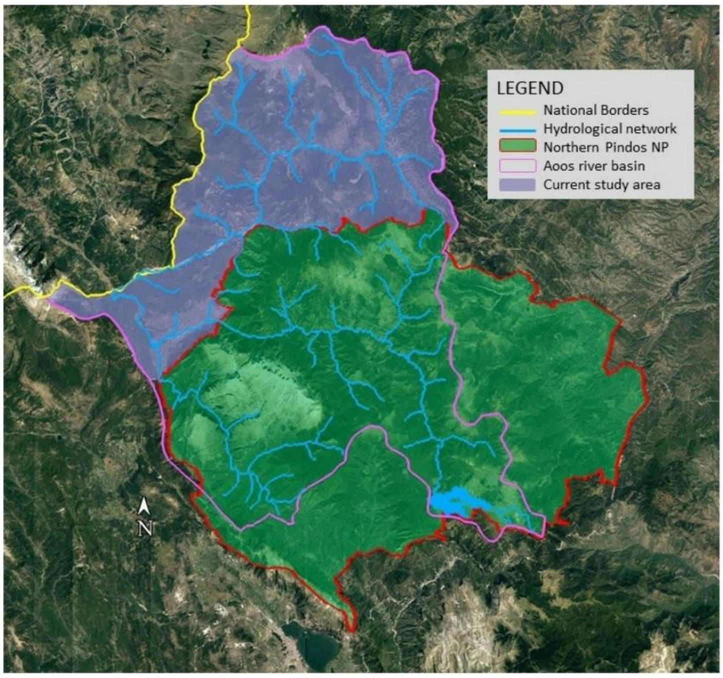
CONTRIBUTION TO BIODIVERSITY KNOWLEDGE OF THE AOOS RIVER BASIN



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Cover Photo:

Map of the study area laying between the Northern Pindos NP and the Greek – Albanian borders, in relation to the three main fauna groups that this study focuses upon: large mammals, otter and Odonata.

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CONTENTS

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Preface

The Vjosa/Aoos river still flows freely from the Pindus mountains in Greece, to the river mouth in Albania largely without artificial obstacles. The river stretches for 270km in total and 70km are flowing within the Greek area. Downstream of the Pigai dam in Greece (10km from the springs of Aoos), the river is near natural, representing all types of river ecosystems, including canyon sections, braided parts and meandering stretches.

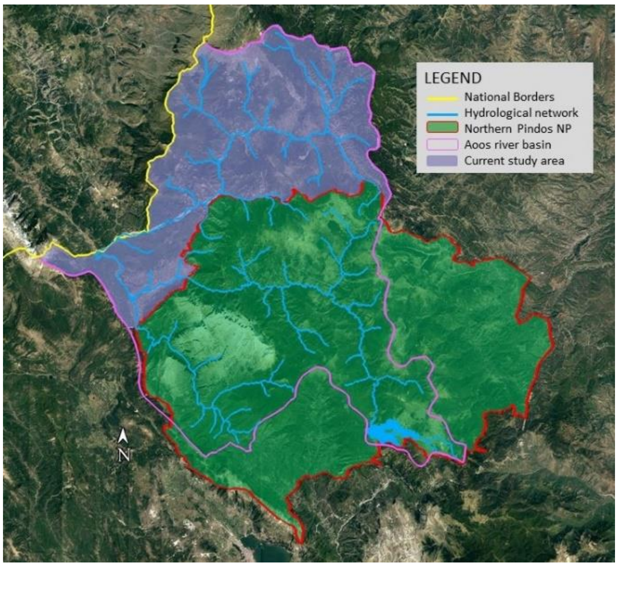
In Greece the protected area, that partly includes river Aoos, belongs to the Northern Pindos National Park. The existing National Park is already protecting 50kms of Aoos' river stretch, leaving nearly 20km of the river unprotected, towards the GR-AL borders (see Map 1). At the same time one of the major tributaries, Voidomatis (15km long) is included in the existing National Park, leaving 6km of the tributary unprotected, towards the GR-AL borders. Another major tributary, river Sarantaporos (50km long), stretches under no protection zone, from its springs until its confluence with Aoos, right upon the GR-AL borders. Voidomatis and Sarandaporos rivers are the main tributaries of Aoos. Voidomatis meets up with Aoos in the plain of Konitsa, and Sarandaporos joins them right on the Greek-Albanian border.

Through this year's biodiversity research, we aim to increase the biodiversity knowledge for the unprotected area of the Aoos river basin, in order to further support the efforts of the campaign for the expansion of the Aoos' protected area towards the GR-AL borders, in a way that will include the unprotected stretches of Aoos and its major tributaries (Voidomatis, Sarantaporos).

The present study is focusing on insect species related to water (Odonata), as well as on large mammals, either directly related to the riverine ecosystems (otter) or indirectly (carnivores and ungulates).

The present biodiversity research sets four distinct objectives:

- To provide a georeferenced database of species distribution in the study area, with special focus on the part of the area that is under no protection status.
- To assess different microhabitats of Aoos' catchment in terms of their ecological value for the target species.
- To assess potential pressures and threats for the species.
- To crystalize research findings into concrete conservation objectives.



Map 1. Study area (purple) laying between the Northern Pindos NP (green) and the Greek – Albanian border.

Assessing the distribution and relative abundance of large mammals using camera traps in the Aoos river basin, Greece

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Abstract

Information on the status and distribution of species within a geographical region is vital for designing effective conservation plans. We assessed the distribution and relative abundance of four large mammalian species in the Aoos river basin and its main tributaries with a focus on the unprotected parts of the area, by using remotely triggered camera traps from July to October 2019. A total of 878 camera trap days at 16 camera trap 5x5 km2 grid cells were deployed. We recorded 334 independent photographs of the focal species. Based on the photographic rate of the large carnivore species, the brown bear and the grey wolf both exhibited high relative abundance indices (RAI_{bear}=6.49 and RAI_{wolf}=5.69). Among the large herbivores, wild boar showed higher relative abundance (RAI_{boar}=16.29) than roe deer (RAI_{roe}=9.23). The presence of Balkan chamois was recorded as well. Furthermore, reproduction success was confirmed in three grids for the bear, in three grids for the wolf, in seven grids for the roe deer and in eleven grids for the wild boar. Our study showed that the areas surrounding the Aoos river and its main tributaries are of great importance for large carnivores, and that the nonprotected parts of the study area are of similar importance as the protected ones. We suggest the establishment of a Greek-Albanian transnational park in the non-protected part of Aoos basin, in order to protect large carnivores from harmful development projects in the basin.

Keywords: Aoos river, brown bear, conservation, camera trapping, large mammals, relative abundance index, roe deer, wild boar, wolf

Introduction

Large carnivores, such as brown bears (Ursus arctos) and grey wolves (Canis lupus), are some of the world's most admired and iconic mammalian species. However, habitat loss and degradation, depletion of prey, poaching, and other human-wildlife conflicts have driven many populations to decline and local extinction (Ripple et al. 2014). Large carnivores can serve both as essential functional component of the ecosystem as well as "umbrella species" across a wide range of habitats, and therefore their conservation should be a global priority (Sergio et al. 2008, Fernández et al. 2017).

At the European level, large carnivores have suffered severe population declines in the past, mainly because of human persecution and habitat degradation (Chapron et al. 2014). Still, Chapron et al. (2014) highlighted that during the 21st century, large carnivore populations have been recovering in many European areas mainly due to protective legislation, supportive public opinion, and conservation actions. However, their long-term survival can be only guaranteed if all present and potential future threats are carefully considered (Boitani et al. 2015).

Brown bears in Greece reach the southernmost range of the species in Europe, making them an important component of the European biodiversity. In Greece, they have managed to survive past demographic and habitat pressures and their population appears to be stable at around >450 individuals (Karamanlidis et al. 2015). Since 1986 the species is strictly protected by greek national law, according to which killing, capture, and exhibition to public view are strictly prohibited. According to European Community legislation (Habitats Directive 92/43/EEC), the brown bear in Greece is strictly protected (Annex II and IV, Table 1). Moreover, bears in Greece are fully protected under the Bern Convention (Annex II). These provisions prohibit deliberate disturbance of individuals, particularly during the period of breeding, rearing and hibernation and moreover, require authorities to explicitly prohibit damages to breeding, resting and hibernating sites. Nonetheless, the species is still considered as endangered in Greece, mainly because of human-related threats such as poaching and traffic fatalities, or habitat fragmentation due to large infrastructure development, which continues to affect the potential for survival (Mertzanis et al. 2009).

Grey wolves in Greece have experienced decades of persecution, bounties and legal use of poison baits (Iliopoulos 2010). After 1993, a stricter legal status reversed the wolf population decline and its distribution has been expanded mainly in south-central Greece, Boetia and Attica. The most recent population census estimated the wolf population of Greece to 795-1020 individuals (Iliopoulos et al. 2015). According to the Habitats Directive 92/43/EEC the wolf in Greece south of 39o longitude is listed in Appendix II and IV, while wolf populations north of 39o are listed in Appendix V. Moreover, wolves throughout their range in Greece are fully protected under the Bern Convention (Annex II). According to the convention wolf killing, capture and trade are forbidden. The treaty requires the authorities to explicitly prohibit the damage to breeding sites, as well as the disturbance of individuals at those places (Sazatornil et al. 2019). Nevertheless, illegal human-caused mortality still remains high throughout the species range and can lead to local population declines or even temporary extinctions [e.g. Prespes National Park, (Iliopoulos and Petridou 2017)]. The main threats for the long-term survival of the species in Greece include poaching and illegal poisoning, prey depletion, habitat fragmentation, and hybridization (Iliopoulos et al. 2015).

Large-bodied herbivores are similarly important in maintaining the natural dynamics in ecosystems, regulating the vegetation structure and succession, nutrient cycling, and the fire regime (Fernández et al. 2017). In the vicinity of Aoos River stretches three large herbivores are present: the roe deer (Capreolus capreolus), the wild boar (Sus scrofa), and the chamois (Rupicapra rupicapra balcanica).

