THE ROLE OF NATURA 2000 NETWORK IN PROTECTING THE ORCHID FLORA OF EAST MACEDONIA (NE GREECE)

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ABSTRACT

East Macedonia (northeast Greece) is a relatively small part of Greece, where a considerable number of orchid taxa occurs. Some of these orchids can only be found there and this fact makes the specific area of Greece unique. In this study, an up-to date database of orchid records was used to assess the effectiveness of the existing Natura 2000 network. Specifically, the effectiveness of the Natura 2000 network was evaluated by identifying the number of orchids whose distribution is overlapping to a lesser or greater extent with the network, which chorological categories are included/excluded from it, and whether the rare and threatened orchid taxa are adequately distributed within that. Out of the 73 orchid taxa recorded in East Macedonia so far, 14 taxa are exclusively distributed outside the Natura 2000 network. Specifically, the Natura 2000 network is not overlapped with a number of Balkan and Mediterranean orchid taxa, which are only sparsely found in East Macedonia. Moreover, most of the orchid taxa that have been classified in the threat categories of the IUCN are distributed within the Natura 2000 network of East Macedonia, and specifically, some of the most threatened ones are almost exclusively distributed within that network. Consequently, although the Natura 2000 network is not congruent with the distribution of a number of species of southern origin, which are widely distributed elsewhere in Greece, it can conserve important floristic elements of Greece, which are orchid taxa of northern or central European origin.

Keywords: conservation; East Mediterranean; Orchidaceae; threatened species

Introduction

The human impact and activities over the past few decades have caused serious declines in organisms all around the world, and as a result, governments have signed environmental agreements to reverse these declines (Rogalla von Bieberstein et al. 2019). Globally, the Convention on Biological Diversity to which 196 countries are contracting parties, is one of the most important agreements, whose Aichi Biodiversity Targets referred to its Strategic Plan for Biodiversity 2011–2020 (Decision X/2) include the protection of 17% of the earth and 10% of the oceans (strategic goal C: target 11). Thus, all around the world, protected areas, such as national parks and nature reserves, constitute a key strategy for conserving biodiversity (Geldmann et al. 2019).

In Europe, the 27 member states of the European Union have established a network of protected areas called "Natura 2000 network" by applying two Directives; the Birds (Directive 79/409/EEC, which was amended by the Directive 2009/147/EC) and the Habitats (Directive 92/43/EEC) Directive (European Commission 2020). The Natura 2000 network in Europe covers more than 18% of the EU's land area and more than 8% of its marine territory, and it is considered the largest coordinated network of protected areas in the world. Conservation of plant species and/or habitats is subject to the Habitats Directive (Directive 92/43/EEC) through the establishment of a network of Special Areas of Conservation (SACs). In Greece, this network is composed of 241 sites (SACs), covering 21.27% of the terrestrial area of the country, which is among the highest among the European countries.

Although networks of protected areas are considered to be the most important measures that governments take to conserve biodiversity, the effectiveness of these networks is still uncertain in several cases (Watson et al. 2014; Joppa et al. 2016). Looking at the geographical location of the Special Areas of Conservation of the Natura 2000 network in Greece, one can identify that most of these have been established in high-altitude areas. This could be attributed to two different reasons: (a) the high species diversity of the mountainous areas in Greece, and (b) the rather low human activities in these areas compared to areas of lower altitudes, where natural habitats are more degraded. Based on this, it is unclear, whether SACs in Greece can adequately conserve populations of specific subsets or groups of plant species. For example, the Natura 2000 network in the Peloponnese was only partly congruent with a theoretical network of areas for the protection of the endemic flora of the Peloponnese (Trigas et al. 2012). However, this study is not the only one, where Natura 2000 network did not fully overlap with the distribution of all the target plant species. Similar results presented by Dimitrakopoulos et al. (2004), who worked with the plant species of Crete, and by Tsiftsis et al. (2009; 2011), who explored the effectiveness of the Natura 2000 network using the orchids of a subarea of East Macedonia and Crete, respectively.

