromothrips arorai Bhatti, 1967		+			Leaf
		Subfamily: Panchaetothripinae					
34.	24	Astrothrips lantana Bhatti, 1967		+			Flower
35.		A.tumiceps Karny, 1923	+	+	+		Leaf
36.	25	Caliothrips luckmanni Wilson, 1975	+	+			Leaf
37.		C. indicus (Bagnall,1913)		+	+		Grass
38.	26	Helionothrips kadaliphilus (Ramak. & Marg.,1931)	+	+			Leaf
39.		H. parvus Bhatti, 1968	+		+		Leaf
40.	27	Heliothrips haemorrhoidalis (Bouche, 1833)	+	+			Leaf
41.	28	Monilothrips kempi Moulton, 1929		+			Leaf
42.	29	Panchaetothrips indicus Bagnall, 1912	+	+	+		Pest
43.	30	Phibalothrips peringuegi (Faure, 1925)	+	+	+		Grass
44.	31	Retithrips syriacus Mayet, 1890	+	+	+		Leaf
45.	32	Rhipiphorothrips pulchellus Morgan 1913	+			+	Leaf
46.	33	Selenothrips rubrocintus (Giard, 1901)	+	+	+	+	Leaf
47.	34	Zaniothrips ricini Bhatti, 1967			+		Leaf
		Suborder: Tubulifera					
		(Subfamily: Phlaeothripinae)					
48.	1	Adraneothrips disjunctus Ananthakrishnan, 1972			+		Litter
49.	2	Androthrips flavitibia Moulton 1934	+		+		Predator
50.		Androthrips ramachandrai Karny, 1926		+			Predator
51.	3	Apterygothrips pellucidus (Ananthakrishnan, 1968)			+		Grass
52.	4	Araeothrips longisetis Ananthakrishnan, 1976			+		Leaf
53.		A. vamana Muraleedharan, 1982		+			Leaf
54.	5	Arrhenothrips longisetis Sen, 1977			+		Gall
55.	6	Athlibothrips inquilinus (Ananthakrishnan & Varadu., 1978)	+		+		Gall
56.	7	Bamboosiella hartwigi (Pitkin, 1977)			+		Litter
57.		B. nayari (Ananthakrishnan, 1958)	+		+		Litter
58.	8	Callothrips ascitus Ananthakrishnan, 1969		+			Litter
59.	9	Carissothrips nigrecens Ananthakrishnan, 1964	+				Leaf
60.	10	Crotonothrips nagaensis Muraleedharan, 1982			+		Gall
61.	11	Dexiothrips madrasensis (Ananthakrishnan, 1964)	+		+		Litter
62.	12	Dolichothrips assimilis Priesner & Seshadri, 1952			+		Leaf
63.		D. montanus Ananthakrishnan, 1964	+		+		Leaf
64.	13	Ecacanthothrips tibialis (Ashmead, 1905)	+				Dry twig
65.	14	Gigantothrips elegans Zimmerman, 1900	+				Leaf
66.		G. tibialis (Bagnall, 1921)		+	+		Leaf
67.	15	Gynaikothrips bengalensis Ananthakrishnan, 1973			+		Gall
68.	16	Haplothrips andresi Priesner, 1931	+				Flower
69.		H. ceylonicus Schmutz, 1913	+				Grass
70.		H.ganglbaueri Schmutz, 1913	+		+		Flower
71.		H. gowdeyi (Franklin, 1908)	+	+	+	+	Grass
72.		H. montanus (Ananthakrishnan & Jagadish, 1970)	+				Flower
73.		H. tenuipennis Bagnall, 1918	+	+	+	+	Flower
74.	17	Karnyothrips melaleucus (Bagnall, 1911)			+		Litter
75.	18	Leeuwenia eugeniae Bagnall, 1924	+		+		Leaf
76.		L. vorax Ananthakrishnan,1970	+	+			Leaf
77.	19	Liophlaeothrips pavettae Ananthakrishnan & Jagadish, 1969		+	+		Gall
78.		L. succinctus Ananthakrishnan & Jagadish,1969	+				Gall
79.	20	Liothrips aberrans Muraleedharan & Sen, 1978			+		Gall

