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Impact of mining activities on Orthopteran (Grasshopper) diversity in provinces adjoining lingaraj open cast project, Talcher, Angul, Odisha, India

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Abstract
An exhaustive survey was carried to find out Grasshopper fauna in peripheral areas of Lingaraj Open Cast Project, Talcher, India. The present study is an attempt to study the Grasshoppers regimen in the connecting villages of Lingaraj Open Cast Project (OCP), Talcher, Angul, and Odisha. A total number of 1450 Grasshoppers belonging to 6 families and 38 species under two suborders (Caelifera and Enisifera) were recorded during the entire study period. Shannon – Weiner index (H') was 3.29 in Langijoda village, followed by 3.32 in Gengutia village, 3.28 in Balugaon village, and 3.33 in Talabeda village. Margalef's richness (Dmg) index was found to be 5.45 in Langijoda, 5.42 in Balunga, 5.57 in Talabeda, and 5.44 in Gengutia village. Besides this, it was noted that members of the family Acrididae were found to be 67.8% followed by Tettigoniidae 16.2%, Grylliade 7.4%, and Romaleidae with 7.4%. The lowest population was studied in Pyrgomorphidae and Gryllotalpidae with 0.97% and 0.14% respectively.

Keywords: impact, regimen, biodiversity, lingaraj, grasshopper

Introduction
Grasshoppers are one of the fascinating group of insects. They are considered as bio-indicators of the reclamation of degraded land and their rich diversity and habitat specificity make them ideal tools for assessing the terrestrial ecosystem health. Globally 22,500 species have been identified of which 1750 species have been reported from India. The order Orthopteran is classified into two sub-orders: Enisifera and Caelifera. Superfamily Acridoidea includes locusts under the sub-order Caelifera [2]. They change the color and behavior frequently at high population density. Generally, locusts are solitary and gregarious. They cause massive damage to crops. Acridoidea is the largest superfamily and diverse group representing 11,000 species worldwide wide, has 290 species representing 138 genera reported from India (Shishodia *Et al*. 2010) [21]. Family Acrididae shows maximum diversity, comprising 8000 species, of which 136 species under 28 genera are endemic (Chandra and Gupta 2013).

These hemimetabolous insects complete their life cycle by 3 phase's *viz*. egg, nymph, and adult. They are significant invertebrates in grassland ecosystems and are credited for being an important food source for many predatory birds.

Indian Orthoptera highlighted by Kirby (1914) in the fauna of British India had 329 species belonging to 124 genera and 8 subfamilies, under the family Acrididae. Grasshoppers of India were published by Tandon (1976) [28] and Shisodia Et. al. (2010) [22] and different states of India like Kerala by Priya and Narendran (2003), Madhya Pradesh, Himachal Pradesh by Shisodia and Gupta (2009) [21], Northeast by Usmani and Khan(2010) [30], Jharkhand by Nayeem and Usmani(2012), Punjab by Kumar and Usmani(2012) [13] and Bihar. The study of Indian Acrididae **[24, 25, 26]** was triggered by Stal who is regarded as the first in this field. Walker **[23]** and Shisodia [22, 23] also studied some Indian fauna. Contribution to the Indian Acridoidea was also made by Bolivar [3, 4]. Kirby prepared a catalogue for the Acrididae of the world [12]. Notable taxonomical work on Acrididae was made by Kirby in the series 'Fauna of British India' [12]. Uvarov studied in detail Indian Acrididae [30, 31, 32]. Recently Usmani *et al.* [29], Kumar and Usmani studied Indian Acrididae **[13, 14]**. Tandon and Shishodia [28], Ali *et al.* [1], Chandra [5, 6], Shishodia [21] studied the acridids of Rajasthan. Realising the commercial importance of these pests in a farming, thorough survey to study the taxonomy and distribution of the locusts and grasshoppers belonging to the family Acrididae was made in different areas of Rajasthan. A systematic study of the material collected from various habitats and localities was studied systematically. The collection of the specimens from different habitats and host plants makes the material un-put down able.

In the bygone days, Talcher was known for its unique and brilliantly rich biodiversity of flora and fauna in Odisha. Loss of Biodiversity has been studied extensively in the Talcher mining corridor but fauna particularly Orthopteran remains a neglected sector of study. Therefore, the present maiden study was conducted to explore the abundance, species richness, and diversity of Orthopteran around the peripheral villages of Lingaraj OCP i.e. Langijoda, Talabeda, Gengutia, and Balunga.

