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Abstract

Education is an important component to achieve biodiversity conservation. Given the need to increase environmental awareness and literacy towards more effective biodiversity conservation and more participatory management of protected areas, this paper aims to investigate the level of knowledge and perceptions of Biology students in Greece on Natura 2000 protected areas. The research was conducted using a standardized questionnaire, administered to 434 students from five biology departments. The students' knowledge score was notably low and the department of their study did not differentiate the level of knowledge. In contrast, students in more advanced academic years or interested in Ecology, Zoology or Botany demonstrated a higher knowledge score than participants interested in other scientific disciplines. The majority of the students agreed with the establishment of a protected area in their place of residence. In terms of Natura 2000 management, NGOs, independent authorities and governmental organizations were more favored to the private sector. Regarding Natura 2000 site financing, the payment of users in specific areas and the purchase of local products are preferred. To integrate biodiversity conservation concepts in ecology study programmes and textbooks, the participation of experts from multiple scientific fields and the integration of a diverse array of teaching methods and tools are imperative.

Keywords: higher education; environmental literacy; Natura 2000; SDG14: Life Below Water; SDG15: Life on Land.

Introduction

The current global biodiversity crisis is widely recognized. According to the Red List of Threatened Species published by the International Union for Conservation of Nature (IUCN, https://www.iucnredlist.org/), more than 45,000 species are facing extinction, accounting for 29% of 157,000 assessed species. At the same time, according to the Global Assessment report, compiled by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), one million animal and plant species are calculated to be threatened with extinction (IPBES, 2019). To tackle this issue, biodiversity conservation is included in the legislation of national and global policy conventions and commitments. For instance, in May 2020, the European Union launched the Biodiversity Strategy for 2030, which constitutes a comprehensive, ambitious and long-term plan to protect nature, and reverse the degradation of ecosystems, by emphasizing the importance of protected areas (European Commission, 2020). The strategy aims to put Europe's biodiversity on a path to recovery by 2030, and contains specific actions and commitments. Among them, the formation of a coherent network of protected areas, covering at least 30% of land and sea, is a goal of paramount importance. Towards the same direction, the most notable global commitment to safeguard biodiversity is the Post-2020 Convention on Biological Diversity (CBD) and the Kunming-Montreal Global Biodiversity Framework (GBF) committing nations to halt and reverse nature loss by 2030 (UN, 2022). This framework also supports the achievement of the 2030 Agenda Sustainable Development Goals (SDGs), including Life Below Water (SDG14) and Life on Land (SDG15), and builds on the UN Convention's on Biological Diversity previous Strategic Plans. It sets out an ambitious pathway to reach the global vision of a world living in harmony with nature by 2050 (UN, 2015).

While the Biodiversity Strategy 2030 may set out new ways to implement existing legislation more effectively, biodiversity protection in Europe has been adopted more than thirty years earlier, through the Habitats Directive

92/43/EEC (HD; Council Directive, EEC, 1992) and the Birds Directive 2009/147/EC (BD; Council Directive, EEC, 2009). The two directives form the backbone of the EU's biodiversity policy, providing a strong legislative framework to preserve and restore Europe's most valuable and threatened biodiversity, by coordinating conservation efforts for more than 2000 species and 230 habitats across the EU Member States. The two directives form the Natura 2000 network, a system of managed natural areas to protect Europe's most valuable and threatened species and habitats. It is now the largest coordinated network of protected areas in the world, with more than 27,000 protected areas, covering almost one fifth of the EU's land area, across the 28 Member States, i.e., 18.6% of land and 9% of its marine territory (European Environment Agency, 2020). Greece boasts one of the most extensive Natura 2000 networks in the European Union, since 27.3% of its terrestrial area is designated as protected areas, a percentage above the EU value of 26.4%, so achieving the Aichi Biodiversity Target 11 (Spiliopoulou *et al*., 2021). In Greece, 614 species of animals (among which, 318 birds) and plants are listed in the annexes of the Habitats and Birds Directives.

Despite a range of policies, regulations and directives at global, regional, and national levels, aiming at reverting biodiversity loss, biodiversity loss is, in fact, rampant (European Environment Agency, 2020), while the Natura 2000 network can be further improved in order to protect and preserve biodiversity effectively (Spiliopoulou *et al*., 2023). The notable El Teide Declaration (European Commission, 2002) recognized that "the success of Natura 2000 will require the support of European citizens, especially of local people and landowners, and their participation in the decisions on the implementation of the conservation and management of the areas involved", and committed the signatory EU member states to "Promote awareness and understanding of Natura 2000. Moreover, over the past three decades, the scientific community has recognized that education is an important component for achieving biodiversity conservation. According to Arnon *et al*. (2014), higher education institutions play a key role and have a moral responsibility in cultivating the environmental literacy (EL) of their students, by instilling knowledge, values and attitudes towards sustainability. For example, undergraduates following courses in the fields of ecosystem management and biodiversity conservation will have a greater tendency towards pro-environmental behaviors and practices as adults (Kempton *et al*., 1995; Schmidt & Blumentritt, 2007). Indeed, higher education has been highlighted as one of the key pillars towards environmental protection (Lemons, 1995; Roth, 1992), and higher education institutions are important actors in achieving the Sustainable Development Goals (SDGs) and the 2030 Agenda, by contributing to societal transformation and transition to an environmentally protected world. A low awareness rate may lead to low public participation, with only a small segment of the population being capable of participating in environmental protection actions.

