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Tortricid moth fauna diversity (Lepidoptera: Tortricidae) in Kargil district, Ladakh, India

Mushtaq Ganai and Zakir Khan

Abstract
Tortricid moths were collected from different parts of Kargil during 2010-2012 to determine their diversity, evenness, dominance and species richness. The whole collection of 210 tortricid moth specimens comprised of 18 species were captured from diverse localities of Kargil by using light trap operated from dusk to dawn, out of which one specie (*Acleris birdi* sp. nov.) was reported as new to science and two species [(*Crocidosema plebejana* Zeller and *Matsumuraeses phaseoli* (Matsumura)] as new to Ladakh. When monthly data of individual count is taken into consideration, highest numbers of specimens (94) were captured in the month of August followed by July (76) while as minimum (8) were collected in the month of May and September each during entire study period. Further Diversity index (H), Evenness index (J), Index of dominance (D) and Species richness (M) were observed as 1.11627, 0.755707, 0.244293 and 7.320583 respectively.

Keywords: diversity, fauna, kargil, ladakh, tortricid moth

1. Introduction
Diversity refers to number of different items and their relative frequency. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus the term encompasses different ecosystems, species, genes and their relative abundance [1]. Class Insecta comprise more than half of the world's known animal species [2] of which the Lepidoptera is the second largest and more diverse order which includes moths and butterflies [3]. Among moths Tortricidae is the largest and relatively homogeneous family, the members of which are commonly known as Tortrix moths or leaf roller moths [4]. This family has over 10,350 described species richly distributed worldwide in 1,050 or more genera; incalculable numbers remain unnamed in tropical regions [5]. Adults are small to moderately large (wingspan 1-3.3 cm), and are typically nocturnal with cryptically coloured forewings in gray, brown, rust, or tan, occasionally with colourful markings [6]. At rest, wings are held like a flattened roof, giving the resemblance of an arrowhead. The common name "leaf roller" has been applied to this family owing to its larval habit of shelter building by folding or rolling leaves of the food plants [7]. The larvae of these moths employ a wide range of feeding strategies, many have the habit of leaf rolling some are gall makers, root borers, fruit borers, flower feeders etc [8].
The economic importance of these moths arises almost entirely from the activities of the larvae. They have chewing-type mouthparts and are among the world's greatest pests [9] as most of these cause major economic damage in agriculture and horticulture on wide variety of crops including pome fruits, stone fruits, citrus fruits, grapes, ornamental crops, tea, coffee, cereals and cotton. This family has been further divided into three subfamilies Tortricinae, Olethreutinae and Chlidanotinae [10]. In general, members of the subfamily Tortricinae tend to be polyphagous, while Olethreutinae have narrower host range and hosts of Chlidanotinae are poorly known. Tortricid moths from the Indo-Pak sub-continent were collected and identified from various localities by Meyrick [11], Diakonoff [12], Rose and Pooni [13] and Razowski [14]. In case of Kashmir & Ladakh, 64 species of tortricid moths have been reported [15], although no exhaustive study has been performed and the few works that have been published offer only little information about tortricid moth diversity. The objectives of the present research were to explore the Tortricid moth fauna of Kargil and to estimate their species richness, species evenness and species diversity.

2. Materials and Methods

The study was conducted in Kargil district of Ladakh region of northern India. This district spans the entire length of Ladakh in the north-south direction, with Jammu and Kashmir to the west, the Leh district to the east, the Pakistan-administered region of Gilgit–Baltistan to the north and Himachal Pradesh to the south with a total area of 14086 sq. km. This district forms the Joint Capital of the union territory of Ladakh and is the second largest town after Leh. It is located 60 km from Drass, 204 km from Srinagar, 234 km from Leh, 240 km from Padum and 1,047 km from Delhi. Since Tortricid moths being nocturnal in behaviour, their collection was done during night with the help of portable bucket type light trap fitted with 125 W mercury vapour lamp. Specimen tubes with a piece of cotton soaked in benzene and a piece of blotting paper placed over it, were also used for trapping and killing the moths sited near trap. Chargeable electric lamp was also used for collection purpose in some areas where electricity supply was not available. Sampling was done fortnightly in each district from March to November during 2010-2012.