The orchid family is characterized by a complex biology and an especially high speciation rate, but many orchid taxa are at the verge of extinction (Swarts and Dixon 2009). These characteristics make orchids an important group in biological conservation and because of the threats and danger that many orchids face they are protected in several countries (in Greece, as well) by
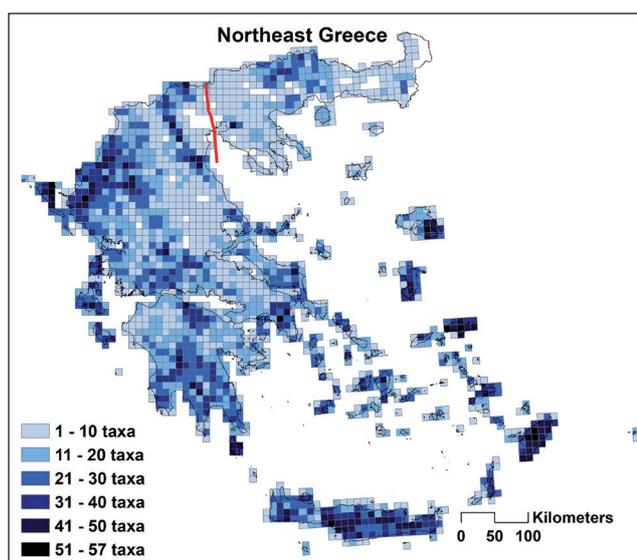
Fig. 1 Distribution of the orchid taxa of Greece (red line represents the limit among the northeast and northcentral floristic regions of Greece).

legislation. Under general legislation, many orchid taxa are protected by the Directive 92/43/EEC (21-5-1992), whereas the whole family of Orchidaceae is included in the three Appendices of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

Greece is especially rich in orchids (193 orchid taxa have been recorded so far) and one of the most orchid rich countries in Europe (Delforge 2006; Tsiftsis and Antonopoulos 2017). However, as in all plant families, orchids are not evenly distributed throughout Greece (Tsiftsis et al. 2019). As it can be seen in Fig. 1, northeast Greece is relatively poor in number of orchid taxa compared to the other areas of Greece. East Macedonia constitutes an exception to this general trend, as the

specific area hosts quite a large number of orchid taxa. Based on Tsiftsis et al. (2007), 62 orchid taxa were found in East Macedonia in 2007 and additional orchid taxa were recorded later (e.g. *Gymnadenia odoratissima*: Lafranchis and Sfikas 2009; *Pseudorchis albida*: Tsiftsis and Antonopoulos 2011). East Macedonia unique in Greece, because specific orchid taxa, some of which cannot be found elsewhere in the country, have been recorded in the high-altitude mountains. Under this perspective, the reassessment of the effectiveness of the Natura 2000 network in the area is desirable.

It is well-known that the effectiveness of a network of protected areas in conserving a set of target species is influenced (a) by the degree of representation of the target species within these areas, and (b) the management actions that will be focused on these species (González-Maya et al. 2015; Geldmann et al. 2019; Neugarten et al. 2020). Compared to the database used by Tsiftsis et al. (2009), the database of orchid records of East Macedonia was enriched by additional species distribution data obtained after 2009. Thus, the queries I tried to answer were:

a) How effectively is the Natura 2000 network conserving the orchid flora of East Macedonia in the light of the new data?

b) Which chorological categories of orchid taxa does the Natura 2000 network conserve?

c) What is the significance of the Natura 2000 network of East Macedonia in conserving rare and threatened orchid taxa of Greece?
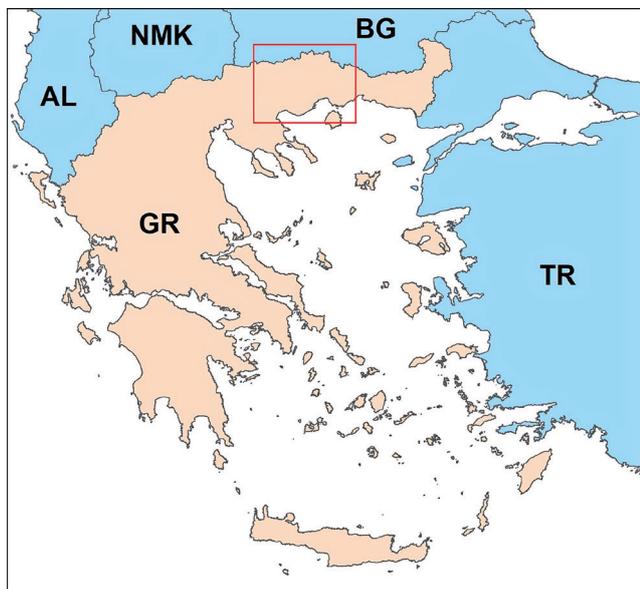
Material and Methods