In spite of universities being important for the genera-tion of knowledge and implementation of SDGs, aligned with the 2030 Agenda, there is still a need to document whether universities provide an effective source of expertise in research and education on Natura 2000 protected areas towards the achievement of SDGs 14 and 15, since these particular SDGs recognize the importance of protected areas regarding biodiversity conservation and sustainable development. In addition, capturing students' perceptions is crucial in order to fully understand their level of support for protected areas (Bennett *et al*., 2019), and propose actions on how these areas can be designated depending on their social acceptability; this is referred to as a 'social license' (Vanclay, 2017). Up to today, most studies on environmental literacy mainly focus on secondary education students (Nastoulas *et al*., 2017) or teachers (Gavrilakis *et al*., 2017). Little attention is paid to tertiary education (Kyriazi & Mavrikaki, 2013), and specifically to biology students. This paper represents the first comprehensive study that has been conducted in Greece, regarding the level of awareness and perceptions of students of Biology Departments concerning the Natura 2000 network protected areas. In addition, as students' interest seems to affect environmental literacy (Ozgurler & Cansaran, 2014), we seek to analyze whether there are any significant differences in knowledge and perceptions about Natura 2000 protected areas between students with different research interests, years and departments of study, since these grouping variables could constitute significant factors of differentiation.

Materials and Methods

We adopted a quantitative approach as more appropriate in order to identify differences between groups.

Research Instrument

A questionnaire was developed, which was divided into three sections and designed to gather information about students': (a) demographic data (specific biology department, academic year of study and scientific interests), (b) knowledge of Natura 2000 protected areas (3 items), and (c) perceptions on the management of Natura 2000 protected areas (3 items).

In section (b), the section of the questionnaire about knowledge, for each correct answer, participants receive one point, and the sum of these points constitutes the knowledge score. Additionally, to explore students' perceptions, the participants were asked whether they agree/disagree with the establishment of a new Natura 2000 protected area in their place of residence. The measurement was realized on a 5-point Likert scale. Moreover, the participants were asked to declare whether they agree that each of five different actors (state, independent authority supervised by the state, experienced NGOs, al authorities, private actors) should be responsible for management activities in the protected area. In the same part of the questionnaire, alternative means of financing were

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presented and students' perceptions were measured on a 5-point scale, where higher scores represented higher levels of agreement. The options of financing were: i. the implementation of a user's fee, ii. payment from users in specific areas and the purchase of local products, iii. the introduction of an environmental tax and iv. payment from the annual budget of the local authorities.

Sample

In Greece, the duration of studies is four years in four Biology Departments[1] in the following Higher Education Institutions: Aristotle University of Thessaloniki (AUTH), National and Kapodistrian University of Athens (NKUA), the University of Crete and the University of Patras. A fifth Department also exists in the University of Ioannina (UOI)[2], with a more applied approach to Biological Sciences and a five-years' program of studies. A sample of N=434 students was selected by random sampling from these five institutions, and completed the questionnaires under the supervision of their professor during the spring semester of 2022. Although we were not able to estimate the response rate to the questionnaire, professors indicated that it was high, since students were willing to answer them.

Data analysis

Questionnaire data were analyzed using IBM SPSS (version 29) and R programming language (version 4.2.1). Non-parametric tests (Kruskal–Wallis H test) were applied as normality of our data was not established. Cross-tabulation was used to display the breakdown of the data and the results of crosstabs were tested with Pearson chi-square.

A p-value of less than or equal to 0.05 significance level indicates a statistically significant result.

Results

Demographic data

More than half of our sample study at NKUA, while the other four institutions are almost equally represented (Fig. 1A). The majority of respondents are first-year students and constitute almost 50% of the sample (Fig. 1B). Regarding the scientific interest of the participants, the largest percentage (58%) selected the field of "Molecular/Cell biology or Genetics or Biochemistry", followed by those who are interested in the field of "Ecology or Zoology or Botany" (31%). Only a small percentage (3%) reported that they were interested in the field of "Didactics" (Fig. 1C).

