Indian Forester, 143 (10) : 1088-1090, 2017
http://www.indianforester.co.in
ISSN No. 0019-4816 (Print)
ISSN No. 2321-094X (Online)

(IV)

DUNG BEETLES (SCARABAEIDAE): AN EFFICIENT MODEL FOR LONG TERM ECOLOGICAL MONITORING

Ecological monitoring can provide advanced warning of undesirable ecological change (climate change, forest fragmentation and biodiversity loss) thus permit managers and policy makers to adopt an adaptive management approach to conserving biological diversity. The nature of landuse changes in recent decades has not only resulted in a dramatic decrease in total forest cover, but also accelerated biodiversity loss and forest fragmentation. Forest fragmentation is an important process contributing to the present-day concern over the loss of biodiversity and rates of species extinction. There is now an urgent need to identify the key effects of forest fragmentation on biotic systems and to find management solutions, for this ecological monitoring is very important to understand the complex process of biodiversity loss. Bioindicators have been proven to be useful tools for monitoring and detecting changes in the environment. Bioindicator can be defined as a species or group of species that readily reflects the impact of environmental change on habitat, community or ecosystem or is the indicative of the diversity of a subset of taxa or the whole biodiversity within an area. Especially, living things are so closely related to the environment that the indicator between the environment and living things shows close interrelationship. Also, the indicator related to environment provides information about representative or decisive environmental phenomenon and is used to simplify complicated facts (Noss, 1990: Dufrene and Legendre, 1997; Mcgeoch *et al.,* 2002; Han *et al.,* 2015). It is impossible to evaluate the total biodiversity and also to measure the impact of environmental change on each and every species therefore we need efficient model system for analyzing the concern. Dung beetles provide an effective model to understand the effect of environmental change, habitat fragmentation or any stress.

Dung beetles (Scarabaeidae) compose widely distributed taxa; about 5000 species (Scholtz *et al.,* 2009) are present worldwide. Dung beetles are divided into three functional groups: rollers, tunnelers and dwellers, which largely feed on dung and carrion. Dung beetles perform various ecological functions in diverse ecological services (Nichols *et al.,* 2008) such as dung removal, nutrient cycling, bioturbation, secondary seed dispersal and parasitic control which are very useful to maintain ecosystem integrity. Community structure of dung beetles is largely affected by forest modification, fragmentation and elevated anthropogenic pressure hence this group clearly reflects the impact of anthropogenic pressure and habitat alteration. Community structure, population of dung beetles can be rapidly determined using simple, standardized, time and cost effective trapping methods which permits efficient comparative evaluation of ecological changes at landscape scale.