The roe deer populations of Greece are amongst the most vulnerable in Europe. They display low densities and a fragmented distribution pattern, being present mainly in mountainous woodland areas with low levels of human disturbance (Tsaparis et al. 2019). They have suffered significant population reductions and local extinctions in the previous century mainly due to intense hunting and deforestation (Tsaparis 2011). Roe deer hunting has been banned since the late 1960s which has caused local population increases, but poaching and human-caused habitat degradation still constitute considerable threats for the long-term survival of the species in Greece (Tsaparis et al. 2019).

Balkan chamois is the southernmost subspecies within the distribution of the genus in Europe. In Greece, which is its marginal area of distribution, the population presents a fragmented pattern (Papaioannou et al. 2019). In Greece, after a decreasing trend that lasted until the year 2000 with 477–750 individuals across the whole Greek mainland, the total population of chamois is now increasing and counts around 1500 individuals, mainly because of the implementation of conservation measures (Papaioannou et al. 2019). Its hunting has been officially forbidden since 1969. The major threat to chamois survival in Greece is considered to be poaching, enhanced by the dense mountain road network constructed either for livestock breeding activities or logging (Papaioannou and Kati 2007).

The wild boar is an animal that has received far less scientific attention than the rest of the large wild herbivores in Greece. The populations of the species in Greece seem to have spectacularly increased in numbers, at least locally. This numerical increase follows similar trends that have been observed in all of Europe a few decades ago (Saez-Royuela and Telleria 1986, Massei et al. 2015). The increase in the numbers of the wild boar in Greece is probably due to more than one single cause and related to certain local conditions. These could include the following: socio-economic changes (drift from the rural areas) which improve the environmental conditions necessary for the species, reintroductions, hybridization, lack of predators and limited hunting, compensatory population responses of wild boar to hunting pressure, variations in the type of dominant crops. However, this dramatic growth in wild boar's numbers has increased conflicts with humans, which in turn resulted in recent changes in hunting quota and grounds, something that could have a long-term impact on the other more vulnerable large mammalian species of Greece.

Table 1: Protection status of large mammals in the study area

Species	92/43 Habitats Directive	Bern Convention	Status	Red data book GR
Ursus arctos	II and IV	II	U1+ (inadequate with improving trend)	Endangered
Canis lupus	V (north of 39o)	II	U1+ (inadequate with improving trend)	Vulnerable
Rupicapra rupicapra balcanica	II and IV	III	U2+ (bad with improving trend)	Near Threatened
Roe deer	No	No	-	Vulnerable
Sus scrofa	No	No	-	Not Evaluated

Objectives

The current study aims at: (a) assess the ecological value of the study area, in terms of large mammals conservation, (b) increase basic knowledge on the distribution patterns and reproduction success patterns for the targeted large mammal species in the study area, (c) record the main current and forthcoming pressures and threats for the targeted species, and finally (d) investigate the potential of the non-protected part of Aoos basin with its tributaries (Voidomatis, Sarantaporos) to support a transnational Greek-Albania protected area.

Materials and Methods

Study area

The study area extends over an area of 400 km2, covering the catchment of Aoos, Voidomatis and Sarantaporos rivers, along with their streams (Figure 1). It was defined by setting a buffer zone of 3 km around the river stretches (142.8 km river length). A great part of the study area (48.5%) falls within the sites of the Natura 2000 network and the Northern Pindos National Park (Figure 1). Hydropower investments are planned for the lower basin of Aoos, including the river stretches of Voidomatis and Sarantaporos, which is not protected as a site of Natura 2000 network, as well as for the Aoos river head.

Site selection

We used the 5km×5km European Environment Agency (https://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2) grid system to define our sampling units, considering the large home-ranges of large carnivores, as well as EU recommendations for standardized data collection. All the grid cells that overlapped >30% with the 3 km buffer zone were considered as candidate sampling units, resulting in 41 candidate grid cells (overall area 400 km2) [Figure 1].

We selected sampling grids, so as to cover both, the unprotected river stretches of Aoos and its main tributaries, and the Aoos River head (Figure 1). We considered previous knowledge on the distribution, ecological requirements and movement ecology of the two targeted large carnivores (Mertzanis 1999, Iliopoulos 2008), for site selection (camera trapping) within each grid. Sampling sites were first selected using satellite maps (Google Earth Pro) by carefully examining the topographic features of the area. We chose sites with the highest probability of focal species detection along forest roads and trails (Sanderson and Trolle 2005, Tobler et al. 2008). We initially positioned 1 camera trap per grid cell, under the scope to maximize the capture probability of the targeted species in the field.

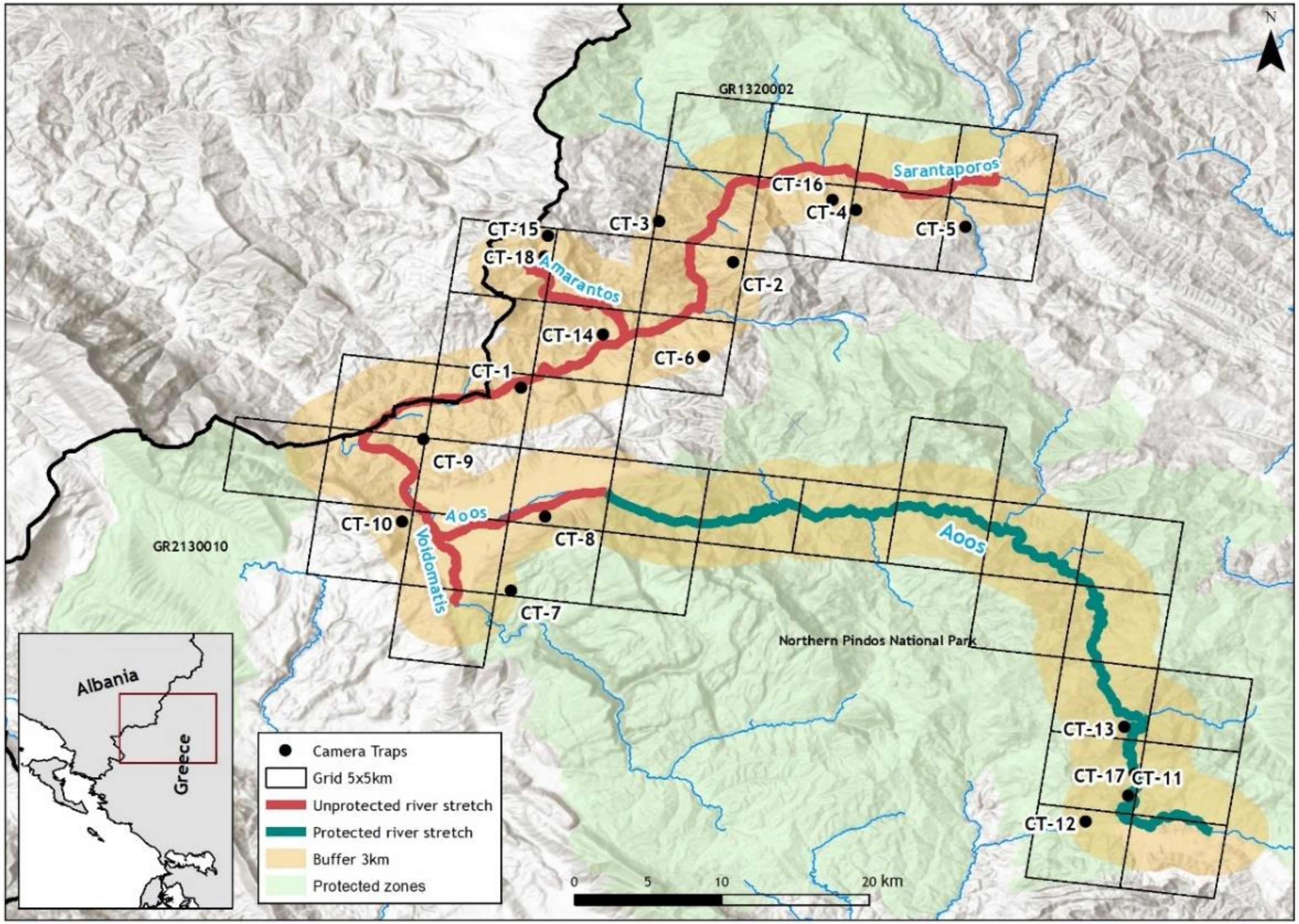

Fig. 1: Survey area for large mammals in Aoos River and its main tributaries by camera trapping, as defined by a buffer distance of 3km around the river stretches and the 5km X 5km EEA grid, pinpointing the protection status of the river stretches. Our goal was to well cover the unprotected river stretches and the Aoos River head.

Data collection

We carried out the study for three consecutive months, between July and October 2019 by using automatically triggered camera traps.

Camera traps have become an invaluable and widely used tool for surveying populations of large mammals, since a) they are non-invasive b) they are independent of activity patterns and shyness of species and c) they provide objective observations with photographic evidence (Kays and Slauson 2008, O'Connell et al. 2010). Working day and night, camera traps are ideally suited for detecting rare and cryptic species an observer may rarely, if ever, encounter. They are an ideal tool for remote areas since they do not need to be accessed daily. Moreover, they work independently of weather conditions, substrate conditions, and human and livestock presence. For the abovementioned reasons, camera trapping was considered ideal to study wolf and bear (highly cryptic species with large home-ranges), in the remote mountainous regions of our interest.

We used one type of camera traps, the Browning Dark Ops HD Pro X 2019 (USA), which uses a no-glow infrared flash technology that is undetectable by people, thus reducing the likelihood of camera detection and theft.

We installed the camera traps by strapping them on trees, 60-300 cm above the ground (Figure 2). Higher positions were often chosen to reduce the likelihood of detection and theft by vandals. Camera traps were set to operate 24 hours per day and programmed to record 3 photos per detection, with intervals of 1 sec between successive triggers. The trigger speed of the cameras is 0.2 sec. We did not use any lures or attractants at camera trap stations.

