Insect communities of the Greek Nature Reserve Dadia

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Dadia Nature Reserve in North Eastern Greece was originally established to protect the black vulture (*Aegypius monarchus*) and other birds of prey. This paper reviews and combines data on three groups of insect species: butterflies, Orthoptera, and beetles, with the aim to identify the key areas of the reserve for insect conservation, and to test if they overlap with the strictly protected pine forest core areas. Broad-leaved forests, in particular open oak forests turn out to be the most important habitats for insect species. They are the most species rich habitats for all three groups and more importantly, contain two species that have to be of European conservation priority: the butterfly *Lycana ottomanus*, and the orthopteran *Paranocarodes chopardi*. The oak forest habitats of these two species are not situated in core areas of the reserve, but in the surrounding buffer zone, where human activities like grazing and traditional agriculture are permitted. Updating European Nature Legislation, like Appendix II of the Bern Convention with little known, but threatened, species like these, is highly desirable.

Introduction

Greece is a hotspot of endemism and differentiation for many taxonomic groups. Its geographical position and topography make the country one of the most diverse within Europe (Sfenthourakis & Legakis 2001) with a fauna influenced by European, Asian and African elements. The Southern Balkans served as refugia for thermophilic species during the Pleistocene glaciations (e.g. for butterflies, see: Dennis & al. 1995). Most of them have re-expanded their ranges in the course of postglacial global warming, leaving regionally very diverse gene-pools as traces of their glacial retreats. These refuge-areas are usually rich in species as well as in genetic variants of these species, and

often contain a high proportion of endemics. Hence, they are a kind of diversity "source" for neighbouring regions. In this vein, Greece contains a number of invertebrates endemic to Europe or even to certain regions or mountain ranges. Nevertheless, it also belongs to the least studied areas in Europe (Balletto and Casale 1991; Munguira 1995) and knowledge on the invertebrate fauna of Greece is still relatively scarce and anecdotic (Sfenthourakis & Legakis 2001).

This is one of the reasons why European nature legislation documents, like the Appendix II of the Bern Convention, or other lists of threatened invertebrates include a number of species that are common in Greece, while many endemic, rare and potentially threatened endemic Greek species are absent (see, e.g., Council of Europe 1979, Legakis 1990, Council Directive 92/43/EEC 1992; IUCN 1994).

This paper focuses on a region of the Greek mainland where certain groups of insects have been increasingly studied within the last few years: Dadia Nature reserve in north-eastern Greece. The reserve was originally established to protect the more than 35 species of birds of prey feeding and nesting in the area (Adamakopoulos & al. 1995). Since then, research and conservation efforts have been targeted mainly on these raptors (Adamakopoulos & al. 1995, Grant & Vlachos 1995, Bakaloudis & al. 1998, 2001). Recently, attention has been drawn to other groups such as, for example, orchids (Kati 2001), orthoptera (Kati & Willemse 2001, Kati & al. 2004), butterflies (Grill & Cleary 2003), and beetles (Argyropoulou & al. 2005).

Traditionally, nature reserves were centered mainly around areas that are important for vertebrate diversity. But the usefulness of centering nature reserves around areas that are important for vertebrate diversity has not gone unchallenged. Choosing protected areas with respect to vertebrates may lead to large gaps in the overall protection of biodiversity (Kerr 1997). This problem is widely recognized (e.g. Haslett 1997, Wettstein & Schmid 1999) but has hardly been accounted for in practice.

To investigate this problem, I reanalyze and combine previously published data on three groups of insect species in Dadia nature reserve: a) butterflies, c) orthoptera, and c) beetles (Grill & Cleary 2003, Kati & al. 2004; Argyropoulou & al. 2005). In a habitat-based approach, I overlay the diversity patterns of these communities, in order to identify the key-areas of the reserve for each of these very diverse groups and to test their overlap with the designated core-areas of the reserve.

Identifying habitat-types and land use practices that support the diversity of resident insect species in an area originally defined for the protection of birds will provide useful information when establishing general habitat con-

servation and management priorities towards other groups beside birds. By establishing which taxa are associated with particular habitats, this paper sets priorities for habitats supporting taxa that might be vulnerable to extinction. Conclusively, I assess, if insect species of potential European conservation concern, i.e. species that are endemic to Europe and threatened in most of their ranges, occur in Dadia.