Greek biology students' knowledge about the Natura 2000 network

Only 33.0% of our sample are aware of the Natura 2000 network of protected areas, with one out of five of the participants never having heard of the Natura 2000 network (Fig. 2A). Regarding the proportion of land area and marine territory of Greece covered by Natura 2000 network, the majority of the respondents (49%) did not know the answer, and only one out of four participants correctly responded that the coverage percentage is "20-50%" (Fig. 2B). Finally, almost half of the participants (45%) do not know what comprises the Natura 2000 network (Fig. 2C).
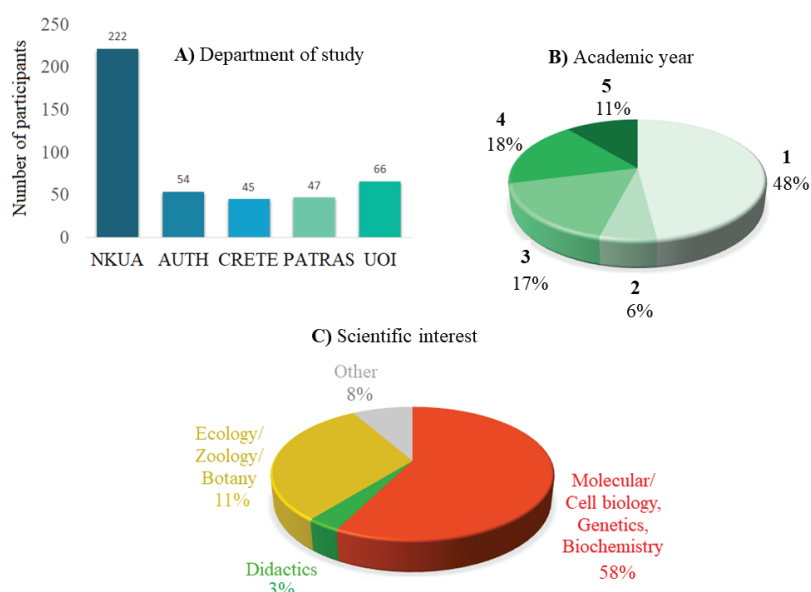

Fig. 1: Demographic data of the participants (department of study, academic year and scientific interest).

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1 The Department of Molecular Biology and Genetics in the Democritus University of Thrace was not considered in this study, due to its narrow biological focus.
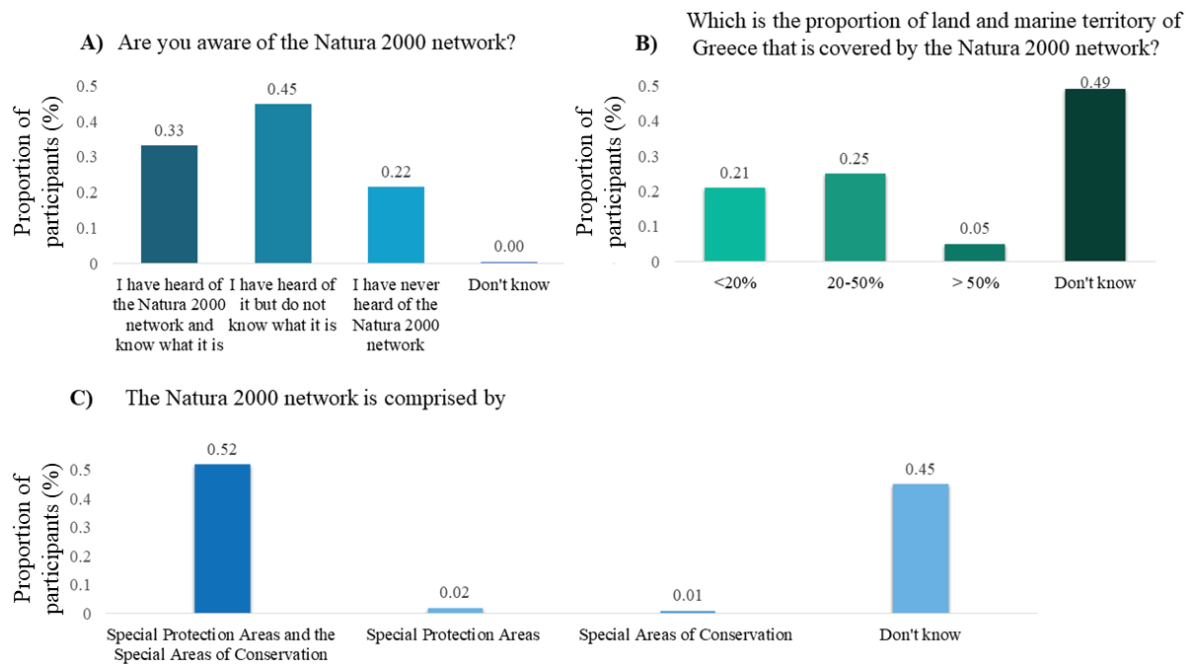2 Department of Biological Applications and Technology.

Fig. 2: Greek biology students' knowledge on the Natura 2000 protected areas.

