THE DADIA–LEFKIMI–SOUFLI FOREST NATIONAL PARK, GREECE: BIODIVERSITY, MANAGEMENT AND CONSERVATION

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WWF Greece
Athens 2010

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Suggested citation:

Author's name. 2010. Title of paper. – In: Catsadorakis, G. and Källander, H. (eds). The Dadia–Lefkimi–Soufli Forest National Park, Greece: Biodiversity, Management and Conservation. WWF Greece, Athens, pp. 000–000.

Published by:
WWF Greece,
26 Filellinon str.,
GR-105 58 Athens, Greece
Tel:+30 2103314893, fax: +302103247578
e-mail: support@wwf.gr
http://www.wwf.gr

ISBN 978-960-7506-10-8

Typeset by ZooBo Tech, Torna Hällestad, Sweden
Printed by Schema + Chroma, GR-574 00 Sindos, Thessaloniki, http://www.kethea-print.gr
Illustrations by Paschalis Dougalis
Maps on pages 18–28, 36, 42, 86, 89, 217 and 231–243 prepared by Nikolaos Kasimis, those on pages 23, 27 and 232 by Konstantinos Poirazidis.
The book was printed on130 g FSC-certified Sappi Era Silk paper.
Cover photo: Giorgos Catsadorakis.

Diversity patterns in insect communities of the Dadia–Lefkimi–Soufli Forest National Park: butterflies, grasshoppers, beetles

Andrea Grill, Vassiliki Kati, Georgios Karris, Maria D. Argyropoulou

In this paper we combined data on three groups of insect species in Dadia–Lefkimi–Soufli Forest National Park: (a) butterflies, (c) Orthoptera and (c) beetles, and analysed their occurrence across different habitats in order to identify key areas of the park for each of these groups and to test the overlap of key areas with the designated core areas of the park. The main gradients in insect species richness (low to high) were from the core areas dominated by pine forest, to peripheral sites of fragmented mixed forests in the heterogeneous buffer zone. A number of insect species endemic to, or threatened in Europe occurred in relatively high abundance in Dadia, e.g. the grasshopper *Paranocarodes chopardi* and the butterflies *Lycaena ottomanus, Thymelicus acteon* and *Pseudophilotes vicrama.* For insects, the 'buffer zones' are not only transition zones to the unprotected areas around the cores, but are essential parts of the reserve that contribute to its importance for nature conservation.

Keywords: Biodiversity, community ecology, insects, conservation

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 and Legakis 2001), with a fauna influenced by European, Asian and African elements. What is more, the Southern Balkans served as refugia for thermophile species during Pleistocene glaciations (e.g., for butterflies, see Dennis et al. 1995). Most of these have re-expanded their ranges in response to postglacial global warming, leaving very diverse gene pools regionally as evidence 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 is also among the least studied areas in Europe (Balletto and Casale 1991, Munguira 1995) and knowledge of the Greek invertebrate fauna is still relatively meagre and anecdotic (Sfenthourakis and Legakis 2001).

This is one of the reasons why European nature legislation documents, such as the Appendix II of the Bern Convention, or other lists of threatened invertebrates include a number of species that are common in Greece, while its many endemic, rare and potentially threatened species are absent from these lists (see, e.g., Council of Europe 1979, Legakis 1990, Council of the European Communities 1992, IUCN 1994).

This paper focuses on a region of the Greek mainland where certain groups of insects have increasingly been studied within the last few years, the Dadia–Lefkimi–Soufli Forest National Park (DNP) in north eastern Greece. The reserve was originally established to protect the more than 35 species of birds of prey that nest or feed in the area (Adamakopoulos et al. 1995). Since then, research and conservation efforts have been targeted mainly on these raptors (Adamakopoulos et al. 1995, Grant and Vlachos 1995, Bakaloudis et al. 1998, 2001). Recently, attention has been drawn to other groups, such as orchids (Kati et al. 2000, Kati 2001), orthoptera (Kati and Willemse 2001, Kati et al. 2004), butterflies (Grill and Cleary 2003), and beetles (Argyropoulou et al. 2005).

Traditionally, nature reserves have been centred mainly in areas that are important for vertebrate diversity. But the usefulness of this 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 and Schmid 1999) but has hardly been accounted for in practice.