The main aims of the study are: (1) to combine data on insect species richness in the seven predominant habitat types in Dadia nature reserve (oak forest, pine forest, mixed forest, wet meadow, dry meadow, pasture, agricultural land), (2) to explore the association of insect communities to different habitats and human impact gradients, (3) to identify rare species of European conservation concern, and (4) to inquire into the suitability of the existing nature reserve for insect conservation.

Already from the first conversation with Konrad Thaler it became clear that we both shared an infatuation with Greece. Greece was the starting point which finally led to a doctorate thesis co-supervised by Konrad Thaler, who above all taught me the combination of confidence and doubt indispensible for successfully carrying out a scientific project. Selecting a Greek subject for a volume to his memory was thus more than evident.

Materials and Methods

Dadia nature reserve is located in Dadia-Lefkimi forest in Thrace, in the prefecture of Evros which is part of the south-eastern edge of the Rodopi mountains in Greece (026_000/026_190 E, 40_590/41_150 N) (Fig. 1). It is a public forest that belongs mainly to the villages of Dadia, Lefkimi, and Soufli. Most parts of the area are situated at altitudes ranging from approximately 300 to 650 m a.s.l. The whole protected area covers 42.450 ha, and is mostly forested (80% cover with *Pinus brutia* and *Pinus nigra*). The two strictly protected 'core areas', where human activities are prohibited, cover 7290 ha (Adamakopoulos & al. 1995), and are surrounded by a 'buffer zone' where limited human activities are allowed but controlled by the reserve management. Dadia reserve functions as a centre of conservation, environmental education, and scientific research. Dadia forest is one of the last regions in Europe that is still largely unmodified by human influence and consists of a very heterogeneous largely forested habitat mosaic. The main human influences include domestic livestock grazing, traditional agriculture (small fields, little to no use of pesticides), tourism, and activities to create suitable habitat for birds of prey (Adamakopoulos & al. 1995).

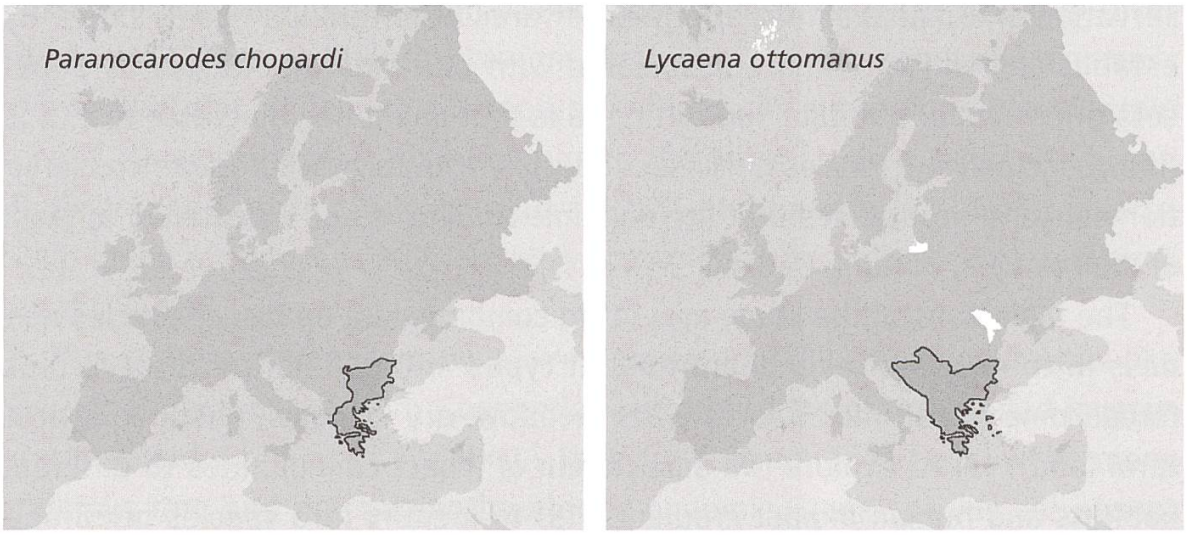

Fig. 1: Administrative borders of countries, where the two priority species *Paranocarodes chopardi* (Orthoptera) and *Lycaena ottomanus* (Lepidoptera) occur, are indicated with a black line. White areas indicate that no information on the species is available.