Fig. 2: Camera trap installment. We used the Browning Dark Ops HD Pro X 2019 (USA). Site selection was supplemented by locating large carnivores' bio-indices.

In total, we covered 16 out of 40 gird cells (16 camera traps in 18 camera trap stations), in the period from 14 July 2019 to 6 October 2019 (Figure 1).

Data analysis

After retrieving all the camera traps we carefully observed all the photographs and identified the animals up to species level. We recorded details of camera trap data, such as date and time of photos, only for the focal species. Following O'Brien et al. 2003, we defined an independent event as consecutive photographs of individuals of the same species taken more than 30 minutes apart. Photos with more than one individual of the same species in the frame were counted as a single detection for that species.

We used the number of events for a species as an index of species abundance and estimated the relative abundance index (RAI). RAI for each species was calculated as :

$$RAI = \frac{A}{N} \times 100$$

Where A is the total number of events for a species and N is the total number of camera trap days (Carbone et al. 2001, Rovero et al. 2014). Our focus was on comparing photo rates between areas. For this reason, RAI for each large mammalian species was calculated separately for each camera trap cell. Our data were presented, analyzed and computed in the GIS platform ArcGIS 10.7 (ESRI) as raster data.

Results

The overall camera trap effort was 878 trap days. We detected 12 different wild mammal species: brown bear, wolf, roe deer, wild boar, Balkan chamois (Figure 3), wild cat (*Felis silvestris*), badger (*Meles meles*), red fox (*Vulpes vulpes*), European hare (*Lepus europaeus*), marten (*Martes sp.*), red squirrel (*Sciurus vulgaris*) and hedgehog (*Erinaceus sp.*).

Fig. 3: A male Balkan chamois in grid 13 and a female wild cat with its young in grid 8.

Large Mammals

Camera trapping resulted in a total of 334 events of the focal species (range: 3 to 143 detections per species). Wild boar (143 events) and roe deer (81 events) were the two most common large mammal species recorded. The brown bear was detected 57 times and the wolf 50 times. Chamois was detected only 3 times in one camera trap grid (13), but mostly because the study design was inappropriate for the species, which inhabits the most inaccessible and high parts of the area. The number of large mammalian species captured per grid cell ranged from 2 to 4 (mean=3.25, SD=0.66, Figure 4). Results for each camera trap grid are presented in Table 2.

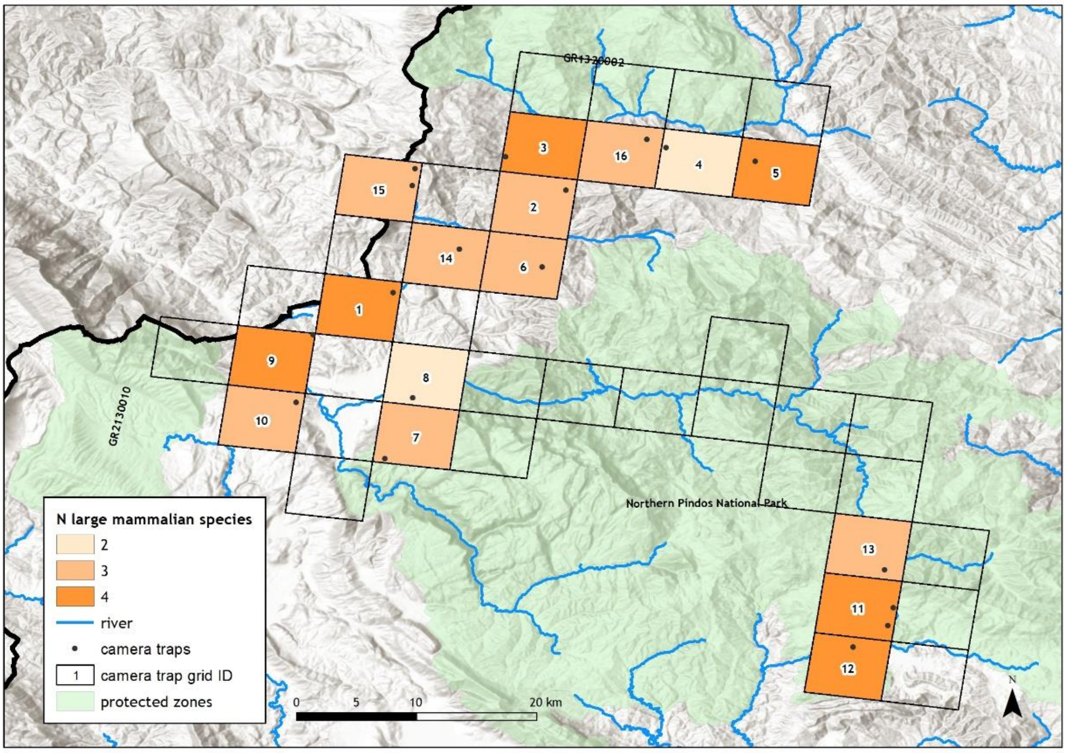

Fig.4: Number of large mammalian species (bear, chamois, roe deer, wild boar, wolf) in the sampled grids as revealed with camera trapping.

Based on the photographic rate of the large carnivore species, the brown bear and the grey wolf both exhibited high relative abundances (RAI_{bear}=6.49 and RAI_{wolf}=5.69). Among the large herbivores, wild boar showed higher relative abundance (RAI_{boar}=16.29) than roe deer (RAI_{roe}=9.23). In the following sub-chapters, we present detailed camera trap results for the bear, wolf, roe deer, and wild boar.

Table 2: Independent events and reproduction success for large mammals in each sampled grid, as recorded by camera traps. We highlighted the occurrence of reproduction for the bear and wolf. Two major types of anthropogenic disturbance were recorded, livestock grazing (L) and hunting activity (H).

Grid ID	Bear	Wolf	Roe deer	Wild boar	Human activity
1	2	2	2 *	23 *	L, H
2	0	7 *	26 *	30 *	H
3	4 *	1	6 *	4 *	L, H
4	0	0	6 *	7	L
5	4	8	3 *	14 *	L
6	19	0	6	7 *	
7	4	2 *	0	10 *	
8	0	0	2	2	L
9	6	7	5 *	12 *	H, BP
10	3	0	7	2 *	L
11	3	14 *	1	10 *	H, L
12	6 *	7	1	4 *	H, L
13	0	0	1	2	
14	0	1	10 *	1	H, L
15	2 *	0	4 *	14 *	H, L
16	4	0	1	1	H, L

(*) Reproduction, (L) Livestock presence, (H) Hunting activity, (BP) Bear poaching

Brown bear

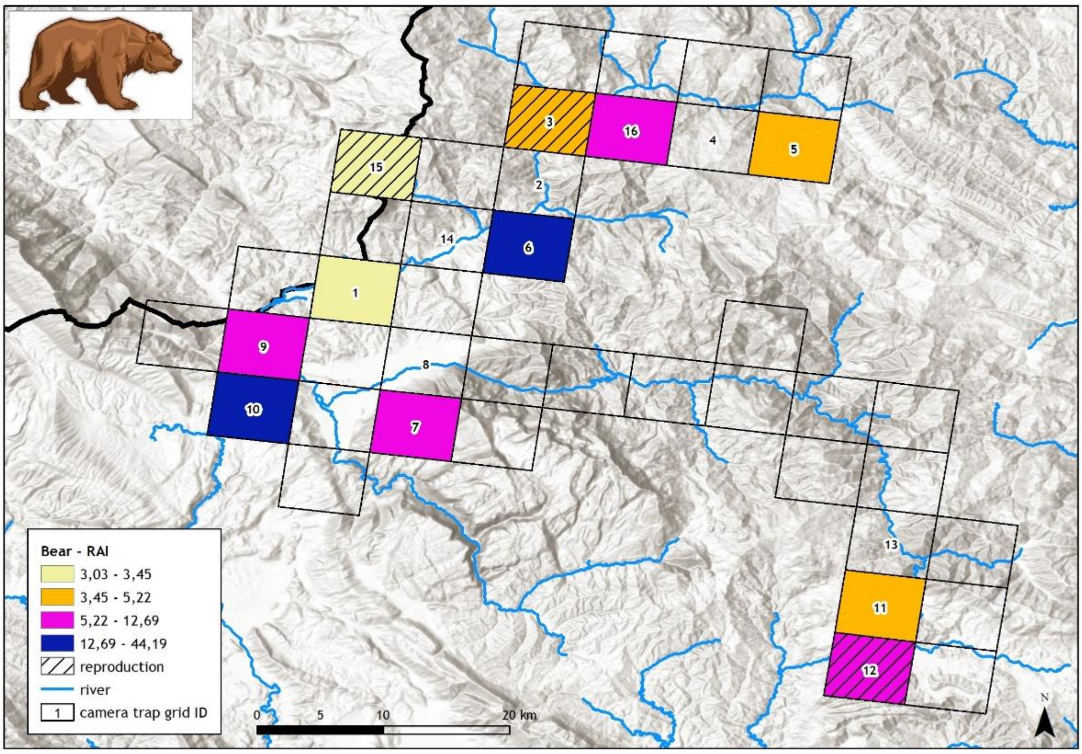

Fig. 5: Gradient of Relative Abundance Index (RAI) for brown bear in Aoos basin (878 camera trap days, 2019), pinpointing the grids with reproduction success.

Camera trapping resulted in 57 brown bear events (mean=3.56, SD=4.47) at the 11 of the 16 camera trap grids (Figure 5). RAI ranged from 3.02 to 44.19. Recordings of bears were examined visually for identification purposes. Based on body shape and color, we identified 1-3 individuals per grid, excluding cubs (mean=1.13, SD=0.93). Furthermore, we detected reproduction in three different grids: 3, 12 and 15. The number of cubs recorded with a female bear was one, two and three (in cells 15, 12 and 3 respectively, Figure 6).

Fig. 6: Examples of brown bears photos and females with cubs in four different camera traps.