The study area comprises the whole of East Macedonia (longitude 23°17′ to 24°54′ E, latitude 40°38′ to 41°34′ N)

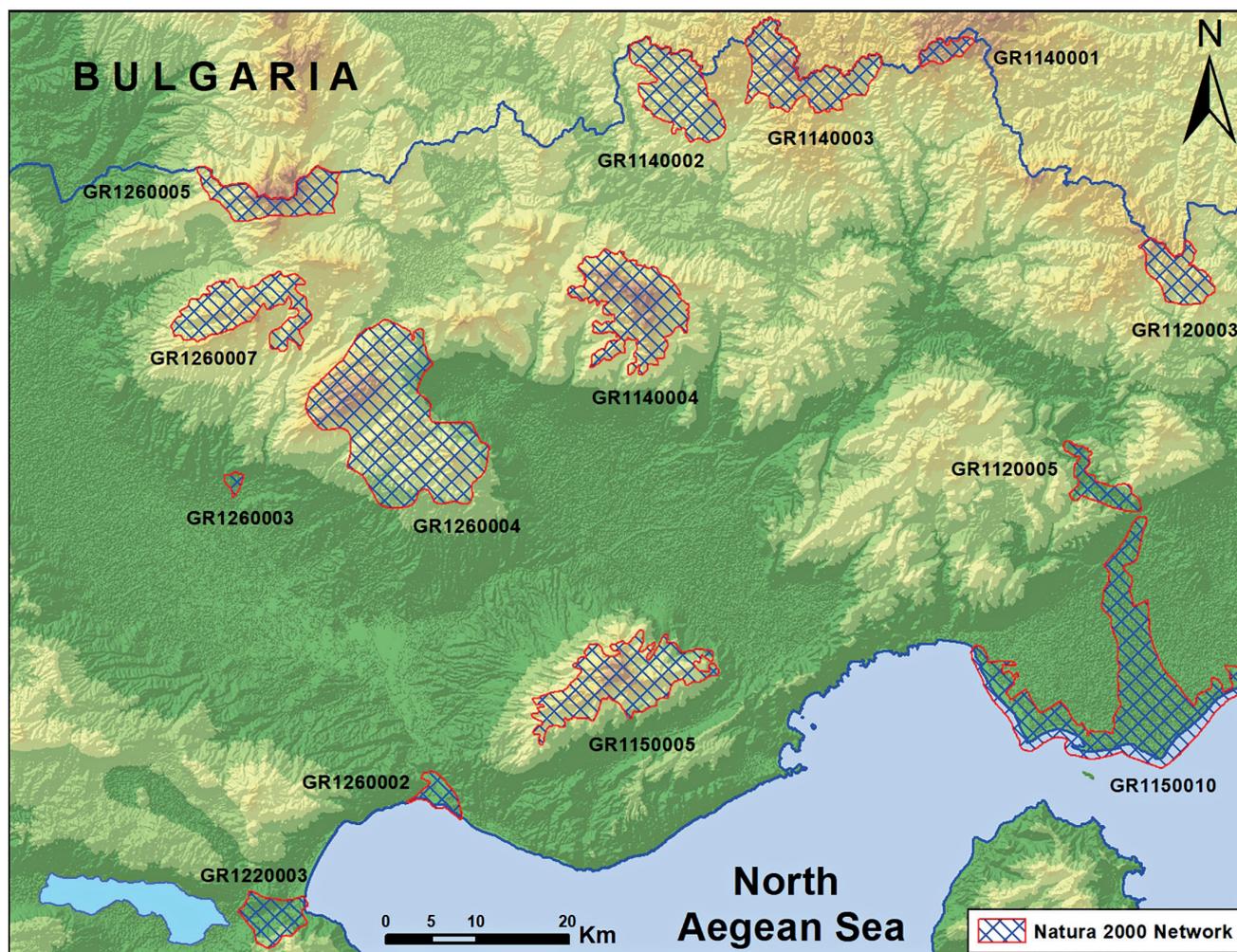**Table 1** Special Areas of Conservation in East Macedonia (NE Greece).

