

SCRUTINIZING LEAF BEETLES' (COLEOPTERA : CHRYSOMELIDAE) HETEROGENEITY OF FOREST & URBAN LANDSCAPES OF WEST BENGAL

*Sumana. Saha¹, Shrabanti. Saha¹ and Dinendra Raychaudhuri²

¹Post Graduate Department of Zoology, Barasat Government College,
10, K.N.C. Road, Barasat, Kolkata – 7000124, West Bengal, India.

²Department of Zoology, Ramakrishna Mission Vidyamandira, Belur Math,
Howrah - 711202, West Bengal, India

*Author for Correspondence: sahasumana2010@gmail.com

ABSTRACT

This study has enhanced our comprehension on the diversity of Chrysomelid beetles of Buxa Tiger Reserve, located in West Bengal. This reserve is a renowned biodiversity hotspot at the foothills of the Eastern Himalayas. Further, this discourse has also aided in creating a reliable public database for Chrysomelidae species found in India and globally. The variability in altitude, latitude, rainfall patterns, and plant diversity within the Buxa forest has contributed to its expansive range of leaf beetle fauna. A grand total of 38 species, comprising 308 individuals from 25 genera and 6 subfamilies, were studied. Among the recorded species, 15 are newly identified in the Alipurduar district of West Bengal, while 21 are previously unreported from the state and nine (9) have not been documented in the country before. Additionally, four (4) of these species are unique to India. Conversely, the abundance of host plants and varied cropping patterns in the plains contribute significantly to the diversity of insect species. In the urban ecosystems of North and South 24 Parganas, West Bengal, a total of eight (8) species and 84 individuals from seven (7) genera across two (2) subfamilies of the Chrysomelidae (leaf beetle) family were observed. The Galerucine beetles inhabit diverse habitats and feed on a wide range of host plants. As indicators of floral community richness, assessing the faunal diversity of Galerucine beetles can provide insights to the attributes of the local ecosystem.

Keywords : Leaf Beetles, Heterogeneity, Forest, Urban, Landscapes, West Bengal

INTRODUCTION

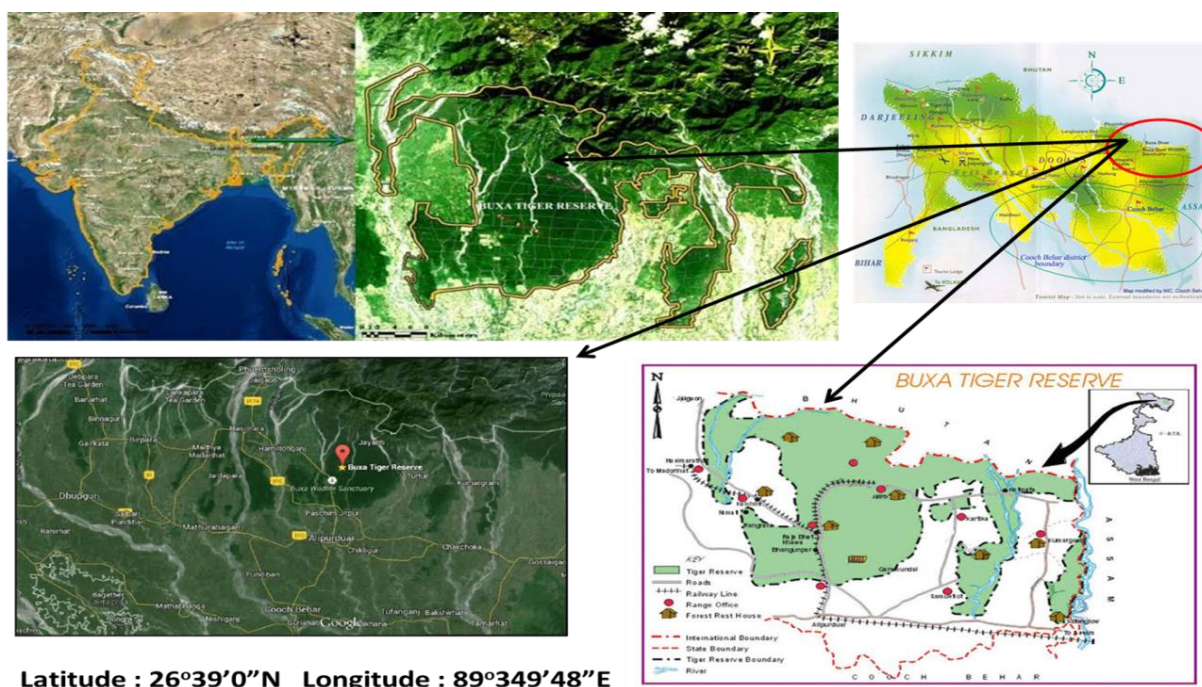
Leaf beetles (Coleoptera: Chrysomelidae) represent one of the most extensive insect families globally. With a range of 35,000–60,000 described species worldwide (Schmitt, 1996; Futuyama, 2004; Splipnski *et al.*, 2011; Jolivet, 2015) they exhibit a remarkable level of diversity and are categorized into 19 subfamilies. As phytophagous insects, they encompass numerous established and potential agricultural pests. Both adult beetles and their larvae are phytophagous, typically consuming the roots, stems and leaves of herbaceous plants, as well as mining the leaves of woody plants. In addition to their agricultural importance, the biodiversity of leaf beetles serves as a direct reflection of the diversity present in the surrounding flora. Furthermore, seasonal variations in leaf beetle populations can serve as indicators of impending weather changes (Kalaichelvan, 2000). Despite their economic significance, leaf beetles in India have not received sufficient attention in terms of taxonomic, biological, and ecological studies.

There have been taxonomic studies on Oriental Leaf Beetles, including Indian Chrysomelidae by Jacoby (1908), Maulik (1919, 1926, 1936) Kimoto (1967, 1970, 1982, 1989, 2003), Kimoto & Gressitt (1979), Kimoto & Takizawa (1983), Takizawa (1980a,b, 1983, 1984, 1985a,b,c, 1986, 1987a,b 1988a,b, 1989, 1990a,b), Takizawa & Basu (1987), Takizawa & Kimoto (1990), Borowiec (1985, 1990, 1996, 1999), Silfverberg (1990), Lopatin (1995), Swietojska (2001), Erfurt & Moscow (2003), Kantner & Bezdek (2007), Warchalowski (2011), Bezdek (2016), Lee & Beenen (2017), Borowski (2020), Nguyen (2022).

Several Indian researchers have made significant contributions to the classification of Indian leaf beetles, including Basu (1985, 1986, 1996) and Basu *et al.* (1981). Notable contributions to Indian leaf beetles were of Pajni & Bansal (1977), Pajni & Singla (1981), Verma & Shrivastava (1985, 1986), Borowiec & Takizawa (1991), Verma (1988, 1992), Kalaichelvan & Verma (2003), Prathapan & Konstantinov (2003), Kantner & Bezděk (2007), Basu *et al.* (2017), Medvedev (2018), Debbarma & Patel (2020), Dilipsundar *et al.* (2022). Mann & Crowson (1981), Jolivet & Hawkeswood (1995), Farrell (1998), Farrell *et al.* (1992), Ray & Banerjee (2023), Adorada *et al.* (2023) have helped understanding speciation and coevolution of chrysomelids with host plants. There are many species, particularly those found on tropical forest canopies, that are yet to be discovered. Against this backdrop, the current study was conducted to examine and compare the variety of leaf beetles in forest and urban landscapes in West Bengal. The purpose of this study is to document the diversity of species and address gaps in knowledge regarding different leaf beetle species through a comprehensive photographic catalogue of the study areas.

Study Area

A study was conducted to collect leaf beetle exemplars by sampling insects from various areas of the Buxa Tiger Reserve (Fig. 1A & B) (for details see Raychaudhuri and Saha, 2014) between 1992 and 2009. Additionally, specimens from urban areas of N & S 24 Parganas [Ashoknagar (Fig. 2A) & Narendrapur (Fig. 2B) respectively] were sampled from August 2023 to June 2024.