Wolf

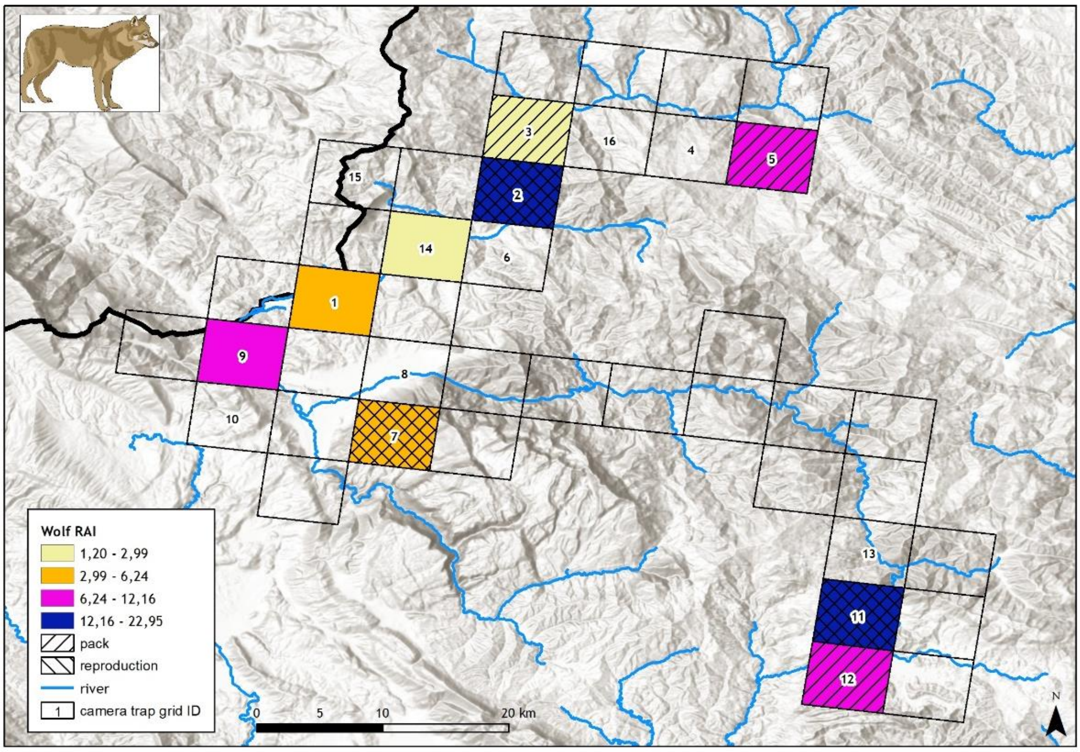

Fig. 7: Gradient of Relative Abundance Index (RAI) for the grey wolf in the Aoos basin (878 camera trap days, 2019), pinpointing the grids with pack presence (≥2 individuals) and reproduction success.

Data collection resulted in 50 wolf events (mean=3.06, SD=4.08) at 9 of the 16 camera trap grids (Figure 7). RAI ranged from 2.38 to 22.95. We detected wolf pack presence (≥2 individuals) in 6 different grids. We identified 1-8 different individuals per grid (mean=2.89, SD=2.51). Based on the linear distance between camera traps, as well as body characteristics in one case, we can safely conclude that at least four different wolf packs are occupying the study area. We did not record any pups, although there was evidence of reproduction in three cases (females with swollen nipples, wolf carrying food to pups) in grids 2, 7 and 11 (Figure 8).

Fig. 8: Examples of wolf camera trap photos and reproduction success.

Roe deer

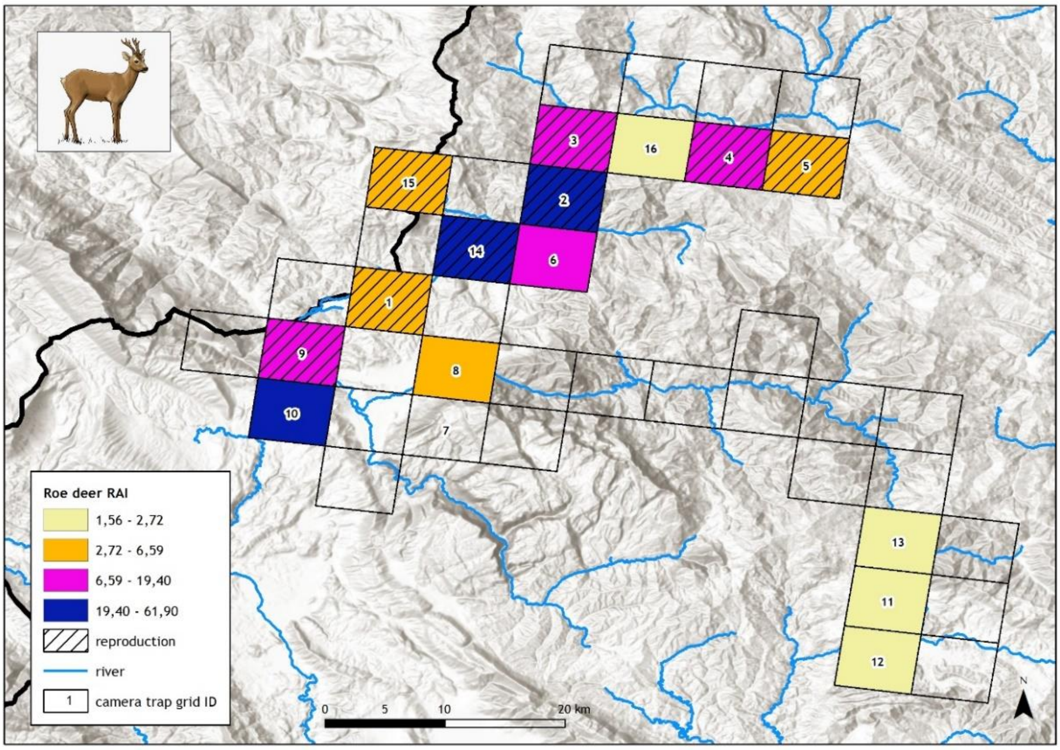

Fig. 9: Gradient of Relative Abundance Index (RAI) for the roe deer in the Aoos basin (878 camera trap days, 2019), pinpointing the grids with reproduction success.

Camera trapping resulted in 81 roe deer events (mean=5.06, SD=6.05) at the 15 of the 16 camera trap grids (Figure 9). RAI ranged from 1.56 to 61.90. Reproduction was detected in eight different grids. The number of fawns recorded with a female roe deer ranged from one to three (Figure 10).

Fig. 10: Examples of roe deer camera trap photos and reproduction success.

Wild boar

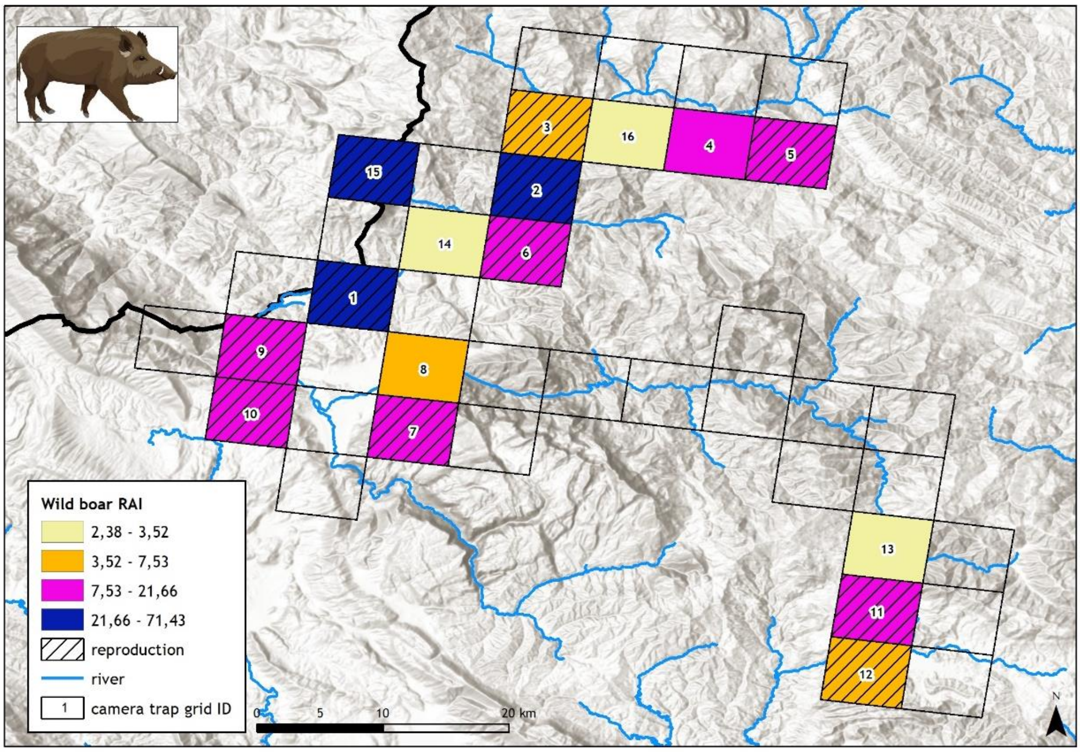

Fig. 11: Gradient of Relative Abundance Index (RAI) for the wild boar in the Aoos basin (878 camera trap days, 2019), pinpointing the grids with reproduction success.

Camera trapping resulted in 143 wild boar events (mean=8.94, SD=8.03) in all 16 camera trap grids (Figure 11). RAI ranged from 2.38 to 71.43. We identified 1-28 different individuals per grid cell (mean=7.11, SD=2.51). Reproduction was detected in 11 different grids (Figure 12).

Fig. 12: Examples of wild boar photos and reproduction success in four different camera trap grids

Threats identified

The main threats identified for the survival of the focal species in the study area during our survey were poaching and vehicle collision.