	Special Areas of Conservation	Area (ha)	Official name
1	GR1260002	1,297.10	Ekvoles Potamou Strymona
2	GR1120003	3,491.99	Oros Chaintou – Koula and Gyro Koryfes
3	GR1120005	2,335.87	Aisthitiko Dasos Nestou
4	GR1140001	1,090.05	Dasos Fraktou
5	GR1140002	6,715.45	Rodopi (Simyda)
6	GR1140003	7,447.10	Periochi Elatia, Pyramis Koutra
7	GR1140004	9,845.62	Koryfes Orous Falakro
8	GR1150005	10,345.47	Koryfes Orous Pangaio
9	GR1150010	22,484.64	Delta Nestou kai Limnothalasses Keramotis – Evryteri Periochi kai Paraktia Zoni
10	GR1220003	2,905.16	Stena Rentinas – Evryteri Periochi Spilaio Drakotrypa – Spilaio Lakkia kai Rema Neromana
11	GR1260003	327.29	Ai Giannis – Eptamyloi
12	GR1260004	23,288.69	Koryfes Orous Menoikion - Oros Kouskouras – Ypsoma
13	GR1260005	4,871.04	Koryfes Orous Orvilos
14	GR1260007	6,799.47	Ori Vrondous – Lailias – Epimikes – Spilaia Zesta Nera kai Katarrakton

(Fig. 2), including all the high mountains of North-East Greece (Mts Menikion, Orvilos, Falakron, Pangeon, Vrondous, Lekani, Simvolo, Kerdilion and Rodopi). The area comprises of fourteen Special Areas of Conservation (SAC) of the European Ecological Network Natu-

ra 2000 (Table 1). The network of these areas covers the summits and the high altitudinal zones of Mts Falakron, Pangeon, Menikion, Vrondous and Orvilos, four areas of Rodopi mountain range (Simyda, Elatia, Frakto, Koula), and a part of Nestos river (two SACs) (Fig. 2). Moreover, three other small-sized SACs include riparian areas in the lowlands (GR1260002, GR1260003 and GR1220003). The total area of these SACs is approximately 103,244.92 Ha (Dafis et al. 1996).

East Macedonia, as most parts of Greece, presents a high variability of vegetation types (from maquis-pseudomaquis to *Picea abies* forests and subalpine grasslands) and the geological substrates (e.g. limestones, granites, schists). The combinations of these factors, together with the human impact observed during the last few decades, creates a mosaic of different habitats, where many orchids can occur (Tsiftsis et al. 2007; Tsiftsis and Antonopoulos 2017). Another factor that has a positive effect on the number of orchid taxa is the geographical position of the study area. As a part of northern Greece, which shares some common mountainous ranges with Bulgaria (e.g. Rodopi mountain range, Mt. Orvilos), the area hosts orchids of northern origin, some of which are endemic here (e.g. *Neottia cordata*; Tsiftsis et al. 2019).

Fig. 2 Map of East Macedonia (NE Greece) (GR: Greece; AL: Albania, NMK: North Macedonia; BG: Bulgaria; TR: Turkey). The official names of the Special Areas of Conservation are presented in Table 1.

The distribution data used for the analyses were based on the database that was built for the purposes of the Orchid Flora of Greece project (Tsiftsis and Antonopoulos 2017), which is still being updated with new orchid records based on recent literature cites and unpublished data (records made up to now). The nomenclature of the orchid taxa follows Dimopoulos et al. (2013), Antonopoulos and Tsiftsis (2017) and Tsiftsis and Antonopoulos (2017). In total, distribution data (8,788 records) of 73 orchid taxa occurring or being reported for the study area were used. *Ophrys insectifera*, recorded by Zaganiaris (1940), was excluded from the total number of orchids in East Macedonia, because this very old record has not been confirmed recently and could not be georeferenced with sufficient accuracy. To assess the effectiveness of the Natura 2000 network in conserving all the orchid taxa of the study, a 1 × 1 km resolution Universal Transverse Mercator (UTM) grid was used in the analyses. Although the size of almost all grid cells was 1 km², the size of a number of cells was different. Specifically, the grid cells that were adjacent to the Greek-Bulgarian borders, those close to the sea shoreline and close to the borders between different UTM coordinate zones (34T and 35T zones in the UTM projection) were of slightly different size.