The collected individuals were killed with benzene or ethyl acetate vapours in the killing bottles, transferred into butter paper envelops and were brought to the laboratory, where these were properly stretched in the small adjustable wooden stretching boards or thermocol sheets after pinning through the mid of mesothorax. Before stretching, the specimens were relaxed on blotting paper placed over water soaked cotton sterilized with phenol in an airtight Petri dish and left for 4-6 hours. The stretched specimens were then oven dried for 72 hours at 60oC and preserved in the insect storage boxes, fumigated with naphthalene balls. Before the specimens were preserved in the boxes, each was furnished with data such as name of the locality, locality altitude, date of collection, and name of the collector etc.

The sorting of collected adult moths was done on the basis of external morphological characters like scales on frons and vertex, presence of chaetosema, labial palpi, maxillary palpi, antennae, proboscis, wing venation, maculation and coastal fold, colour and markings of thorax, abdominal characters, position and number of tibial spurs etc. All the specimens after sorting were identified with the help of relevant literature [16] especially the Tort fauna of Korea, Guide to tortricid moths of America at the first instance. Identified adult moths were then photographed with the help of digital camera attached to Stereo zoom Olympus microscope and deposited in the insect collection museum of bio-systematic laboratory in the Division of Entomology, SKUAST-Kashmir Srinagar.

2.1. Statistical analysis

Data was analyzed by using Index of species diversity [17], Evenness index [18], Index of dominance [19], Species richness [20] and relative abundance formulae as follows.

1. Index of species diversity [H]

Index of species diversity (H′) = -Σ pi log10 pi

Where pi = Important probability of each species (Ni/N)

Ni = Important value of each species

N = Total of important value

2. Evenness index [J].

Evenness index (J) = H'/Log10 S

Where H′ = Shannon Wieners index

S = Number of species

3. Index of dominance [D].

Index of dominance (D) = 1-J

Where J = Evenness index

4. Measurement of species richness [M].

Margalef's index = (S-1)/Log10 N

Where S = total number of species

N = total number of individuals in the sample

5. Relative abundance (R)

R = n/N ×100

Where n = number of individuals in one species

N = number of individuals in all the species

3. Results and Discussion

Results revealed that adult trap catch initiated in the month of May and finished in September during entire period from 2010-12. Highest number of specimens 94 comprised of 16 species was captured in the month of August followed by July 76 specimens comprised of 15 species and minimum 8 specimens comprised of 4 species in month of May and September each (Table 1). Over all 210 specimens of Tortricid moths were captured from diverse localities of Kargil by using light trap operated from dusk to dawn. The whole collection was comprised of 18 species belonging to 12 genera, 5 tribes and 2 subfamilies out of which one specie (Acleris birdi sp. nov.) was reported as new to science and two species [(Crocidosema plebejana Zeller and Matsumuraeses phaseoli (Matsumura)] as new to Ladakh (Table 2). Diakonoff [21] also described five species of tortricids from north-west Karakoram which were later on incorporated as belonging to Jammu and Kashmir, while as Razowski [22] reported two genera and sixteen species as new from Kashmir and Ladakh. Further tribes Archipini and Eucosimini were found most diverse at species level with 4 species each followed by Olethreutini with 2 species while as tribes Cnephasiini and Tortricini were found to be least diverse with one species each (Fig. 1). Also Neocalyptis ladakhana Razowski was the most dominant species in terms of relative abundance (13.80%) followed by Clepsis rurinana (Linnaeus) (13.33%), while as Celypha constructa (Meyrick) was found least dominant (0.47%) (Fig. 2). The study further revealed that Diversity index (H), Evenness index (J), Index of dominance (D) and Species richness (M) of Tortricid moth fauna in Kargil were observed as 1.11627, 0.755707, 0.244293 and 7.320583 respectively (Table 3).

Table 1: Diversity and monthly trap catch of tortricid moths in district Kargil.