80.		L.aequilus Ananthakrishnan&Jagadish, 1969	+				Gall
81.		L. ananthakrishnani Sen, 1976		+			Gall
82.		L.himalayanus Ananthakrishnan & Jagadish, 1970	+		+		Gall
83.		L. mohanrami Bhatti et al., 2006	+				Gall
84.	21	Membrothrips indicus (Hood, 1919)	+				Flower
85.	22	Mesothrips acutus Muraleedharan & Sen, 1981		+			Gall
86.		Mesothrips extensivus Ananthakrishnan & Jagadish, 1969		+			Gall
87.		M.jordani Zimmerman,1900		+	+		Gall
88.	23	Ocnothrips indicus Ananthakrishnan, 1969			+		Gall
89.	24	Plicothrips apicalis (Bagnall, 1915)	+		+		Grass
90.	25	Podothrips graminum, Priesner, 1938	+	+	+		Grass
91.	26	Praepodothrips priesneri Ananthakrishnan, 1955	+	+			Grass
92.	27	Preeriella formosana Okajima, 1998			+		Litter
93.	28	Xylaplothrips debilis Ananthakrishnan&Jagadish, 1971			+		Litter
94.		X. pusillus Ananthakrishnan & Jagadish, 1969			+		Dry twig
		Subfamily: Idolothripinae					
95.	29	Bactrothrips luteus Ananthakrishnan,1973			+		Litter
96.	30	Elaphrothrips curvipes Priesner, 1929			+		Litter
97.		E. denticollis (Bagnall, 1909)	+		+		Litter
98.		E. greeni (Bagnall, 1914)	+				Litter
99.		E. insignis Ananthakrishnan, 1973			+		Litter
100.	31	Meiothrips menoni Ananthakrishnan, 1964	+		+		Dry twig
101.		M. nepalensis Kudo & Ananthakrishnan, 1974			+		Litter
102.	32	Nesothrips lativentris (Karny, 1913)	+				Dry twig
103.	33	Oidanothrips enormis Ananthakrishnan,1969			+		Dry twig
104.	34	Acallurothrips amplus (Faure, 1949)	+			+	Dry twig
105.	35	Baenothrips asper (Bournier, 1963)	+		+		Litter
106.	36	Bradythrips herperus Hood & Williams, 1925			+		Litter
107.	37	Coxothrips tarai (Stannard, 1970)	+		+		Litter
108.	38	Stephanothrips occidentalis Hood & Williams, 1925			+		Litter

S1- Spring, **S2**- Summer , **S3**- Autumn**, S4**- Winter, +- Present

Haplothrips, Liothrips and *Elaphrothrips* were represented by 7, 6, 5 and 4 species respectively, while *Megalurothrips* and *Mesothrips* with 3 species each and the rest being represented by 1 or 2 species. The three predatory species namely *Mymarothrips garuda* Ramak. & Marg., *Androthrips flavitibia* Moulton and *A. ramachandrai* Karny were also collected during the survey. Generally members of the suborder Tubulifera are bigger than individuals of the suborder Terebrantia, of which the body length of the former is more than 1mm with the exception of individuals of the genus *Preeriella*. Such smallest thrips among the tubuliferans, *Preeriella formosana* Okajima has been collected for the first time from India and its occurrence is earlier known only from Taiwan (Okajima, 1998). Therefore, it forms a new record for India and the predatory thrips *M. garuda* is the new record for North East India through the present study.

