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Review the relationship between reproductive cycle and ecosystem management of acridids

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Abstract
Grasshoppers especially belong to family Acrididae are major role in their respective niches and are significant component in biodiversity model system. They are one of the most important invertebrate groups for environmental monitoring and assessment. Each species has its own reproductive potential to reproduce their offspring in different seasons. The relationship between biodiversity and ecosystem functioning has received increasing scientific interest in recent decades. The dynamic of acridid biodiversity reveals the coupling relationship among abiotic factors, vegetation community and acridid biodiversity in forest ecosystems. This coupling relationship is one of the essential interrelationships in forest ecosystems and it imposes directly on their structure. They are ideal organisms to study effects of climate and agricultural land use on biodiversity.

Keywords: acridids; reproductive cycle; biodiversity; forest management

Introduction

Insects play important functional roles in their respective niches and are significant contributors to a variety of ecosystem process (Obrist and Duelli, 2010; Chapman. 2012; Santorufo *et al*., 2012) [27, 8, 33]. The conservation of insect diversity has, therefore, become an urgent task for entomologists and all citizens (You *et al*., 2005) [39]. Despite their ecological and economic importance, insects are still underrepresented in scientific research, leading to potential bias in our understanding of the functional ecology of ecosystems (Lamarre *et al*., 2018) [22].

Grasshoppers are one of the most dominant and important herbivorous insects which play an important role in the functioning of forest ecosystems worldwide. Many studies implies effects of environmental changes on grasshoppers, amongst other things they have been used to assess the effects of forest fire land, overgrazing (Fielding *et al*., 2001) [11], species richness and diversity (Joshi *et al*., 1999; Saha and Haldar 2009) [18, 30], habit reduction (Nufio *et al*., 2011) [26], environmental factors (Steck *et al*., 2007, Kati *et al*., 2012) [35, 19], Ski run management (KeBler *et al*., 2012) [20], forest ecosystem management (Schmitz, 2005) [34], grassland managements (Badenhausser *et al*., 2007; Marini *et al*., 2008) [3, 25], habitat indicator (Bàldi *et al*., 1997; Andersen *et al*., 2001; Saha and Haldar, 2013) [4, 1, 31]. Grasshoppers have been documented as a very rich protein resource (Ramos-Elorduy *et al*., 2012) [29]. They are important food for many birds, reptiles and mammals (Kok and Louw, 2000) [21].

Therefore, they are ideal organisms to study effects of climate and agricultural land use on biodiversity. Key challenges for the future are to improve environmental monitoring and assessment and to secure the overall functioning of ecosystems.

Reproductive cycle of acridids

We observed acridid species in Chaupahari forest (3.05 sq. km), a dry deciduous type (23°29´N and 87°42´E with an average altitude of 58.9 m), located near Santiniketan in Birbhum district in West Bengal, India (Saha and Haldar, 2009) [30]. Table1 reflects the reproductive cycles of some acridid species in dry deciduous forest. List of multivoltine, bivoltine and univoltine acridids species of the dry deciduous forest are shown in Fig. A. Acridid differs in their life histories and different life stages. Their life cycle only has three stages: egg, nymph (three to five stages), and adult. They have a high reproductive potential and high nutritional value (Ramos-Elorduy *et al*., 1997) [29] and may be important in energy and nutrient cycling. Each species has its own reproductive potential to reproduce their offspring in different seasons. Occurrence of species throughout the year with different nymphal stages suggests continuous breeding, i.e. multivoltine nature. The occurrence of species twice a year with different nymphal stages suggests bivoltine in nature and once a year suggests univoltine in nature. Ganguly *et al*., (2014) [12] reported that *O. fuscovittata* present in the field and laboratory condition throughout the year with different nymphal stages suggest multivoltine cycle respectively. According to Hazra *et al*., (1984) [14] the *P. infumata*, *S. prasiniferum prasiniferum* (Walker) and *A. crenulata* showed multivoltine nature in cultivated grassland. Thus the populations of acridid species are maintained a unique balance through their reproduction in the ecosystems, and so it is established that the number of multivoltine, bivoltine and univoltine species maintain the population structure of forest ecosystem. They form the basis of many food webs & ecological interactions, promote soil fertility and structure and provide mechanism of biological control.

Being a voracious feeder and good recycler, acridids are an ecologically important community of insects. Besides being sensitive to environmental changes and their abundance they also act as primary consumer in a food chain and thus hold a key position.

