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Moth (Lepidoptera: Heterocera) diversity of Sunderban Biosphere Reserve, India and their pest status to economically important plants

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Abstract
The present communication gives a comprehensive account of moth (Lepidoptera: Heterocera) of Indian Sunderbans. Total 45 species have been reported from Indian part of Sunderban Biosphere Reserve. Among them, 16 species are reported for the first time from Sunderban Biosphere Reserve of which 9 species are reported for the first time from the state of West Bengal, India. Moreover, 25 species are found as recognised pests of different agriculturally important plants of India.

Keywords: Moth, Lepidoptera, Sunderban Biosphere Reserve, West Bengal, pest.

Introduction
Among the 17 Biosphere reserves in India, Sunderban Biosphere Reserve (SBR) is unique for its most extensive mangrove forest in the world, existing in a vast deltaic regions where fresh water and salt water mix [1]. Sunderban mangrove forests, a continuous landmass expanded over both India and Bangladesh, is considered to be one of the most biodiverse but threatened region of the world. More than half of the mangrove forest (around 60%) lies in the Bangladesh and the rest (40%) in the West Bengal (India). The Indian Sunderban Delta spread over about 9,630 sq. km and lies between 21 °40'04" N and 22 °09'21" N latitude, and 88 °01'56" E and 89°06'01" E longitude.
There is vast extent of information available based on long years of research in the Sunderbans especially on biological and physical components of the ecosystem. Several workers have previously worked on the butterfly (Lepidoptera: Rhopalocera) diversity of this ecosystem. [2] reported 24 species under 18 genera of butterflies and [1] compiled a total of 117 species under 85 genera of 5 families of butterflies from Sunderban Biosphere reserve. The study of moth fauna of West Bengal in recent past has been undertaken by [3, 4, 5, 6, 7]. They have significantly contributed to the study of moth fauna from different districts of West Bengal after the earlier works undertaken by [8, 9, 10, 11, 12, 13]. Very recently, [14] published 580 species from the state of West Bengal by compiling the previous records. But till date, very little is known about the moth (Lepidoptera: Heterocera) diversity of this unique ecosystem. [15] Had reported only two species of the moths, *Hymenoptychis sordida* (Zeller, 1852) and *Hypsipyla robusta* (Moore, 1886) as fruit borers of the Sunderban mangroves. [1] reported 26 species under 23 genera of 8 families of moths from this Biosphere Reserve. Later, [16] added 1 more species from the Indian part of Sunderbans.
Apart from the report of [15], nothing has been reported on the lepidopteran pest from this biosphere Reserve. Therefore, this study was made to identify and document the moth fauna of SBR and their role in ecosystem. This communication is the pioneering work on moth fauna and their present status in SBR.

Materials and methods
The study was carried out in the Sunderban Biosphere Reserve from 2014 to 2016 under the project titled 'Role of Insect Pollinators on the Conservation of Major Mangrove Species in Sunderban Islands, West Bengal' Funded by Ministry of Environment, Forest and Climate Change (MoEF & CC). Moths were mostly collected at night with the help of a light trap. Light traps were operated using 27 Watt Philips energy saver CFL Lamp from 6.00 p.m. to 9.00 p.m. for collecting specimens at night on a white sheet of cloth measuring approximately 3x2 m. Photographs were taken by using Nikon D7000 camera. Methodology for collection,

Preservation etc. were followed after [17] and for identification of species, standard literatures [10, 11, 12, 13, 18, 19, 20] have been followed. Leica EZ4 and Leica EZ4 HD microscopes were used for specimen identification. Scientific names of the specimens were validated following the database of Natural History Museum [21]. The distributions were checked from available literatures. The coordinates of the collection sites were recorded using GPS (Garmin Oregon 550) which were further used in preparing maps of the survey sites. Map has been prepared using [22] accessed on dated 26/12/2015 (Fig. 1).

