Ecological Indicators 76 (2017) 178–183

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Research paper

Assessing disturbance-sensitivity and generalism in mammals: Corroborating a hump-shaped relationship using a hemerobiotic approach

Corrado Battisti[a,*], Giuliano Fanelli[b], Lorella Mariani[a], Dario Capizzi[c]

[a] "Torre Flavia" LTER (Long Term Ecological Research) Station, Protected area Service, Città Metropolitana di Roma Capitale, via Tiburtina, 691, 00159 Rome, Italy
[b] Laboratorio di Aerobiologia, Dipartimento di Biologia, Seconda Università di Roma Tor Vergata, via della Ricerca Scientifica, 00133 Rome, Italy
[c] Regione Lazio, Direzione Ambiente e sistemi naturali, via del Pescaccio, 96-00166 Rome, Italy

ARTICLE INFO

Article history:
Received 16 October 2016
Received in revised form 14 January 2017
Accepted 17 January 2017
Available online 27 January 2017

Keywords:
Atlas data
Intermediate disturbance hypothesis
Intermediate generalism hypothesis
Hemeroby
Alien species

ABSTRACT

Hemeroby is an indicator widely used in plant ecology to evaluate the level of disturbance of the optimal habitat of a species. Hemeroby can be scaled on a range of ten point scores, higher scores of hemeroby meaning higher level of disturbance. In this study we applied two indicators of sensitivity to disturbance based on the concept of hemeroby: HS_i (mean hemeroby score), calculated on the habitat types where each species occurs, and the recently proposed HH_i (mean hemerobiotic entropy), i.e. the level of generalism of a species with respect to the range of levels of disturbance where the species occurs. Both indices are based on the position and range of species along a gradient of disturbance, from pristine to completely human-made habitats. From a recent regional atlas of mammals, it was possible to calculate the ecological preferences for a large number of habitat types for 36 common mammal species for Latium (Central Italy). From the occurrences of mammals in each habitat, we calculated the HS_i (here rescaled: $HS_{rescaled}$) and HH_i indices. The relationship between habitat-related disturbance ($HS_{rescaled}$) vs. generalism (HH_i) of species showed a hump-shaped relationship peaking at intermediate levels of $HS_{rescaled}$, suggesting that generalism is maximum at intermediate levels of disturbance and corroborating analogous results obtained for birds. Alien mammal species exhibited higher averaged values of HS_i when compared to autochthonous species, supporting the evidence regarding the close relationship between alien species and more disturbed ecosystems. The application of the two indices to mammals could open new perspectives in conservation and management of species inhabiting a wide range of differently disturbed habitat types.

1. Introduction

In ecology, disturbances are physical, chemical or biological events that may cause alteration in structure and function at different ecological levels (from individuals to ecosystems; White, 1979; Pickett and White, 1984). At the species level, ecological traits may be considered strong predictors of sensitivity to disturbance (Sousa, 1984; Mouillot et al., 2013). Among species traits, habitat specialization has been considered a main predictor in this regard (Ewers and Didham, 2006; Julliard et al., 2006; Katayama et al., 2014). In fact, specialized species may respond differently to both natural and anthropogenic disturbances when compared to ecological generalists (Wiens, 1989; Reifa et al., 2013). At the level of assemblages of species, the degree of coexistence and diversity may be largely determined from the level of specialization (or generalism) of co-occurring species (see the intermediate disturbance hypothesis: Connell, 1978; Huston, 1994; Crandall et al., 2003; Barnagaud et al., 2011). In this model, the effect of disturbance on a community depends on intensity, frequency duration, and extension of the regime of disturbance (Sousa, 1984; Battisti et al., 2016). Communities where disturbances have low intensity, frequency or duration tend to be relatively stable and dominated by more specialized species. On the contrary, communities exposed to high levels of these disturbances tend to be unstable and dominated by species that are more adapted to stressed contexts. When the level of disturbance of specific regime attributes is intermediate, species

* Corresponding author.
E-mail addresses: c.battisti@cittametropolitanaroma.gov.it (C. Battisti), giuliano.fanelli@uniroma2.it (G. Fanelli).

http://dx.doi.org/10.1016/j.ecolind.2017.01.014
1470-160X/

assemblages are generally structured with a mixture of generalist and specialized species (Wilson, 1994; McCabe and Gotelli, 2000).

Mammals comprise a large number of species inhabiting different habitat types, ranging from strictly specialized species to broad generalists, and showing different levels of adaptation and response to natural and anthropogenic disturbances (Macdonald, 2009). The level of sensitivity of mammals to disturbance is indirectly related to the level of disturbance experienced by the habitat where the species occur. In this regard, we may distinguish species linked only to pristine (less-disturbed) habitats from species that dominate heavily human-transformed habitats. Nonetheless, an explicit and systematic quantification of the relationship between species, differently disturbed habitat types and level of generalism for mammals is still lacking. Conversely, in plant ecology a long tradition has established a close link between disturbance levels and species distribution using the concept of hemeroby (van der Maarel, 1975; McDonnel and Pickett, 1990; Kowarik, 1989; Kowarik, 2006; Hill et al., 2002; Fanelli et al., 2005). Hemeroby broadly corresponds to the position of the optimal niche of species along the gradient from pristine to heavily settled habitats, and is, widely adopted in vegetation assessment (Grabherr et al., 1998; Steinhardt et al., 1999; Testi et al., 2009; Schleupner and Schenider, 2013). Recently, the concept of hemeroby has been applied to a set of Mediterranean birds (Fanelli and Battisti, 2015; Battisti and Fanelli, 2015a), linking the distribution of avian species obtained from a regional atlas to levels of habitat-related disturbance. This effort allowed not only to calculate an index of the average level of disturbance tolerated by each bird species (hemeroby score, HS_i) but also another index expressing the range of habitats occupied by the species (hemerobiotic entropy, HH_i). Extending the analysis to another group of homoeothermic vertebrates, in this paper we go a step forward and calculate the scores of HS_i and HH_i for a set of species of terrestrial mammals occurring in Central Italy, studying the relationship between these variables. We think that enlarging the comparison between habitat-related disturbance of species and their generalism from birds to mammals could facilitate the definition of a general model for these two important ecological traits.