Table 1: Reproductive cycles of acridid species of dry deciduous forest

Nature	Name of acridid species
Multivoltine	1. *Aulacobothrus luteipes* (Walker) 2. *Chrotogonus trachypterus trachypterus* (Blanchard) 3. *Dittopternis venusta* (Walker) 4. *Oedaleus abruptus* (Thunberg) 5. *Oxya fuscovittata* (Marschall) 6. *Oxya hyla hyla* Serville 7. *Truxalis indica* (Bolivar).
Bivoltine	8. *Atractomorpha crenulata (Fabricius)* 9. *Phlaeoba infumata* Burnner 10. *Spathosternum prasiniferum prasiniferum* (Walker) 11. *Tylotropidius varicornis* (Walker).
Univoltine	12. *Catantops pinguis innotabilis* (Walker) 13. *Catantops sp.* 14. *Eucoptacera sp.* 15. *Gastrimargus africanus africanus* (Saussure) 16. *Gastrimargus africanus orientalis* Sjist. 17. *Heiroglyphus banian* (Fabricius) 18. *Heteracris pulchra* (Bolivar) 10. *Trilophidia annulata* (Thunberg) 20. *Tristria pulvinata* (Uvarov).

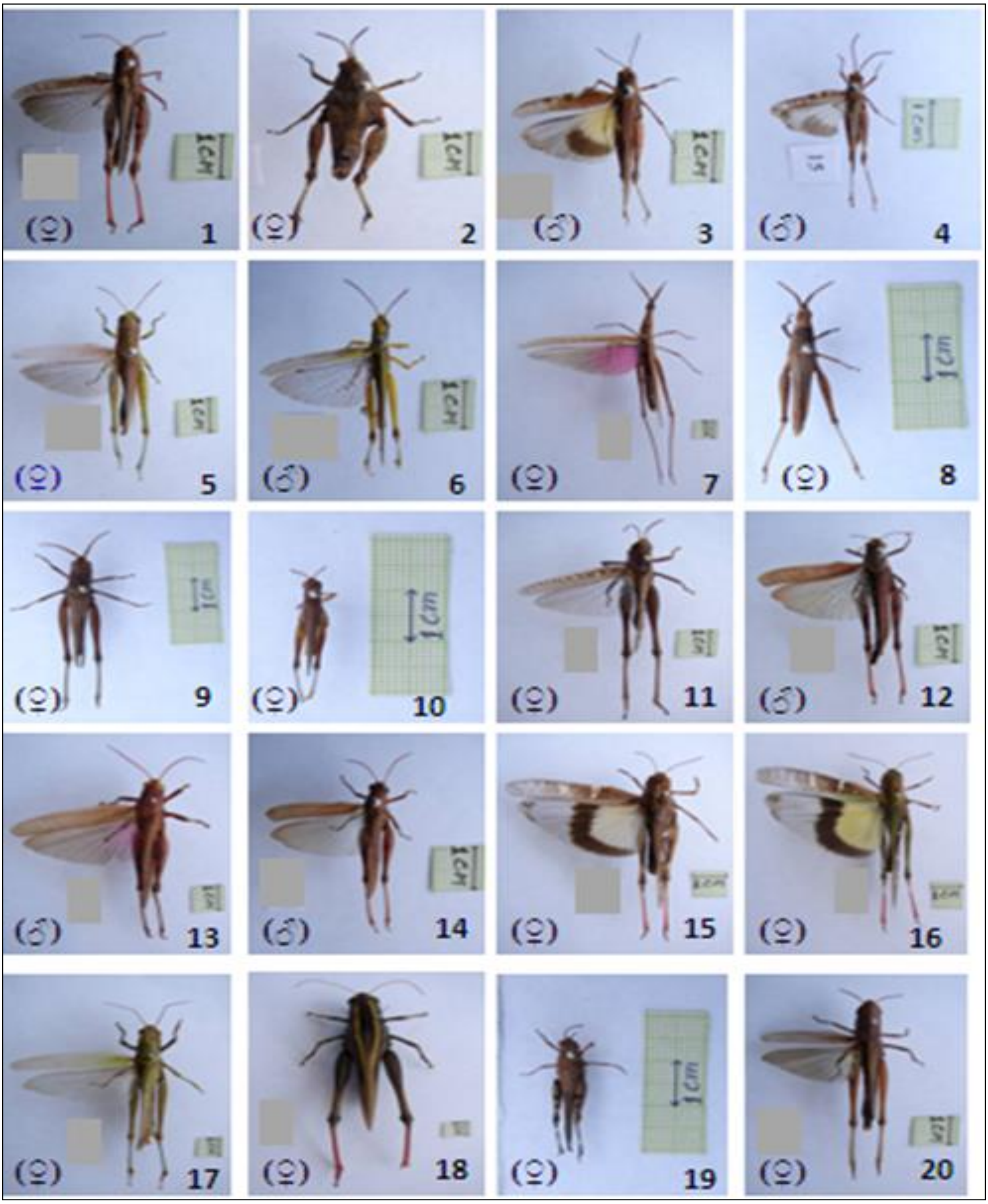

Fig 1: A List of multivoltine (Plate 1 to 7), bivoltine (Plate 8 to 11) and univoltine (Plate 12 to 20) acridids species of dry deciduous forest.