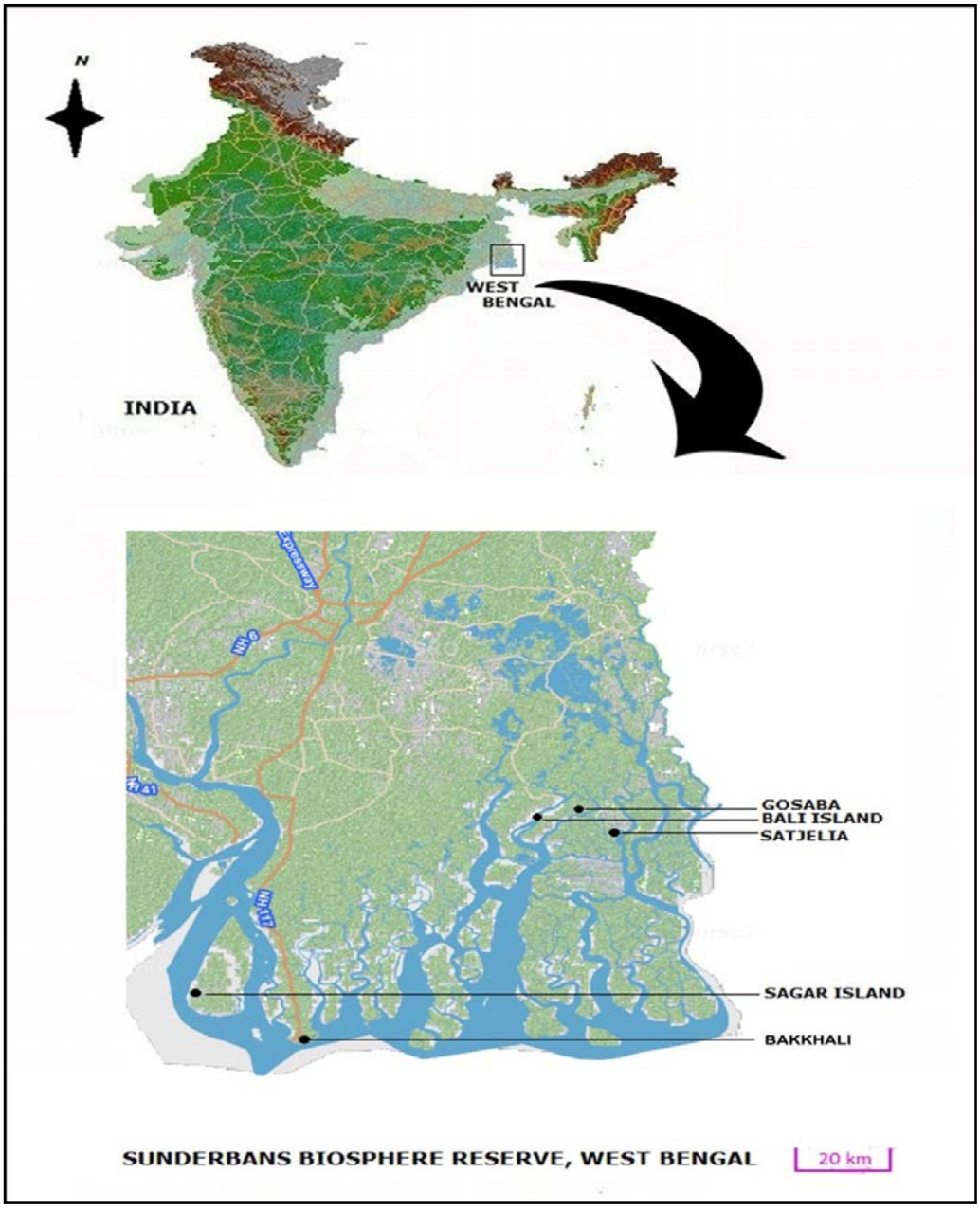

Fig 1: Map showing the collection site of moths.