Taxa used in this study

The taxa on which information is compiled here, cover groups using different niches of the ecosystem by different foraging strategies (herbivores, hunters, detrivores).

a) Butterflies

Butterflies are the best-known group of insects in Greece (Pamperis 1997; Dennis & al. 2000). They have been widely proposed as a key indicator group of biodiversity, and could serve as a charismatic insect counterpart to birds. Their ecological requirements as herbivores with some species relying on single host plant species, and the fact that they undergo a complete metamorphosis during their life cycle (egg, larva, pupa, adult butterfly) – meaning that the larvae potentially use a very different ecological niche as compared to the adult – make them react relatively quickly (within one season) to changes in management.

b) Orthoptera

Orthoptera are known to be a major component of grassland biodiversity (Gandar 1982; Ryszkowski & al. 1993). They play a central role in food webs, as they are mostly primary herbivores and constitute an abundant food resource

for other groups such as lizards and raptors (Parr & al. 1997). Some species have a keystone character affecting grass communities (Quinn & al. 1993; Lockwood 1998), while others are known as good indicators of land use change (Samways 1997, Armstrong & van Hensberen 1999). Nevertheless, Orthoptera are rarely taken into account in conservation programs. This is probably because some species are known as pests, by the severe damage they can cause to crops and farmland. Consequently, an obvious conflict between conservation and pest management programs arises (Lockwood 1998, Samways & Lockwood 1998). As opposed to butterfly larvae, Orthoptera are hemimetabolic, meaning that they only undergo an incomplete metamorphosis during their life cycle (egg, nymph, adult). Consequently, nymphs and adults always use the same ecological niche.

c) Beetles

Coleoptera are the most species-rich group of all insects with very diverse foraging strategies: herbivores, predators, detrivores. Their short reaction time to environmental changes makes them good ecological indicators even for short-term monitoring studies (Perner & Malt 2003). Many bioindication studies aiming to habitat evaluation and monitoring have been based on the coleopteran fauna, focusing either on certain species or families or even on the whole order (e.g. Bohac 1999, Humphrey & al. 1999, Molina & al. 1999, Magura & al. 2000, Baur & al. 2002, Argyropoulou & al. 2005). In many of these studies, the researchers tried to assess the effect of human practices, such as grazing (Gardner & al. 1997, Petit & Usher 1998), farming activities (Krooss & Schaefer 1998, Kromp 1999, Varchola & Dunn 1999) and forestry practices (Ings & Hartley 1999, Magura & al. 2001, 2002) on the coleopteran communities. Like butterflies, coleoptera are holometabolic, and the larvae often use different food sources and ecological niches as compared to the adult beetles.

Results and Discussion

1. Butterflies

Seventy-five butterfly species belonging to five families [viz. Papilionidae, Lycaenidae, Pieridae, Nymphalidae, and Hesperiidae] were recorded during the

sampling period. Eight species dominated the records: *Aporia crataegi, Maniola jurtina, Argynnis paphia, Polyommatus icarus, Brenthis daphne, Satyrium ilicis, Melitaea trivia, Colias croceus*. All the species recorded are resident in the area, meaning that they lay their eggs in close proximity to where the adults fly.

The highest mean numbers of species were observed in broadleaved mixed forests, which had a significantly higher species richness than all other sites, and in oak forest sites. Pine forests had significantly lower species richness than all other sites. The number of species covered in Grill & Cleary (2003) was close to the number of species that can potentially be found in the area (shown in Pamperis 1997).

Ten of the species found in Dadia are of European conservation concern, four of them are European endemics, if we consider Turkey as part of Europe (Kudrna 1986; van Swaay & Warren 1999) (viz. *Lycaena ottomanus, Aricia anteros, Thymelicus acteon*, and *Hipparchia fagi*); and six species have their main distribution in Europe (viz. *Pseudophilotes vicrama, Agrodiaetus admetus, Brintesia circe, Hipparchia statilinus, Melanargia galathea*, and *Thymelicus sylvestris*).