Free-ranging livestock presence was recorded by camera traps in 11 grids and hunting activity was recorded in 9 grids (Table 2, Figure 13). Poaching was identified as a major threat during the study period in the unprotected part of the study area, in grid 9. This grid was greatly used by two different bears during July and August 2019 but we did not capture any bear photos in September-October. Information from a trusted local source indicated that at least one bear was killed in the area because it was causing damages to corn crops. Moreover, the presence of a wolf pack was not confirmed in the grid, despite the good quality of the habitat and the frequent presence of a lone wolf. This is a non-confirmed indication that wolves may be heavily poached in this area.

Fig. 13: Left- shepherd carrying a riffle. Right- a hunter in grid cell 9.

In July 2019 one brown bear was fatally injured during a car collision in grid cell 8, on the unfenced National Road EO20, close to the town of Konitsa. The bear killing was verified. The research team was informed about the incident several weeks later and only a few bear remains were found close to the accident spot (Figure 14).

Fig. 14: Remains of a brown bear fatally injured during a car collision in July 2019 on the National Road EO20, close to Konitsa.

Protected vs non-protected areas

We defined as grids inside protected areas (n=4) all the grids that are overlapped by >70% with Natura 2000 areas. Although sampling design does not allow to safely compare protected and non-protected grids, we present a comparative overview of the results (Table 3). Results show that non-protected areas host important populations of large mammals and are of similar importance as protected areas.

Table 3: Number of grid cells with recorded presence and reproduction in the sampled grids (5km X 5km) in the protected (4) and unprotected (12) part of the Aoos basin. In parenthesis the respective percentages (%).

	Species/type	Protected (n=4)	Non-protected (n=12)
Presence in sampled grids	Bear	3 (75%)	8 (67%)
	Wolf	3 (75%)	6 (50%)
	Wolf pack	3 (75%)	4 (33%)
	Roe deer	3 (75%)	12 (100%)
	Wild boar	4 (100%)	12 (100%)
Reproduction in sampled grids	Bear	1 (25%)	2 (17%)
	Wolf	2 (50%)	1 (8%)
	Roe deer	0 (0%)	8 (67%)
	Wild boar	3 (75%)	9 (75%)
Threats	Livestock	2 (50%)	9 (75%)
	Hunting	2 (50%)	7 (58%)

Discussion

The present study assesses the presence, relative abundance and reproduction success of large terrestrial mammals through the Aoos river basin and its major tributaries, with a focus on the unprotected parts of the area, by using camera trapping. Northern Pindos has always been a stronghold for large carnivores in Greece, where they have survived, even in times where their populations reached their minimum in the country (e.g. Mertzanis 1994). Results of the present study confirmed that the area is still particularly important for large mammalian species, and especially for the brown bear and wolf, two species of European concern, which are particularly sensitive to human activities.

Large mammals are particularly vulnerable to anthropogenic impacts, such as habitat loss and degradation (i.e increase of artificial land and infrastructure development), overharvesting, persecution, human disturbance and accidental mortality (i.e vehicle collisions) (Temple and Terry 2007). From the above threats, we recorded in the study area an important hunting activity and free-ranging livestock presence. A major threat to the conservation of large carnivores is their intentional killing in retaliation for conflicts - such as livestock depredation, other damages to properties, competition for game species, or threat to humans (Treves and Karanth 2003, Boitani et al. 2015, Petridou et al. 2019). In the study area, large carnivores still cause notable damages on livestock, beehives, and crops (unpublished data from the Hellenic Farmers Insurance Organization–ELGA, and information from locals). Another issue of concern in the study area is the frequent occurrence of hunting dog depredation by wolves (Iliopoulos and Petridou, unpublished data), which can cause especially high levels of retaliatory killing (e.g. Prespes National Park, Petridou and Iliopoulos 2017).

Moreover, we recorded vehicle collision mortality on the unfenced national road that traverses the unprotected part of our study area. For large carnivores with their huge spatial requirements direct mortality due to carnivore-vehicle collision has been a major concern (Kaczensky et al. 2003, Mertzanis et al. 2011).

In the future, there are 62 small hydropower plants planned to be constructed in the study area. Although impacts of human infrastructure development such as road and railway network and oil and gas pipelines, as well as wind farms on large mammals have been acknowledged, this is not the case for river dams and bibliography is very limited. The construction and operation of river dams can have similar to above-mentioned infrastructure impacts on large mammals: 1) increase accessibility and human presence in areas with a priori low disturbance; 2) increase access for traffic related to recreation, forestry, agriculture and hunting; 3) increase direct mortality due to traffic collisions; 4) destruction and modification of the habitat, including road development, habitat fragmentation and barriers to gene flow; 5) changes in land use to the surrounding area (Santos et al. 2008, Gibson et al. 2017).

These consequences can be even more prominent in remote areas and are expected to be particularly severe for large carnivores – with their low-density occurrences, huge home ranges, and long-distance dispersal. Wolves and bears tend to avoid areas that are regularly used by humans, and show a preference for rugged, undisturbed areas away from forest roads and villages, especially for breeding and/or hibernating (Linnell et al. 2000, Sazatornil et al. 2016), which are often chosen for river dam development. As a result, dam construction could cause changes in the breeding site/hibernating locations of large carnivores as well as their reproduction success. This raises conservation concerns, particularly where availability of suitable breeding/hibernating sites is a limiting factor and cumulative effects of other threats (e.g. additional infrastructure, human-related wolf and bear mortality) may affect the local wolf and bear population (Iliopoulos et al. 2014, Costa et al. 2018).

The need for a transnational protected area

Our results also support the great importance of the non-protected part of Aoos basin for the conservation of large mammals, and particularly for large carnivores. The Aoos/Vjosa catchment in Albania shelters a high diversity of mammalian species, including the brown bear, grey wolf, roe deer, Balkan chamois, and wild boar, which contribute to the rich biodiversity of the whole catchment (Shumka et al. 2018). For the adjacent populations of large carnivores in Greece and Albania, there is geographic continuity that is characterized by migration phenomena along the borderline (Mertzanis 1994). The long-term conservation of large carnivores depends on large protected areas and, thus, it is highly recommended to prioritize measures that target to maximize reserve size (Woodroffe and Ginsberg 1998). Therefore, it is of crucial importance to expand the protected area in Greece towards the Greek-Albanian borders and, even more, to establish a Transboundary Wild River National Park – Vjosa/Aoos.

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References

Boitani, L., F. Alvarez, O. Anders, H. Andren, E. Avanzinelli, V. Balys, J. Blanco, U. Breitenmoser, G. Chapron, and P. Ciucci. 2015. Key actions for large carnivore populations in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070307/2013/654446/SER/B3).

Carbone, C., S. Christie, K. Conforti, T. Coulson, N. Franklin, J. R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D. W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D. J. L. Smith, M. Sunquist, R. Tilson, and W. N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. Animal Conservation **4**:75-79.

Chapron, G., P. Kaczensky, J. D. C. Linnell, M. von Arx, D. Huber, H. Andrén, J. V. López-Bao, M. Adamec, F. Álvares, O. Anders, L. Balčiauskas, V. Balys, P. Bedő, F. Bego, J. C. Blanco, U. Breitenmoser, H. Brøseth, L. Bufka, R. Bunikyte, P. Ciucci, A. Dutsov, T. Engleder, C. Fuxjäger, C. Groff, K. Holmala, B. Hoxha, Y. Iliopoulos, O. Ionescu, J. Jeremić, K. Jerina, G. Kluth, F. Knauer, I. Kojola, I. Kos, M. Krofel, J. Kubala, S. Kunovac, J. Kusak, M. Kutal, O. Liberg, A. Majić, P. Männil, R. Manz, E. Marboutin, F. Marucco, D. Melovski, K. Mersini, Y. Mertzanis, R. W. Mysłajek, S. Nowak, J. Odden, J. Ozolins, G. Palomero, M. Paunović, J. Persson, H. Potočnik, P.-Y. Quenette, G. Rauer, I. Reinhardt, R. Rigg, A. Ryser, V. Salvatori, T. Skrbinšek, A. Stojanov, J. E. Swenson, L. Szemethy, A. Trajçe, E. Tsingarska-Sedefcheva, M. Váňa, R. Veeroja, P. Wabakken, M. Wölfl, S. Wölfl, F. Zimmermann, D. Zlatanova, and L. Boitani. 2014. Recovery of large carnivores in Europe's modern human-dominated landscapes. Science **346**:1517-1519.

Costa, G., J. J. Salvado Paula, F. Petrucci-Fonseca, and F. Álvares. 2018. The Indirect Impacts of Wind Farms on Terrestrial Mammals: Insights from the Disturbance and Exclusion Effects on Wolves (Canis lupus).

Fernández, N., L. M. Navarro, and H. M. Pereira. 2017. Rewilding: A Call for Boosting Ecological Complexity in Conservation. Conservation Letters **10**:276-278.

Gibson, L., E. N. Wilman, and W. F. Laurance. 2017. How Green is 'Green' Energy? Trends in Ecology & Evolution **32**:922-935.

Iliopoulos, Y. 2008. Distribution, population estimates, conservation problems and management of wolf, in Northern Pindus National Park. In: Special Environmental study (monitoring) of the Northern Pindus National Park., Callisto NGO, Management authority of Northern Pindus National Park.

Iliopoulos, Y. 2010. Wolf (*Canis lupus*) packs territory selection in Central Greece. Habitat selection, movement patterns and effects on livestock. PhD Thesis. Aristotle University of Thessaloniki, Thessaloniki, Greece.

Iliopoulos, Y., and M. Petridou. 2017. Preliminary study for addressing the conflict with large carnivores in Prespes National Park. Final report, Management Body of Prespes National Park.

Iliopoulos, Y., M. Petridou, C. Astaras, and E. Sideri. 2015. Total deliverables for wolf monitoring.*in* C. Papamichail, T. Arapis, and K. Petkidis, editors. Monitoring and assessment of the conservation status of species of mammals of Community interest in Greece. YPEKA, Athens, Greece.