To investigate this problem, we reanalysed and combined previously published data on three groups of insect species in DNP: (a) butterflies, (c) Orthoptera, and (c) beetles (Grill and Cleary 2003, Kati et al. 2004, Argyropoulou et al. 2005). In a habitat-based approach we overlaid the diversity patterns of these communities, in order to identify the key areas of the park for each of these very diverse groups and to test their overlap with the designated core areas of the park.

Identifying habitat types and land use practices that support a diversity of resident insect species in an area originally defined for the protection of birds, will provide useful information when establishing general habitat conservation and management priorities towards other groups. By establishing which taxa are associated with particular habitats, this paper sets priorities for habitats supporting taxa that might be vulnerable to extinction. Finally, we assess whether insect species of potential European conservation concern, i.e. species that are endemic to Europe and threatened in most of their ranges, occur in DNP.

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

The taxa treated in this study

The taxa on which information is compiled here cover groups using different niches of the ecosystem by different foraging strategies (herbivores, predators, detritivores): butterflies, Orthoptera and Coleoptera.

Butterflies are the best-known group of insects in Greece (Dennis et al. 1995, Pamperis 1997). 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, including some species restricted to single host plants, and that they undergo a complete metamorphosis during their life cycle (egg, pupa, larva, imago) means that the larvae potentially use a very different ecological niche from that of adults making them react relatively quickly (within one season) to changes in the management of an area.

Orthoptera are known to be a major component of grassland biodiversity (Gandar 1982, Ryszkowski et 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 et al. 1997). Many orthopteran species are also predators of other insects. A number of species have a keystone character affecting grass communities (Quinn et al. 1993, Lockwood 1998), while others are known as good indicators of land use change (Samways 1997, Armstrong and van Hensberen 1999). Nevertheless, the Orthoptera are rarely taken into account in conservation programmes probably because some are known pests, inflicting severe damage to crops and farmland. Consequently, an obvious conflict between conservation and pest management programmes arises (Lockwood 1998, Samways and Lockwood 1998). Unlike butterflies, the Orthoptera are hemi-metabolous, undergoing an incomplete metamorphosis during their life cycle (egg, nymph, adult). Consequently, nymphs and adults always use the same ecological niche.

Coleoptera are the most species-rich group of all insects with very diverse foraging strategies: herbivores, predators, detritivores. Their short reaction time to environmental changes makes them good ecological indicators even for short-term monitoring studies (Perner and Malt 2003). Many bioindication studies aiming at 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 et al. 1999, Molina et al. 1999, Magura et al. 2000, Baur et al. 2002, Argyropoulou et al. 2005). In many of these studies, the researchers have tried to assess the effect of human practices, such as livestock grazing (Gardner et al. 1997, Petit and Usher 1998), farming activities (Krooss and Schaefer 1998, Kromp 1999, Varchola and Dunn 1999) and forestry practices (Ings and Hartley 1999, Magura et al. 2001, 2002) on coleopteran communities. Like butterflies, Coleoptera are holo-metabolous, and larvae may use different food sources and ecological niches from those of adults.

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, laying their eggs in close proximity to where the adults fly.

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

Ten of the species in Dadia are of European conservation concern; four of them, *Lycaena ottomanus, Aricia anteros, Thymelicus acteon* and *Hipparchia fagi* are European endemics, if Turkey is considered part of Europe (Kudrna 1986, van Swaay and Warren 1999). The other six species, *Pseudophilotes vicrama, Agrodiaetus admetus, Brintesia circe, Hipparchia statilinus, Melanargia galathea* and *Thymelicus sylvestris* have their main distribution in Europe. Of these, *Lycaena ottomanus* has been classified as a SPEC 1 species in the Red Data Book of European butterflies (van Swaay and Warren 1999). This means that the species is globally threatened and of the highest conservation importance, requiring stringent conservation measures wherever is occurs. It was found in mixed forests and oak woods. It is restricted to south-eastern Europe with its main distribution in Albania, Greece and Turkey, where it is declining (van Swaay and Warren 1999). Therefore, it has been given top priority in the Red List of European butterflies. Its main habitats are dry calcareous grasslands and wet, richly structured valleys in the hotter southern parts of Turkey (van Swaay and Warren 1999). The larvae live on *Rumex acetosella* and mostly feed on leaves or young flowers (Tolman and Lewington 1997). It is on the list of candidates proposed for inclusion in Appendix II of the Bern Convention (van Swaay and Warren 1999). *Lycaena ottomanus* is also mentioned in the book “Prime Butterfly Areas in Europe” (van Swaay and Warren 2003), together with another species, *Euphydryas aurinia*, which we did not record within the frame of our study, but which has been observed in the area by other researchers (Lazaros Pamperis, pers. comm.). The region “Eastern Evros” has been designated as one of the Prime Butterfly Areas in Greece because of the presence of these two butterflies and includes part of DNP.