Results

The current communication documents 45 species under 39 genera of 10 families of moths from Sunderban Biosphere Reserve. Of them, 9 species *viz. Eressa discinota* Moore, *Amsacta emittens* Walker, *Parallelia onelia* Guenée, *Spirama retorta* (Clerck), *Aucha velans* (Walker), *Thosea cana* Walker, *Thosea tripartita* Moore, *Altha nivea* Walker and *Eupterote hibisci* (Fabricius) are reported for the first time from Sunderban Biosphere Reserve as well as from West Bengal, India (Table. 1). In addition to this, 7 species, *viz*. *Argina astrea* (Drury), *Grammodes geometrica* (Fabricius), *Asota producta* (Butler), *Artena dotata* Fabricius, *Spodoptera litura* (Fabricius), *Theretra silhetensis* (Walker) and *Acherontia lachesis* (Fabricius) are reported for the first time only from Sunderban Biosphere reserve (Table. 1). Family Eupterotidae is also reported for the first time from Sunderban Biosphere Reserve (Table. 1). (* - denotes first report of species from Sunderban Biosphere Reserve; # - denotes first report of species from West Bengal, India).

This present communication also compiles 25 species of moths which are the recognised pests of different agriculturally important plants of India (Table.1).

Table.1: List of reported species of Moths from SBR and their host plants

Sl. No.	NAME	FAMILY	PEST
1	*Agylla remelana* (Moore, 1865)	Arctiidae	Data deficient
2	*Amata cyssea* (Stoll, 1782)	Arctiidae	Data deficient
3	*Amata passalis* (Fabricius)	Arctiidae	a. Cow pea [23] b. Mulberry [24] c. Fenugreek (*Trigoniella foenumgraecum* L.) [25] d. Mentioned as harmful to *Morus alba* (Mulberry), caster, Red gram, sunflower, ornamental plants [26] e. Turmeric (*Curcuma longa* Linn.) [27]
4	#*Amsacta emittens* Walker, 1855	Arctiidae	Data deficient
5	*Amsacta lineola* (Fabricius, 1793)	Arctiidae	Data deficient
6	**Argina astrea* (Drury, 1773)	Arctiidae	a. Tea (*Camellia sinensis* L.) [28]
7	*Asura undulosa* (Walker, 1854)	Arctiidae	Data deficient
8	*Caeneressa diaphana* (Kollar, 1844)	Arctiidae	Data deficient
9	*Ceryx godartii* (Boisduval, 1829)	Arctiidae	a. Mentioned as harmful to Mulberry (*Morus alba* L.) [26] b. *Sorghum* sp. [26]
10	*Creatonotos gangis* (Linnaeus, 1763)	Arctiidae	a. Sweet Potato [29] b. Turmeric (*Curcuma longa* Linn.) [27] c. Tea (*Camellia sinensis* L.) [28]
11	#*Eressa discinota* Moore	Arctiidae	Data deficient
12	*Spilosoma obliqua* Walker, 1855	Arctiidae	a. Sweet Potato, Potato, Cole crops, Cowpea, garden pea, Beans, Radish, Yam [29] b. Fenugreek (*Trigoniella foenumgraecum* L.) [25] c. Turmeric (*Curcuma longa* Linn.) [27] d. *Costus speciosus* [30] e. Castor (*Ricinus communis*) [31] f. Jute [32] g. Black gram *Vigna mungo* (L.) [33] h. Groundnut (*Arachis hypogaea* L.) [34] i. *Cannabis* sp. [35] j. Soybean [36] k. Cauliflower [37]
13	*Utetheisa lotrix* (Cramer, 1779)	Arctiidae	a. *Crotalaria júncea* [38]
14	*Utetheisa pulchella* (Linnaeus, 1758)	Arctiidae	a. Sunn hemp [29] b. *Heliotropium* sp. [39]
15	*Cnaphalocrocis medinalis* (Guenee, 1854)	Crambidae	a. Rice [40]
16	*Cryptographis indica* (Saunders, 1851)	Crambidae	a. All Cucurbitaceous plants, Melons, Cucumbers, Gourd, Sugar-beet, Chow-chow, Coccina, Bitter gourd, Pumpkin [29] b. Pointed gourd, *Trichosanthes dioica* Roxb. (Cucurbitaceae). [41] c. The most preferred food of larvae of the pest was leaves of *Benincasa hispida,* followed by those of cucumber, loofah, bottle gourd and *Citrullus vulgaris* [*C. lanatus*, watermelon]. *Cucurbita moschata* and bottle gourd were the least preferred foods. [42] d. Cotton [43]
17	*Hymenoptychis sordida* (Zeller, 1852)	Crambidae	a. Fruit borer of *Heritiera sp.* [44]
18	*Parapoynx diminutalis* (Snellen, 1880)	Crambidae	a. *Nymphoides cristatum* [45]
19	*Parapoynx fluctuosalis* (Zeller, 1852)	Crambidae	Data deficient
20	*Sameodes cancellalis* (Zeller, 1852)	Crambidae	Data deficient
21	*Scirpophaga bisignatus* Swinhoe, 1885	Crambidae	Data deficient
22	*Scirpophaga incertulas* (Walker, 1863)	Crambidae	a. Paddy [46]
23	*Syngamia abruptalis* (Walker, 1859)	Crambidae	a. Sweet basil (*Ocimum basilicum*) [47]
24	#*Eupterote hibisci* (Fabricius, 1775)	#Eupterotidae	a. Drumsticks [23]
25	*Agathia lycaenaria* (Kollar, 1844)	Geometridae	Data deficient
26	#*Altha nivea* Walker, 1862	Limacodidae	*a. Costus speciosus* [30]
27	#*Thosea cana* Walker, 1865	Limacodidae	*a.* Tea [48]
28	#*Thosea tripartita* Moore, 1884	Limacodidae	Data deficient
29	*Anua coronata* (Fabricius, 1775)	Noctuidae	a. Chillies [23]
30	**Artena dotata* Fabricius, 1794	Noctuidae	Data deficient
31	**Asota producta* (Butler, 1875)	Noctuidae	Data deficient
32	#*Aucha velans* (Walker, 1857)	Noctuidae	Data deficient
33	*Ericeia inangulata* (Guenee, 1852)	Noctuidae	Data deficient
34	**Grammodes geometrica* (Fabricius, 1775)	Noctuidae	Data deficient
35	#*Parallelia onelia* Guenée, 1852	Noctuidae	Data deficient
36	#*Spirama retorta* (Clerck, 1764)	Noctuidae	a. *Acacia mangium* [49] b. Devastating pest of *Albizia* in forest nurseries and young plantations in Central India. [50]
37	**Spodoptera litura* (Fabricius, 1775)	Noctuidae	a. Tobacco [39] b. Tomato, Coccina, Brinjal, Pea, Cabbage, Cauliflower, Chillies, elephant's foot, Cowpea, Colocasia, Radish, Beet root, Onion, Sweet Potato, Potato, Amranthus, Okra, yam, Arum, Beans [29] c. Fenugreek (*Trigoniella foenumgraecum* L.) [25]