Further, the collection record has shown that out of 108 species, 34 are endemic to India. On the basis of micro-niche that they occupy, presence of 26 foliage feeders, 22 flower dwellers, 17 litter thrips, 15 gall inducers, 12 grass thrips and 5 pest species have been collected for the first time from the biodiversity rich Itanagar wildlife sanctuary. Although 58 plant species belonging to 31 families were screened in this work for thrips collection, members of certain plant families could harbor appreciable number of thrips species and they are given in a descending order i.e., Poaceae with 25 species of thrips, Fagaceae- 13, Moraceae- 8, Verbenaceae- 7, Euphorbiaceae- 6, Fabaceae, Asteraceae and Anacardiaceae- 4 each, Rosaceae and Zingiberaceae- 3 each and rest of the families with either 1 or 2 thrips species. Thus, the field survey reflects diverse feeding habits and habitats of thysanopterans, besides association with members of different plant families.

In an attempt to compare the faunal similarity of IWS with other regions, the collection data was compared with that of Western Ghats of India (WGI) and South East Asia (SEA). Data pertaining to thrips collections of WGI were taken from the monograph on "*Indian Thysanoptera*" by Ananthakrishnan and Sen (1980) and "*Terebrantians of the Indian Subcontinent"* by Bhatti (1990) and that related to SEA were obtained from a number of research articles viz., Ananthakrishnan (1984), Kudo (1992), Okajima (1998) Majid (2011) and Li-Hong *et al* (2014). Such analysis indicated that the faunal similarity of IWS was to the extent of 60% with Western Ghats and 57% with SEA and about 20% of the fauna appear to be confined to the Great Himalayas as they have not been reported from other regions. Considering such similarity, it may be said that the fauna of IWS is a mixed bag comprising species from the above said regions. This observation corroborates the existing view that thrips fauna of

NE India constitutes species from northern and southern India besides elements of its own. Further, the proximity of NE region of India to other countries of SE Asia enables to share certain thrips genera among them (Varatharajan *et al.,* 2010). Since the Western Ghats region and the Eastern Himalayas are considered as the important biodiversity hotspots of India (Myers *et al*., 2000), the faunal similarity is also found to be appreciably high in these two sectors.

By and large, abundance of thrips was found to be abysmally low during winter, appreciably more in summer and significantly high during spring and autumn. The mean number of thrips species collected during spring and autumn was 32 and 30 respectively. Summer months yielded the record of 22 species and winter with a meager of just 8 species. This trend was observed in all the four years of study period. The reduction in their density during winter is owing to the prevailing cold climate during which the mean minimum and maximum temperature has been 8°C and 15°C (http://imd.gov.in). In addition, the off-season of certain plant hosts and blooming period of the flowers were also probable reasons for the low abundance of thrips. This aspect of field work indicates that spring and autumn seasons appear to be ideal for thrips collection. Another noteworthy result observed in the present study is that certain plant families have been found to harbour more number of thrips. For instance, in the present study members of Poaceae were found to give 25 thrips species; followed by Fagaceae with 13 species, Moraceae with 8 species and so on. It is known that over 300 species of thrips are completely dependent on grasses & bamboos and it corresponds to more than 10% of all the phytophagous thrips (Mound, 2011; Bala, 2013). But in Australia, almost 70 species of Thripidae are known to be specific to Poaceae. Most of them breed on the leaves, some colonize on grass florets and a few feed on both leaf and flower tissues (Mound, 2011). Species such as *Anaphothrips sudanensis*, *Thrips hawaiiensis*, *T. tabaci*, *T. orientalis*, *Haplothrips tenuipennis, H. gowdeyi, Selenothrips rubrocinctus, Megalurothrips distalis* and *Microcephalothrips abdominalis* were found to occur all round the year by virtue of their plant host being available all through the year. Barring the 17 spore feeders and 3 predatory thrips, the survey indicated that the collection of 88 species of phytophagous thrips indirectly reflects the richness of plant diversity of the Itanagar Wildlife Sanctuary.

4. ACKNOWLEDGEMENTS

The authors are grateful to DST, New Delhi for the financial support and to the Principal Chief Conservator of Forest, Arunachal Pradesh for granting permission to undertake the survey inside the Itanagar Sanctuary (IWS) and to the Head, Department of Life Sciences, Manipur University for the encouragement.

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