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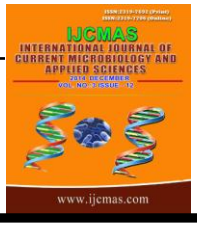


**Original Research Article**

# Grasshoppers as multidisciplinary model organism in changing environment

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**A B S T R A C T**

The primary goal of this work is to highlight on the potential of grasshopper as multidisciplinary model in the field of environmental changes. Grasshoppers are effective indicator because of their high mobility, wide variety of microhabitats, and sensitivity to anthropogenic activities. The present study will provide initial references as an avenue in the literature and it lends support to the suggestion that grasshopper are potentially useful bioindicator for ecological disturbances.

## Introduction

Environmental changes, viz fragmentation of habitat (Bieringer, 2003; Fahrig, 2003; Nufio *et al*., 2011), landscape changes (Jackson and Jackson, 2002; Steck, 2007), industrialization (Stern, 1976, 1977; Jana *et al*., 2006), overgrazing (Fielding *et al*., 1995; Joern, 2005; Branson, 2010), invasion, over exploitation of exotic species, climate change and wildfire (Fahrig, 2003; Thomas *et al*., 2004) are the major threats to ecosystem health.

Biological conservation typically involves either setting aside large tracts of land for "nature", or addressing and remediating specific processes that threaten large and charismatic invertebrates such as endangered insects, or plant species or communities. The concept of conserving habitats for insects, thereof, seems of low priority on a threatened planet (Meffe and Carroll, 1994). Various ecological studies strongly suggests that ecosystem drivers such as grazing, fragmentation and climate can adversely affect biota and ecosystem (Branson 2005; Jana *et al*., 2006; Jonas, 2007). Biodiversity study is now recognized increasingly as a vital parameter to assess global and local environmental changes and sustainable development (Lovejoy, 1995; Andersen, 2004; Jana *et al*., 2006).

The indicator criteria for environmental changes are sensitive to changes, widely distributed, easily and cost effectively

measurable, collectable and identifiable, able to differentiate between natural and anthropogenic variations, relevant to ecological phenomena, and economically important (Noss, 1990; Goldsmith, 1991; Pearson, 1994). The most commonly used operational units to prevent environmental changes and further loss of biodiversity is multicellular species (Purvis and Hector, 2000). There is a contemporary trend to use arthropod species especially grasshoppers, as more appropriate indicator taxa (Bock, 1991; Bàldi *et al*., 1997; Andersen *et al*., 2001; Saha *et al*., 2009; Cherrill, 2010; Saha *et al*., 2011; Holusa, 2012 and Kati *et al*., 2012). Grasshopper constitute one of the most abundant invertebrate groups and are leading consumers of plant biomass and thus play key role in ecosystem process (Ingrisch and Köhler, 1998). Grasshopper especially belongs to family Acrididae are major component in biodiversity model system.

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 multidisciplinary studies using grasshopper models and to demonstrate a number of gaps in current knowledge.

## Grasshopper as indicator in environmental changes

### Why grasshopper?

Grasshoppers are one of the most dominant and important herbivorous insects which play an important role in the functioning of forest ecosystems worldwide. It is potentially useful bioindicators for land management (Andersen *et al*., 2001; Saha *et al*., 2009; Branson *et al*., 2010) due to their abundance species composition (Gaines, 1990; Lockwood, 1993; Lockwood, 1997; Belovsky and Slade 2000; Joern and Meyer *et al*., 2002 Branson *et al*., 2006;) and their importance as a food resource for a variety of predators especially for birds and snakes (Bock *et al*., 1992; Oedekoven and Joern, 1998; Andersen *et al*., 2001). The structure of communities is sensitive to environmental changes, habit specificity, simple sweep net sampling methodology, identification is relatively easy, due to low number of species and their taxonomic stability, their pronounced functionality in food web, attributed to their ability to recycle ground biomass so as to generate nutrients for other taxa (Samways, 1994).

Many studies implies effects of environmental changes on grasshoppers, amongst other things they have been used to asses the effects of forest fire land, overgrazing (Fielding *et al*., 1995; Prendini *et al*., 1996; Joern, 2004; Jonas *et al*., 2007; Paschetta, 2012), habit reduction (Nufio *et al*., 2011), environmental factors (Steck *et al*., 2007; Kati *et al*., 2012), Ski run management (KeBler *et al*., 2012), edge effect (Bieringer *et al*., 2003), forest ecosystem management (Schmitz, 2005), grassland managements (Badenhausser *et al*., 2007; Marini *et al*., 2008), radiation (Møller *et al*., 2011), pollution (Devkota *et al*., 2000) and urbanization (Cherrill, 2010) and predation (Joern, 1986).

Compelling support for the use of grasshopper as model was illustrated by studies of wildfire and grazing impacts. Branson *et al*., (2006) recently argued that burning and live stock grazing could be

used as important habitat manipulation tool for use in ecologically based grasshopper management strategies that seek to prevent or moderate the occurrence of damaging out breaks.

Fire and grazing by large mammals were the large scale disturbance that act as primary ecosystem drivers in North Americana tall grass Praire (Axelrod, 1985; Collines and Wallace, 1990; Joern, 2005), over the past several decades, particularly with respect to the effect of burning (Moranz *et al*., 2012), fire is useful for maintaining vegetation and preventing the spread of woody species (Kerstyn *et al*., 1999; Joern 2005), but it has been hypothesized to modify and can reduce, their arthropod communities. Fire can be a source of insect mortality (Gillon, 1971; Reed, 1997; Branson *et al*., 2006).