S. No.	Species	No. of specimens/month					Total specimens	Relative abundance (%)
		May	June	July	Aug.	Sept.		
1.	*Acleris orphnocycla* (Meyrick)	0	2	6	10	0	18	8.571429
2.	*Acleris birdi* sp. nov.	0	0	6	9	0	15	7.142857
3.	*Archips cantinus* Razowski	2	3	10	12	0	27	12.857140
4.	*Archips naltarica* Razowski	0	4	8	10	0	22	10.476190
5.	*Clepsis rurinana* (Linnaeus)	1	2	10	13	2	28	13.333330
6.	*Clepsis translucida* (Meyrick)	0	0	0	2	0	02	0.952381

7.	*Celypha constructa* (Meyrick)	0	0	1	0	0	01	0.476190
8.	*Crocidosema plebejana* Zelle	0	0	3	1	0	04	1.904762
9.	*Cydia pomonella* (Linnaeus)	0	4	5	0	0	09	4.285714
10.	*Eucosma conterminana* (Guenee)	2	3	5	5	0	15	7.142857
11.	*Eucosma tetraplana* (Moschler)	0	1	3	3	1	08	3.809524
12.	*Gibberifera obscura* Diakonoff	0	0	2	2	0	04	1.904762
13.	*Matsumuraeses capax* Raz. &Yasuda	0	0	0	2	0	02	0.952381
14.	*Matsumuraeses phaseoli* (Matsumura)	0	0	0	3	0	03	1.428571
15.	*Neocalyptis chlansignum* Razowski	0	0	4	5	1	10	4.761905
16.	*Neocalyptis ladakhana* Razowski	3	5	9	8	4	29	13.809520
17.	*Pandemis thomasi Razowski*	0	0	3	6	0	09	4.285714
18.	*Pelochrista teleopa* Razowski	0	0	1	3	0	04	1.904762
	Total number of specimens	8	24	76	94	8	210	
	Total number of species	4	8	15	16	4	18	100.00

Table 2: Classification of reported Tortricid moth species

S. No.	Family	Sub family	Tribe	Genus	Species
1.	Tortricidae	Tortricinae	Tortricini	*Acleris* Hubner	*Acleris orphnocycla* (Meyrick)
2.					*Acleris birdi* sp. nov.*
3.			Archipini	*Archips* Hubner	*Archips cantinus* Razowski
4.					*Archips naltarica* Razowski
5.				*Clepsis* Guenee	*Clepsis rurinana* (Linnaeus)
6.					*Clepsis translucida* (Meyrick)
7.				*Neocalyptis* Diakonoff	*Neocalyptis chlansignum* Razowski
8.					*Neocalyptis ladakhana* Razowski
9.				*Pandemis* Hubner	*Pandemis thomasi* Razowski
10.		Olethreutinae	Eucosimini	*Eucosma* Hubner	*Eucosma conterminana* (Guenee)
11.					*Eucosma tetraplana* (Moschler)
12.				*Gibberifera* Obraztsov	*Gibberifera obscura* Diakonoff
13.				*Pelochrista* Lederer	*Pelochrista teleopa* Razowski
14.				*Crocidosema* Zeller	*Crocidosema plebejana* Zeller **
15.			Grapholitini	*Matsumuraeses* Issiki	*Matsumuraeses capax* Raz. &Yasuda
16.					*Matsumuraeses phaseoli* (Matsumura)**
17.				*Cydia* Hubner	*Cydia pomonella* (Linnaeus)
18.			Olethreutini	*Celypha* Hubner	*Celypha constructa* (Meyrick)

*= New to Science, **= New to Ladakh.

Table 3: Diversity indices of tortricid moths in Kargil.

S. No.	Total No. of species	Index			
		Diversity Index (H)	Evenness Index (J)	Index of Dominance (D)	Species Richness (M)
1.	18	1.11627	0.755707	0.244293	7.320583

Systematics

Family-Tortricidae

Subfamily-Tortricinae

Tribe-Archipini

Genus Archips Hubner, 1822, Syst.-alphab. Verz. 58

Archips cantinus Razowski, 2006

cantinus Razowski, 2006 (Archips), Acta Zool. Cracov. 49B:122.