Latitude : 26°39'0''N Longitude : 89°34'48''E

Figure 1A : Study Area : Buxa Tiger Reserve, a forest of foothills of eastern Himalaya

MATERIALS AND METHODS

Leaf beetles were identified through visual inspection of plants, focusing on signs of adult or larval feeding damage. The beetles were primarily collected by handpicking, indicated by the presence of large holes on the leaves. Subsequently, the samples were euthanized and preserved in 70% alcohol, following the guidelines of Raychaudhuri & Saha (2014). Detailed information such as the date of collection and the number of individuals was recorded in a field notebook. The insect samples were then transported to the laboratory for permanent storage, in accordance with the recommendations of Jonathan & Kulkarni

(1986) and Raychaudhuri & Saha (2014). The samples were examined using a Stereo Zoom Binocular Microscope, specifically the Olympus SZX-16 model. Identification of the materials was carried out based on the works of Maulik (1919, 1926, 1936) and Kimoto (2005). The materials are currently housed in the Entomology Laboratory at Ramakrishna Mission Vidyamandira, Belur Math, Howrah, West Bengal, and the Department of Zoology at Barasat Govt. College, Barasat, Kolkata.



Figure 1B :Study Sites : Buxa Forest




Figure 2A : Survey of Leaf beetles around urban areas of North 24 Parganas (Ashoknagar)








Figure 2B: Survey of Leaf beetles around urban areas of South 24 Parganas (Narendrapur)

RESULTS & DISCUSSION





Table 1: Encountered Leaf beetles (Chrysomelidae : Coleoptera) during survey of Buxa Tiger Reserve







Subfamily	Name of Species		Distribution			
			Within India	In World	Zoogeographic	Seasonal
Chrysomelinae	♣ <i>Agasta formosa</i> Hope		Assam, Meghalaya, Sikkim, West Bengal (Alipurduar, Darjeeling)	Bangladesh, Bhutan, China, India, Indonesia, Laos, Myanmar, Nepal, Singapore, Thailand, Vietnam	OR, PL	PrM (14), M (15), Ps M (1)





Cryptocephalinae	♣ <i>Aspidolopha spilota</i> (Hope)		Sikkim, West Bengal (Alipurduar, Darjeeling)	India, Nepal, Thailand.	OR	M (6)
	♣ <i>Diapromorpha pallens</i> (Fabricius)		Arunachal Pradesh, Sikkim, West Bengal (Alipurduar, Darjeeling, Hooghly, Kolkata, Maldah, 24 Parganas)	Bhutan, China, India, Laos, Myanmar, Nepal, Philippines, Thailand, Vietnam.	OR, PL	PrM (3), M (9)
Criocerinae	♣ <i>Lema lacordairei</i> Baly		West Bengal (Alipurduar)	India, Laos, Myanmar, Nepal, Thailand, Vietnam.	OR	PrM (6), M (1)
	♣ <i>Lema palpalis</i> Lacordaire		Andaman Is., India, Karnataka, Sikkim, West Bengal (Alipurduar, Darjeeling)	India, Indonesia, Laos, Nepal, Thailand, Vietnam	OR	PrM (3)
	♣ <i>Lema rugifrons</i> Jacoby		Tamil Nadu, West Bengal (Alipurduar, Kolkata)	India, Laos, Myanmar, Taiwan, Thailand, Vietnam.	OR	PrM (1)







	♠ <i>Lema coromandeliana</i> (Fabricius)		Chhattisgarh, Himachal Pradesh, Karnataka, Orissa, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal (Alipurduar, Bankura, Darjeeling, Howrah, Hoogly, Jalpaiguri, Kolkata)	Cambodia, Celebes, China, India, Indonesia, Laos, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam.	OR, PL	PrM (31), M (10), PsM (1)
Eumolpinae	♠ <i>Aoria nigripes</i> (Baly)		Assam, Kerala, Tamil Nadu, West Bengal (Alipurduar, Darjeeling)	China, India, Indonesia, Myanmar.	OR, PL	PrM (4)
	♠♣ <i>Chrysolampra flavipes</i> Jacoby		Assam, West Bengal (Alipurduar)	India	OR	PrM (1)
	♠♣ <i>Chrysolampra minuta</i> Jacoby		West Bengal (Alipurduar)	India, Myanmar	OR	PrM (4)
	♠ <i>Colaspoides subrugosa</i> Jacoby		West Bengal (Alipurduar, Darjeeling).	India, Nepal	OR	PrM (43), M (4), PsM (1)




	♣ <i>Colasposoma pretiosum</i> Baly		Assam, Maharashtra, Meghalaya, Sikkim, Tamil Nadu, West Bengal, (Alipurduar, Darjeeling, Maldah),	China, India, Laos, Myanmar, Nepal, Sri Lanka, Vietnam.	OR, PL	PrM (1)
	♦♣ <i>Heterotrichus balyi</i> Chapuis		West Bengal (Alipurduar)	India, Myanmar	OR	PrM (25)
Galerucinae	♣ <i>Aulacophora bicolor</i> (Weber)		Andaman & Nicobar Island, Arunachal Pradesh, Meghalaya, Tamil Nadu, West Bengal (Alipurduar)	Afghanistan, Algeria, Bangladesh, Cambodia, China, Cyprus, Egypt, Greece, India, Indonesia, Iran, Iraq, Israel, Laos, Myanmar, Pakistan, Philippines, Sri Lanka, South Europe, Taiwan, Thailand, Turkey, Vietnam	OR, PL	PrM (6), M (6), PsM (1)
	♣ <i>Aulacophora nigripennis</i> (Motschulsky)		Andaman Island, Tamil Nadu, West Bengal (Alipurduar)	Afghanistan, Algeria, Bangladesh, China, Cyprus, Egypt, Greece, India, Iran, Iraq, Israel, Japan, Korea, Myanmar, Pakistan, Sri Lanka, South Europe, Taiwan,	OR	PrM (1)

				Turkey, Vietnam		
	♠Hoplasoma unicolor (Illiger)		Andaman Is., Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Maharashtra, Meghalaya. Orissa, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh West Bengal (Alipurduar, Bankura, Birbhum, Coach Beher Darjeeling, Hooghly, Howrah, , Maldah, Murshidabad,N adia, Purulia, 24-Parganas, Medinipur	Bhutan, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sunda Island, Thailand, Vietnam	OR, PL	PrM (15), M(5)
	♠♣Hyphasis magica Harold		West Bengal (Alipurduar)	India	OR	PrM (1)
	♠♣Liroetis clermonti (Laboissiere)		West Bengal (Alipurduar)	India, Vietnam	OR	PrM (12), M(1)
	♠Meristata fallax (Harold)		Arunachal Pradesh, Assam, Sikkim, West Bengal (Darjeeling, Alipurduar)	Bangladesh, Bhutan, India, Nepal	OR	PrM (1)

	♣ <i>Miltina dilata</i> Chapuis		Arunachal Pradesh, Assam, Manipur, Sikkim, West Bengal (Alipurduar)	Bhutan, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Thailand, Vietnam	OR, PL	PrM (10), M (1)
	♦♣ <i>Monolepta feae</i> (Jacoby)		West Bengal (Alipurduar)	India, Myanmar	OR	PrM (4) PsM (1)
	♦♣ <i>Monolepta labiata</i> (Jacoby)		West Bengal (Alipurduar)	India, Nepal	OR	PrM (24), M (3), PsM (6)
	♣ <i>Monolepta leechi</i> Jacoby		Meghalaya, Sikkim, West Bengal (Alipurduar, Darjeeling),	China, India, Laos, Nepal, Taiwan, Thailand, Vietnam	OR, PL	PrM (1), M(1)
	♣ <i>Monolepta orientalis</i> Jacoby		West Bengal (Alipurduar) Tamil Nadu	India, Myanmar, Nepal, Thailand	OR	PrM (1), M(1)
	♣ <i>Monolepta signata</i> (Olivier)		Arunachal Pradesh, Assam, Chattishgarh, Kerala, Meghalaya, Punjab, Sikkim, Tamil Nadu, Uttarakhand, West Bengal (Alipurduar,	Bhutan, Cambodia, China, Indonesia, India, Malaysia, Myanmar, Nepal, Philippines, Singapore, Sri Lanka,	OR, PL	PrM (2)

			Darjeeling, Nadia)	Thailand, Vietnam		
	♣ <i>Nisotra gemella</i> (Erichson)		Andaman & Nicobar Islands, West Bengal (Alipurduar)	Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Taiwan, Thailand, Vietnam	OR, PL	PrM (1)
	♣ <i>Oides maculatus</i> (Olivier)		Andaman Is., Assam, Bihar, West Bengal (Alipurduar, Darjeeling and 24 Parganas), Mcghalaya, Sikkim, Uttar Pradesh	Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Taiwan, Thailand, Vietnam	OR, PL	M (1)
	♣ <i>Oides palleata</i> (Fabricius)		Arunachal Pradesh, Assam, Punjab, Rajasthan, Sikkim, Tamil Nadu, West Bengal (Alipurduar)	Bangladesh, Cambodia, China, India, Indonesia, Laos, Myanmar, Nepal, Thailand, Vietnam,	OR, PL	PrM (1)
	♣ <i>Periclitena vigorsii</i> (Hope)		Arunachal Pradesh, Assam, Bihar, Kerala, Manipur, Meghalaya, Nepal, Punjab, Sikkim, Tamil Nadu, West Bengal (Alipurduar, Darjeeling, Kolkata)	Bangladesh, Bhutan, China, India, Laos, Malaysia, Myanmar, Nepal, Pakistan, Thailand, Vietnam	OR, PL	PrM (1)

