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Habitat preference of four protected bush-cricket species (Orthoptera, Phaneropteridae, *Isophya*) in South Hungary

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Abstract: During a two-year study the distribution of four protected *Isophya* species was studied at 41 sites with 14 different natural, semi-natural and secondary vegetation habitat types in the Mecsek and Villányi Hills (South Hungary). The habitat requirements of the species were partly overlapping, but they were clearly definable. *Isophya camptoxypha* was found in moist, mesic grasslands and forest edge ecotones. *Isophya costata* was found in various types of grassland habitats, mainly in mesic habitats, but it also occurred in more xeric habitats. *Isophya modesta* was found both in mesic and xeric grasslands and in xeric and south faced forest edge ecotones. *Isophya modestior* was found in mesic meadows, meso-xeric grasslands and in bushes of forest edge ecotones. Two or three species co-occurred in 39.0% of the sites.

Key words: *Isophya*, Orthoptera, bush-cricket, habitat preference, co-occurrence.

Introduction

One of the main problems in conservation work on Orthoptera species is the limited availability of natural history and ecological data about the species at risk. Numerous literature sources have addressed pest species, but rare and endemic Orthoptera have been poorly studied.

Most sites of occurrence of Hungarian *Isophya* species are situated in the Mecsek Hills and Villányi Hills in the SW part of the country (Vadkerti, 2004). Four out of the six Hungarian *Isophya* species occur in these regions. One of these, *Isophya costata* Brunner v. Wattenwyl, 1878, is under special protection and is included in the Hungarian Biodiversity Monitoring System (HBMSC) and is protected also under Habitats Directive EU as Annex II species. The other three species, *I. camptoxypha* (Fieber, 1853), *I. modesta* (Frivaldszky, 1867), *I. modestior* Brunner v. Wattenwyl, 1882, are protected. Knowledge on the species-specific habitat preferences of *Isophya* spp. is scarce in the studied region (Rácz & Varga, 1985; Nagy et al., 1998; Szövényi & Nagy, 1999).

Species of the genus *Isophya* are phytophagous and flightless. Their common characteristic is that, depending on weather and climate, their larvae emerge relatively early, generally during March in Hungary (Kis, 1960; Nagy & Szövényi, 1998; Szövényi et al., 2001). Adult specimens can be found from May to August (Nagy & Szövényi, 1999). Due to their early emergence (Nagy & Nagy, 2000), hidden way of life (Nagy, 1974) and nocturnal activity (Szövényi et al., 2001) little has been known about the habitat requirements of *Isophya.* This knowledge is essential for the development of an appropriate conservation management for the species.

Isophya camptoxypha is sub-endemic to the Carpathian Basin and occurs in Transylvania, the Carpathian Ranges and in the E Alps (Szövényi & Nagy, 1999). *Isophya costata* is a postglacial steppe-relict species (Rakonczay, 1990), endemic in the Carpathian Basin (Nagy & Szövényi, 1999). This is the earliest hatching orthopteran in the region (Szövényi et al., 2001). *Isophya modesta* is a characteristic steppe-dweller (Čejchan, 1957) and also a postglacial relict species in Hungary (Rakonczay, 1990). *Isophya modestior* is distributed from N and W Balcan to the SW Alps (Szövényi et al., 2001).

Most of the studies carried out on *Isophya* spp. are of a faunistic character, or describe orthopteran communities (Adamović, 1970; Čejchan, 1957; Ingrisch, 1991; Storozhenko & Gorochov, 1992; Berg et al., 1996; Szövényi & Nagy, 1999); the investigations have been performed separately from each other both in space and in time. Although habitat types have been dealt with at certain levels (association, habitat, food plant) in these studies, the data were always collected from single populations. No comprehensive

analysis has yet been produced on the habitat choice of *Isophya* spp. and future conservation work would greatly benefit from an increased knowledge on species habitat demands.

Therefore, the objectives of our study were (i) to investigate the particular habitat types and characteristics where *Isophya* spp. were found at the study sites, (ii) to study the overlap between the distribution of different species in the study areas.