Grasshopper differs in their life histories and different life stages. Grassland fire can kill grasshopper alive at the time of a fire (Branson, 2005). Fire affect plant community dynamics would indirectly affect grasshopper based on their feeding modes. Nymph of grasshopper would seem to be less likely to survive a fire composed with egg in the soil (Branson, 2005).

However, elevated soil temperature during a fire could increase mortality rates of over wintering egg. Several studies have addressed the role of fire on grasshopper population reduced litter, modified soil, moisture and temperature changes in cover which alter predator hunting efficiency and change in food quality from altered plant growth patterns (Siemann *et al*., 1997).

Grazing also has the potential to harm grassland Orthopteran population, depending upon grazing intensity (Kruess and Tscharntke, 2002; Poyry *et al*., 2005) and through competition or indirectly via changes in plant community composition (Kruess, 2002; Branson, 2010). Grasshopper assemblage is increasingly investigated locally and regionally for habit conservation, monitoring and restoration. Grasshopper communities clearly show that where anthropogenic disturbance is greater, the biodiversity of this group tends to decline.

The sedentary nature of Orthopteran give rapid response to habitat disturbance, due in part to their high vagility and rapid rate increase. Orthopteran 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.

**Frontiers in grasshopper research with direct application to environmental changes**

The frontier in biotechnology and molecular research has produced spectacular advancements in genetic and understanding of environmental changes at genetic, biochemical and molecular levels. Techniques with a biotechnology base are providing new way to fight such pollution and the consequent environmental problem. Monoclonal antibodies are being used to build antibody based biosensors to identify pollutants and measuring the levels of contamination.

One by one, the natural sciences have found grasshopper ideal for study. Their study has produced major advances in our understandings of biomechanics, climate change, developmental biology, ecology, evolution, genetics, paleolimnology and physiology.

**Grasshopper revealed as prolific choice in basic research**

Basic research being conducted on grasshopper is comprehensive and occurs at impressive levels of sophistication. For example karyological characterization of grasshopper species for cytotaxonomical study and detection of gross aberrations in chromosome number, morphology and sex chromosome mechanism (Dave, 1965; White *et al*., 1967; Ferreira, 1969; Ueshima, 1979; Camacho *et al*., 1981; Türkoğlu *et al*., 2002; De Franca *et al*., 2004; Bugrov *et al*., 2004; Ferreira 2006; Singh, 2009; Mesa *et al*., 2010).

A research group from India publishing over 393 papers and 117 species of the grasshoppers have been utilized which revealed profile choice of this insect as study material on various aspect of karyology, feeding behavior (Husain, 1946; Gangwere, 1957; Chapman *et al*., 1990; Rackauskas *et al*., 2006), thermoregulation (Chapman, 1955; Stower *et al*., 1966; Kemp, 1986; Lactin, 1995, 1996), growth and reproductive behavior (Reinhardt, 2002; Barbeheann *et al*., 2004; Asshoff, 2005). Plant-grasshopper herbivore interactions (Fajer, 1989; Bezemer, 1998; Goverde, 2003), grasshopper predator such as vertebrate, invertebrate (Belovsky *et al*., 1993) avian (Joern, 1986) and spider (Oedekoven, 1998), anatomy and physiology (Gillott, 1982; Schan, 2004; Tembhare, 2013) studied extensively.

In particular, grasshoppers respond readily to change in temperature more promptly and with greater intensity than other components of the terrestrial biota. They are providing evidence for major climatic changes in the past, such evidences are vital for current decision making with respect to the management of ecosystem and give an indication of what might occur with climate change in the near future. Ample evidence now shows that grasshoppers are one of the first groups of living organism to respond to ongoing global warming. Predicting insect response is now an active area of investigation. Understanding grasshopper strategies for survival under these circumstances, such as how they cope up with new food source and adjust to more acute temperature and humidity fluctuation is still a challenge.

**Implications for nature conservation**

Present work highlights the effects of habitat management strategies on a range of taxa rather than assuming the results for a bioindicator will support for management decisions. The several authors have recommended the following conservation measures.

1) We should manage humid grasslands in a way to maintain high humidity, as it is proven to be important for the survival of grasshopper species for conservation concern.
2) Defining the stages of development of the habitat type as well as its rate of change.
3) Manage the low intensity grazing may enhance habitat heterogeneity at fine scales, generating and maintaining open microhabitats, which are of primordial importance for the life cycle and feeding resource availability of grasshopper (Oedekoen, 1998; Joern, 2004; Schmitz, 2005; Branson, 2005 and 2010; Nufio, 2011)

The implication for ecosystem management is serious in the central European pastures and meadows as they

use extensive area of grassland for agriculture purpose. About 77% of Lower Austrain nature reserves designated to the conservation of dry grassland is affected by shrub encroachment or by afforestation (Bieringer, 2003). 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, for example Berg and Zuna- Kratky (1997) listed eight Orthoptera species is extinct in Lower Austria belong to the Acrididae. After reviewing the various studies it can be concluded that, factors such as fertilization, nutrient deposition, afforestation, shrub encroachment and litter accumulation are adversely affect on grasshopper population, which will be major component of food web. Thus, appropriate management of harmful ecosystem is of key importance for the conservation of Orthopteran assemblages, which also contain the most grassland-specialized species. This review suggests that next steps to strengthen these efforts and conservation policies in the world can lead its community towards a more sustainable future.

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