The geographical coordinates of all orchid records were transformed into the UTM projection and then a matrix "*species × grid cells*" was generated. Afterwards, the grid cells that were totally within the Natura 2000 network, or of which more than half was included into the network, were characterized as grid cells of the Natura 2000 network. Thus, the grid cells with orchid occurrences in East Macedonia were divided into two categories: the Natura 2000 grid cells and the non-Natura 2000 grid cells. Based on this, the effectiveness of Natura 2000 in conserving the orchid flora in East Macedonia was assessed. To compare the number of orchids of the 1 × 1 km grid cells inside and outside the Natura 2000 network, the Mann-Whitney U test was used.

To answer the second query, the chorological categories of the orchids of East Macedonia were adopted, as referred by Dimopoulos et al. (2013). For a few orchid taxa, not referred to by Dimopoulos et al. (2013), the chorological category was determined by taking into consideration their general distribution. The third query requires information about the threat categories of the Greek orchids, which were obtained from Tsiftsis and Tsiripidis (2016). One orchid taxon (*Epipactis helleborine* subsp. *distans*), not referred by Tsiftsis and Tsiripidis (2016), was evaluated at a regional scale using the IUCN Red List Criteria (IUCN 2012a) and the guidelines for application of IUCN Red List Criteria at a National Level (IUCN 2012b).

Results

Out of the 73 orchid taxa recorded in East Macedonia, 14 taxa are exclusively distributed outside of the Natura 2000 network. Orchid taxa absent within Natura 2000 network are mainly found in the southern and central part of Greece. Such orchids (e.g. *Neotinea lactea, N. maculata,* several *Ophrys* taxa, *Serapias cordigera* subsp. *cordigera, S. parviflora*) have been recorded in a large number of 1 × 1 km grid cells in Greece, but their distribution in East Macedonia is very restricted (Table 2). Apart from these, two species – *Epipactis pontica* and *Epipogium aphyllum* – although found in high altitude areas of Mt. Rodopi, were found in areas outside the Natura 2000 network. The Mann-Whitney U test has shown that the 1 × 1 km grid cells of the Natura 2000 network host more orchid taxa compared to the grid cells outside the Natura 2000 network (p < 0.05).

In total, the orchid taxa of East Macedonia are classified into 15 chorological categories (Fig. 3; Table 2). Most of them belong to the European-SW Asian (20.55%), Mediterranean (17.81%) and Balkan (15.07%) categories, followed by the Mediterranean-European taxa (12.33%).
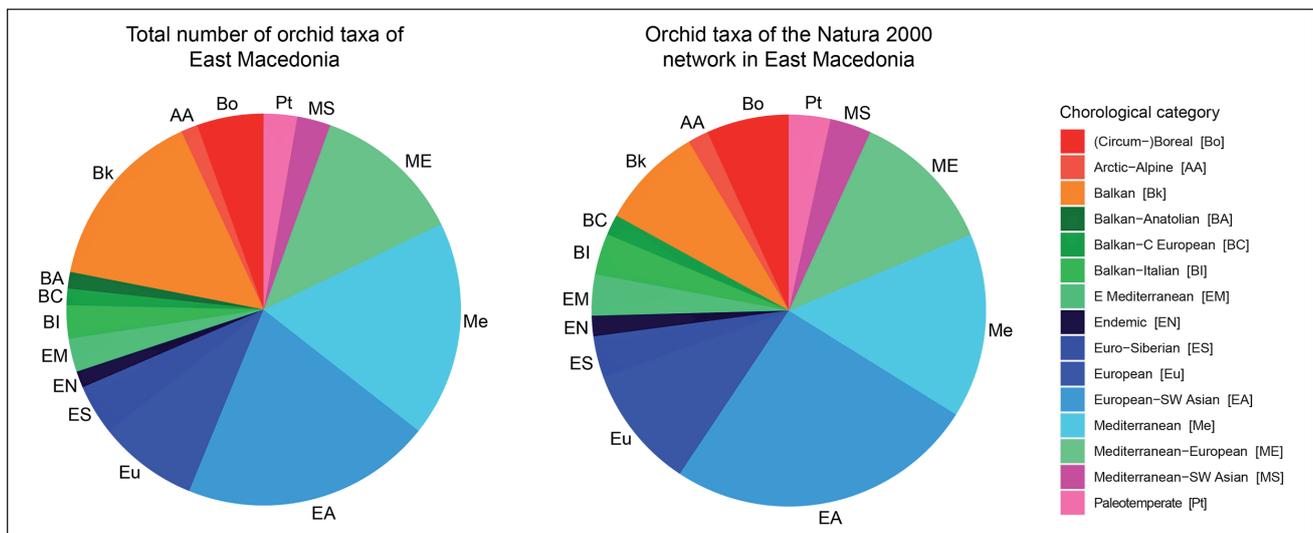
Fig. 3 Chorological spectrum of all orchid taxa recorded in East Macedonia (left graph) and of those recorded within the Natura 2000 network (right graph).