			d. Turmeric (*Curcuma longa* Linn.) [27] e. Cotton [51] f. Groundnut [52] g. *Jatropha curcas* Linn. [53]
38	*Canthelea oegnusalis* (Walker, 1859)	Pyralidae	Data deficient
39	*Hypsipyla robusta* (Moore, 1886)	Pyralidae	a. Mahogany (*Khaya ivorensis* and *Swietenia macrophylla*) [54] b. Meliaceae[55] c. Fruit borer of *Xylocarpus granatum* and *Xylocarpus moluccensis* [44]
40	*Actias selene* (Hubner, 1806)	Saturniidae	a. Drumsticks [29] b. *Populus alba* [56]
41	*Antheraea paphia* Linnaeus, 1758	Saturniidae	a. Telsur (*Hopea odorata*) [57] b. Jujube (*Ziziphus* sp.) [58]
42	**Acherontia lachesis* (Fabricius, 1798)	Sphingidae	a. Brinjal [23] b. Tobacco [59] c. Dadap tree [60] d. *Curcuma domestica* [61] e. *Tectona grandis* [62] f. Pest of Gingelly (*Sesamum indicum*), Brinjal (*Solanum melongena*), and Field Bean (*Lablab niger*). [63]
43	*Hippotion celerio* (Linnaeus, 1758)	Sphingidae	a. Elephant's foot, Yam [29] b. Nayar *et al.* (1976) mention this as a pest on Elephant Yam (*Amorphophallus campanulatus*), and Grapevine (*Vitis vinifera*). [63]
44	**Theretra silhetensis* (Walker, 1856)	Sphingidae	a. Arum: Colocasia [23]
45	*Thyrassia subcordata* Walker, 1854	Zygaenidae	Data deficient

Systematic Account

Family Arctiidae

***Amsacta emittens* Walker, 1855**

1855. *Creatonotos emittens* Walker, *List Lep. Het. Brit. Mus.* 3: 638.