Iliopoulos, Y., D. Youlatos, and S. Sgardelis. 2014. Wolf pack rendezvous site selection in Greece is mainly affected by anthropogenic landscape features. European Journal of Wildlife Research **60**:23-34.

Kaczensky, P., F. Knauer, B. Krze, M. Jonozovic, M. Adamic, and H. Gossow. 2003. The impact of high speed, high volume traffic axes on brown bears in Slovenia. Biological Conservation **111**:191-204.

Karamanlidis, A. A., M. d. G. Hernando, L. Krambokoukis, and O. Gimenez. 2015. Evidence of a large carnivore population recovery: Counting bears in Greece. Journal for Nature Conservation **27**:10-17.

Kays, R. W., and K. M. Slauson. 2008. Remote cameras. Pages 110-140 *in* R. A. Long, P. McKay, J. C. Ray, and W. J. Zielinski, editors. Noninvasive survey methods for carnivores. Island Press.

Linnell, J., D. C., J. E. Swenson, R. Andersen, and B. Barnes. 2000. How Vulnerable Are Denning Bears to Disturbance? Wildlife Society Bulletin (1973-2006) **28**:400-413.

Massei, G., J. Kindberg, A. Licoppe, D. Gačić, N. Šprem, J. Kamler, E. Baubet, U. Hohmann, A. Monaco, J. Ozoliņš, S. Cellina, T. Podgórski, C. Fonseca, N. Markov, B. Pokorny, C. Rosell, and A. Náhlik. 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. Pest Management Science **71**:492-500.

Mertzanis, G. A. 1994. Brown Bear in Greece: Distribution, Present Status: Ecology of a Northern Pindus Subpopulation. Bears: Their Biology and Management **9**:187-197.

Mertzanis, G. A., A. Giannakopoulos, and C. Pilides. 2009. Status of the brown bear Ursus arctos (Linnaeus, 1758) in Greece. Pages 385-387 *in* A. Legakis and P. Maraggou, editors. Red data book of threatened vertebrates of Greece. Hellenic Zoological Society, Athens.

Mertzanis, Y. 1999. Brown bear: biology, ecology. Special Environmental Study for Grammos -NW Voios Mountains. LIFE96NAT/GR/003222 - LIFE ARCTOS. Arcturos. 310 pp.

Mertzanis, Y., I. Aravidis, A. Giannakopoulos, C. Godes, A. Mazaris, A. Riegler, S. Riegler, S. Sgardelis, and A. Tragos. 2011. Telemetry as a Tool to Study Spatial Behaviour and Patterns of Brown Bears as Affected by the Newly Constructed Egnatia Highway-N. Pindos-Greece.*in* O. Krejcar, editor. Modern telemetry. INTECH Open Access Publisher.

O'Connell, A. F., J. D. Nichols, and K. U. Karanth. 2010. Camera traps in animal ecology: methods and analyses. Springer Science & Business Media.

Papaioannou, H., M. Fernández, T. Pérez, and A. Domínguez. 2019. Genetic variability and population structure of chamois in Greece (Rupicapra rupicapra balcanica). Conservation Genetics **20**:939.

Papaioannou, H., and V. Kati. 2007. Current status of the Balkan chamois (Rupicapra rupicapra balcanica) in Greece : Implications for conservation. Belgian Journal of Zoology **137**:33-39.

Petridou, M., D. Youlatos, Y. Lazarou, K. Selinides, C. Pylidis, A. Giannakopoulos, V. Kati, and Y. Iliopoulos. 2019. Wolf diet and livestock selection in central Greece. Mammalia **83**:530.

Ripple, W. J., J. A. Estes, R. L. Beschta, C. C. Wilmers, E. G. Ritchie, M. Hebblewhite, J. Berger, B. Elmhagen, M. Letnic, M. P. Nelson, O. J. Schmitz, D. W. Smith, A. D. Wallach, and A. J. Wirsing. 2014. Status and Ecological Effects of the World's Largest Carnivores. Science **343**:1241484.

Rovero, F., E. Martin, M. Rosa, J. A. Ahumada, and D. Spitale. 2014. Estimating Species Richness and Modelling Habitat Preferences of Tropical Forest Mammals from Camera Trap Data. PLOS ONE **9**:e103300.

Saez-Royuela, C., and J. L. Telleria. 1986. The increased population of the Wild Boar (Sus scrofa L.) in Europe. Mammal Review **16**:97-101.

Sanderson, J. G., and M. Trolle. 2005. Monitoring Elusive Mammals: Unattended cameras reveal secrets of some of the world's wildest places. American Scientist **93**:148-155.

Santos, M. J., N. M. Pedroso, J. P. Ferreira, H. M. Matos, T. Sales-Luís, Í. Pereira, C. Baltazar, C. Grilo, A. T. Cândido, I. Sousa, and M. Santos-Reis. 2008. Assessing dam implementation impact on threatened carnivores: the case of Alqueva in SE Portugal. Environmental Monitoring and Assessment **142**:47-64.

Sazatornil, V., A. Rodríguez, M. Klaczek, M. Ahmadi, F. Álvares, S. Arthur, J. C. Blanco, B. L. Borg, D. Cluff, Y. Cortés, E. J. García, E. Geffen, B. Habib, Y. Iliopoulos, M. Kaboli, M. Krofel, L. Llaneza, F. Marucco, J. K. Oakleaf, D. K. Person, H. Potočnik, N. Ražen, H. Rio-Maior, H. Sand, D. Unger, P. Wabakken, and J. V. López-Bao. 2016. The role of human-related risk in breeding site selection by wolves. Biological Conservation **201**:103-110.

Sazatornil, V., A. Trouwborst, G. Chapron, A. Rodríguez, and J. V. López-Bao. 2019. Top-down dilution of conservation commitments in Europe: An example using breeding site protection for wolves. Biological Conservation **237**:185-190.

Sergio, F., T. Caro, D. Brown, B. Clucas, J. Hunter, J. Ketchum, K. McHugh, and F. Hiraldo. 2008. Top predators as conservation tools: ecological rationale, assumptions, and efficacy. Annual Review of Ecology, Evolution, and Systematics **39**:1-19.

Shumka, S., F. Bego, S. Beqiraj, A. Paparisto, L. Kashta, A. Miho, O. Nika, J. Marka, and L. Shuka. 2018. The Vjosa catchment–a natural heritage. Acta ZooBot Austria **155**:349-376.

Tobler, M. W., S. E. Carrillo-Percastegui, R. Leite Pitman, R. Mares, and G. Powell. 2008. An evaluation of camera traps for inventorying large- and medium-sized terrestrial rainforest mammals. Animal Conservation **11**:169-178.

Treves, A., and K. U. Karanth. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology **17**:1491-1499.

Tsaparis, D. 2011. Genetic diversity and aspects of ecology of roe deer (Capreolus Capreolus) populations in Greece. Doctoral dissertation. School of Sciences, Faculty of Biology, Section of Zoology & Marine Biology, National & Kapodistrian University of Athens, Athens, Greece.

Tsaparis, D., K. Sotiropoulos, A. Legakis, G. Kotoulas, and P. Kasapidis. 2019. New phylogeographic insights support the distinctiveness and conservation value of the little-known Greek roe deer populations. Mammalian Biology **96**:23-27.

Woodroffe, R., and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. Science **280**:2126-2128.

A study on the presence and conservation status of the otter (*Lutra lutra*) in a selected section of the Aoos river basin

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Introduction

The Eurasian otter (*Lutra lutra* (L., 1758))[1] is a carnivorous mammal, member of the family Mustelidae. It is a flagship species, being the top predator of Europe's freshwater ecosystems (Remonti et al., 2009). Otters are remarkably well-adapted to their semi-aquatic existence and are nearly always found beside water; they mainly live along rivers, but are also found in and around canals, marshes, ponds, lakes, streams and estuaries, even along rocky shores. They are opportunistic predators and they exploit prey in proportion to its availability in the environment. Their diet consists mainly of fish, amphibians and crustaceans but they also regularly feed on waterbirds, water snakes or even small mammals (Krawczyk et al., 2016).

Its suitable habitat has been well described (Kruuk et al., 1998; Chanin, 2003a). Being large mammalian predators, otters are tolerant of a wide range of habitat conditions. In order to determine whether their habitat is favourable, the main factors that need to be considered are food supply, pollutants and availability of secure breeding sites. In general, where aquatic prey is abundant, water quality is acceptable and adjacent habitats offer plenty of cover, healthy otter populations can be expected. In fact, in studies on habitat selection it has been shown that the main limiting factor for the otter is the availability of prey, which in Mediterranean areas is conditioned by the availability of water (López-Martín et al., 1998).

Picture 1. The Eurasian otter (*Lutra lutra*).

Although otters travel large distances, most adults stay in a well-defined territory in which they feed, rest, and reproduce (Kruuk, 2006). Otter territories are measured as length of riverbanks or coasts. The sizes of individual territories depend on the quality of habitat and amount of food. Male otters have much larger territories than female ones; one male otter's territory generally overlaps with those of several females. Significant lengths of this territory range may be covered in one night's travelling (Chanin, 2013). Otters mark their territories with their unmistakable faeces (called spraints) which they deposit on often conspicuous, predictable sites (sprainting sites) for the purpose of scent communication (Calzada et al., 2010).

Otters usually maintain numerous underground holts within their territories. Holts can take many forms – among falls of rocks, in caves, within root systems of mature bank-side trees (Kruuk, 1995). Natal dens tend to be especially well hidden, usually far from other otter traffic to avoid potential intra-specific aggression (Kruuk, 1995).

Although the otter's global distribution ranges from Ireland in the west to Japan in the east and from the Arctic to North Africa (Mason, 1990), otters have suffered a severe decline during the 20th century in most European countries (Chanin, 2013) because of a reduction of food supplies, increases in water pollution, persecution by humans and the destruction of their habitat (Kruuk, 2006).

Picture 2. Potential otter holt located as part of this study.

However, environmental improvements and focused conservation efforts have helped to re-establish widespread healthy populations in many European countries, and the species was downgraded from "Vulnerable" to "Near threatened" in the IUCN red list (Roos et al., 2015).