Table 2 Orchid taxa recorded in East Macedonia, their chorological category and the number of 1 × 1 km grid cells in which they have been recorded.

Taxon	Chorological category	IUCN category	Total number of 1 × 1 km grid cells	1 × 1 km grid cells within Natura 2000 network	Total number of 1 × 1 km grid cells in Greece
Anacamptis coriophora subsp. *coriophora*	EA		18	2	137
Anacamptis coriophora subsp. *fragrans*	Me		69	18	2,212
Anacamptis laxiflora subsp. *laxiflora*	Me		32	11	1,703
Anacamptis morio subsp. *caucasica*	MS		378	46	2,389
Anacamptis palustris subsp. *elegans*	BA	NT*	3	0	70
Anacamptis papilionacea subsp. *papilionacea*	MS		53	13	446
Anacamptis pyramidalis	Eu		253	41	4,121
Cephalanthera damasonium	ME		216	70	914
Cephalanthera longifolia	EA		202	47	1,033
Cephalanthera rubra	EA		214	66	1,130
Coeloglossum viride	Bo		43	35	80
Corallorhiza trifida	Bo		116	54	257
Dactylorhiza cordigera subsp. *cordigera*	Bk		44	22	122
Dactylorhiza incarnata	EA	EN*	8	4	13
Dactylorhiza macedonica	EN	VU*	17	8	40
Dactylorhiza romana	Me		21	4	448
Dactylorhiza saccifera	Me		41	21	862
Dactylorhiza sambucina	Eu		244	125	696
Epipactis atrorubens	EA		46	36	199
Epipactis helleborine subsp. *distans*	Eu	EN**	3	3	5
Epipactis helleborine subsp. *helleborine*	Pt		371	145	1,317
Epipactis leptochila subsp. *naousaensis*	BI	EN*	7	6	40
Epipactis leptochila subsp. *neglecta*	Eu	VU*	6	3	7
Epipactis microphylla	EA		54	21	506
Epipactis palustris	EA		15	7	179
Epipactis persica subsp. *exilis*	BI		109	19	297
Epipactis pontica	ME	NT*	8	0	12
Epipogium aphyllum	ES		5	0	48
Goodyera repens	Bo		61	38	65
Gymnadenia conopsea	EA		146	82	410
Gymnadenia frivaldii	Bk	NT*	5	2	22
Gymnadenia odoratissima	Eu	CR*	1	1	1
Gymnadenia rhellicani	AA	CR*	4	4	7
Himantoglossum jankae	BC		269	23	755
Limodorum abortivum	Me		146	18	1,708
Neotinea lactea	Me		1	0	931
Neotinea maculata	Me		2	0	1,467
Neotinea tridentata	Me		251	83	1,194
Neotinea ustulata	Eu		77	36	209
Neottia cordata	Bo	VU*	18	11	18
Neottia nidus-avis	EA		413	138	1,051
Neottia ovata	EA		90	13	487
Ophrys apifera	ME		27	3	798