Materials and methods
Study Area
Talcher coalfield is located on the Brahmani River in the Angul District in the Indian state of Odisha. It covers an area of 500 km^2. It lies in the latitude of $20^0$53' to $25^0$12' North and longitude 84^0 to $85^0$23'East. Coal was discovered in Talcher Coalfield at Gopal Prasad in 1837. Before industrialization, it was rich in biodiversity.

There are about 9 open cast projects and 3 underground mines locked in the Talcher Coal corridor. Lingaraj Open Cast Project was opened in 1991 to supply coal to the various power sectors of the Angul District as well as

Odisha and India. The total area covered by this project is 1410.01 hectares. It lies in the latitude of 20^0 57' 39 "and 200 58' 18 "North and Longitude 85^0 09' 33 "and 850 12' 12 ". The climate of this region is generally dry and arid except in the monsoon season. The Coalfield is drained by the Brahmani River flowing along the eastern fringe of coalfields. Singhidajhor, Nandira, Tikira, and Bangurnala are important tributaries of the Brahmani River. The study area covered Langijoda, Talabeda, Gengutia, and Balunga vegetation areas which are adjacent to Lingaraj Open Cast Project with a 15 km radius. Coal mines have sincerely although secretly contributed to the degradation of biodiversity. However, the population growth of Orthopteran has been due to increased moisture, pollution, humidity in certain areas.

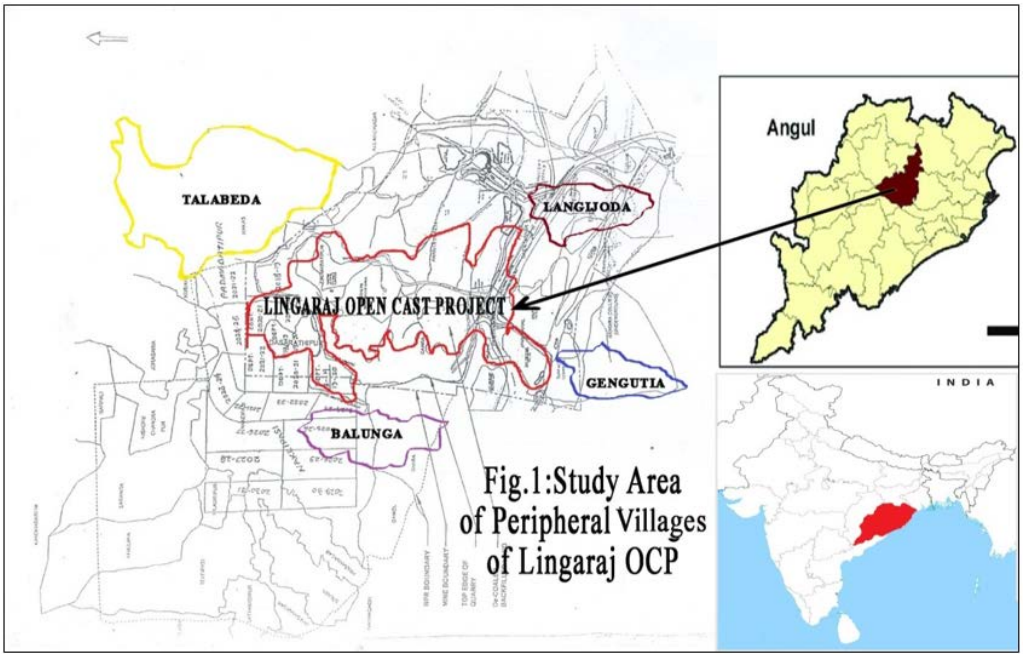

Fig 1: Study area of Lingaraj Open Cast Project, Talcher, Angul, Odisha, India

Study Design

Four regions were selected from the peripheral areas of the Lingaraj Open Cast Project based on habitat which may be important according to Clark and Swamy. Study regions were divided into four areas as follows.

1. Area-I-LangijodaVillage
2. Area -II- Talabeda Village
3. Area -III-GengutiaVillage
4. Area -IV-Balunga Village

As they are poikilotherms and being temperature-sensitive and conscious, mostly they operate between 10 am. And 4 pm. whose exposure improves momentum with an increase in temperature. Based on their availability, Orthopteran can be categorized as very regular (VR,>100views), regular (Re, 50-100 views), Rare (Ra, 2-50views), and unexceptional (UE,<2views).