The otter is a European Protected Species under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) - Appendix II (special protection for listed animal species and their habitats). The species is also included in the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive) Annex IIa and IVa (designation of protected areas for animal and plant species listed), which requires statutory protection and the maintenance of "favourable condition" for the species and its habitats.

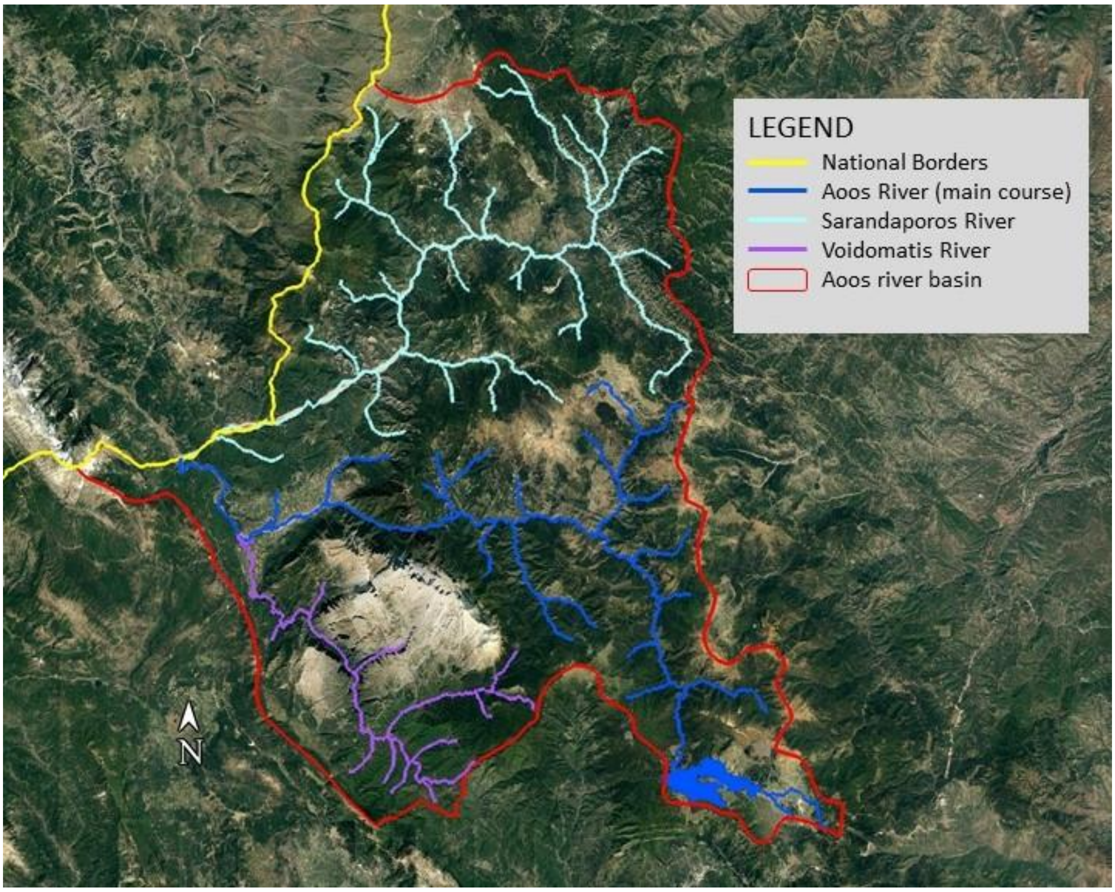
With its relatively undisturbed and unpolluted freshwater systems, Greece is considered to host one of the healthiest otter populations in the European Union and therefore bears an increased responsibility for the species conservation. Although our understanding of essential aspects of the otter's ecology in Greece still leaves much to be desired, it is becoming increasingly apparent that the species enjoys a broad distribution throughout most of the mainland, as well as on some of the islands. Due mainly to uncertainties concerning its population densities though, otters are listed in the Greek Red Data Book as Endangered (Galanaki & Gaethlich, 2009). Main threats to the species wellbeing in Greece include habitat degradation, drainage of wetlands, destruction of riparian cover and intensification in the use of chemicals.

The biggest threat, though, for the survival and wellbeing of the otter in Greece is probably the looming construction of a great amount of small hydro power plants along much of its riverine habitat. In this study, a search for otter signs and holts has been conducted in order to shed light on the distribution and breeding site preferences of the species in a selected section of the Aoos river basin. Its findings were correlated with proposed plans for an expansion of small hydro power production in the same area. This was made to estimate the threat level that such a prospect poses to the species.

Study area

The Aoos river rises near Metsovo, and after flowing through Greece for 67 km it enters Albanian territory, 15 km west of the town of Konitsa. It then enters into Albania and after crossing 170 km it flows into the Adriatic Sea. Voidomatis and Sarandaporos rivers are the main tributaries of Aoos. Voidomatis meets up with Aoos in the plain of Konitsa, and Sarandaporos joins them right on the Greek-Albanian border. The highest altitude in the basin is the peak of Mt Smolikas, at 2,637 m, and the lowest is at 371 m, at the point where Aoos flows into Albania.

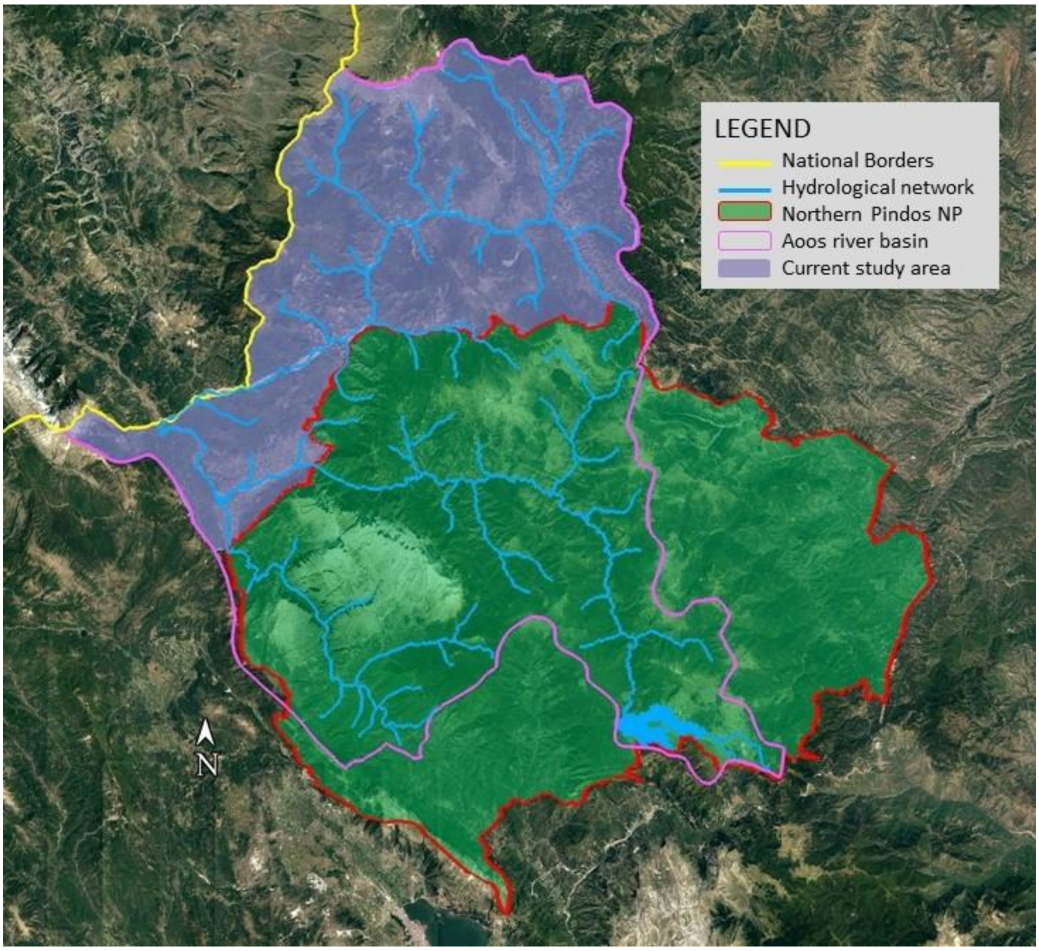
The three aforementioned rivers divide the Greek part of the Aoos river basin into the following three sub-basins: the Aoos (827 km^2), the Sarandaporos (922 km^2) and the Voidomatis (392 km^2) sub-basins.



Map 1. The Aoos river basin with its three distinct sub-basins.

The whole watershed is one of the most mountainous in Greece and is considered to be among the wildest and naturally most important both at the national and the European level, as it holds a remarkable diversity of plants and animals, including a large number of endemic and rare species. A large part of the Aoos river basin lies within the borders of the largest mainland protected area of Greece, the Northern Pindos National Park (appr. 2000 km^2). However, squeezed between the National park and the Greek-Albanian border, the northern part of the river basin currently remains largely unprotected.

This (largely) unprotected section forms our study area and it covers almost all of the Sarandaporos sub-basin, as well as the lowest sections of Aoos and Voidomatis rivers. It is a predominantly mountainous, forested and wild region, with small villages and a low (and dwindling) human population. Sarandaporos collects a large number of streams from the two highest mountains of the Pindos range, Grammos and Smolikas, and their offshoots. Most notable among them are the Zouzouliotiko stream (flowing down from the village of Zouzouli), the Pistiliapis stream (flowing from the village of Aetomilitsa), the Vourbianitiko stream (flowing from the village of Plikati), and the Vourkopotamos stream (flowing from the village of Agia Paraskevi). Sarandaporos flows gently between the two mountains until their slopes fade off and almost meet each other, forming two small canyons. After that the river actually marks the border between Greece and Albania for a while, before it eventually joins Aoos.



Map 2. Our study area (purple) squeezed between the Northern Pindos NP (green) and the Greek – Albanian border. The whole of the Aoos basin is depicted.