Material examined: Kargil, 18.v.10-1♂; Kharbo, 25.vi.10-1♂; 17.vii.12-4♂,1♀; Silikchi, 27.vii.10-2♂, 1♀; 10.v.12-1♂; Shargol, 03.viii.10-3♂,1♀; 09.viii.11-2♂, 1♀; Panikhar, 02.vii.11-2♂; Sankoo, 19.vi.12- 2♂; Mulbek, 20.viii.12-4♂,1♀.

Archips naltarica Razowski, 2006

naltarica Razowski, 2006 (Archips), Acta Zool. Cracov. 49B:122.

Material examined: Kharbo, 25.vi.10-1♂; 26.vi.11-1♂; Silikchi, 27.vii.10-2♂, Shargol, 03.viii.10 2♂,1♀; 09.viii.11-2♂; Panikhar, 02.vii.11-3♂; Drass, 17.vi.12-2♂; 05.vii.12-4♂,2♀; Mulbek, 18.vii.12-3♂; 20.viii.12-3♂,2♀.

Genus Clepsis Guenee, Guenee, 1845, Annls Soc. ent. Fr (2)3: 149.

Clepsis rurinana (Linnaeus, 1758)

rurinana Linnaeus, 1758 (Phalaena (Tortrix)), Systema Naturae (10th ed.): 823.

Phalaena Tortrix modeeriana Linnaeus, 1761: 347.

Phalaena Tortrix moderiana: Linne, 1767: 880

Phalaena Tortrix angulana Villers, 1789: 417, 612

Pyralis avellana Panzer, 1804 (nee Linne): 124

Tortrix consimilana Treitschke, 1830 (nee Hiibner): 75

Cacoecia idana Kennel, 1919: 51, pl. 2, fig. 1.

Tortrix semialhana Guenee, 1845: 139

Tortrix obscura Dufrane, 1957

Phalaena angulosa Fourcroy, 1785

Tortrix croceana Curtis, 1850 (nee Haworth): 110

Clepsis (Siclobola) rurinana: Diakonoff, 1955: 45

Clepsis (Siclobola) semialhana: Obraztsov, 1954—1957: 52, 193, 213, 315.

Tortrix liotoma Meyrick, 1936: 60.

Material examined: Silikchi, 27.vii.10-1♂, 1♀; Shargol, 03.viii.10-3♂,1♀; Silmoo, 10.v.11-1♂; 11.ix.12-2♂; Panikhar, 02.vii.11-2♂,1♀; Mulbek, 10.viii.11-2♂,1♀; 20.viii.12-4♂,2♀; Sankoo, 19.vi.12- 2♂; Kharbo, 17.vii.12-4♂,1♀.

Clepsis translucida (Meyrick, 1908)

translucida (Meyrick, 1908) (Cacoecia), J. Bombay nat. Hist. Soc., 18: 616.
Cacoecia translucida Meyrick, 1908.
Material examined: Shargol, 03.viii.10 1♀; Mulbek, 20.08.12-1♀.

Genus Neocalyptis Diakonoff, Diakonoff, 1941, Treubia, vol. 18, p. 407.
Neocalyptis chlansignum Razowski, 2006
chlansignum Razowski, 2006 (Neocalyptis), Acta Zool. Cracov. 49B: 125.
Material examined: Shargol, 03.viii.10-2♂; Drass, 05.vii.11-2♂; Kharbo, 17.vii.12-2♂; Sankoo, 21.viii.12-2♂.