	<i>Periclitena</i> sp.		West Bengal (Alipurduar)	India	OR	PrM (1)
	▲♣ <i>Phaelota maculipennis</i> Prathapan & Konstantinov		Tamil Nadu, West Bengal (Alipurduar)	India	OR	PrM (1)
	◆♣ <i>Plagioderia violacipennis</i> Bryant		West Bengal (Alipurduar)	China, India, Sri Lanka, Nepal	OR, PL	PrM (1)
	♣ <i>Podontia quatuordecimpunctata</i> (Linnaeus)		Andaman Island, West Bengal (Alipurduar)	Cambodia, India, Laos, Malaysia, Myanmar, Nepal, Thailand	OR	PrM (4)
	◆♣ <i>Pyrrhalta maculata</i> Gressitt & Kimoto		West Bengal (North 24 Parganas, Alipurduar)	China, India, Thailand, Vietnam	OR	PrM (2), M (3)
	<i>Pyrrhalta</i> sp.		West Bengal (Alipurduar)	India	OR	PrM (1)

	▲♣ <i>Cassena bengalensis</i> (Jacoby)		Rajasthan, West Bengal (Alipurduar)	India	OR	PsM (1)
Megalopodinae	◆♣ <i>Temnaspis ashlocki</i> Kimoto & Gressitt		West Bengal (Alipurduar)	India, Laos, Nepal, Thailand	OR	PrM (2)
	◆♣ <i>Temnaspis downesi</i> Baly		West Bengal (Alipurduar)	India, Nepal, Laos	OR	M (2)
						PrM (237), M (60), PsM (11)

[Legend : OR = Oriental ; PL = Palearctic; PrM = Premonsoon; M = Monsoon; PsM = PostMonsoon; ♣ = New record from district; ♠ = New record from state; ◆ = New record from country ▲ = Endemic to India]

A total of 38 species and 308 individuals were identified from various ecosystems within Buxa forest, belonging to 25 genera under six (6) subfamilies of family Chrysomelidae (leaf beetles) (Table 1; Fig. 3). The majority of these species were collected in the field through methods such as bush beating, shaking, netting, using inverted umbrella, and light traps. Among the 38 recorded species, 15 are new reports from Alipurduar district of West Bengal, 21 are new to the state, nine (9) are new to the country, and four (4) are endemic to India [*Chrysolampra flavipes* Jacoby – **Eumolpinae**, *Hyphasis magica* Harold, *Phaelota maculipennis* Prathapan & Konstantinov, *Cassena bengalensis* (Jacoby) - **Galerucinae**]. The subfamily Galerucinae is composed of highest number of species (23) and individuals (120) (Fig 4). The premonsoon season (35 species, 237 individuals) is identified as the best time for their occurrence (Fig. 5). Analysis of their zoogeographical distribution revealed that the fauna, in addition to being Oriental, also includes 15 Palearctic (39.5%) elements. The ranking sequence of the most abundant six (6) species in descending order are: *Colaspoides subrugosa* (15.58%), *Lema coromandeliana* (13.64%), *Monolepta labiata*

(10.71%), *Agasta formosa* (9.74%), *Heterotrichus balyi* (8.11%), *Hoplasoma unicolor* (6.49%). In contrast, only eight (8) species and 84 individuals from seven (7) genera under two (2) subfamilies of family Chrysomelidae (leaf beetles) were found in different urban landscapes of N & S 24 Parganas, West Bengal. The subfamily Galerucinae is found to accommodate highest number of species [eight (8)] (Fig. 6) and individuals (84). The most abundant species, *Aulacophora fovaecollis* (Lucas), is a major pest of *Cucurbita* spp. (Family: Cucurbitaceae) (Fig.6). The monsoon season (July – September) is identified as the best time for their occurrence. The grub of these beetles damages plants by skeletonizing the leaves and consuming the green tissue between the veins (Fig.7). The adult beetles feed on the leaves, stems, and fruits of the plants and damage to crops, overall affecting the plant health. These beetles can transmit bacterial wilt, detrimental to cucurbit plants. They are prominent decomposers, particularly in forests. *Aulacophora* spp. play a crucial role in providing essential ecosystem services to agriculture, including pollination and the innate regulation of plant pests (Sethuraman *et al.*, 2016; Khan *et al.*, 2018; Dash *et al.*, 2021). Finally, a taxonomic key for the subfamilies of species encountered is provided (Fig.8).

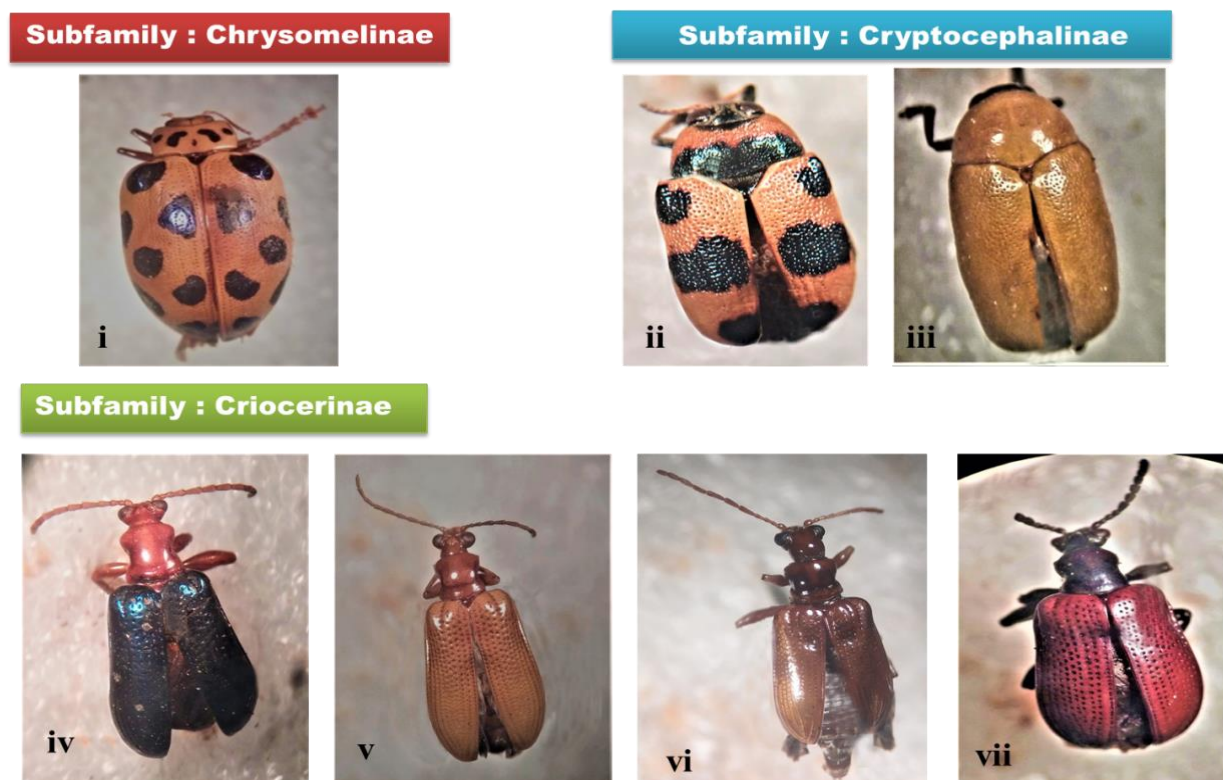


Figure 3. Encountered Leaf beetles (Chrysomelidae : Coleoptera) during survey of Buxa Tiger Reserve i. ♣ *Agasta formosa* Hope ii. ♣ *Aspidolopha spilota* (Hope) iii. ♣ *Diapromorpha pallens* (Fabricius) iv. ♣ *Lema lacordairei* Baly v. ♣ *Lema palpalis* Lacordaire vi. ♣ *Lema rugifrons* Jacoby vii. ♣ *Lema coromandeliana* (Fabricius)