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 and Warren 1999). *Thymelicus acteon* is declining in Central Europe but is still stable around the Mediterranean. Outside Europe it is found only in a small area of the Middle East. In Dadia, it was observed in dry meadows and pine forest. Similar declines in its European range are reported for *P. vicrama* (van Swaay and Warren 1999). *P. vicrama* was observed in dry meadows, pastures and pine forest. 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 are reluctant to pupate, possibly in the absence of their particular host ant species. *Thymelicus acteon* larvae live on grasses that are typical of nitrogen-poor calcareous grasslands, such as *Brachypodium pinnatum, B. sylvaticum, Elymus repens,* and *Calamagrostis epigejos* (Tolman and Lewington 1997, van Swaay 2002). This may be one of the main reasons for the vulnerability and rarity of these two species in Europe. Agricultural fertilizers increase the nitrogen levels in meadows, which are often irrigated artificially or suffer intense grazing. Such measures have been shown to have dire consequences for lycaenid butterflies (Fischer and 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 of the geographical area of Dadia (Pamperis 1997), *Aricia anteros, Hipparchia syriaca, Hipparchia fatua, Coenonympha leander, Kirinia roxelana, Carcharodus orientalis, Zerynthia cerisy* and *Pontia chloridice*), underline the importance of Dadia National Park for butterfly conservation.

Grasshoppers, crickets and bush-crickets

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

In terms of conservation, the most important species is *Paranocarodes chopardi* (Fig. 1). Its distribution range in the world is restricted to only eight known sites around the Dadia National Park (Kati and Willemse 2001) and one in Bulgaria (Pechev 1965). It is an apter-

Fig. 1. *Paranocarodes chopardi* Pechev 1965, is an omnivorous orthopteran restricted to the oak-forested hills of the eastern Rhodopi mountains, between 200 and 900 m asl, met in open habitats dominated by thermophilous oaks with an undergrowth of Graminae and shrubs of *Phyllirea* and *Erica*. Until now, it has been recorded in a few localities within and to the west of the DNP and in one locality in SE Bulgaria . Photo: G. Catsadorakis.

ous omnivore, with a low dispersal ability that renders it prone to extinction if its habitat becomes degraded or fragmented (Samways 1997, Samways and Sergeev 1997). Its conservation status is Critically Endangered and as a priority species it ought to be listed in Annex II of the Habitat Directive (92/43/EEC) for conservation.

In general, the richest sites for Orthoptera were in open oak forests with scrub undergrowth and an arid stony substrate, sparsely covered with oak litter and grass. Other rich sites were grassy borders and hedges of habitat mosaics, combining mixed broad-leaved 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 were mostly concentrated in sunny, bushy patches. Forests are less important habitats for Orthoptera in the Dadia area and 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 bornhalmi, Aiolopus strepens, Acrida ungarica* and *Tylopsis lilifolia*. There are also generalist species that indicate dry (*Oedipoda caerulescens*) or wet (*Platycleis incerta*, *Poecilimon brunneri*, *Omocestus rufipes*) habitat conditions.