Greek biology students' perceptions about Natura 2000

A great majority (88%) of the respondents are positive about the establishment of a new Natura 2000 protected area in their place of residence (Fig. 3A). NGOs, an independent authority supervised by the state, governmental management and governmental actors were the most accepted scenarios as regards the management of these areas, while the lowest percentages of positive responses were reported for private actors and local authorities (Fig. 3B). The least accepted means of financing were the enforcement of an environmental tax and the implementation of a user's fee, while the largest percentage of positive responses are related to payment from users in

specific locations of the protected area, combined with the possibility to purchase local products, and funding by local authorities (Fig. 3C).

Relationship between demographic variables, level of knowledge and perceptions

Students' responses varied considerably with reference to their scientific interest (Kruskal-Wallis $\chi^2 = 45.275$, df = 3, p< .05) (Fig. 4), with participants having a scientific interest in Ecology or Zoology or Botany, showing higher score values than the rest of the sample. In more detail, as far as the first question on the awareness of the Natura
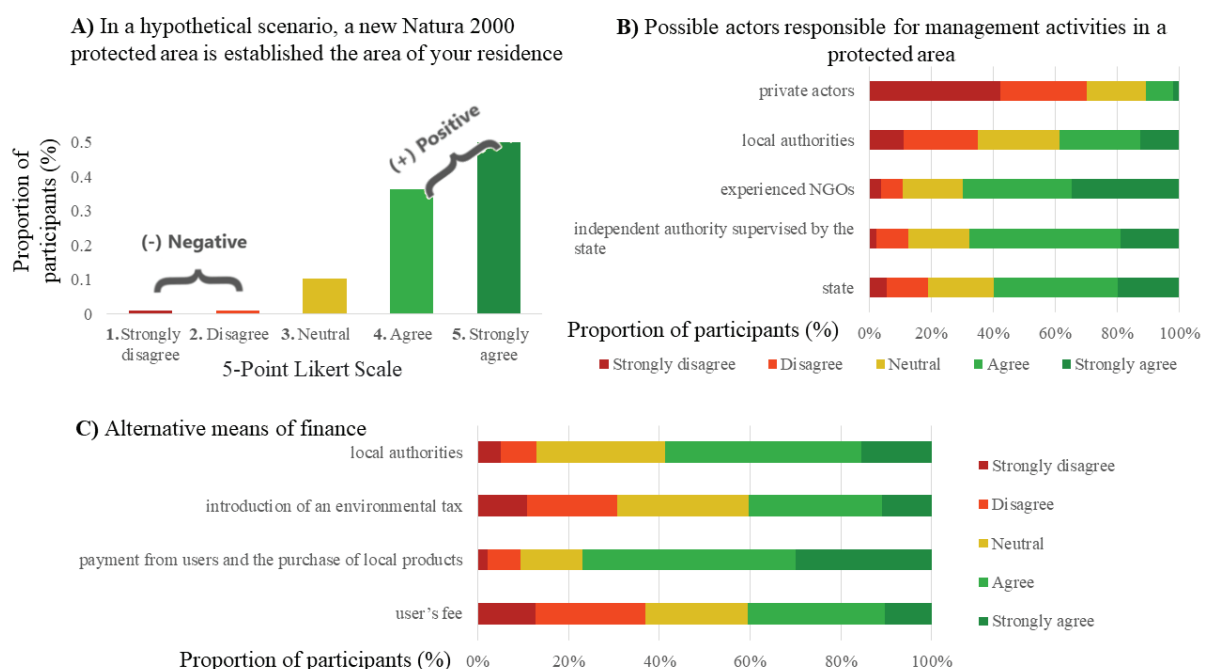

Fig. 3: Greek biology students' perceptions about Natura 2000.

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2000 network is concerned, the students' responses varied considerably ($\chi^2 = 113.849$, p<.05). Participants with an interest in the field of Ecology or Zoology or Botany showed higher knowledge about Natura 2000 (65.5%), when compared to all the other groups of participants (Table S1).

Responses demonstrated considerable variation as to the proportion of land area and marine territory of Greece covered by a Natura 2000 network ($\chi^2 = 24.939$, p<.05). Those respondents interested in Ecology or Zoology or Botany, answered correctly and formed the highest percentage (33.1%) (Table S2). Regarding what comprises the Natura 2000 network, most participants interested in Ecology or Zoology or Botany answered correctly (69.8%) (Table S3).

The participants' views on the establishment of a protected area were diversified, based on their scientific interest. While 88% of the respondents "strongly agree" and "probably agree" with the establishment of a protected area, almost one out of two participants of those who are interested in "Didactics" (45.5%), selected that they remain neutral ($\chi^2 = 34.958$, p<.05) (Table S4). It should be noted here that the perceptions on Natura 2000 management and means of financing were not differentiated in relation to students' scientific interest.