Subfamily : Eumolpinae

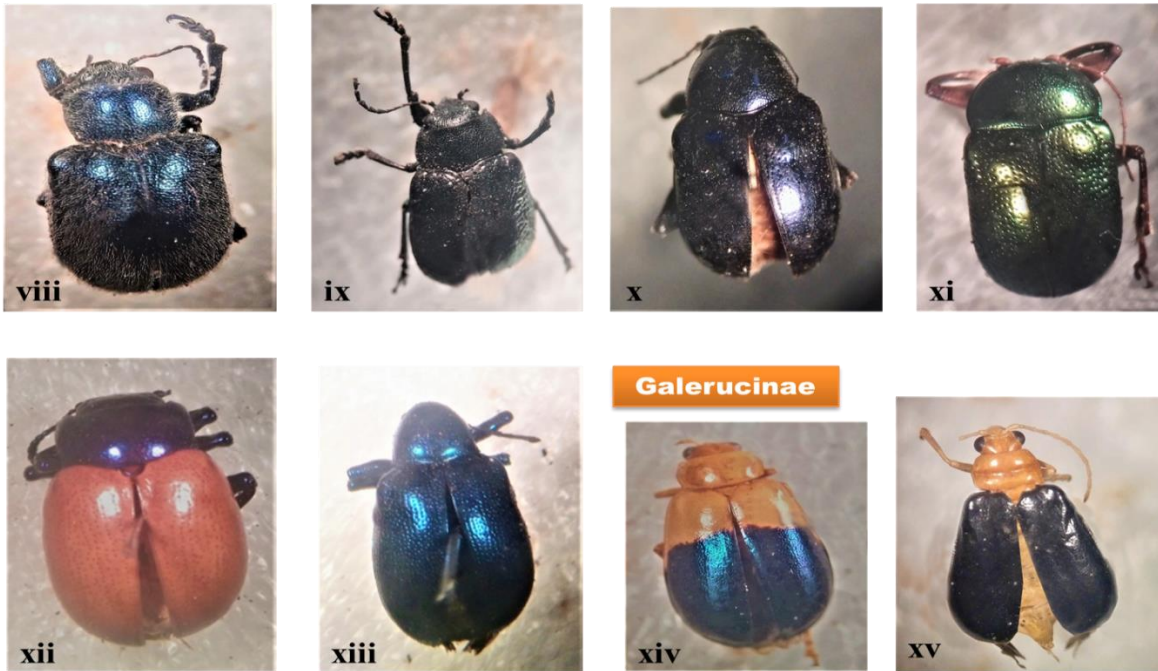


Figure 3.(contd.) viii. ♠*Aoria nigripes* (Baly) ix. ▲♣*Chrysolampra flavipes* Jacoby x. ◆♣*Chrysolampra minuta* Jacoby xi. ♠*Colaspoides subrugosa* Jacoby xii. ♠*Colasposoma pretiosum* Baly xiii. ◆♣*Heterotrichus balyi* Chapuis xiv. ♣*Aulacophora bicolor* (Weber) xv. ♣*Aulacophora nigripennis* (Motschulsky)

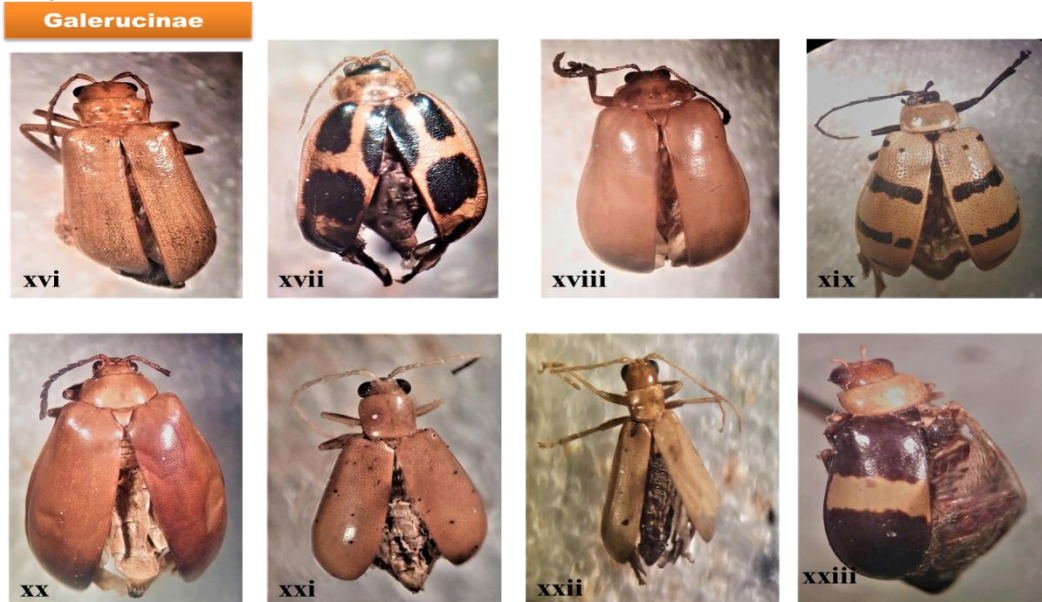


Figure 3. (contd.) xvi. ♠ *Hoplasoma unicolor* (Illiger) xvii. ▲♣*Hyphasis magica* Harold xviii. ◆♣*Liroetis lermonti*(Laboissiere) xix. ♠*Meristata fallax* (Harold) xx. ♣*Miltina dilata* Chapuis xxi.◆♣*Monolepta feae* (Jacoby) xxii. ◆♣*Monolepta labiata* (Jacoby) xxiii. ♠*Monolepta leechi* Jacoby

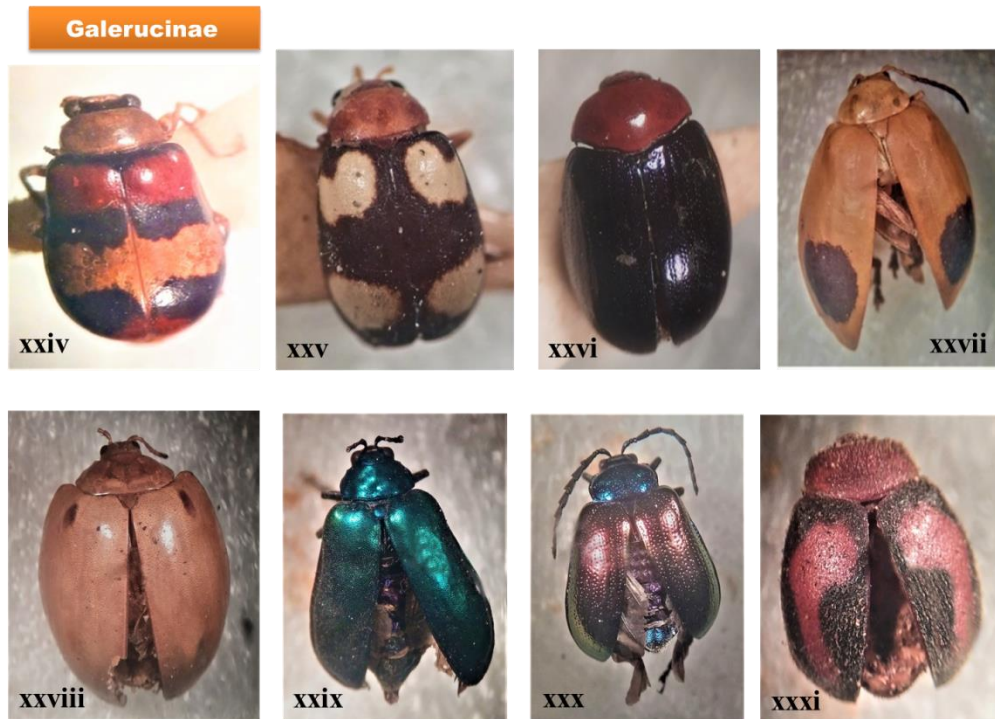


Figure 3. (contd.) xxiv.♣*Monolepta orientalis* Jacoby xxv.♠*Monolepta signata* (Olivier) xxvi.♣*Nisotra gemella* (Erichson) xxvii. ♠*Oides palleata* (Fabricius) xxviii. ♣*Oides maculalus* (Olivier) xxix. ♠*Periclitena vigorsii* (Hope) xxx. *Periclitena* sp. xxxi. ▲♣ *Phaelota maculipennis* Prathapan & Konstantinov