Beetles

Thirty-four epiedaphic (= surface dwelling) beetle species were found in DNP (Argyropoulou et al. 2005) belonging to the Carabidae, Staphylinidae, Scarabaeidae, Curculionidae, Cerambycidae, Anthicidae, Silphidae, Elateridae, Chrysomelidae, Tenebrionidae. Oak forest and mixed forest harboured the highest numbers of species. Grazing did not affect the species composition of the beetle communities, but changed the community structure, and hence, generally increased the diversity of the studied sites. The communities in the ungrazed sites were dominated by one species, while on the grazed sites, a wider range of abundant species was present in similar numbers. As coleopteran communities are affected by several factors influenced by grazing, such as the amount of light reaching the understorey, the development of ground vegetation and the degree of structural heterogeneity at micro-scale, grazing can have positive effects on beetle diversity, particularly in forested areas. Small-scale agriculture (wheat-cultivation without the use of pesticides), on the other hand, did not change the overall diversity and structure but induced profound changes in species composition. The agricultural sites were dominated by characteristic species that were almost absent from all other sites, such as, for example, *Trechus quadristriatus* or *Oxytelus* sp. (Argyropoulou et al. 2005).

Conclusions

In terms of species richness, the strictly protected core areas of the DNP do not contain the most important sites for the three insect groups studied. The data show clearly that the reserve was not originally 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 tall pine trees (*Pinus brutia*) and rocky outcrops, features that are important for vultures and other raptors (Poirazidis et al. 2000). The types of habitat identified as being important for butterflies and Orthoptera are broad-leaved mixed forests, in particular oak woods, which have an 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. Beetles are less dependent on open habitats, but also have 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 core areas 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 insect conservation, (2) insect 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 practices in the area, but increased understanding of the suite of environmental characteristics would be 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 et al. 2001), agricultural sites that are close to forests or forest fragments support important butterfly species. 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.

We 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 incompatible with conservation of insects. Successful insect conservation requires a network of various complementary habitats, including open oak forests, mixed forests, agricultural fields separated by hedges, wet meadows, and dry, nutrient-poor grasslands. This is ideally fulfilled by the buffer-zone of the reserve (Fig. 2).

The importance of the Dadia–Soufli–Lefkimi Forest National Park does not only derive from its considerable natural richness but also from its geographical location. The park is situated in a crucial position on the Turkish border and close to Bulgaria. In the last century, the area has been ruled by several different regimes from Greek to Turkish, and German to Bulgarian, creating socially and politically difficult circumstances which are still evident. A nature-protected area of international importance in this location not only aids repopulation and

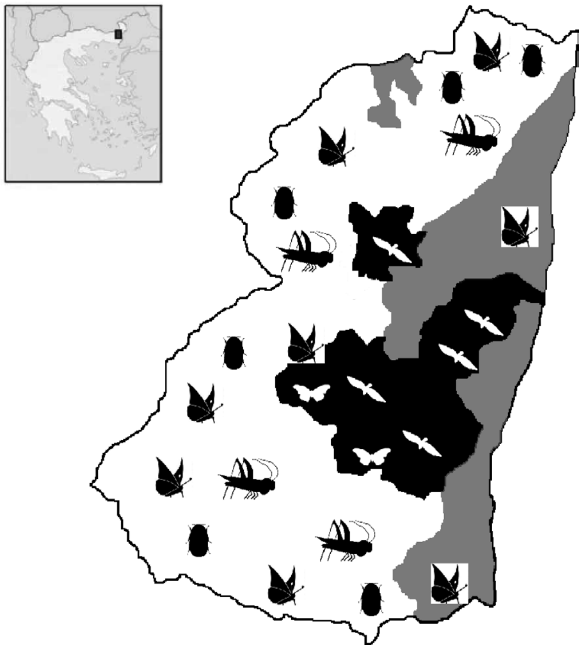

Fig. 2. The Dadia Nature Reserve (presently Dadia–Lefkimi–Soufli Forest National Park). The strictly protected core areas are in black, agricultural areas in grey, the rest of the area (= buffer zone) is a mosaic of broadleaved forests and grasslands. The silhouettes indicate the suitability of the habitat type for the conservation of 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. The buffer zone is more important for grasshoppers and beetles.

employment but might also provide a certain political 'buffer-zone'. Dadia gains further importance because areas where controlled scientific long-term research and monitoring are facilitated are scarce in this geographical region. Future research could focus on the priority species identified here. In particular, the narrow endemic orthopteran *Paranocarodes chopardi* should be included in the park's monitoring programme. Updating European Nature Legislation, such as Appendix II of the Bern Convention, with little known species such as this one, is highly desirable.

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