Of these, *Lycaena ottomanus* has been classified a SPEC 1 species in the Red Data Book of European butterflies (van Swaay & Warren 1999). This means that the species is globally threatened and of highest conservation importance, requiring stringent conservation measures wherever is occurs. It was found in mixed and oak forests. It is restricted to south-eastern Europe and has its main distribution area in Albania, Greece and Turkey (see Fig. 1), where it is declining (van Swaay & Warren 1999). Therefore, it has been given top priority in the Red List of European butterflies. The species' main habitats are dry calcareous grasslands, and wet, richly structured valleys in the hotter southern parts of Turkey (van Swaay & Warren 1999). The larvae live on *Rumex acetosella* and mostly feed on leaves or young flowers (Tolman & Lewington 1997). The species is on the list of candidates proposed to be included in Appendix II of the Bern Convention (van Swaay & Warren 1999).

The other two European Red List species found in Dadia forest, *Thymelicus acteon* and *Pseudophilotes vicrama*, are not endemic to Europe but they are threatened in their European range (van Swaay & Warren 1999). *Thymelicus acteon* is declining in Central Europe but still stable around the Mediterranean. Outside Europe it is only found in a small area in the Middle East. In Dadia, it was observed in dry meadows and in the pine-forest. Similar declines in its European range are reported for *P. vicrama* (van Swaay & Warren 1999). *P. vicrama* was observed in dry meadows, pastures and the pine-forest sites. Both species are known to occur in dry, hot situations. *Pseudophilotes vicrama*

lays its eggs on the flowers of *Thymus* spp. and *Satureja* spp. The larvae are myrmecophilous and in captivity reluctant to pupate, possibly due to the absence of their particular ant species. *Thymelicus acteon* relies on grasses as larval host plants that are typical for nitrogen-poor calcareous grasslands, such as *Brachypodium pinnatum, B. sylvaticum, Elmyus repens, and Calamagrostis epigejos* (Tolman & Lewington 1997, van Swaay 2002). This may be one of the main reasons for the vulnerability and rarity of these species in Europe. Fertilization increases the nitrogen level in meadows, and they often are irrigated artificially or suffer intense grazing. Such measures have been shown to have dire consequences for lycaenid butterflies (Fischer & Fiedler 2000). Both species, *T. acteon* and *P. vicrama*, are among the butterflies that are under the greatest risk of extinction in Europe (van Swaay 2002). Other species characteristic for the geographical area of Dadia (Pamperis 1997) (viz. *Aricia antheros, Hipparchia syriaca, Hipparchia fatua, Coenonympha leander, Kirinia roxelana, Carcharodus orientalis, Zerynthia cerisy*, and *Pontia chloridice*) underline the importance of Dadia nature reserve for butterfly conservation.

2. Orthoptera

Thirty-nine Orthoptera species were recorded in the reserve (Kati & al. 2004). In the Ensifera 15 species of bush crickets (Tettigoniidae) were found, belonging to the subfamilies Phaneropterinae, Conocephalinae, Tettigoniinae and Decticinae. Three species of crickets (Gryllidae, Gryllinae) were identified. In the Caelifera, one species of Pamphagidae and 20 species of true grasshoppers (Acrididae) were identified, belonging to the subfamilies Catantopinae, Calliptaminae, Acridinae, Oedipodinae, and Gomphocerinae.

In terms of conservation, the most important species is *Paranocarodes chopardi*. Its distribution range in the world is restricted to only eight known sites around the Dadia reserve (Kati & Willemse 2001) and one in Bulgaria (Pechev 1965) (see Fig. 1). It is an apterous pamphagid with a low dispersal ability that renders it prone to extinction if its habitat becomes degraded or fragmented (Samways 1997; Samways and Sergeev 1997). The species' conservation status is Critically Endangered and it ought to be listed in Annex II of the Habitat Directive (92/43/EEC) as a priority species for conservation.

In general, the richest sites for Orthoptera were open oak forests with scrub undergrowth and an arid stony substrate that is sparsely covered by dead oak leaves and grass. Other rich sites were the grassy borders and hedges of habitat mosaics combining mixed broadleaved forests and grasslands with

agricultural fields. Natural Mediterranean grasslands are of higher conservation value for Orthoptera than the same type of grassland regularly grazed by livestock. Orthoptera species were mostly concentrated in sunny bushy patches. Forests are less important habitats for Orthoptera in the Dadia area. All species encountered at forest sites were also present in open habitats.

Some generalist species occur almost everywhere. The most pronounced generalists present in the area were *Calliptamus barbarus, Chorthippus borin, Aiolopus strepens, Acrida ungarica,* and *Tylopsis lilifolia*. There are also generalist species that indicate dry (*Oedipoda caerulescens*) or more humid (*Platycleis incerta*, *Poecilimon brunneri*, *Omocestus rufipes*) habitat conditions.