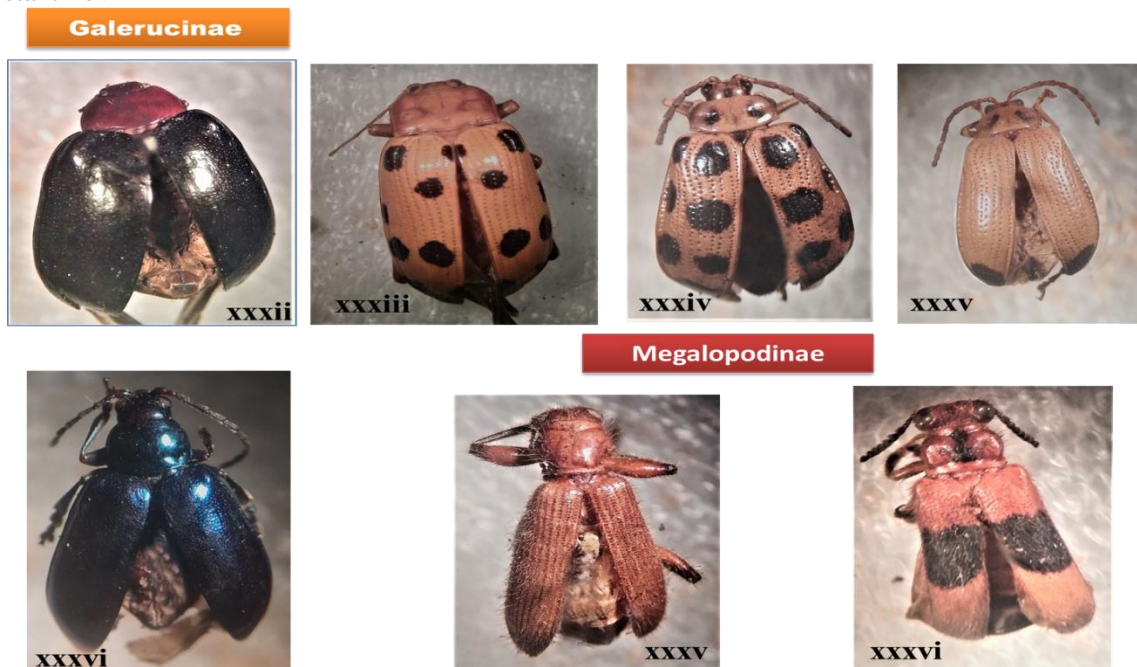


Figure 3. (contd.) xxxii.♦♣*Plagioderia violacipennis* Bryant xxxiii.♣*Podontia quatuordecimpunctata* (Linnaeus) xxxiv. ♦♣*Pyrrhalta maculata* Gressitt et Kimoto xxxv. *Pyrrhalta* sp. xxxvi. ▲♣*Cassena bengalensis* (Jacoby) xxxv. ♦♣*Temnaspis ashloki* Kimoto & Gressitt xxxvi. ♦♣*Temnaspis downesi* Baly

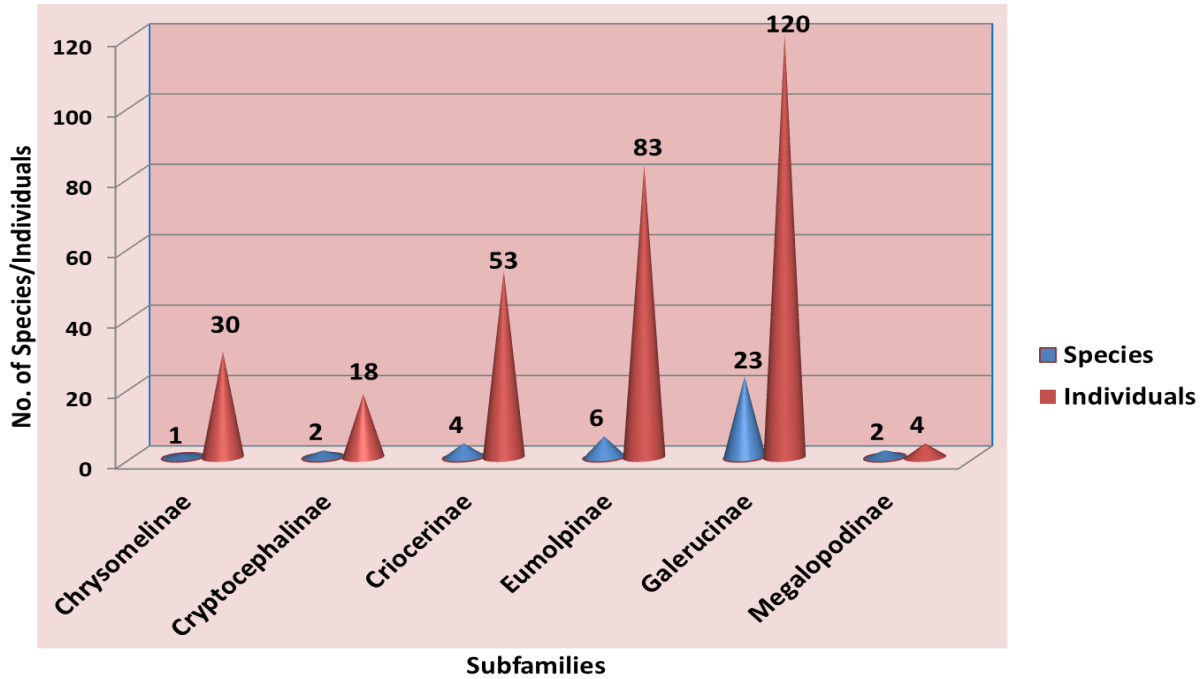


Figure 4: Total leaf beetle Species & Individuals under different subfamilies trapped from Buxa Tiger Reserve, West Bengal