Dung beetles as bio-indicator across landscape matrix

Dung beetles have been used in empirical studies (Klein, 1989; Davis *et al.,* 2001, 2008; Gardner *et al.,* 2008) to evaluate the biodiversity loss, forest fragmentation and the impact of habitat modification. The structure, organization and composition of guild structure of dung beetles primary forest are totally different from the fragmented forests and also a transition guild is also present in ecotones which have its own structure (Halffter and Favila, 1993). Changes in dung beetle assemblage structure are correlated with climatic and/or edaphic variables, which clearly interact to drive biogeographical composition and population responses of dung beetle species across regional and local gradients. Studies (Estrada *et al.*,1998; Numa *et al.,* 2009, 2012; Shahabuddin *et al.,* 2014; Batista *et al.,* 2016) showed that the existence of a rich pool of forest dung beetles species exist in the fragmented landscape but the majority of the species are represented in low numbers. Species richness, abundance, and biomass declined drastically on smaller and more isolated islands (Larsen *et al.,* 2008). Fragment characteristics such as vegetation structure, ground cover, litter depth, age, and isolation distance also influence dung beetle assemblage in forest. Due to the modification in tree cover or canopy cover, native forest species undergo local extinction and are replaced by open area species (Halffter and Arelleno, 2002). Canopy cover is thought to be influence humidity as well as atmospheric and soil surface temperature, which might affect the survival and reproduction of dung beetles, as well as food availability and attractiveness. Edge effects also considered as an important factor in the distribution and composition of dung beetles communities as abundance, species richness and species composition of dung beetles changed with distance from roads/trails Forest edges act as a barrier and affect the patterns of dispersal and spatial distribution of dung beetles communities. Narrow or small forest clearings for skid trails, logging roads, log yards, and logging camps affect local distributions of dung beetles. Litter has been reported to be important for modifying soil characteristics such as moisture, density, and nutrient load, which may increase the recruitment and/or reproduction of dung beetles. Changes in land management practices such as pastures replaced by arboreal crops results the replacement of a rich assemblage of native species by introduced species just as *Digithonthophagus gazella*, a savanna specialist, that has been expanding its range southward from the United States in part as a result of conversion of large extension of rain forest to pastures (De Oca and Halffter, 1998). Escobar *et al.* (2007) evaluated the effect of expanded cattle ranching along three altitudinal gradient in one located in the Mexican Transition Zone and two located in northern Andes. All three sites are facing immense pressure of not only dairy farming but also expansion of mountain into agricultural areas. They reported that processes of disturbance caused by human activity along altitudinal gradients can impact communities in different ways, depending on the geographic position of each mountain and particularly the biogeographical history of the group of species that inhabits it. Drawing upon historical data, comparisons among dung beetle collections across parts of Africa and the Mediterranean provide circumstantial evidence of strong, linked changes in mammal-dung beetle assemblages, typically within a context of broader land-use change (Nichols *et al.,* 2009). Lobo *et al.* (2002) also analyzed which factor or factors govern the species richness and distribution of dung beetles of France mainland and Corsica Island. Six climate variables were utilized mean annual temperature, temperature variation, maximum mean temperature, minimum mean temperature, mean annual precipitation and precipitation variation. Results showed that Minimum mean temperature is the most influential variable on a local scale, while maximum and mean temperature are the most important spatially structured variables. In Europe Menendez *et al.* (2014) compared historical and current data on dung beetle distributions along elevation gradients for 30 species in the South-western Alps (France) and 19 species in the Sierra Nevada (Spain) and reported that up-slope range shifts for 63% and 90% of the species in the SW Alps and Sierra Nevada, respectively. The magnitudes of range shifts were consistent with the level of warming experienced in each region, but they also reflected the asymmetrical warming observed along the elevation gradients. This study reveals that climate change is directly or indirectly responsible for range-shift of the species. Anthropogenic land use and habitat fragmentation clearly promote community level taxonomic divergence in human modified landscapes. This community level taxonomic divergence suggests that edge-dominated and matrix habitats ensure the persistence of disturbance adapted species, some of which exclusively in these habitats, which are unsuitable for forest dependent species (Filgueiras *et al.,* 2016).

New paradigms in conservation biology propose that not only protected areas but also patches of natural habitat via corridors should be analyzed in the context of the agricultural or managed matrix. Land use patterns significantly affect the species assemblages, diversity, and richness and also guild structure across various habitats. We need long-term observations and basic ecological studies to assess the impact of land management practices. The success of using dung beetles is based on cost-effective data collection, sensitivity to different environmental factors and wide habitat requirements. Species richness, abundance of dung beetles varies widely depending on the period of the year, habitat, seasonality, rain fall and land use practices. Forest fragmentation has strong negative consequences on dung beetle biodiversity. Environmental changes also have considerable influence on the community structure of dung beetles. Bioindicator based approach to ecological monitoring is crucial for developing countries largely having complicated landscape matrix as it includes protected areas, dominated agriculture system and patchy habitats. Ecological data on population structure, community composition, habitat specificity of dung beetles correlated with biogeographic and historical data can be efficient model to analyze the impact of human induced changes in forest along different land use gradient, climate change and forest fragmentation.

References

Filgueiras K.C.B., Tabarelli M., Leal R.I., Vaz-de-Mello Z.F., Peres C.A. and Luciana Iannuzzi L. (2016). Spatial replacement of dung beetles in edge-affected habitats: biotic homogenization or divergence in fragmented tropical forest landscapes?. *Diversity and Distributions,* 22:400-409

Batista M.C., Lopes G.S., Marques P.J.L. and Teodoro V.A. (2016).The dung beetle assemblage (Coleoptera: Scarabaeinae) is differently affected by land use and seasonality in northeastern Brazil. *Entomotropica,* 31(13):95-104

De Oca M.E. and Halffter G. (1998). Invasion of Mexico by Two Dung Beetles Previously Introduced Into the United States. *Studies on Neotropical Fauna and Environment,* 33:37-45

Davis A.J., Holloway J.D., Huijbregts H., Kirk-Spriggs A.H. and Sutton S.L. (2001). Dung beetles as indicators of change in the forests of northern Borneo. *J. Applied Ecology,* 38:593-161

Davis A.L.V., Scholtz C.H. and Deschodt C. (2008). Multi-scale determinants of dung beetle assemblage structure across abiotic gradients of the Kalahari-Nama Karoo ecotone, South Africa. *J. Biogeography,* 35:1465-1480