3. Beetles

Thirty four epiedaphic (= surface dwelling) beetle species were found in Dadia reserve. Oak forest and mixed forest harbored the most species. Grazing did not appear to have adverse effects on species richness and increased the general diversity of the studied sites. As coleopteran communities are affected by several factors that are altered through grazing, i.e., the amount of light penetrating the overstorey, the development of ground vegetation and the degree of structural heterogeneity at microscale, it is well understandable, that it can induce positive effects on beetle diversity, particularly in forested areas. The communities in the un-grazed sites were over-dominated by one species, while those of grazed sites were hierarchically structured. Agriculture, on the other hand, profoundly changed the species composition. The agricultural site was dominated by species that were almost absent from all other sites.

Conclusions

In terms of species richness, the strictly protected core areas of Dadia nature reserve do not contain the most important sites for the three insect groups studied. The data show clearly, that originally, the reserve was not established for the protection of insects, but for the protection of birds. Sites providing ideal conditions for butterflies, Orthoptera or beetles can obviously be very different from those ideal for birds of prey. The strictly protected core areas of the reserve are dominated by high pine trees (*Pinus brutia*) and rocky outcrops, features that are important for vultures and other species of birds of prey (Poirazidis & al. 2000). The types of habitats identified as being important for butterflies and Orthoptera are broadleaved mixed forests, in particular

oak woods, must have a rather open structure and contain clearings, meadows and/or different types of deciduous trees. Grasslands have a greater conservation value when undisturbed by regular livestock grazing. The recorded beetles are less dependent on open habitats, but also had lower species richness in pine-forest sites than in other habitats.

Consequently, relying solely on the core areas of the reserve for insect conservation would neglect many important species, such as the endangered butterfly *Lycaena ottomanus*, and the orthopteran *Paranocarodes chopardi*, which were both found in oak forest sites. On the other hand, the cores did contain two butterflies of European conservation concern: *T. acteon* and *P. vicrama*.

For all three taxonomic groups, the sites with the highest species richness are situated in the buffer zone of the reserve. The core areas are important for butterfly conservation, but do not hold all species of conservation interest. The main gradients in insect species richness (low to high) go from sites dominated by the pine forest matrix of the core areas of the reserve, to peripheral sites in landscapes of mixed or oak forest, and from sites with little human impact to more disturbed areas with high grazing pressure. The combined data on butterflies, Orthoptera and beetles suggest that (1) traditional agricultural practices in areas surrounded by forest can be considered as important management tools in butterfly conservation, (2) insect butterfly species richness is found in the periphery of the reserve rather than in the core areas, and (3) for insect conservation the zones surrounding the strictly protected areas are equally important as the core areas.

Enhancing conservation efforts towards insects would not require a complete change of the management in the area, but increased understanding of the suite of environmental characteristics essential for these groups. Traditional land use techniques such as extensive agriculture and low-intensity livestock grazing do not have adverse effects on any of the three groups and can even support particular species assemblages. As has also been shown in another recent study on Lepidoptera in agricultural habitats (Ricketts & al. 2001), agricultural sites that are close to forests or forest fragments support a large proportion of butterflies. The encouragement of traditional agricultural practices in areas surrounded by forest and low-intensity grazing should be considered as an important management tool in conservation.

I want to emphasize that the 'buffer zones' are not only transition zones to the unprotected areas around the cores, but essential parts of the reserve, contributing to its benefits for nature conservation. This does not mean, that management focusing on raptors is not compatible with conservation of insects. Successful insect conservation requires a network of various complementary