Sampling and identification

A sampling of Orthopterans was carried out from March 2019 to September 2020 in different study areas in and around of Lingaraj Open Cast Project. Random sampling was carried out by direct searching methods following Sutherland. (Sutherland, 1996) [18] At a thirty days interval during the period of 10:00 to 16:00 hours, because Orthopterans are found most active during the middle of the day. A sweep net sample was taken, using an insect aerial net with a four-foot handle, in the vegetation surrounding 20m by 20m sampling plot to establish grasshopper community composition. Vegetation structure was dominated by grasses and forbs, with few shrubs. An equal number of 50 sweeps were taken while walking rapidly [24]. Sweep net samples were frozen, and grasshoppers were later identified as species in the laboratory. The identification of grasshoppers has also been carried out with the help of a grasshopper identification guide [17, 18, 31] Most of the species were photo-documented. Photographs are taken by Nokia 32 Mpa camera with a microlens. Suspected species were collected through entomological nets and preserved in alcohol. Some were identified by Google lens. Patterns of grasshopper species diversity were examined using numerical species richness, Shannon index of species diversity, and Simpson evenness index. [26]

Data analysis

Margalef diversity index (Margalef, 1958) (D_{Mg}) can be calculated as follows

$$D_{Mg} = \frac{S-1}{\ln N}$$

Where 'S' is the no. Of species and 'N' represents the total no. of individuals in the study area. It explains the species richness of the study area.

The Shannon- Weiner index (Shannon and Weaver, 1949) is used to calculate the diversity of species in different areas adjacent Lingaraj open cast project. The Shannon-Weiner index (H^1) is calculated as follows:

$$H' = -\sum_{i=1}^{s} p_i ln p_i$$

Where *pi = ni/N*, n_i = No of Individuals of a Species at a time, N= Size of the whole community and ln = Natural Logarithm.

Evenness of Grasshoppers (j')

The evenness of a species was calculated by using [27, Pielou EC.] which is defined as

$$J' = \frac{H'}{\ln S}$$

Where S= No. of Species present in the site, ln = Natural logarithm, and H' is the diversity Index.
The Value of J varies from 0 to 1.

Jacard's index (Cj)

It was used to calculate the similarity of Orthopteran species between two habitats among different types of areas studied. It was given by the following relation

$$Cj = \frac{a}{a+b+c}$$

Where a=Total number of species observed in both Area-I & Area-II.
b=Species found in Area-I, but not in Area-II.
c=Species found in Area-II, but not in Area-I

Table 1: List of Orthopteran diversity in and around areas of Linjaraj OCP, Talcher, and Odisha