Material examined: 2 ex., Bali Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 30.v.2014. coll: B. Mitra & Party; 1exs., Debnibash, Bakkhali, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vi.2015. coll: B. Mitra & Party.

***Argina astrea* (Drury, 1773)**

1773. *Phalaena (Noctua) astrea* Drury, *Illust. nat. Hist. ext. Insects*, 2: 11.

Material examined: 2 ex., Bali Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 26.v.2014. coll: B. Mitra & Party.

***Eressa discinota* Moore, 1879**

1879. *Syntomis discinota* Moore, *Lep. Atk,* p. 13.

Materials examined: 1 ex., Bali Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 11.iii.2015. coll: B. Mitra & Party; 1 ex., Gangasagar Crematorium, Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vii.2014. coll: B. Mitra & Party.

Family Eupterotidae

***Eupterote hibisci* (Fabricius, 1775)**

1775. *Bombyx hibisci* Fabricius, *Syst. Ent.*, p. 564.

Material examined: 2exs, Debnibash, Bakkhali, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vi.2015. coll: B. Mitra & Party.

Family Limacodidae

***Altha nivea* Walker, 1862**

1862. *Altha nivea* Walker, *Journ. Linn. Soc. Lond. Zool.* VI: 173.

Material examined: 1 ex., Yuva abash Ghat, Bali Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 14.iii.2015. coll: B. Mitra & Party.

***Thosea cana* Walker, 1865**

1865. *Parasa cana* Walker, *List. Lep. Ins. Brit. Mus.* xxxii: 484.

Material examined: 1 ex., Gangasagar Crematorium, Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vii.2014. coll: B. Mitra & Party.

***Thosea tripartita* Moore, 1884**

1884. *Aphendala tripartita* Moore, *Trans. Ent. Soc. Lond.,* p. 376.

Material examined: 2 ex., Gangasagar Crematorium, Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vii.2014. coll: B. Mitra & Party.

Family Noctuidae

***Artena dotata* Fabricius, 1794**

1794. *Noctua dotata* Fabricius, *Ent. Syst.* III, 2: 55.

Material examined: 1 ex., 4 No., Satjelia Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 30.v.2015. coll: B. Mitra & Party.; 1 ex., Pakhirchor, Gosaba Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 30.v.2015. coll: B. Mitra & Party.

***Asota producta* (Butler, 1875)**

1875. *Hypsa producta* Butler, *Trans. Ent. Soc. London,* p. 320.

Material examined: 1 ex., Pakhirala, Gosaba Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 15.iii.2015. coll: B. Mitra & Party.

***Aucha velans* (Walker, 1857)**

1138. *Aucha velans* Walker, *Cat.* Xiii: 1138.

Material examined : 1 ex., Jharkhali, Basanti Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 28.v.2015 coll: B. Mitra & Party.; 1 ex., Kalisthan, Bakkhali, Sunderban Biosphere Reserve, dist. South 24 Parganas, 18.vi.2015. coll: B. Mitra & Party.

***Grammodes geometrica* (Fabricius, 1775)**

1775. *Noctua geometrica* Fabricius, *Syst. Ent.,* p. 599.

Material examined: 1 ex., Paschimpara, Fulbari, Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 20.v.2014. coll: B. Mitra & Party.; 1 ex., Peyaratoli, Bali

Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 12.xii.2014. coll: B. Mitra & Party.

***Parallelia onelia* Guenée, 1852**
1852. *Naxia onelia* Guenée, *Noct.* Iii: 256.
Material examined: 2 ex., Gangasagar Crematorium, Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vii.2014. coll: B. Mitra & Party.

***Spirama retorta* (Clerck, 1764)**
1764. *Phalaena retorta* Clerck, *Icon. Ins. rariorum*: pl. [54]
Material examined: 1 ex., Pakhirala, Gosaba Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 11.v.2015. coll: B. Mitra & Party.

***Spodoptera litura* (Fabricius, 1775)**
1775. *Noctua litura* Fabricius, *Syst. Ent.,* p. 601.
Material examined: 1 ex., Debnibash, Bakkhali, Sunderban Biosphere Reserve, dist. South 24 Parganas, 17.vi.2015. coll: B. Mitra & Party.