The academic year of study is one of the most important factors affecting both the knowledge score and the perceptions of the participants. 4th year students scored higher, compared to those of the 1st and 5th years (Fig. 5) (Kruskal-Wallis $\chi^2 = 38.965$, df = 4, p< .05). In more detail, most participants studying in the 4th year selected "I've heard of it and I know what it is" (77.5%), while almost one-third of the students from the 1st and 2nd year have never heard of the term Natura 2000 network ($\chi^2 = 119.355$, p<.05) (Table S5). In the question that raised the issue of the coverage percentage of the Natura 2000 network in Greece, the participants of the 4th year responded correctly, representing one of the highest percentages (37.5%) ($\chi^2 = 31.711$, p<.05). In all other cases, most participants selected the "Don't know" option (Table S6). Regarding the third question, about which types of areas comprise the Natura 2000 network, most participants from the 2nd, 3rd, 4th and 5th academic years answered correctly, although the highest percentage was observed for students being in their 4th year of study (67.5%) ($\chi^2 = 22.117$, p<.05). The majority of 1st year respondents selected the "Don't know" option (Table S7).

One out of five participants (19.1%) from the 5th academic year were neutral to the establishment of a new protected area of the Natura 2000 network in their place of residence ($\chi^2=30.716$, p<0.05) (Table S8). Views on Natura 2000 management remained consistent in relation to the participants' academic year, whereas participants' perceptions varied in terms of "Payment from users & purchase of local products" ($\chi^2 = 26.608$, p<.05). Students being in their 4th and 5th academic years of study showed the lowest percentages of agreement (Table S9).

Finally, the students' responses varied as per the department of study, although the statistical significance was marginal (Kruskal Wallis $\chi^2 = 9.96$, df = 4, p<.05) (Fig. 6). The only statistically significant difference was observed in the indicator about the awareness of the Natura 2000 network ($\chi^2= 22.880$, p<.05), with most participants from the University of Crete, NKUA and AUTH reporting that "I've heard of it but I don't know what it is". Most participants who "have heard of it and know what it is" study either at the University of Ioannina (48.5%) or the University of Patras (44.7%) (Table S10). Ultimately, no significant differences in students' perceptions were found in connection with participants' department of study.
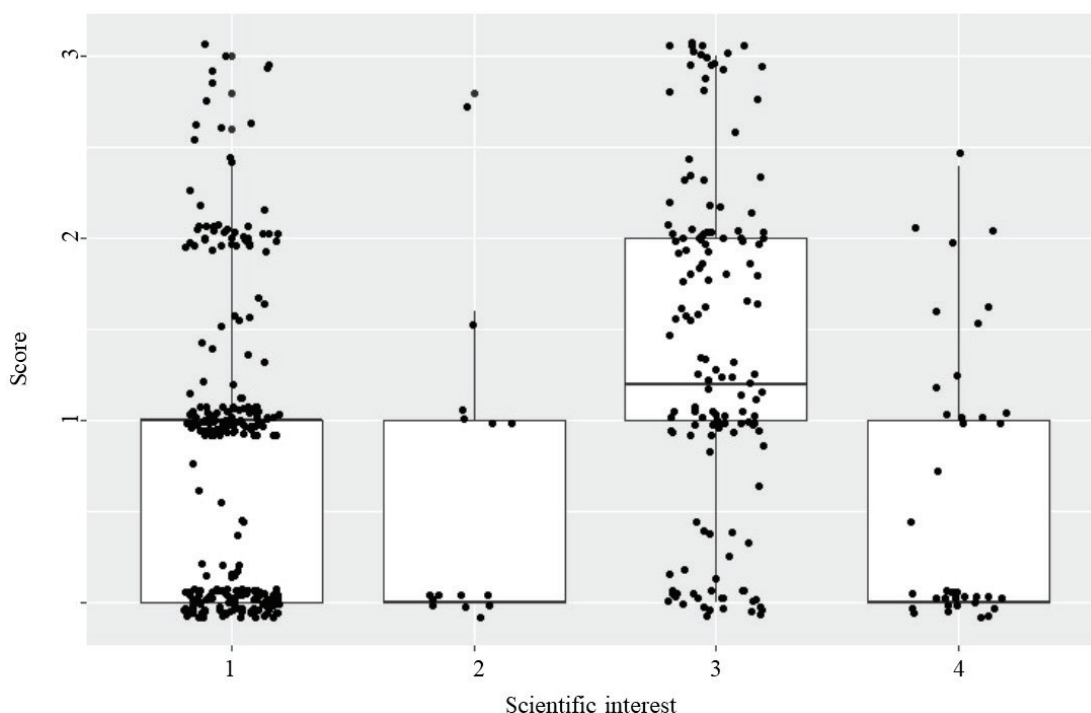