Material and methods

Study area

The study was carried out in the Mecsek Hills and the Villányi Hills in S Hungary, near the Hungarian-Croatian state border. The Mecsek Hills are a mid-altitude hilly region, with the highest peak rising to 680 m a.s.l. It covers an area of 350 km^2 (66.5% is forest). The Villányi Hills are located about 20 km from the Mecsek Hills, with the highest point being 442 m a.s.l. It covers an area of 50 km^2 (48% is forest).

Of the 41 study sites 11 were in the Villányi Hills and 30 were situated in the Mecsek Hills (Vadkerti et al., 2003). The habitats were classified into 14 classes (Tab. 1) by the Hungarian Biodiversity Monitoring System (Fekete et al., 1997).

Sampling

The sampling was carried out in May and June 2000 and 2001 using sweeping-nets, by visually searching for individuals, or by acoustic detection. Individuals of *Isophya* spp. are vulnerable animals that can be easily wounded by sweep-nets, therefore this method was applied only if the visual and acoustic detection of individuals failed. The fact that the species live in well-structured grassland and bushy habitats mean that collection of individuals is difficult. When the weather was rainy, windy or when there was strong sunshine or strong heat, specimens retired to the lower, dense layers of vegetation. During the study adult individuals of the genus had a typical crepuscular-nocturnal activity maximum according to Szövényi et al. (2001). The animals called from early afternoon to just after dusk, depending on the particular species. When the heat was intense, the first calls of the day were delayed for several hours. When daytime temperatures exceeded 30 °C, *I. costata,* started to call at about 7.00 p.m., whereas *I. modestior* and *I. modesta* at 8.00 p.m. and 9.00 p.m., respectively. *I. camptoxypha* started to call around sunset (c.a. 8.00–9.00 p.m.).

Heller at al.'s (2004) nomenclature was used for identification of species.

Data analyses

For the habitat preference analysis of the species a multiple Principal Coordinate Analysis (PCoA) and a similarity function of the Bray-Curtis ratio type were used, using the NuCoSA statistical program package (Tóthmérész, 1996). For the similarity function the data matrix contained the numbers of the four species in the 14 habitat groups.

Results

Individuals of the *Isophya* spp. were found at least once in the 14 types of habitats examined (Tab. 1). The habitats ranged from wet grasslands to dry clearings in karstic semi-open forests, but they were not found in closed forests. *Isophya costata* was found in the broadest range of habitat types, occurring in 9 of the 14 different types. *Isophya modesta* and *I. modestior* occurred in 7 of the habitats, and *I. camptoxypha* were found in five of the habitat types.

Table 1. Habitat types where *Isophya* species were found in the Mecsek Hills and Villányi Hills. The numbers show the occurrence of different species in the particular habitat type.

N°	Habitat	I.b.	I.c.	I.ma.	I.mr.
1.	False oat-grassland meadows in montane and colline regions	2	5	1	2
2.	Marshy meadows in colline regions	1	1	–	–
3.	Tall weeds along brooks and marshes	1	–	–	–
4.	Grassy steppe slopes and forest-steppe meadows	–	4	3	2
5.	Stabilized meso-xeric clearings and grasslands	–	1	–	1
6.	Grassy stripe between forest and roadside	–	–	1	–
7.	Bushy forest of pubescent oak	1	–	2	–
8.	Warm and xeric forest edge	–	–	2	3
9.	Moist forest edge	4	–	–	–
10.	Secondary, dry grasslands of mountains and hilly areas	–	5	1	–
11.	Secondary, moist grasslands of mountains and hilly areas	–	7	1	1
12.	Semi-natural vegetation of embankments	–	3	–	2
13.	Abandoned wineyards and orchards	–	1	–	1
14.	Forested areas with spontaneous bushy growth	–	1	–	–

Key: I.b. – *I. camptoxypha*; I.c. – *I. costata*; I.ma. – *I. modesta*; I. mr. – *I. modestior*.

Three species (*I. camptoxypha, I. costata, I. modesta* and *I. camptoxypha, I. modesta, I. modestior,* respectively) were found to co-occur at two of the 41 sites (4.87%), and fourteen sites (34.15%) hosted two *Isophya* species. At the remaining 25 sites (60.98%) only one species was found at each site. Although the habitat choice of the four species was overlapping, each of the species showed attraction to certain habitat types (Fig. 1).