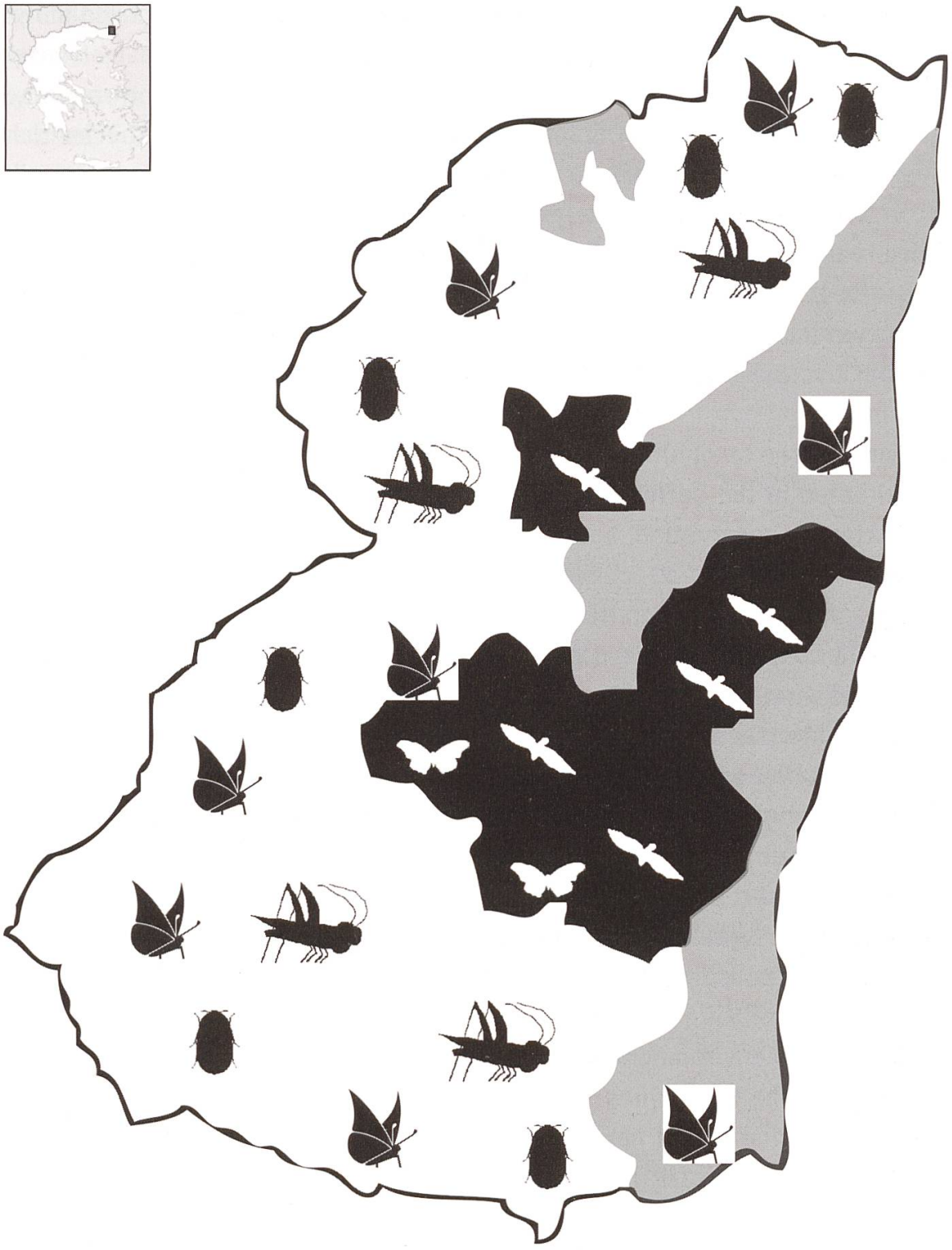

Fig. 2. Dadia Nature Reserve in North Eastern Greece. The strictly protected Core Areas are shaded in black, agricultural areas in grey, the rest of the area (= buffer zone) is a mosaic of broadleaved forests and grasslands. The silhouettes of the individuals show the suitability of the habitat type for the conservation birds of prey, beetles, butterflies and grasshoppers. The Core areas are mostly suitable for birds of prey and some butterfly species of European Conservation concern. For grasshoppers and beetles the buffer zones are more important.

habitats, including open oak forests, mixed forests, agricultural fields separated with hedges, wet meadows, and dry, nutrient poor grasslands. This is ideally fulfilled by the buffer-zone of the reserve (see Fig. 2).

The importance of Dadia nature reserve is not only based on its considerable natural richness but also on its geographical location. Dadia gains further importance due to the fact that areas where controlled scientific long-term research and monitoring is facilitated are scarce in this geographical region. Future research could focus on the priority species identified here. In particular, the endemic orthopteran *Paranocarodes chopardi* should be included in the reserve monitoring program. Updating European Nature Legislation, like Appendix II of the Bern Convention with little known species like this one, is highly desirable.

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