	Scientific Name	Area-I	Area-II	Area-III	Area-IV	Status	Total
	Sub-order -Caelifera (Short horned Grasshopper)						
Sl. No	***Family-Acrididae***						
1	*Acrida cinerea (*Thunberg,1815*)*	13	14	17	18	VR	62
2	*Anacridium aegyptium (*Linnaeus,1758*)*	4	9	8	5	Re	26
3	*Chorthippus biguttulus (*Linnaeus,1758*)*	13	15	12	18	VR	58
4	*Dichromorpha viridis* (Morse,1896)	17	21	15	19	VR	72
5	*Dissosteria carolina (*Linnaeus,1758*)*	18	12	16	17	VR	63
6	*Leptysma marginicollis (*Serville,1838*)*	18	16	12	11	VR	57
7	*Melanoplus alpinus* (Stal,1873)	17	19	15	19	VR	70
8	*Miramella alpine (*Scudder,1897*)*	15	13	9	12	Re	49
9	*Oedipoda germanica (*Latreille,1829*)*	12	14	13	16	VR	55
10	*Oedipoda caerulescens* (Linnaeus,1758)	15	17	13	15	VR	60
11	*Omocestus viridulus (*Serville,1838)	13	14	11	16	VR	54
12	*Oxyolena mucronata* (Stal,1875)	19	16	11	18	VR	64
13	*Oxya adentata (*Serville, 1831) .	16	19	15	13	VR	63
14	*Pezotettix giornae (*Rossi,1794*)*	13	14	17	12	VR	56
15	*Pseudochorthippus parallelus (*Zetterstedt,1821*)*	15	9	16	12	VR	52
16	*Schistocerca nitens (*Thurnberg,1815)	21	14	11	15	VR	61
17	*Trimerotropis pallidipennis (*Burmeister,1838*)*	12	20	13	17	VR	62
	Family-Pyrgomorphidae						
18	*Aularchis miliaris* (Stal,1873)	0	1	2	0	Ra	3
19	*Pyrgomorpha agarena (*Bolivar,1894)	1	2	1	1	Ra	5
20	*Pyrgomorpha granulate (*Stal,1875)	0	1	2	1	Ra	4
21	*Sphenarium purpurascens (*Charpentier,1842)	1	0	0	1	Ra	2
	Family-Romaleidae						
22	*Tropidacris cristata* (Linnaeus,1758)	11	12	16	12	VR	51
23	*Tropidacris violaceous* (Scudder,1869)	16	12	17	11	VR	56
	Sub-order – Enisifera (Long horned Grasshopper)						
	Family: Tettigoniidae						
24	*Concocephalus melaenus (*Dehann,1843*)*	14	11	12	19	VR	56
25	*Microcentrum rhombifolium* (Saussurie.1859)	2	4	0	3	Ra	9
26	*Microcentrum retinerve (*Scudder,1862)	1	1	2	0	Ra	4
27	*Phaneroptera falcate (*Poda,1761*)*	17	12	21	13	VR	63
28	*Pseudophyllus titan* (Burmeister,1840)	2	1	0	0	Ra	3
29	*Pterophylla camellifolia (*Fabricius,1775)	0	2	1	0	Ra	3
30	*Sathrophyllia arabica* (Stal,1874)	9	11	12	8	Re	40
31	*Tettigonia viridissima (*Linnaeus,1758*)*	10	18	14	12	VR	54
32	*Tettigonia paoli (*Capra,1936*)*	0	0	2	1	Ra	3
	Family: Gryllidae						
33	*Acheta domesticus (*Linnaeus,1758)	5	11	17	19	VR	52
34	*Gryllus bimaculatus* (De Geer,1773)	3	8	9	4	Re	24
35	*Teleogryllus commodus (*Walker,1869)	2	0	0	0	Ra	2
36	*Velarifictorus micado (*Saussure,1877*)*	7	9	5	4	Re	25
37	*Xenogryllus marmoratus (*Bolivar,1890*)*	2	0	1	2	Ra	5
	Family: Gryllotalpidae						
38	*Neocurtilla hexadactyla (* Perty,1832)	0	1	0	1	Ra	2
	Total	354	373	358	365		1450
	Margalef Index (D_{Mg})	5.45	5.57	5.44	5.42		
	Shannon-Weiner Index (H')	3.29	3.33	3.32	3.28		
	Evenness (j')	0.94	0.94	0.95	0.94		

VR-Very Regular (>50 views), Re-Regular (11-50 views), Ra-Rare (2-10 views)

Table 2: Showing Jacard's similarity index (Cj)

	Area-I	Area-II	Area-III	Area-IV
Area-I	1	0.81	0.77	0.83
Area-II	0.81	1	0.86	0.81
Area-III	0.77	0.86	1	0.83
Area-IV	0.83	0.81	0.83	1