Taxon	Chorological category	IUCN category	Total number of 1 × 1 km grid cells	1 × 1 km grid cells within Natura 2000 network	Total number of 1 × 1 km grid cells in Greece
Ophrys attica	Bk		1	0	556
Ophrys epirotica	Bk		12	0	442
Ophrys grammica	Bk		46	15	547
Ophrys hansreinhardii	Bk		2	1	43
Ophrys hebes	Bk		13	2	168
Ophrys helenae	Bk		1	0	518
Ophrys leucophthalma	Bk		1	0	71
Ophrys mammosa	ME		268	39	2,600
Ophrys oestrifera	ME		171	26	2,108
Ophrys reinhardiorum	Bk		1	0	34
Ophrys reinholdii	EM		8	4	475
Ophrys sicula	ME		1	0	5,502
Ophrys zeusii	Bk		11	0	125
Orchis italica	Me		70	9	2,770
Orchis mascula subsp. *mascula*	EA		155	72	976
Orchis militaris subsp. *militaris*	EA	VU*	10	9	13
Orchis pallens	ME		25	17	233
Orchis pauciflora	Me		11	4	660
Orchis provincialis	ME		7	4	836
Orchis purpurea subsp. *purpurea*	EA		122	20	474
Orchis quadripunctata	Me		59	29	2,002
Orchis simia subsp. *simia*	EA		53	13	616
Platanthera bifolia	Pt		24	6	145
Platanthera chlorantha subsp. *chlorantha*	ES		326	80	1,100
Pseudorchis albida	ES	CR*	1	1	1
Serapias bergonii	EM		13	1	3,515
Serapias cordigera subsp. *cordigera*	Me		2	0	212
Serapias parviflora	Me		1	0	1,056
Serapias vomeracea	ME		69	4	1,419
Spiranthes spiralis	EA		134	6	1,260

CR: critically endangered; EN: endangered; VU: vulnerable; NT: near threatened
* Evaluation according to Tsiftsis and Tsiripidis (2016); ** Evaluation based on recent distribution data and not by Tsiftsis and Tsiripidis (2016)

The categories with the smallest number of orchid taxa where the Balkan-Anatolian, Balkan-Central European, Arctic-Alpine and the Endemics, with one orchid taxon each. Similarly, in the total orchid flora of East Macedonia, the richest categories within the Natura 2000 network were the European-SW Asian taxa (25.42%), the Mediterranean taxa (15.25%) and the Mediterranean-European taxa (11.86%). On the contrary, 6 Balkan and 4 Mediterranean orchid taxa have not been recorded within the Natura 2000 network.

Out of the 37 Greek orchid taxa that have been classified in the threat categories (Critically Endangered, Endangered and Vulnerable) of the International Union for the Conservation of Nature (IUCN), nine occur in East Macedonia (Table 2), whereas 3 out of 11 orchid taxa were classified as Near Threatened. One more taxon (*Epipactis helleborine* subsp. *distans*), is classified as Endangered (criterion D).

The three critically endangered taxa (*Gymnadenia odoratissima, G. rhellicani, Pseudorchis albida*) are either exclusively distributed in the Natura 2000 network, or have their highest populations there (Table 2). Among the endangered species, *Dactylorhiza incarnata* and *Epipactis helleborine* subsp. *distans* are mainly found in East Macedonia, whereas *Epipactis leptochila* subsp. *naousaensis* has some viable populations in the Natura 2000 network. From the vulnerable orchid taxa recorded in East Macedonia, two (*Epipactis leptochila* subsp. *neglecta* and *Dactylorhiza macedonica*) can be found elsewhere in Greece. Out of the areas where they have been recorded in East

Macedonia, about one-half is within the Natura 2000 network. The other two orchids (*Neottia cordata* and *Orchis militaris* subsp. *militaris*) are almost exclusively distributed in East Macedonia with their larger distribution being within the Natura 2000 network of the area.

Another species category, whose species could not be classified in any of the three threat categories of the IUCN, is the category of the Near Threatened species. East Macedonia hosts three orchid taxa of this category (*Anacamptis palustris* subsp. *elegans, Epipactis pontica and Gymnadenia frivaldii*), from which only *G. frivaldii* is found within the Natura 2000 network (Table 2).