Fig. 4: Boxplots of scientific interest and participants' knowledge about Natura 2000 [1. Molecular/Cell biology or Genetics or Biochemistry 2. Didactics 3. Ecology or Zoology or Botany 4. Other].
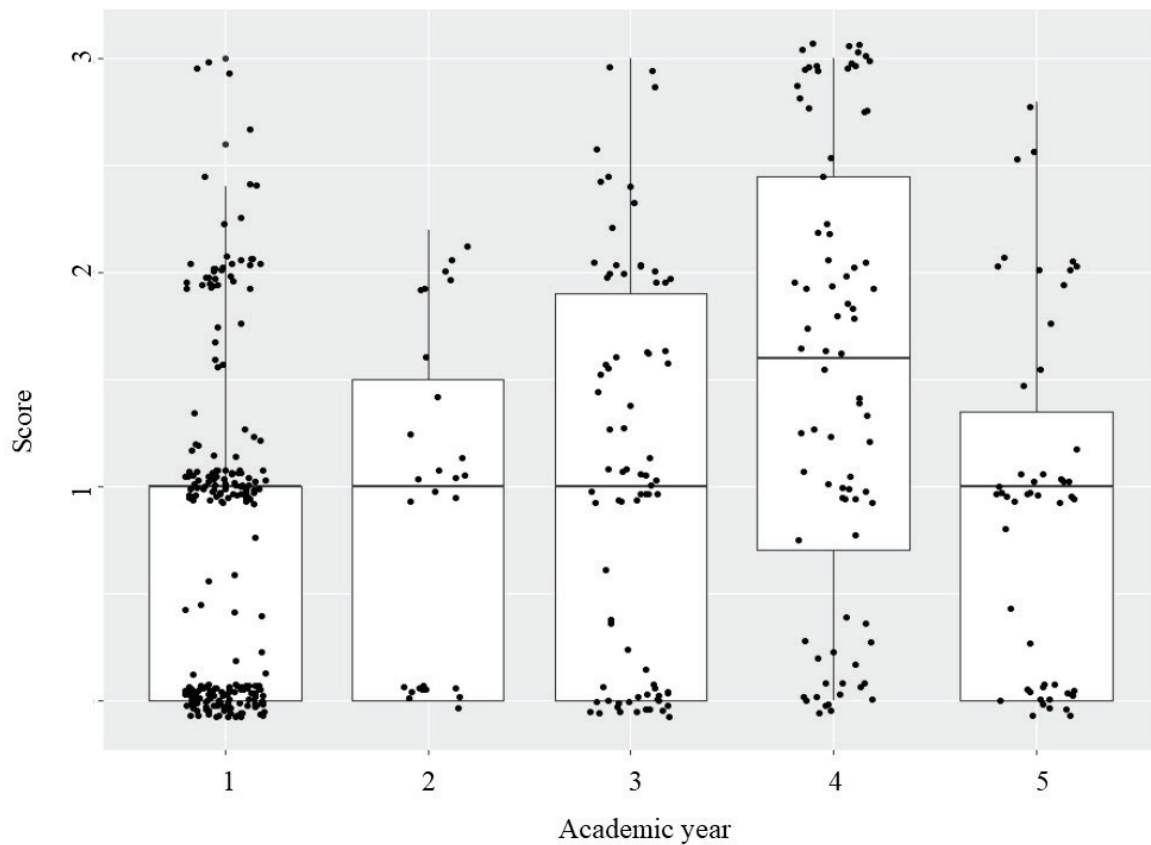
Fig. 5: Boxplots of participants' academic year of study and the knowledge score.
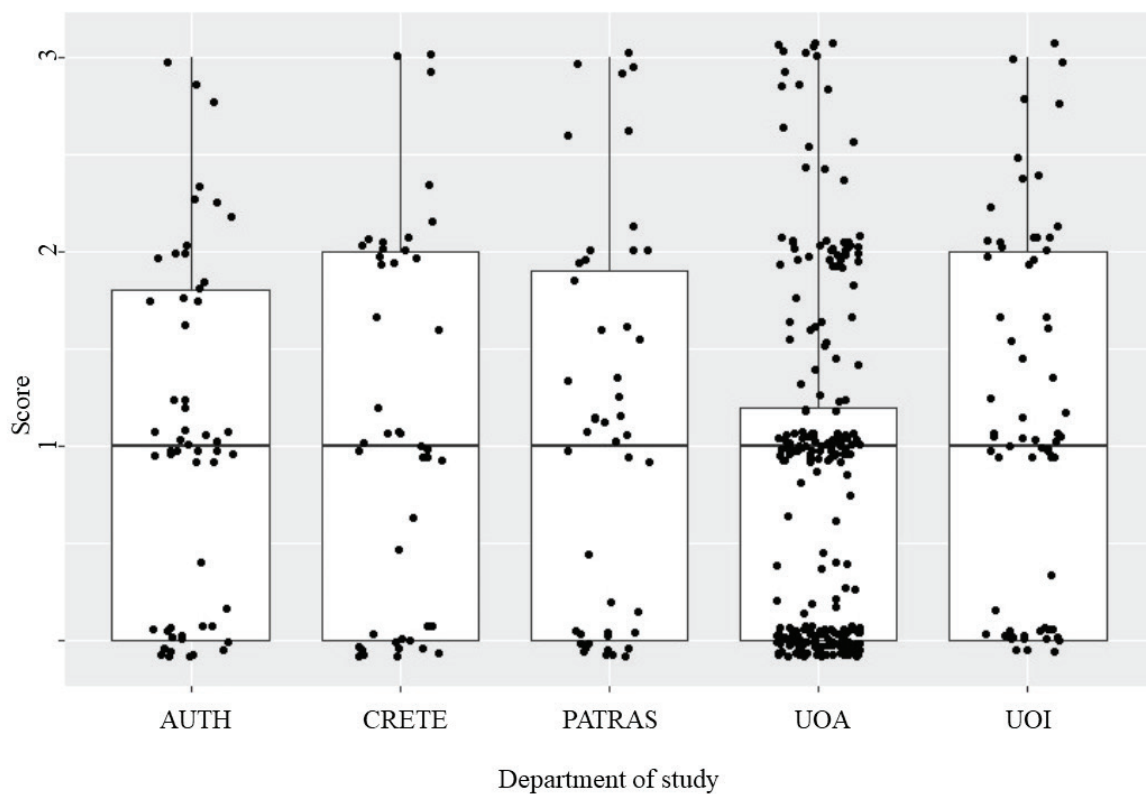