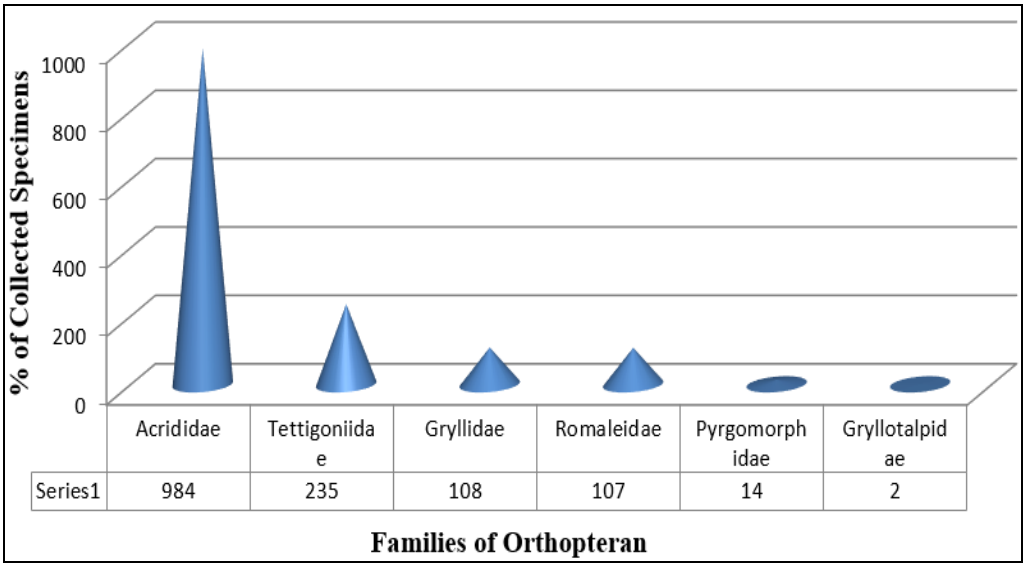

Fig 2: % of Population of collected specimen's w.r.t their families

Result analysis and discussion

The present study was conducted at peripheral areas of Lingaraj Open Cast Project to explore the grasshopper fauna. A total number of 38 species of Orthopterans in 33 genera and 6 families were recorded in the study areas. (Table-1) During the study, Short-horned grasshoppers were found to be more diverse and dominant with 23 species belonging to 3 families, contributed 76% followed by long-horned with 15 species and 3 families. They also contributed a 24% diversity of total Orthopteran recorded in peripheral areas of the Lingaraj Open Cast Project. (Table.1) Among the sub-order, Caelifera, the family Acrididae was found to be widely distributed and dominated with high percentage composition i.e. 67.8% (n = 17) followed by family Romaleidae7.4 % (n=2) and Pyrgomorphidae 0.97% (n =4). (Table– 1). Among the sub-order Enisifera, the family Tettigoniidae was found to be dominated with the highest percentage i.e 16.2% (n =9) whereas, the family Gryllidae and Gryllotalpidae were found to be 7.4% and 0.14% respectively. The Shannon- Weiner Index (Area- I = 3.29, Area –II = 3.33, Area-III = 3.32 & Area -IV =3.28) as shown in the Table-1 does not vary among the different habitats. Species richness or Margalef's richness (D_{Mg}) Index was found to be 5.57 in Area- II, 5.45in Area- I & 5.44 in Area-III. Area-IV has shown comparatively low richness ie.5.42.The jacards similarity index (Cj) as shown in Table-2 was highest (0.86) between Area-II & Area-III and lowest (0.77) between Area-I & Area-III. Evenness (j) in species richness of) Area-II & Area-IV are the same while Area-I & Area-III exhibit little variation. In the current study maximum collection of Grasshoppers was carried out in July and August. Present data revealed that grasshoppers of the study region are rich and diversified may be due to a variety of flora and complex ecological conditions, rainfall patterns, and temperature. Lager size, diverse habitat, and availability of natural and artificial water bodies might be the causes of the maximum diversity of Grasshoppers in the peripheral villages of the Lingaraj Open Cast Project. The size of water bodies stands as an important factor to determine the species richness and diversity of Grasshoppers. However, the study also revealed that the Grasshoppers and their habitat are under threat due to excessive anthropogenic activities like habitat alteration, coal excavation, pollution, deforestation, etc.

Conclusion

A total number of 1450 grasshoppers were observed in peripheral areas of the Lingaraj Open Cast Project. According to IUCN red list data, grasshoppers are the least concerned about natural changes in the environment. From the present data, the grasshopper population has decreased due to anthropogenic actions like coal excavation and habitat fragmentation in the Talcher Area which could be a danger signal for the disappearance of this glorious creature, especially in Talcher. So far, fewer studies have been carried out on the jeopardy of this glorious organism, vigorous studies are essential.