Neocalyptis ladakhana Razowski, 2006
ladakhana Razowski, 2006 (Neocalyptis), Acta Zool. Cracov. 49B: 125.
Material examined: Kharbo, 25.vi.10-1♂; 26.vi.11-1♂; 17.vii.12-5♂, 1♀; Silikchi, 27.vii.10-1♂, 1♀; Shargol, 03.viii.10-2♂; Mulbek, 14.v.11-1♂; 11.v.12-2♂; Drass, 05.vii.11-1♂; Kargil, 11.viii.11-1♂; 23.ix.11-2♂; Sankoo, 19.vi.12- 2♂, 1♀; 21.viii.12-3♂,2♀; Silmoo, 11.ix.12-2♂.
Genus Pandemis Hubner, Hubner, [1825] 1816, Verz. bekannter Schmett. 388.
Pandemis thomasi Razowski, 2006
thomasi Razowski, 2006 (Pandemis), Acta Zool. Cracov. 49B: 124.
Material examined: Mulbek, 29.vii.10-1♂; 20.viii.12-2♂,1♀; Kargil, 04.vii.11-2♂; Shargol, 09.viii.11-2♂,1♀.

Tribe-Tortricini
Genus Acleris Hubner, Hubner, [1825] 1816, Verz. bekannter Schmett. 384
Acleris orphnocycla (Meyrick, 1937)
orphnocycla Meyrick in Caradja & Meyrick, 1937 (Peronea), Dt. ent. Z. Iris 51: 178.
Peronea orphnocycla Meyrick in Caradja & Meyrick, 1937.
Material examined: Silikchi, 27.vii.10-1♂,3♀; Shargol, 03.viii.10-3♂; 09.viii.11-2♂; Kharbo, 26.vi.11-1♂; 09.vi.12-1♂; Sankoo, 01.vii.11-1♂; Kargil, 18.vi.12-1♂; Mulbek, 18.vii.12-3♂; Panikhar, 22.viii.12-2♂.
Acleris birdi sp. nov.
Material examined: Silikchi, 27.vii.10-2♂; Drass, 04.viii.10-2♂; Panikhar, 02.vii.11-1♂; Shargol, 09.viii.11-2♂; Kharbo, 17.vii.12-3♂; Mulbek, 20.08.12-3♂; Kargil, 24.viii.12-2♂.

Subfamily-Olethreutinae
Tribe-Olethreutini
Genus Celypha Hubner, Hubner, [1825] 1816, Verz. bekannter Schmett. 382.
Celypha constructa (Meyrick, 1922)
constructa Meyrick, 1922 (Argyroploce), Exotic Microlepid. 2: 526.
Material examined: Mulbek, 18.vii.12-3♂.

Tribe-Eucosimini
Genus Eucosma Hubner, Hubner, 1823, Zutr.Samml.exot.Schmett. 2: 28.
Eucosma conterminana (Guenee, 1845)
conterminana Guenee, 1845 (Catoptria), Annls Soc.ent. Fr. (2) 3: 189.
Catoptria conterminana Guenée, 1845, Annls Sc.ent. Fr., (2)3: 189.
Eucosma caecimaculata Duponchel, 1835, Hist. Nat. Lépid. Papillons Fr., 9: pl. 249.
Material examined: Kharbo, 25.vi.10-1♂; 09.v.12-2♂; Silikchi, 27.vii.10-1♂; Shargol, 27.vi.11-2♂; Drass, 05.vii.11-2♂; Mulbek, 10.viii.11-1♂,2♀; 18.vii.12-2♂; Sankoo, 21.viii.12-2♂, 1♀.
Eucosma tetraplana (Moschler, 1866)
tetraplana Moschler, 1866 (Grapholitha), Berl. Ent. Z. 10: 148.
Material examined: Silikchi, 27.vii.10-1♂; Kharbo, 26.vi.11-1♂; Mulbek, 10.viii.11-1♂; Kargil, 23.ix.11-1♂; Kharbo, 17.vii.12-2♂; Sankoo, 21.viii.12-2♂.

Genus Pelochrista Lederer, Lederer, 1859, Wien. ent. Monatschr. 3: 331.
Pelochrista teleopa Razowski, 2006
teleopa Razowski, 2006 (Pelochrista), Acta Zool. Cracov. 49B: 129.
Pelochrista telopea Razowski, 2006
Material examined: Shargol, 03.viii.10-1♂, 2♀; Kharbo, 17.vii.12-1♂,1♀; Sankoo, 21.viii.12-2♂.