Discussion

As also stated in the introduction, the Natura 2000 network in Europe has been designed to ensure the long-term persistence of a large number of species (valuable and threatened) and habitats of European importance (European Commission 2020). Fourteen Special Areas of Conservation (SACs) of the Natura 2000 network have been established in East Macedonia (Table 1), aiming at the protection of the local flora and habitats (Dafis et al. 1996). Here I show that the Natura 2000 network fails to protect the total orchid flora in the area, because the distribution of 14 orchid taxa is not overlapping with any of the Special Areas of Conservation established in East Macedonia, similarly to Tsiftsis et al. (2009), whose results were based on fewer data, corresponding to a more restricted area. However, East Macedonia is not the only exception in this respect. Dimitrakopoulos et al. (2004), Tsiftsis et al. (2011) and Trigas et al. (2012) show that the spatial overlap of the Natura 2000 network with the important areas for the endemic species of the Peloponnese, the orchids of Crete and the plant biodiversity of Crete, respectively, was low in all cases.

Most orchid taxa that are not found within the Natura 2000 network in East Macedonia belong to the chorological category of the Balkan species, followed by the Mediterranean species. These Balkan species belong to the genus *Ophrys* and are mainly distributed in central and northwestern Greece (Antonopoulos and Tsiftsis 2017; Tsiftsis and Antonopoulos 2017), whereas Mediterranean species belong to the genera *Serapias* and *Neotinea*, with a wider distribution both in Greece and Europe (Delforge 2006; Kretzschmar et al. 2007). The most important part of the Natura 2000 network in East Macedonia exists in the high mountainous areas, characterized by cold climatic conditions and analogous to such climate vegetation. Orchid taxa preferring milder climatic conditions, such as several Balkan and Mediterranean species, cannot therefore be found in the high-altitude areas of East Macedonia. Species of these genera are disturbance-tolerant, widely distributed in open habitats at low or medium altitudes, where human activities are rather intense (Dafni 1987; Tsiftsis et al. 2019). Although

such areas are not included in the Natura 2000 network, strict protection of the habitats where these orchid taxa occur might cause a reduction to their populations as the result of the natural vegetation succession.

Contrary to the orchid taxa mentioned above, *Epipactis pontica* is a Mediterranean-European taxon, whose most populations, and among them the largest ones in size, are distributed in East Macedonia. However, the sites where it has been recorded so far are not overlapping with the Natura 2000 network. This species is categorized as Near Threatened according to the classification of the IUCN, with the possibility to become Vulnerable or even Threatened under improper management (Tsiftsis and Tsiripidis 2016).

Anacamptis palustris subsp. *elegans* is another taxon, whose distribution in East Macedonia is not overlapping with the Natura 2000 network. It was recorded in several sites all around Greece (70 grid cells; Table 2), mostly in low or medium altitudes. A number of these sites has been severely degraded and its total populations greatly reduced during the last two decades.

A great advantage of the Natura 2000 network in East Macedonia is that the Special Areas of Conservation established here strongly overlap with the distribution of the IUCN red listed orchid taxa. Such orchids usually reach their southernmost distribution limits in northern Greece (e.g. *Gymnadenia odoratissima, G. rhellicani, Neottia cordata, Pseudorchis albida*) and their distribution is mainly driven by climate. Thus, these orchid taxa are sensitive to increasing temperatures and might be influenced by climate change (Kolanowska and Jakubska-Busse 2020).

Except of the high overlap between the distribution of the IUCN red listed orchids and the Natura 2000 network in East Macedonia, the higher number of orchid taxa per grid cell in the network compared to the grid cells outside it, is another advantage. The natural conditions of the Natura 2000 network create suitable circumstances for the existence of most orchid taxa. This confirms the design and the establishment of the Special Areas of Conservation in East Macedonia as this network offer, under suitable management actions, multiple possibilities for the future survival of such an important group of plant species.

Conclusions

Natura 2000 network established in East Macedonia hosts a significant number of orchids (59 out of the 73 orchid taxa). Among them, the distribution of almost all orchids of central and northern European origin (e.g. *Coeloglossum viride, Dactylorhiza incarnata, Goodyera repens, Gymnadenia rhellicani, Neottia cordata, Orchis militaris* subsp. *militaris*) and the distribution of those that have been classified in the threat categories of the IUCN is highly overlapped with the Special

Areas of Conservation in East Macedonia. Although this demonstrates the significance of the Natura 2000 network in conserving the orchid taxa in East Macedonia, I have used only a small area of Greece. A similar study should be conducted for the whole of Greece.

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