Table 1
Values of HS_i, $HS_{rescaled}$, HH_i, number of habitat types occupied and E_i (evenness) for the set of terrestrial mammals studied. Alien species are indicated in bold.

Species	HS_i	$HS_{rescaled}$	HH_i	n. habitats	Ei
Rupicapra pyrenaica ornata	2.67	1.4	1.2	25	0.858
Cervus elaphus	2.77	1.52	1.65	52	0.418
Capreolus capreolus	2.91	1.69	2.11	78	0.484
Ursus arctos	2.95	1.74	2.01	46	0.525
Felis sylvestris	2.97	1.76	2.15	40	0.583
Canis lupus	3.03	1.83	2.24	67	0.533
Dama dama	**3.46**	**2.37**	**2.03**	**68**	**0.481**
Sus scrofa	3.57	2.52	2.33	95	0.512
Lepus corsicanus	3.74	2.75	2.45	58	0.603
Martes martes	3.94	3.02	2.36	56	0.586
Myodes glareolus	3.96	3.04	2.07	37	0.573
Lepus europaues	3.98	3.07	2.4	71	0.563
Neovison vison	**4.02**	**3.13**	**2.18**	**27**	**0.661**
Apodemus flavicollis	4.08	3.21	2.34	57	0.579
Glis glis	4.17	3.35	2.82	54	0.707
Sciurus vulgaris	4.28	3.51	2.72	62	0.659
Martes foina	4.52	3.92	2.71	70	0.638
Mustela putorius	4.7	4.38	2.68	52	0.678
Muscardinus avellanarius	4.79	5.17	2.38	62	0.577
Meles meles	4.8	5.21	2.67	85	0.601
Hystrix cristata	4.87	5.37	2.55	91	0.565
Apodemus sylvaticus	4.9	5.45	2.45	66	0.585
Vulpes vulpes	5.04	5.71	2.52	103	0.544
Mustela nivalis	5.31	6.14	2.55	73	0.594
Talpa romana	5.7	6.69	2.54	41	0.684
Crocidura suaveolens	5.77	6.79	2.27	57	0.561
Oryctolagus cuniculus	**5.84**	**6.88**	**2.4**	**44**	**0.634**
Microtus savi	5.96	7.03	2.13	53	0.536
Rattus rattus	**5.97**	**7.04**	**2.6**	**73**	**0.606**
Crocidura leucodon	6.06	7.16	2.13	52	0.539
Mus musculus	**6.31**	**7.47**	**2.46**	**59**	**0.603**
Suncus etruscus	6.34	7.51	2.23	52	0.564
Myocastor coypus	**6.4**	**7.59**	**2.24**	**74**	**0.520**
Erinaceus europaeus	6.47	7.67	2.34	81	0.532
Sorex samniticus	6.48	7.68	1.78	29	0.529
Rattus norvegicus	**7.03**	**8.35**	**2.41**	**43**	**0.641**

2. Methods

2.1. Study area

The study area was the administrative region of Latium, extending over 17,000 km^2 in Central Italy, with about 5,100,000 people and an average density of 297 inhabitants per km^2. The study area extends from the Apennines to the Tyrrhenian Sea and is characterized by a varied orography. Mountains represent 26% of the area, hills 54%, and lowlands 20% (Regione Lazio, 2000; Regione Lazio, 2004). Geology is also varied, with limestones, sandstones, clays, volcanic and alluvial rocks.

2.2. Protocol

In this geographical area 71 species of mammals occur in total and their distribution at regional scale has been reported in the Regional Mammal Atlas and related data bank (Capizzi et al., 2012).

Data were collected from different sources by trained personnel located throughout the region (especially keepers, expert volunteers, professional zoologists). Specific surveys were carried out to monitor the various groups of mammals in different parts of the Latium region (e.g. transects for collecting faeces of hares and locating mammal signs of presence, live trapping for small mammals, camera trapping for medium sized and large mammals, hair tubes for arboreal mammals). For mammals with localized distribution, we used specific data bank (i.e. chamois and brown bear). Data were also drawn from general data banks of protected areas, universities, public authorities, and private subjects. Detailed account of data collection is given in Capizzi et al. (2012).

From the whole set, we selected a sub-set of species, according to the following criteria:

a we excluded bats (Chiroptera, 2036 records), since these species are nocturnal and difficult to observe and the information on the suitable habitat types obtained from the data bank may have a low reliability; furthermore, these species use markedly different habitat types depending on the biological phase (foraging, nursing, hibernation, roosting);
b we excluded from the analyses species with <30 independent records. The choice of not including rarely observed species was done to avoid that random factors and bias in observer efficiency may play an important role (Sutherland, 2006);
c we considered only geo-referenced records, i.e. data obtained from GPS tools (see below) or reports with high geographical detail.

According to these criteria, we finally selected a subset of 36 species. Among them, 7 species are non native for Latium (hereafter 'alien species', reported in bold in Table 1). Taxonomic nomenclature followed Amori et al. (2009).

For these 36 species the data bank of the atlas of mammals of Latium included 10,396 geo-referenced records in total. We linked the records of occurrence to the land use categories of the GPS point of the record. For land use classification we refer to Corine Land Cover levels 4 and 5 (Regione Lazio, 2012) comprising 116