Fourteen sites (34.15%) out of 41 were situated in the close vicinity of public roads. *Isophya costata* was found at 13 (46.43%) out of 28 sites in road verges. False oat-grass meadow (1) was the only habitat type proved to be suitable for all of the four species (Fig. 1). Grassy steppe slopes and forest-steppe meadows (4) and secondary, moist grasslands of hills (11) were suitable for three species (*I. costata, I. modesta, I. modestior*).

The species occurred in different rates in natural and semi-natural types of vegetation as well as in secondary vegetation (Fig. 2). *Isophya camptoxypha* occurred only in natural and semi-natural vegetation but the sites where *I. costata, I. modesta* and *I. modestior* were found consisted of 57.1%, 18.2% and 33.3% secondary vegetation, respectively.

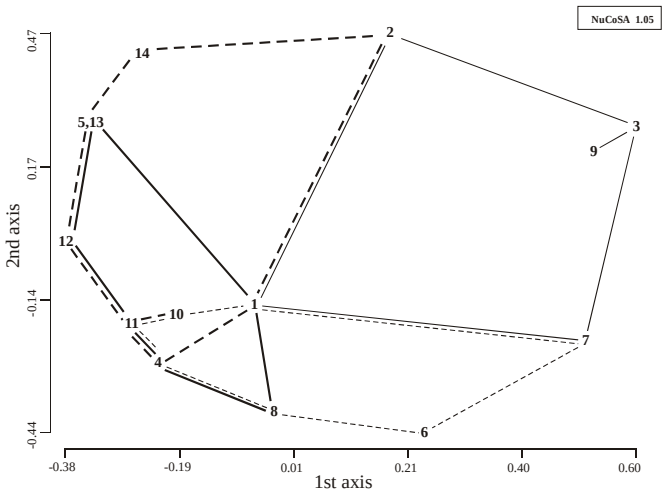

Fig. 1. Habitat segregation pattern of *Isophya* species occurring in SW Hungary demonstrated by PCoA. — *I. camptoxypha*, – – – *I. costata*, – – – *I. modesta*, — *I. modestior*. Numbers correspond with different habitat types, as specified in Table 1.

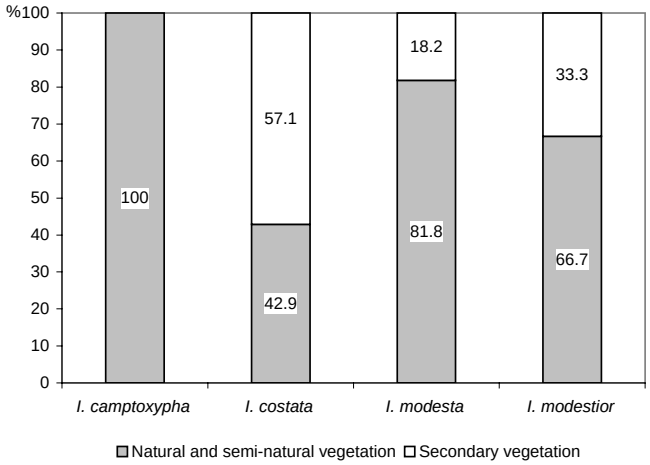

Fig. 2. Occurrence of *Isophya* species at sites with natural and semi-natural, and secondary vegetation.

Discussion

Isophya camptoxypha occurred in moist, grassland areas (1, 2, 3) and in bushes of forest edges (7, 9). In Romania it is found in montane meadows, pastures, forest-edges and forest clearings (Kis, 1960). In SE Slovakia it lives in bushy clearings of beech forests and mesic meadows (Nagy et al., 1998). In Ukraine it occurs in forest-edge bushes and in grass areas, clearings and meadows (Storozhenko & Gorochov, 1992). In the Örség region in W Hungary Nagy & Szövényi (1997) found individuals of the species in clearings, bushes, meadows and forest edges. Our results confirm these observations. However, Szövényi & Nagy (1999) also found the species in chestnut grooves, dry roadsides and orchards, which we did not confirm in this study.