Family Sphingidae
***Acherontia lachesis* (Fabricius, 1798)**
1798. *Sphinx lachesis* Fabricius, *Ent. Syst. Suppl.,* p. 434.
Material examined: 1 ex., Bakkhali, Sunderban Biosphere Reserve, dist. South 24 Parganas, 07.xi.2015. coll: B. Mitra & Party.

***Theretra silhetensis* (Walker, 1856)**
1856. Chaerocampa silhetensis Walker, List. Lep. Ins. Brit. Mus. 8:143. Material examined: 2 ex., Sagar Island, Sunderban Biosphere Reserve, dist. South 24 Parganas, 16.vii.2014. coll: B. Mitra & Party.

Present communication reports only 45 species under 10 families from SBR which is only about 7.7% of total moth fauna reported from West Bengal. Of them, the family Arctiidae (31%) shares the maximum species diversity, followed by Noctuidae and Crambidae (20%), Limacodidae (7%), Pyralidae (5%), Sphingidae (7%), Saturniidae (4%), Eupterotidae (2%), Geometridae (2%), and Zygaenidae (2%). (Fig. 2).

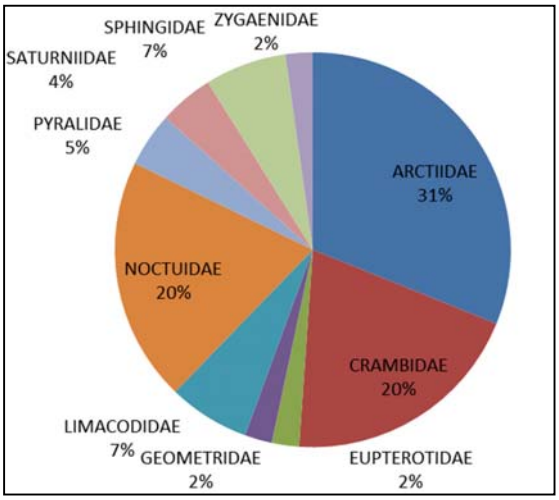

Fig 2: Family wise percentage of species reported

Discussion
A list of 580 species under 16 families of moths *viz.* Zygaenidae, Arctiidae, Pyralidae, Saturniidae, Agaristidae, Geometridae, Ctenuchidae, Limacodidae, Noctuidae, Notodontidae, Sphingidae, Lasiocampidae, Lymantriidae, Syntomidae, Uraniidae and Hypsidae from West Bengal was compiled by [14].
From the above findings it may be concluded that, significant areas of SBR still remain insufficiently explored. Moreover, biology and ecology of this highly economic important group are also less studied. Therefore, efforts should be given on more collection in under or unexplored areas.
Throughout the survey the maximum population were found in the family Crambidae (*Hymenoptychis sordida, Scirpophaga incertulas etc.*) followed by the family Arctiidae (*Utetheisa pulchella*, *Creatonotos gangis etc.*). Family Noctuidae was found rich in species number but population size was found lesser than earlier two. The rest of the families were found very less in numbers.
A significant number of insects are considered as pests for a variety of reasons including their direct damage by feeding on crop plants in the field or by infesting stored products or by spreading viral diseases of crop plants. Several lepidopteran species are of economic interest by virtue of their role as pollinators, the silk they produce, or as pest species. The larvae of many Lepidopteran species are major pests in agriculture. From Table.1 it may be said that *Spodoptera litura* (Fabricius, 1775) is the most notorious pest and attacks most diverse types of plants followed by *Spilosoma obliqua* Walker, *Cryptographis indica* (Saunders), *Amata passalis* (Fabricius), *Acherontia lachesis* (Fabricius), *Cnaphalocrocis medinalis* (Guenee) and so on. They attack different types of agricultural as well as non-agricultural plants thereby causing a great deal of economic loss.

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and Ratardidae. In: Director, Zoological Survey of India (Editor), Fauna of West Bengal (Part-7), State fauna series 3, Zoological Survey of India, Kolkata, India, 1997, 613-687.
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