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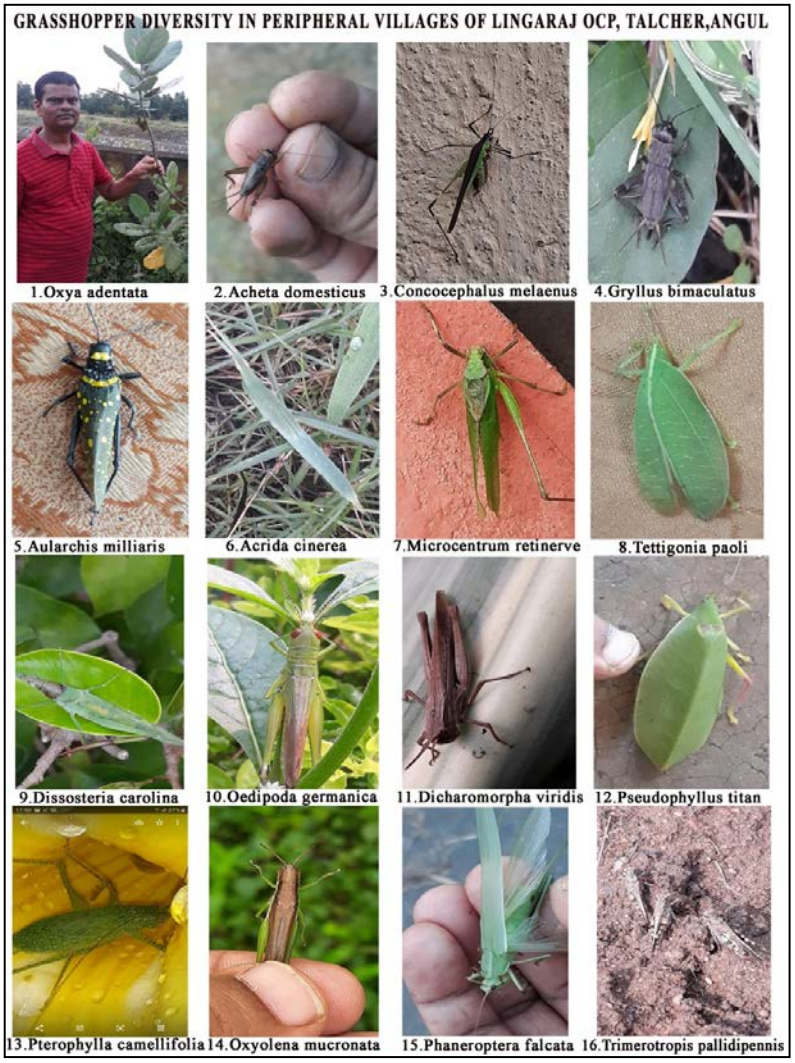

Fig 3: Grasshoper diversity in peripheral villages of Libgaraj OCP, Talcher, Angul, from figure 1-16

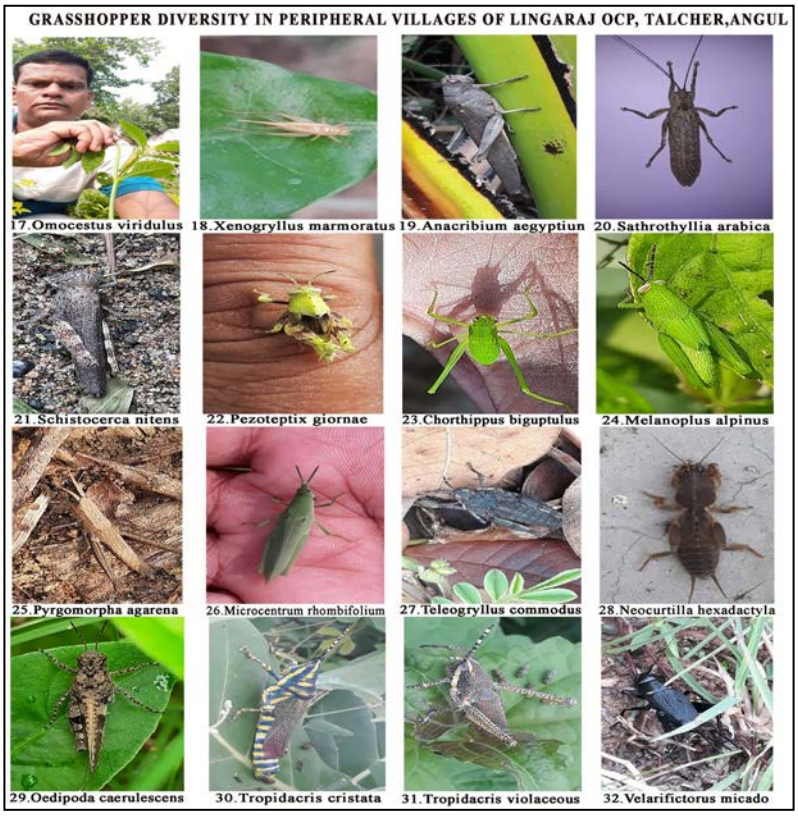

Fig 4: Grasshopper diversity in peripheral villages of Lingaraj OCP, Talcher, Angul from fig 17-32

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