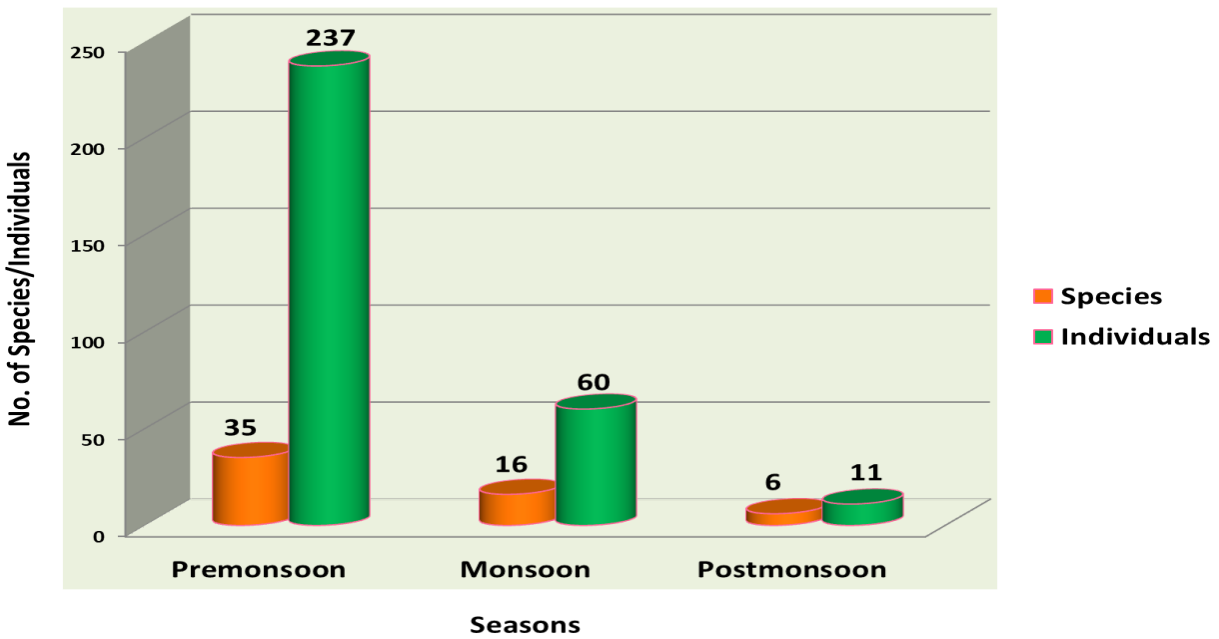


Figure 5: Leaf beetles encountered in different seasons

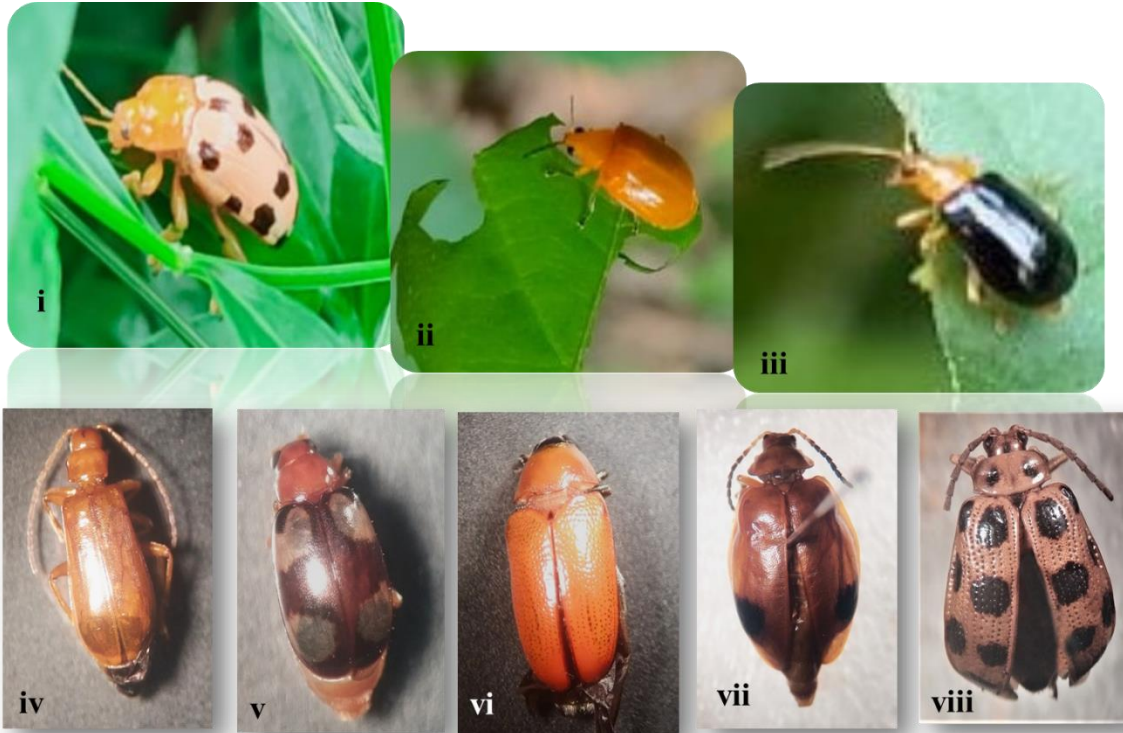


Figure 6. Encountered Leaf beetles (Chrysomelidae : Coleoptera) during survey of urban areas of N & S 24 Parganas : i. *Podontia quatuordecimpunctata* ii. *Hoplasoma unicolor* iii. *Aulacophora nigripennis* iv. *Aulacophora foveacollis* (Lucas) v. *Monolepta signata* vi. *Diapromorpha pallens* vii. *Oides palleata* viii. *Pyrrhalta maculata*



Figure 7. *Aulacophora foveacollis* attacking *Cucurbita* crop : i. *Cucurbita* crop field, ii. *Aulacophora* attacking *Cucurbita* leaf and flower iii. & iv. Damage caused by *Aulacophora* v. Mating of *Aulacophora*

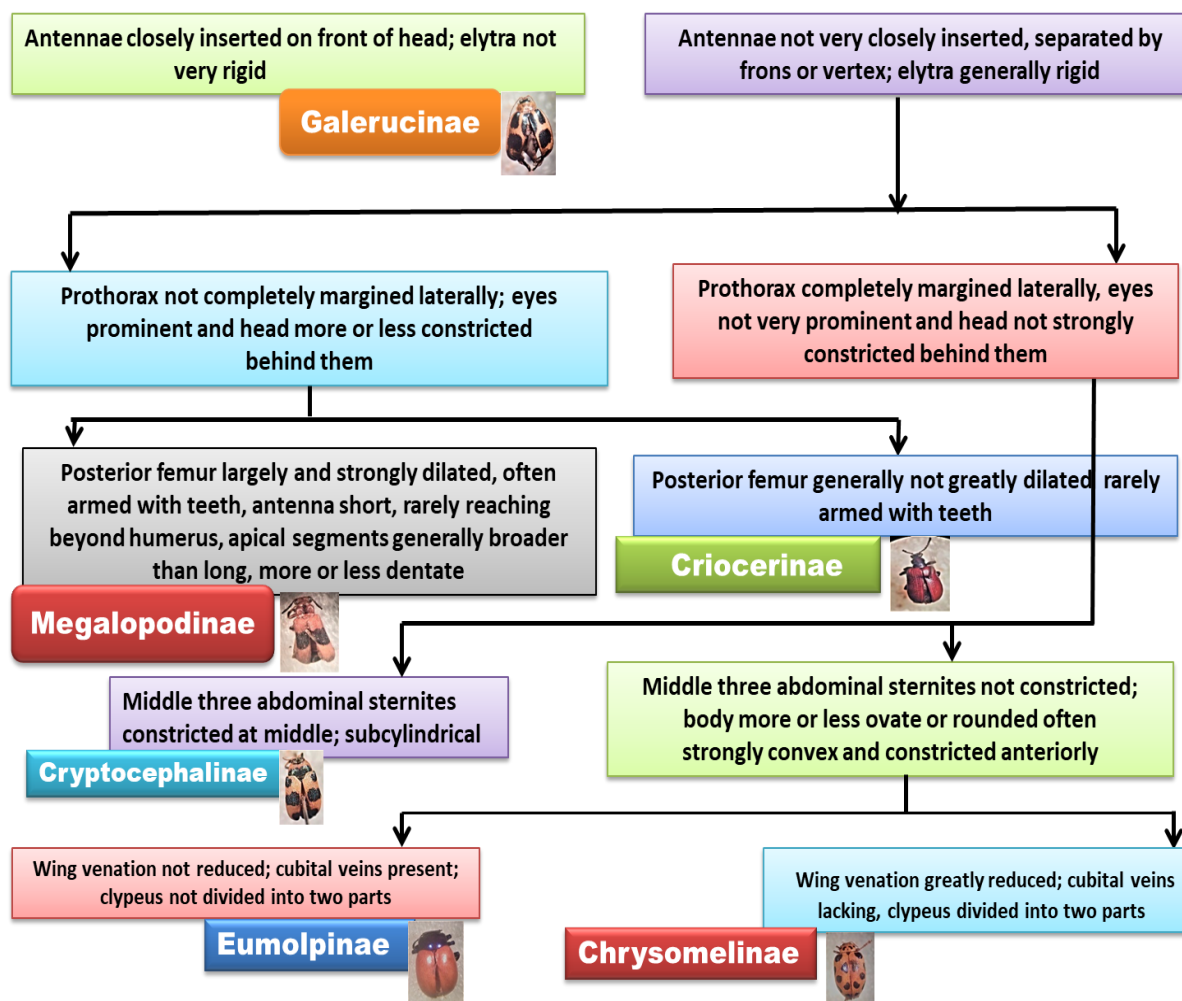


Figure 8. Taxonomic key to subfamilies of encountered chrysomelid species

CONCLUSION

The collection of 38 OTUs from Buxa Tiger Reserve revealed that two (2) species remained undiscovered at the species level, highlighting the necessity for further exploration into the diversity of Chrysomelidae after a decade or more gap. The findings of this research have enhanced our comprehension of the Chrysomelidae diversity within Buxa Tiger Reserve, West Bengal, a key biodiversity hotspot at the foothills of the Eastern Himalayas. Moreover, it has contributed to the establishment of a comprehensive public reference database for Chrysomelidae fauna in India and globally. The diverse leaf beetle fauna in Buxa Tiger Reserve is influenced by variations in altitude, latitude, and rainfall, as well as the availability of food, favourable climatic conditions, and floral diversity that can sustain a wide array of faunal species. In contrast, the richness of insect species in the plains is primarily attributed to the availability of host plants and a diverse cropping pattern. However, due to various socioeconomic factors, there has been a shift from annual crops to plantation crops or fallowing of land, which directly impacts the insect community associated with crops. Galerucinae beetles are found in a range of habitats with a broad host range, serving as indicators of floral richness within an ecosystem. Therefore, assessing the faunal diversity of Galerucinae beetles can provide valuable insights to ecosystem attributes.

ACKNOWLEDGEMENTS

Authors express sincere gratitude to the Principal Barasat Government College and the Principal, Ramakrishna Mission Vidyamandira, Belur Math, Howrah for necessary logistic support. First & third authors especially want to acknowledge the help rendered by their team mates worked under various projects sponsored by UGC, MOEF & NTRF.