Fig. 6: Boxplots of participants' department of study and the knowledge score.

Discussion

Level of knowledge about Natura 2000

The level of knowledge and understanding of core conservation concepts of the Natura 2000 network protected areas, as depicted by students' score, was rather low and disappointing. This comes as no surprise (see also Kokkoris *et al.*, 2023). Previous studies have shown that European citizens are not cognizant of such an extensive network of sites, although awareness is rising on the environmental policy agenda (Nisiforou & Charalambides, 2012; Troumbis 2021). Indeed, 32 years after the launch of the Natura 2000 network, only one out of three biology students in our sample has heard of its existence and understands its meaning. Moreover, one out of five participants in this study "has never heard of the Natura 2000 network", a lower percentage compared to the national level, where 38% of our fellow citizens have never heard of the Natura 2000 network (European Union Commission, 2018). However, opposite patterns were observed in the study by Dimitrakopoulos *et al.* (2010), where a high percentage of the 390 adult residents of three wetlands-Natura 2000 sites in Greece, reported that they were aware of the presence of protected areas (71.3%). This result may be linked to the fact that most of those interviewed were in direct contact with nature, reporting living in close geographical proximity with Natura 2000 areas as locations of particular physical, environmental and natural significance. Generally, students' knowledge of the Natura 2000 network of protected areas is incomplete, a fact that is also demonstrated by the low level of knowledge reported herein.

The results observed in the current study agree with results from repeated surveys carried out by the Eurobarometer over the last 17 years (measurements from the years 2007, 2010, 2013, 2015, 2018), and which recorded an astonishingly persistent lack of awareness of the Natura 2000 network at the European level (Kokkoris *et al.*, 2023). It is important to mention here that Greece shows one of the lowest percentages of awareness among 27 Member States. Indeed, European citizens document a continued lack of awareness of the Natura 2000 network, with the percentage of Europeans who "have never heard of the Natura 2000 network" falling from just 80% in 2007 to 70% after twelve years of awareness-raising efforts (Kokkoris *et al.*, 2023).

Perceptions

The majority of the respondents strongly agree with the establishment of a protected area in their area of residence. Among the five different actors that Greek biology students prefer to be responsible for the management of activities in the Natura 2000 protected areas, the ones favored were experienced NGOs, independent authorities supervised by the state and governmental organizations, whereas private actors and local authorities were the least popular. These results are probably due to the relatively recent presence of various NGOs in Greece, and their close involvement and effectiveness in a range of activities related to environmental protection. Similar views were reported in the study by Papageorgiou & Kassioumis (2005), where visitors in a Greek protected area supported a shift from governmental management to more indirect governmental involvement. This outcome can be attributed to the fact that the management of protected areas in Greece was governmental in the period before the establishment of the Greek Natural Environment and Climate Change Agency, with past management frameworks often proving ineffective. The results of the present study contradict the results observed in Kalloni wetland, where management by local authorities has been reported as the most favorable scenario for the supervision and control of the protected area (Dimitrakopoulos *et al.*, 2010). However, a possible explanation for this preference could be the desire to avoid the imposition of regulations by the central government, as local management is considered more effective and provides the basis for promoting participatory management (Clifton, 2003).

The results regarding the means of financing of a Natura 2000 area showed that the majority of the participants agreed with receiving a payment from visitors in specific areas and the purchase of local products, together with the funding from the annual budget of the local authorities. Most of the participants disagreed with the implementation of a user's fee or the introduction of an environmental tax by the government. Similar patterns were observed in the study by Dimitrakopoulos *et al.* (2010), in which the least accepted means of financing is the enforcement of an environmental tax, whereas the most accepted scenario is payment from users in specific areas, combined with the possibility to purchase local products. More generally, there is a tendency of participants to support the self-sufficiency of protected areas, through the development of ecotourism activities and tax relief (Pipinos & Fokiali, 2009).