Dufrene M. and Legendre P. (1997). Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs,* 67:345-366

Estrada A., Coates-Estrada R., Dadda A.A. and Cammarano P. (1998). Dung and carrion beetles in tropical rain forest fragments and agricultural habitats at Los Tuxtlas, Mexico. *J. Tropical Ecology,* 14:577-593

Escobar F., Halffter G. and Arellano L. (2007). From forest to pasture: an evaluation of the influence of environment and biogeography on the structure of dung beetle (Scarabaeinae) assemblages along three altitudinal gradients in the Neotropical region. *Ecography,* 30:193-208

Gardner T.A., Barlow J., Araujo I.S., Avila-Pires T.C., Bonaldo A.B., Costa J.E., Esposito M.C., Ferreira L.V., Hawes J., Hernandez M.I., Hoogmoed M.S., Leite R.N., Lo-Man-Hung N.F., Malcolm J.R., Martins M.B., Mestre L.A., Miranda-Santos R., Overal W.L., Parry L., Peters S.L., Ribeiro-Junior M.A., da Silva M.N., da Silva M.C. and Peres C.A. (2008). The cost-effectiveness of biodiversity surveys in tropical forests. *Ecological Letters,* 11:139-150

Halffter G. and Favila M.E. (1993). The Scarabaeinae (Insecta: Coleoptera) an animal group for analyzing, inventorying, and monitoring biodiversity in tropical rainforest and modified landscapes. *Biology International,* 27:15-21

Halffter G. and Arellano L. (2002) Response of dung beetle diversity to human-induced changes in a tropical landscape. *Biotropica,* 34:144-154

Han Y., Kwon O. and Cho Y. (2015). A study of bioindicator selection for long-term ecological monitoring. *Journal of Ecology and Environment,* 38(1):119-122

Klein B.C. (1989). Effects of forest fragmentation on dung and carrion beetle communities in central Amazonia. *Ecology,* 70:1715-1725

Larsen T.H., Lopera A. and Forsyth A. (2008). Understanding trait-dependent community disassembly: dung beetles, density functions, and forest fragmentation. *Conservation Biology,* 22(5):1288-1298

Lobo M. J., Lumaret J. and Jay-Robert P. (2002). Diversity, distinctiveness and conservation status of the Mediterranean coastal dung beetle assemblage in the regional natural park of the Camargue (France). *Diversity and Distributions,* 7(6):257-270

Mcgeoch M.A., Van Rensburg B.J. and Botes A. (2002). The verification and application of bioindicators: a case study of dung beetles in a savanna ecosystem. *J. Applied Ecology,* 39:661-672

Montes de Oca E. and Halffter G. (1998). Invasion of Mexico by Two Dung Beetles Previously Introduced into the United States. *Studies on Neotropical Fauna and Environment,* 33:37-45

Menéndez R., González-Megías A., Jay-Robert P. and Marquéz-Ferrando R. (2014). Climate change and elevational range shifts: evidence from dung beetles in two European mountain ranges. *Global Ecology and Biogeography*, 23:646-657.

Nichols E., Spector S., Louzada J., Larsen T., Amezquitad S. and Favila M.E. (2008). Ecological functions and ecosystem services provided by (Scarabaeinae) dung beetles. *Biological Conservation,* 141:1461-1474

Nichols E., Gardner T.A., Peres C.A. and Spector S. (2009). Co-declining mammals and dung beetles: an impending ecological cascade. *Oikos*, 118:481-487

Noss R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology*, 4:335-364

Numa C., Verdu R.J., Sanchez A. and Galante E. (2009) Effect of landscape structure on the spatial distribution of Mediterranean dung beetle diversity. *Diversity and Distributions*, 15:489-501

Numa C., Lobo M.J. and Verdu R.J. (2012) Scaling local abundance determinants in mediterranean dung beetles. *Insect Conservation and Diversity*, 5:106-117

Scholtz C.H., Davis A.L.V. and Kryger U. (2009). Evolutionary Biology and Conservation of Dung Beetle. *Pensoft publisher*, 567pp

Shahabuddin Hasanah U. and Elijonnahdi (2014). Effectiveness of dung beetles as bioindicators of environmental changes in land-use gradient in Sulawesi, Indonesia. *Biotropia,* 21(1):48-58

MONA CHAUHAN AND V.P. UNIYAL
Wild Life Institute of India, Chandrabani, Dehradun
E-mail: uniyalvp@wii.gov.in