REFERENCES

- Adorada JL, Calcetas OA, Anabo RAA, Staines CL, Gallegos MAD, Zulueta BJS, Recuenco MO, Alvarez FC, and Serquina AA (2023).** New Records of *Podontia quatuordecimpunctata* (L.) (Sineguelas Leaf Beetle) (Chrysomelidae: Galerucinae : Alticini) on *Spondias* spp. (Anacardiaceae) and Its Geographic Distribution in the Philippines. *Philippine Journal of Science*, **152** (3) 809-820.
- Basu CR (1985).** Insecta: Coleoptera: Chrysomelidae. In: Fauna of Namdapha: Arunachal Pradesh. *Records of the Zoological Survey of India*, **82**(1-4) 201-214.
- Basu CR (1986).** Chrysomelidae (Coleoptera) of Silent valley, Kerala. *Records of the Zoological Survey of India*, **84**(1-4) 143-155.
- Basu CR (1996).** Insecta: Coleoptera: Chrysomelidae In State Fauna Series 3: Fauna of West Bengal, Zoological Survey of India, Part 6B 559-773.
- Basu CR, Bhaumik, AR, and Sengupta T (1981).** The Chrysomelidae (Coleoptera) of Tripura (India). *Records of the Zoological Survey of India*, **78** 41-61.
- Basu P, Aditya G and Sanyal AK (2017).** Community structure of Coleoptera in Bethuadahari Wildlife Sanctuary, West Bengal, India. *Check List*, **13**(3) 2154.
<https://doi.org/10.15560/13.3.2154>.
- Bezdek J (2016).** Redescription and identity of *Taphinella bengalensis* Jacoby, 1900 (Coleoptera : Chrysomelidae : Galerucinae). *Turkish Journal of Zoology*, **40**(1) 120-124.
- Borowiec L (1985).** Asiatic Cassidinae (Coleoptera, Chrysomelidae) in Polish collection. *Polish Pismo Entomology*, **55** 25-38.
- Borowiec L (1990).** New record and new synonyms of Asiatic Cassidinae (Coleoptera, Chrysomelidae). *Polish Pismo Entomology Bulletin*, **59** 677-711.
- Borowiec, L (1996).** New record of Asiatic Cassidinae (Coleoptera: Chrysomelidae). *Annals of the Upper Silesian Museum, Entomology*, **6-7** 5-47.
- Borowiec L (1999).** A World Catalogue of the Cassidinae (Coleoptera: Chrysomelidae). *Biologica Silesiae, Poland*, 1-476.
- Borowiec L and Takizawa H (1991).** Notes on Chrysomelid Beetles (Coleoptera) of India and its neighboring areas. Part 10. *Japan Journal of Entomology*, **59** 637-654.
- Borowski T (2020).** World Inventory of Beetles of the Family Chrysomelidae (Coleoptera). Part 2: Eastern Europe and Northern Asia. Check List from 1768 to 2004. *World Scientific News*, **29**(2) 75-150.
- Dash L Rout S Ramalakshmi V Padhy D Nihal R and Nayak S (2021).** Studies on biology of Red Pumpkin Beetle (*Aulacophora foveicollis* Lucas) under Odisha condition, India. *Journal of Plant Development Sciences*, **13**(6) 381-384.
- Debbarma R and Patel SR (2020).** Checklist of Leaf beetles of Navsari Agricultural University, Navsari, Gujarat, India. *International Journal of Current Microbiology and Applied Science*, **9**(9) 2717-2724.
- Dilipsundar N Chitra N Balasubramani V Arulprakash R and Kumaraperumal R (2022).** Assemblage and Functional Guild of Galerucinae Beetles (Chrysomelidae: Coleoptera) in different Agro ecosystems of Tamil Nadu. *Biological Forum – An International Journal*, **14**(2) 47-52.
- Erfurt MH and Moscow LNM. (2003).** To the knowledge of Nepalese Chrysomelidae (Coleoptera). *Veroffentlichungen Naturkundemuseum Erfurt*, **22** 153-183.

- Farrell BD (1998)**. “Inordinate fondness” explained : why are there so many beetles? *Science*, **281** 555-559.
- Farrell BD, Mitter C and Futuyma, DJ (1992)**. Diversification at the insect-plant interface. *Bio-Science*, **42**(1): 34-42.
- Futuyma DJ (2004)**. Preface. In: Jolivet P, Santiago-Blay J. A, Schmitt M (eds) New developments in the Biology of Chrysomelidae. SPB Academic Publishing, The Hague, pp. 19–20.
- Jacoby M (1908)**. The Fauna of British India, including Ceylon and Burma. Coleoptera, Chrysomelidae, Taylor & Francis, London, 1 : XX + 534 pp.
- Jolivet P (2015)**. Together with 30 years of symposia on Chrysomelidae! Memories and personal reflections on what we know more about leaf beetles. *ZooKeys*, **547** 35–61.
- Jolivet P and Hawkeswood TH (1995)**. Host-plants of Chrysomelidae of the World. Backhuys Publishers, The Netherlands, 521pp.
- Jonathan JK and Kulkarni PP (1986)**. Manual : Collection, Preservation and Identification of insects and mites of economic importance; Ed. B.K. Tikader, Zoological Survey of India 1-307.
- Kalaichelvan T (2000)**. Deficient rainfall this year claims biologist. Hitawada, City Line 15th May, 2000.
- Kalaichelvan T and Verma KK (2003)**. Check list of leaf beetles (Coleoptera : Chrysomelidae) of Bhilai-Durg. *ZOOS' Print Journal*, **20**(4) 1838-1842.
- Kantner F and Bezděk J (2007)**. Contribution to the knowledge of Clytrinae from Maharashtra state, India (Coleoptera: Chrysomelidae). *Genus*, **18**(2) 247-270.
- Khan MMH (2018)**. Occurrence, distribution, host preference and damage severity of red pumpkin beetle- A review. *Malaysian Journal of Halal Research Journal (MJHR)*, **1**(1) 03-09.
- Kimoto S (1967)**. A list of the Chrysomelid specimens from the Himalayas and Kashmir, preserved in the Zoological Museum, Berlin, *Esakia*, **6** 65-75.
- Kimoto S (1970)**. A list of the Nepalese Chrysomelid specimens preserved in Zoologische Sammlung des Bayerischen Staates, Munchen, Khullibu Hinlal. Bd. 3, Lfg. 3 : 412-421.
- Kimoto S (1982)**. The Galerucinae of Nepal, Bhutan and northern territories of India, in the Natural History Museum in Basel, II. (Coleoptera, Chrysomelidae). *Entomological Review of Japan*, **37** 7–24.
- Kimoto S (1989)**. Chrysomelidae (Coleoptera) of Thailand, Cambodia, Laos and Vietnam. IV. Galerucinae. *Esakia*, **27** 1–241.
- Kimoto S (2003)**. The Chrysomelidae (Insecta: Coleoptera) collected by Dr. Akio Otake, on the occasion of his entomological survey in Sri Lanka from 1973 to 1975. Bulletin of Kitakyushu Museum of Natural History & Human History, Ser. A., **1** 23-43.
- Kimoto S (2005)**. Systematic Catalog of the Chrysomelidae (Coleoptera) from Nepal and Bhutan. Bulletin of Kitakyushu Museum Natural History & Human History, Ser. A., **3** 13-114.
- Kimoto S and Gressitt JL (1979)**. Chrysomelidae (Coleoptera) of Thailand, Cambodia, Laos and Vietnam. I. Sagrinae, Donaciinae, Zeugophorinae, Megalopodinae and Criocerinae. *Pacific Insects*, **20** (2–3) 191–256.
- Kimoto S and Takizawa H (1983)**. Chrysomelid beetles of Nepal collected by the Himalayan Expedition 1979 of the National Science Museum, Tokyo (Part I). Bulletin Natural Science Museum, Tokyo, (A) **9**(2) 83-96.
- Lee CF and Beenen R (2017)**. Revision of the genus *Aulacophora* from Taiwan (Coleoptera: Chrysomelidae: Galerucinae). *Zootaxa*, **3949**(2) 151–190.
- Lopatin L (1995)**. Neue Cryptocephalinen und Chalmisinen der indischen Region (Coleoptera, Chrysomelidae). *Entomology Basiliensia*, **18** 455-466.
- Mann JS and Crowson RA (1981)**. The systematic positions of *Orsodacne* Latr. And *Symmeta* Lac. (Coleoptera, Chrysomelidae) on relation to characters of larvae, internal anatomy and tarsal vestiture. *Journal of Natural History*. **15** 727-749.