Scientific interest, academic year and department of study

Participants' scientific interest was a strong differentiating factor in knowledge levels, but not in their perceptions on management and means of financing. Students interested in Ecology, Zoology or Botany performed higher scores compared to those of all other scientific fields, an outcome in accordance with previous studies (for example, see also Arnon *et al.*, 2014; Cebrián-Piqueras *et al.*, 2020; Lloyd-Strovas *et al.*, 2018; Sigit *et al.*, 2019), where students' knowledge varied according to their study programme. For instance, Loprinzo (2009) found that students under an environmental oriented curriculum in the USA showed greater environmental awareness. However, the perceptions of participants on Natura 2000 management and means of financing were not differentiated in relation to students' scientific interest, contrary to the pattern that was reported for other Greek students, where the majority of them, studying in the broader field

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of ecology, showed high levels of knowledge but also a more environmentally-conscious attitude towards protected areas (Evangelinos *et al*., 2009; Efthimiou *et al*., 2017). In any case, given that many biologists in Greece take only one course in Ecology during their undergraduate studies, one should consider that the concepts of management and conservation are likely not to be covered in depth (Lewinsohn *et al*., 2015).

On the contrary, the academic year of study seems to differentiate both the level of knowledge and the perceptions of the participants, an outcome that is in accordance with previous studies (for example, see Kaplowitz & Levine, 2005; Nisiforou & Charalambides, 2012; Lloyd-Strovas *et al*., 2018). Students in their final academic years tended to have higher levels of knowledge, with the exception of the participants of the 5th year, who demonstrated lower knowledge scores, compared to those of the 4th year. This observation may probably be attributed to the under-representation of participants in their 5th year of studies in the sample, and we acknowledge this limitation. It is not easy to determine whether this is related to courses of management and conservation that students follow, or if it is the result of exposure to environmental information (e.g., media, social media, seminars), although, according to the Eurobarometer (European Commission, 2018), higher knowledge levels were recorded among respondents over 20 years of age. The views of Natura 2000 management did not vary in relation to the participants' academic year, whereas participants' perceptions varied in terms of "payment from users & purchase of local products", with students from final academic years showing the lowest percentages of agreement.

Finally, no statistically significant differences were observed regarding the departments of study, with the exception of the question on awareness of Natura 2000 protected areas, in which the statistical significance was marginal. At this point, we should stress out an innate limitation of our study, due to the quantitative methodology we employed. More generally, regardless of the department of study, the findings of this study suggest the need to integrate protected area management concepts into the ecology study programmes and textbooks of all five departments examined. For the integration of this active field of research to be meaningful, even though practically difficult, the participation of experts from a wide range of scientific disciplines, such as environmental law and public administration, spatial planning, ecology, and conservation biology, is required. The learning process requires rethinking inside and outside the box by exploring the role of problem-solving and field studies.

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Supplementary Material

The following supplementary material is available for this article:

Table S1. Cross-tabulation analysis of the scientific interest of the participants and the awareness of the European Ecological Network of Natura 2000 protected areas. [1. Molecular/Cell biology or Genetics or Biochemistry 2. Didactics 3. Ecology or Zoology or Botany 4. Other].

Table S2. Cross-tabulation analysis of the scientific interest of the participants and the proportion of land area and marine territory of Greece covered by Natura 2000 network. [1. Molecular/Cell biology or Genetics or Biochemistry 2. Didactics 3. Ecology or Zoology or Botany 4. Other].

Table S3. Cross-tabulation analysis of the scientific interest of the participants and the protected areas that form the Natura 2000 network. [1. Molecular/Cell biology or Genetics or Biochemistry 2. Didactics 3. Ecology or Zoology or Botany 4. Other].

Table S4. Cross-tabulation analysis of the scientific interest of the participants and the level of agreement on the establishment of a new Natura 2000 protected area in the participants' area of residence.

Table S5. Cross-tabulation analysis of the academic year of the participants and the awareness of the European Ecological Network of Natura 2000 protected areas.

Table S6. Cross-tabulation analysis of the academic year of the participants and the proportion of land area and marine territory of Greece covered by Natura 2000 network.

Table S7. Cross-tabulation analysis of the academic year of the participants and the protected areas that form the Natura 2000 network.

Table S8. Cross-tabulation analysis of the academic year of the participants and the level of agreement on the establishment of a new Natura 2000 protected area in the participants' area of residence.

Table S9. Cross-tabulation analysis of the academic year of the participants and the means of finance "Payment from users & purchase of local products".

Table S10. Cross-tabulation analysis of the department of the participants and the awareness of the European Ecological Network of Natura 2000 protected areas.