Isophya costata was found in grassy, moist (1, 2, 11, 12,) and meso-xeric and xeric (4, 5, 10, 13, 14) habitats. The species has been found in well-structured, multilayer grasslands habitats with forbs in Transylvania (Kis, 1960) and E Austria (Berg et al., 1996; Ingrisch, 1991). In Hungary it has been found in mesic (Nagy & Szövényi, 1999) and mesothermic loess grasslands (Nagy & Szövényi, 1998) and also in a hemp-stock area neighbouring meadows (Nagy, 1991).

Isophya modesta was found in grassy (4, 6, 10, 11) and bushy habitats (7, 8). This is similar to observations by Kis (1960), Nagy & Rácz (1996), Nagy (1998), and Nagy & Nagy (2000), who found the species in meadows, forest clearings and in bushy areas in plains and hilly regions. Čejchan (1957), on the other hand, has reported the species to be a steppe-dweller.

Habitats of *I. modestior* overlap with *I. costata* and *I. modesta*. This has not been previously reported. In Serbia, *I. modestior* was found in plateaus overgrown with ferns and dense grasses and in wet mountainous meadows (Adamović, 1970). These habitat types are missing from the study areas in Hungary, where the species has been found in bushy *Festucetum* grasslands on fringes of oak grooves (Szövényi & Nagy, 1999) and in karstic semi-open forests with rocky grassland patches (Nagy & Nagy, 2000).

In the Zemplén Mts (NE Hungary) Nagy et al. (1998) investigated 14 sites; at eight of them *Isophya* spp. were found, but the species co-occurred only at one site. Adamović (1970) found *Isophya* spp. at three of 20 study sites, and two of these locations had two co-occurring species. Nagy & Rácz (1996) found only one *Isophya* species per site at seven out of eight habitats in a study area in the Bükk Mts. Nagy (1998) revealed the presence of *I. modesta* in five out of 13 habitats in the Villány Hills. Krištín (1998) reported two sites of 19 with *I. camptoxypha*, and, in a different study Krištín & Mihál (2000) found two species, separately, in four of 19 sites. Nagy (1974, 1991), Nagy & Szövényi (1998, 1999), Holuša (1997) and Rácz (1979) reported the occurrence of only one *Isophya* species in their particular research plots.

In this study two or three *Isophya* species co-occurred in 39.02% of all sites investigated. This is a high co-occurrence rate compared to previous findings. The reason for this high co-occurrence could be that different sampling methods have been applied in the studies. Generally, there is a standard sampling method used in Orthoptera research. Since a more target-oriented method than usually applied was used in this study, the detection probability of the investigated species was probably higher. The secondary vegetation can occur as a consequence of land-use (e.g. mowing, grazing, tourism), or land-use changes (e.g. successional process determined by the abandonment of arable land) (Guido & Gianelle, 2001). The sec-

ondary vegetation can be important in conservation work on *Isophya* spp., as *I. costata* was found in 57.1% of the secondary vegetation sites in this study. We believe that the long-term persistence of bush crickets in the study areas depend on traditional land management (burning by the end of winter, moderate grazing, mowing) or abandoned fields.

As 13 of the sites (46.43% of all) where *I. costata* were found were located in road verges, management of these areas is important for local bush cricket populations. Avoiding the mowing of road verges early in the season is a way to maintain the species-specific value of these habitats (Raemakers et al., 2001). Berggren et al. (2001) found that linear landscape elements such as road verges provide both good habitat and a means of dispersal for the species through the landscape. The linear elements can also increase the survival probability of bush cricket populations, as the corridor has a positive influence on colonisation probability and increases the possibility to escape adverse local conditions.

In order to preserve endangered species it might be important to save a wide range of habitats with different local climates. This could be particularly valid for *Isophya* species as they are distributed over a wide range of habitats and of these many have two, three or all four species co-occurring. Special attention should be paid to sites where two or three species co-occur. To understand the mechanisms operating in the co-occurring populations of the species and to be able to relate this to conservation work more studies need to be carried out.

Acknowledgements

We hereby express our thanks for field work assistance to K.M. Orci, L. Lajos, S. Farkas, K. Légvári and K. Nyárády. Research has been financed by the environmental grant KAC 027876-01/2001 won by E. Vadkerti. We are also grateful to B. Nagy, D. Purger, J. Purger and Z. Varga for their helpful suggestions. The research was permitted by the Danube-Drava National Park Directorate.

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Received May 31, 2004
Accepted May 26, 2005