- Maulik S (1919).** The Fauna of British India, including Ceylon and Burma. Coleoptera-Chrysomelidae (Hispinidae & Cassidinae), Taylor & Francis, London : xii + 440 pp.
- Maulik S (1926).** The Fauna of British India, including Ceylon and Burma. Coleoptera-Chrysomelidae : Chrysomelinae & Halticinae, Taylor & Francis, London : xiii + 442 pp.
- Maulik S (1936).** The Fauna of British India, including Ceylon and Burma. Coleoptera-Chrysomelidae (Galerucinae), Taylor & Francis, London : xiv + 648 pp.
- Medvedev LN (2018).** New taxa of Chrysomelidae (Coleoptera) from South India. *Caucasian Entomological Bulletin*, **14**(2) 249-251.
- Nguyen DT (2022).** Exploring the diversity of leaf beetles (Coleoptera: Chrysomelidae) on the islands of Vietnam: A survey of Phu Quoc Island, south of Vietnam. *Research Square*, 1-23. DOI : <https://doi.org/10.21203/rs.3.rs-1668461/v1>
- Pajni HR and Bansal RK (1977).** First report on the Chrysomelidae fauna of Chandigarh. *Research Bulletin (Science) Punjab University*, **28** (1- 2): 55-59.
- Pajni HR and Singla SR (1981).** Second report on the chrysomelid fauna of Chandigarh and adjoining hilly areas (Coleoptera). *Research Bulletin (Science) Punjab University*, **32** 139-142.
- Prathappan KD and Konstantinov AS (2003).** The flea beetle genus *Aphthona* Chevrolat (Coleoptera: Chrysomelidae) of Southern India, with descriptions of seven new species. *Proceeding of the Entomological Society of Washington*, **105**(1) 154-179.
- Raychaudhuri D and Saha S. (Eds.). (2014).** Atlas of Insects and Spiders of Buxa Tiger Reserve. Publ. West Bengal Biodiversity Board and Nature Books India, Kolkata : 357 pp.
- Ray S and Banerjee A (2023).** Incidence of Leaf Eating Beetle *Podontia quatuordecimpunctata* L. on Greater Hog plum (*Spondias dulcis* Forst.) in Gangetic Plains of West Bengal. *Biological Forum – An International Journal*, **15**(1) 42-47.
- Schmitt M (1996).** The phylogenetic system of the Chrysomelidae - history of ideas and present state of knowledge. In: Jolivet PH, Cox ML (eds) Chrysomelidae Biology, Vol. I. The Classification, Phylogeny and Genetics. Amsterdam. SPB Academic Publishing BV, pp. 57–96.
- Sethuraman T, Vivekananthan T and Ramesh TK (2016).** The biology of pumpkin beetles, *Aulacophora foveicollis* (Lucas) and *Aulacophora nigripennis* (Motschulsky) (Coleoptera: Chrysomelidae) from Tamil Nadu, India. *Indo – Asian Journal of Multidisciplinary Research (IAJMR)*, **2**(5) : 796 – 804; DOI: 10.21276.iajmr.2016.2.5.11.
- Silfverberg H (1990).** Records of Galerucinae (Coleoptera, Chrysomelidae) from the Indian subcontinent. Part 1. *Entomologica Fennica*, **21** XII 201-207.
- Splipnski SA, Leschen RAB and Lawrence JF (2011).** Order Coleoptera Linnaeus, 1758. In: Zhang Z.Q. (ed) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa*. **3148** 203–208. <https://doi.org/10.1371/journal.pone.0005502>. Franz.
- Swietojanska J (2001).** A revision of the tribe Aspoidimorphni of the Oriental Region (Coleoptera: Chrysomelidae: Cassidinae) Genus (Supplement). *Polish Taxonomical Society, Wroclaw*, 318pp+18colour plates.
- Takizawa H (1980a).** Immature stages of some Indian Cassidinae (Coleoptera: Chrysomelidae). *Insecta Matsumurana*, New Series **21** 19- 48.
- Takizawa H (1980b).** Notes on Indian Chrysomelinae based on the collection of the Forest Research Institute, Dehra Dun (Coleoptera: Chrysomelidae). *Insecta Matsumurana*, New Series **21** 49-55.
- Takizawa H (1983).** Chrysomelid-beetles of India in the collection of National Institute of Agricultural Science, Tsukuba (Coleoptera). *Entomological Review of Japan*, **38** 65-79.
- Takizawa H (1984).** Chrysomelidae Collected by the Japan-India Cooperative Survey in India, 1978. Part I, *Entomological Review of Japan*, **39**(1) 9-25.
- Takizawa H (1985a).** Chrysomelidae collected by the Japan-India cooperative survey in India, 1978 Part-II. *Entomological Review of Japan*. **40** 1-8+2plates.

- Takizawa H (1985b).** Notes on Chrysomelid-beetles of India and its neighbouring areas. Part-1. *Kontyu, Tokyo*, **53** 565-575.
- Takizawa H (1985c).** Notes on Chrysomelid-beetles of India and its neighboring areas, Part II (Coleoptera, Chrysomelidae). *Entomological Review of Japan*, **40** 95- 114.
- Takizawa H (1986).** Notes on Chrysomelid-beetles of India and its neighbouring areas. Part-3 (Coleoptera, Chrysomelidae). *Kontyu*, **41** 35-47.
- Takizawa H (1987a).** Notes on Chrysomelid-beetles of India and its neighbouring areas. Part-5. *Proceeding of the Japan Society Systematic Zoology*. **35** 40-58.
- Takizawa H (1987b).** Notes on Chrysomelid-beetles (Coleoptera, Chrysomelidae) of India and its neighbouring areas. Part-5. *Kontyu*, **55** 521-529.
- Takizawa H (1988a).** Chrysomelid Beetles of Nepal, collected by the Hokkaido University Scientific Expedition to Nepal Himalaya. Part IV (Coleoptera, Chrysomelidae). *Entomological Review of Japan*, **43** 1-16.
- Takizawa H (1988b).** Notes on Chrysomelid-beetles (Coleoptera, Chrysomelidae) of India and its neighboring areas. Part 7. *Kontyu*, **56** 534-552.
- Takizawa H (1989).** Chrysomelid Beetles of Nepal, Northeastern India and Western Sikkim collected by the Himalaya Expeditions of National Science Museum, Tokyo. Part 2. *Japanese Journal of Entomology*, **58** 275-291.
- Takizawa H (1990a).** Chrysomelid Beetles of Nepal, Northeastern India and Western Sikkim collected by the Himalaya Expeditions of National Science Museum, Tokyo. Part I. *Japanese Journal of Entomology*, **57** 319-332.
- Takizawa H (1990b).** Notes on Chrysomelid Beetles (Coleoptera, Chrysomelidae) of India and its Neighboring Areas. Part 8. *Proceedings of the Japanese Society of Systematic Zoology*, **41** 45-53.
- Takizawa H and Basu CR (1987).** Notes on Chrysomelid-beetles (Coleoptera, Chrysomelidae) of India and its Neighboring Areas. *Kontyu*, **55**(2) 266-283.
- Takizawa H and Kimoto S (1990).** Notes on Chrysomelid-beetles of S. India preserved in the collection of Staatliches Museum of Munich (Coleoptera: Chrysomelidae). *Entomological Review of Japan*, **45**(1) 7- 10.
- Verma R (1988).** Chrysomelid fauna of the Chhattisgarh Region. In Sovenir, MAPCOST Symposium on Indian Studies on Chrysomelidae and Bruchidae, Feb. 7-9, Govt. Arts & Science College, Durg.
- Verma KK (1992).** Cycloaexy in the tortoise beetle, *Aspidomorpha miliaris*, F. (Coleoptera, Chrysomelidae, Cassidinae). *Chrysomel*, **26** 6.
- Verma KK and Shrivastava RK (1985).** Separate niches for two species of *Aspidomorpha* living on *Ipomoea fistulosa* M. and de Bary (Coleoptera: Chrysomelidae). *Entomography*, **3** 437-446.
- Verma KK and Shrivastava RK (1986). A method of theoretical visualization of niche, with particular reference to chrysomelid beetles, pp.291-295. In: Pathak, S.C. and Sahai, Y.N (editors). *Advances in Insect Physiology*. Today and Tomorrow's Printers and Publishers, New Delhi.
- Warchalowski A (2011).** An introductory review of *Lema* Fabr. species from Eastern and Southeastern Asia (Coleoptera: Chrysomelidae: Criocerinae). *Genus*, **22**(1) 29-93.

Copyright: © 2024 by the Authors, published by Centre for Info Bio Technology. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-NC) license [<https://creativecommons.org/licenses/by-nc/4.0/>], which permit unrestricted use, distribution, and reproduction in any medium, for non-commercial purpose, provided the original work is properly cited.