Genus Crocidosema Zeller, Zeller, 1847, Isis von Oken (Leipzig) 1847(10): 721.
Crocidosema plebejana Zeller, 1847
plebejana Zeller, 1847 (Crocidosema), Isis von Oken (Leipzig) 1847 (10): 721.
Crocidosema plebeiana Zeller
Crocidosema ptiladelpha Meyrick, 1917
Crocidosema synneurota Meyrick, 1926
Crocidosema? insulana Aurivililus, 1922
Eucosma plebeiana Zeller
Grapholitha peregrinana Moeschler, 1866
Paedisca lavaterana Milliere, 1863
Penthina altheana Mann, 1855
Proteopteryx blackburnii Butler, 1881
Steganoptycha obscura Wollaston, 1879
Material examined: Panikhar, 02.vii.11-1♂; Shargol, 09.viii.11-3♂; Kharbo, 17.vii.12-2♂.

Genus Gibberifera Obraztsov, Obraztsov, 1946, Z. Wien. ent. Ges. 30: 35.
Gibberifera obscura Diakonoff, 1964
obscura Diakonoff, 1964 (Gibberifera), Verff. Zool. Staatsamml. Mnchen 8: 48.
Material examined: Shargol, 09.viii.11-1♂, 2♀; Mulbek, 18.vii.12-2♂, 1♀; Sankoo, 21.viii.12-1♂, 2♀.
Tribe-Grapholitini
Genus Cydia Hubner, Hubner, [1825] 1816, Verz. bekannter Schmett. 375.
Cydia pomonella (Linnaeus, 1758)
pomonella Linnaeus, 1758 (Phalaena (Tortrix)), Systema Naturae (10th ed.): 538.
Phalaena (Tortrix) pomonella Linnaeus, 1758
Phalaena Tortrix aeneana Villers, 1789
Carpocapsa splendana ab. glaphyrana Rebel, 1941
Pyralis pomana Fabricius, 1775
Tortrix pomonana [Denis & Schiffermuller], 1775
Cydia pomonella simpsonii Busck, 1903
Material examined: Kharbo, 26.vi.11-1♂; Kargil, 04.vii.11-1♂, 1♀; Mulbek, 18.vii.12-2♂, 1♀; Sankoo, 18.viii.12-2♂, 1♀.
Genus Matsumuraeses Issiki, Issiki, 1957, in Esaki *et al*., Icones heterocerorum Japonicorum in coloribus naturalibus 1: 57.

Matsumuraeses capax Razowski &Yasuda, 1975
capax Razowski & Yasuda, 1975: 99.
Matsumuraeses ochreocervina sensu Danilevsky & Kuznetzov, 1968: 239.
Material examined: Sankoo, 18.viii.12-1♂, 2♀; Mulbek, 20.viii.12-2♂.

Matsumuraeses phaseoli (Matsumura, 1900)
phaseoli (Matsumura): Razowski, 1960: 385.
Semasia phaseoli Matsumura, 1900: 197.
Semasia elutana Kennel, 1900: 147.
Thiodia azukivora Matsumura 1910:165.
Eucelis ochreocervina Walsingham, 1900:407.
Eucosma trophiodes Meyrick, 1908:613.
Material examined: Silmoo, 12.viii.11-2♂; Kargil, 17.viii.12-1♂.

The biodiversity (diversity index, species richness and evenness) of Tortricid moth fauna in Kargil is poor mainly due to the lack of vegetation in this area as vegetation plays an important role for the existence of insect fauna in a community as it provides the main source of food etc. for insects. For instance, the occurrence of a rich and diversified fauna in some parts of Nilgiri biosphere region was largely attributed to the conservation of forests in this region [23]. The survival of a large number of endemic species in a community or habitat warrants frequent monitoring of the ecological processes besides adoption of appropriate conservation strategies in order to safeguard its rich genetic diversity [24].