Special pattern of acridid biodiversity

As biodiversity is a core factor ensuring sustainability and productivity of many ecosystems, benefits from ecosystem services can be viewed as indirect-use value provided by biodiversity. Biodiversity study is now recognized increasingly as a vital parameter to assess global and local environmental changes and sustainable development (Andersen *et al.,* 2004) [2]. Insects and plants are becoming extinct because of habitat loss, over-exploitation, pollution, overpopulation and the threat of global climatic changes. The change in vegetation community diversity can cause variation in the special pattern of grasshopper biodiversity (Guo, 2006) [13]. A positive correlation between plant and grasshopper species richness were also reported (Fielding and Brusven, 1995) [10]. The species like *O. fuscovittata*, *O. hyla hyla* and *H. banian* are adapted for life in standing water and paddy fields (*Oryza sativa* L.). These species are indicated as pest of paddy plants. The similar pattern by Sanjayan and Muralirangan (1997) [32] reported that *Oxya sp.*, and *Heiroglyphus sp*. are adapted for life in standing water and alluvial soil of paddy fields of rice.

Effect of acridid biodiversity on the ecological process of forest ecosystems

Ecosystem diversity refers to the diversity of habitats, communities and ecological processes in the biosphere (McNeely *et al*., 1990) [24]. It is reported that biodiversity contributes to ecosystem stability, structure and productivity (Larsen, 1995) [23] which in turn contribute to sustainability. The relationship between biodiversity (here mainly refers to species diversity) and ecosystem functioning has received increasing scientific interest in recent decades (Balvanera *et al*., 2006; Zavaleta *et al*., 2010) [5, 40].

Various ecological studies strongly suggest that ecosystem drivers such as grazing, fragmentation and climate can adversely affect biota and ecosystem (Branson, 2005; Jonas, 2007) [7, 17]. They are important component of ecosystems in terms of their abundance, species richness and functional contributions (Whiles and Charlton, 2006) [38]. They are also important nutrient cyclers, food for many of the omnivores and carnivores, and can be used as bioindicators of grassland health (Bazelet and Samways, 2011) [6].

Coupling relationship between acridid biodiversity and forest ecosystem

The world is currently facing its greatest ever biodiversity crisis. Biodiversity is one of the important cornerstones of sustainable development and represents the biological wealth of a given nation. Biodiversity of insects, therefore, is one of the most important components of a life supporting system (You *et al*., 2005) [39]. Ecological diversity may contribute importantly to various aspects of ecosystem stability (Walker, 1995; Hobbs *et al*., 1995; Petersen *et al*., 1998) [36, 15, 28]. There is a contemporary trend to use arthropod species especially grasshoppers, as more appropriate indicator taxa (Cherrill, 2010; Holusa, 2012; Kati *et al*., 2012) [9, 16, 19]. Knowledge on the ecological requirements of Orthoptera species is crucial for the implementation of conservation action (Weyer *et al*., 2012) [37].

The dynamic of acridid biodiversity reveals the coupling relationship among abiotic factors, vegetation community and acridid biodiversity in forest ecosystems. This coupling relationship is one of the essential interrelationships in forest ecosystems and it imposes directly on their structure. Acridids being polyphagous herbivores, naturally there could be a close ecological relationship between acridid richness and variation in vegetation cover of the area. The causality between global climate change and dynamics in acridid biodiversities and the coupling relationship between human activities and acridid biodiversity are perhaps essential to the future evolution of forest ecosystems. Thus, they maintain the ecological balance and ensure in this way a proper functioning of the forest ecosystem. In future, we have to conserve and develop natural and near-natural forest communities and to continue to ensure the long-term protection of organisms.

The potential of grasshopper in relation to environmental changes have been documented by reviewing and compiling the scientific literature, which will clear the conservation strategy for grasshopper ecosystem management. The goal of present work is to stimulate interested researcher to engage in multi-disciplinary studies using grasshopper models and to demonstrate a number of gaps in current knowledge. Some species of grasshopper may have an influence on entire ecosystem. These are called as key tone species. If such key tone species are lost, other species or even a whole ecosystem will be affected in several ways. Variation in their number may disrupt the food chain thus disturbing the entire ecological balance. There is a need therefore to conserve and protect our forests and that would, besides other advantages, also preserve the rich grasshopper fauna.

Conclusion

Acridids are one of the most important invertebrate groups for environmental monitoring and assessment. They differ in their life histories and different life stages. Each species has its own reproductive potential to reproduce their offspring in different seasons. The relationship between biodiversity and ecosystem functioning has received increasing scientific interest in recent decades. The dynamic of acridid biodiversity reveals the coupling relationship among abiotic factors, vegetation community and biodiversity in forest ecosystems. This coupling relationship is one of the essential interrelationships in forest ecosystems and it imposes directly on their structure. Acridids can also be used to evaluate the short-term impact of environmental changes on a variety of habitats have resulted in the development of national and global models.

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