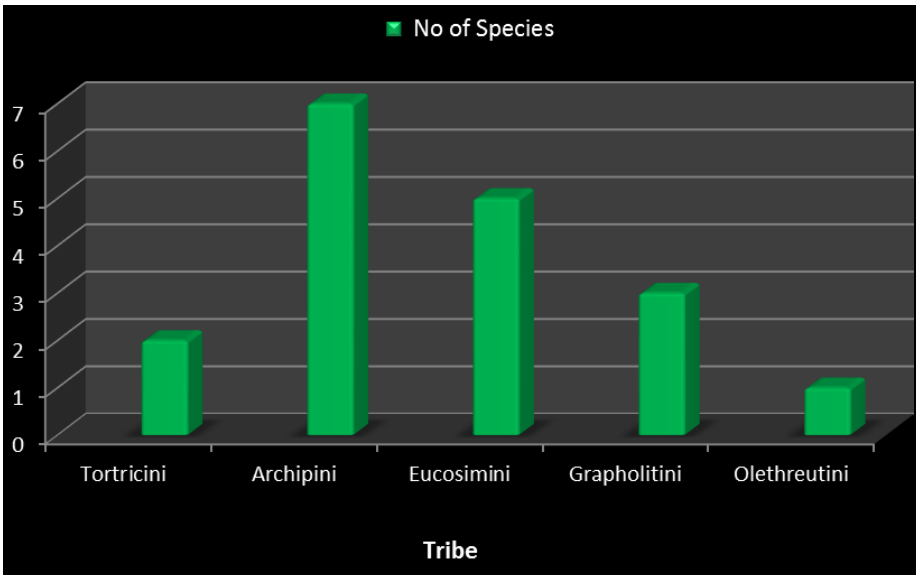

Fig 1: Tribe wise Tortricid moth species caught by light trap in Kargil during 2010-2012

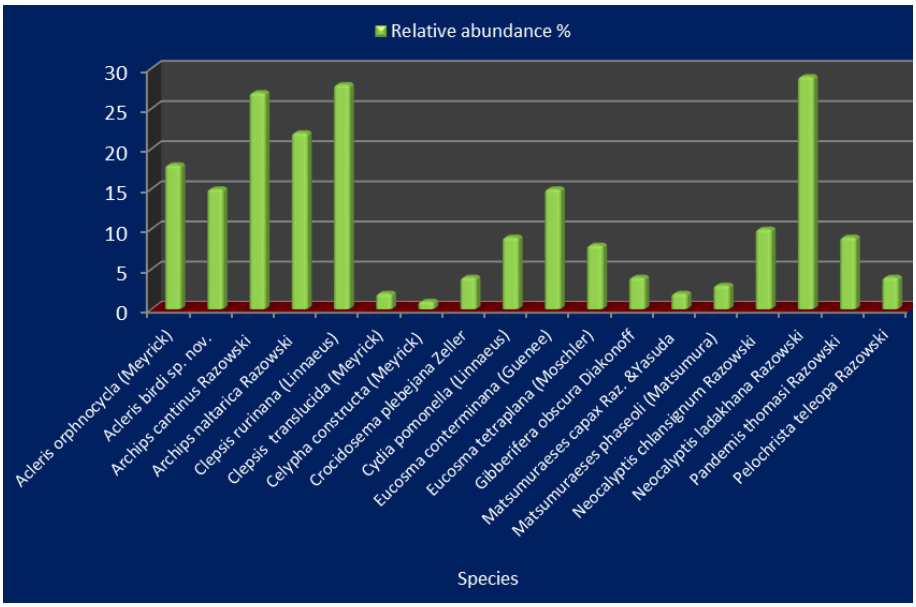

Fig 2: Relative abundance of studied Tortricid moth species in Kargil.

Conclusion

Finally it has been concluded that the population of Tortricid moth fauna of Kargil ecosystem is very poor mainly due to the lack of vegetation in this area, because vegetation plays an important role for the existence of insect fauna in a community as it provides the main source of food them. This work was an attempt to describe some aspects of biodiversity of Tortricid moth fauna. A lot of further work is necessary in this regard and further collections are essential for getting a detailed periodic estimate of the faunal diversity of Tortricid

moths in this area. Ultimately it is hoped that such work may lead to the development of standard monitoring procedures which could be of value in assessing the environmental stability of areas under cultivation for different crops.

7. References

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