Previous otter surveys in the Aoos river basin

Based on a series of otter sign surveys, the species' distribution throughout the Aoos river basin is already well established and documented. The majority of the aforementioned surveys specifically concerned the area within the confines of the Northern Pindos National Park, with only one survey (2009) focusing on the area under current study (namely the Sarandaporos sub-basin and the lowland sections of Aoos and Voidomatis rivers).

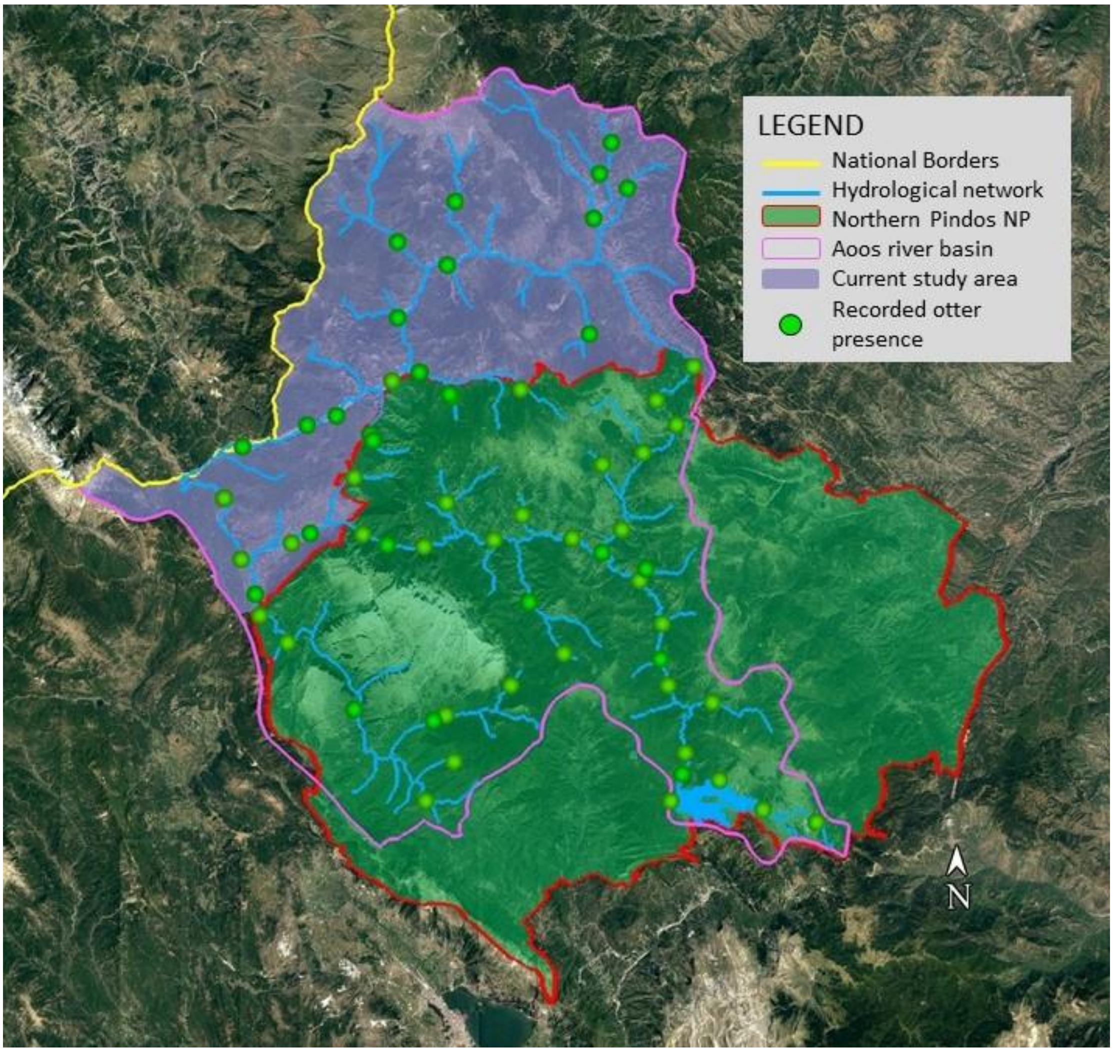
The first survey on the species distribution in the Aoos river basin was carried out by Gaetlich, M. (1988) as part of an otter distribution survey that covered the whole of western Greece. The species was found to be present along the main course of Sarandaporos, Aoos and Voidomatis rivers.

As part of an MSc thesis, the author of this report surveyed the whole length of both Aoos and Voidomatis rivers (main river courses only – 30 stations surveyed). The otter was found to be present along the whole length of both rivers, with the notable exception of the Vikos gorge, where the river flow is intermittent. The density of otter signs was found to be significantly lower in the lowland areas of Aoos river (downstream of Konitsa), but it was not clear if this was due to a lower population density in this stretch, or (rather) due to habitat and behavior-related factors (Theodoropoulos Y., 2006).

As part of a Monitoring Programme on the fauna of the Northern Pindos National Park (Mertzanis G. (ed.), 2008), Y. Theodoropoulos recorded the presence of the otter in both Aoos and Voidomatis rivers, as well as in all the main tributary streams (20 stations surveyed).

As part of a Special Environmental Study (Epirus S.A., 2009) for a number of Natura 2000 sites in the wider region, an otter survey was carried out by Y. Theodoropoulos throughout the whole of Sarandaporos sub-basin, as well as along the lowland stretches of Aoos and Voidomatis rivers (32 stations surveyed). The presence of the species was confirmed all along the main river courses, as well as in some of the tributary streams, with otter signs absent only in certain mountainous streams.

For the purposes of the 3rd National Six-Year Report on the Implementation of Directive IIa/EEC, Y. Theodoropoulos carried out the most detailed survey thus far on the presence and conservation status of the otter within the Northern Pindos National Park, thoroughly covering the area's hydrological



Map 3. Recorded otter presence within the Aoos basin (2008 – 2018)

network (51 stations surveyed within the Aoos river basin section of the National Park alone). Otters were found to be present not only all along the main river courses and the major streams, but even in streams with minimal or intermittent flow, with the species' distribution remarkably stretching up to an altitude of almost 1500m, including the "Aoos Springs" Reservoir. Otters were only absent in the Vikos gorge (with its intermittent flow) and some of the most upstream stretches of certain minor tributary streams. The Degree of Conservation for the otter and for the whole of the Northern Pindos was reported as Excellent (A). The combined results from all mentioned surveys underline that otters are widespread throughout the whole of the Aoos river basin, with practically all suitable habitat occupied by otters and yielding a variety of otter signs.

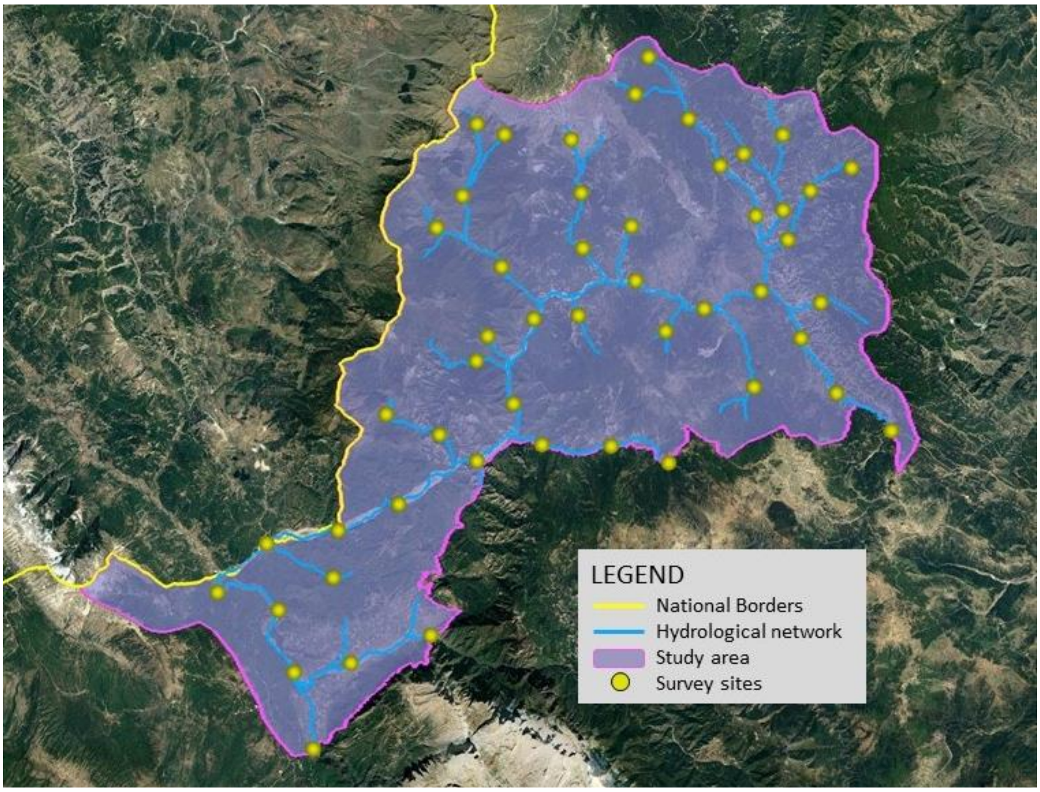
Materials and Methods

Otters are elusive and nocturnal animals and so direct observation in the wild is extremely challenging. Therefore, monitoring uses species incidence data derived indirectly from field signs. The method that has prevailed in otter surveillance during the last decades has come to be known as "Standard Method". Developed in Britain by Lenton et al. (1980) and described in detail by Reuther et al. (2000), the method was considered to be the most appropriate for the purposes of our study.

The Standard Method is a systematic sampling survey for field signs of otters. The study area is covered by a network of sample points ("sites"). Selection of these sites is not strictly statistically random as they have to follow watercourses. The sites are then surveyed for reliable signs of otter presence, notably faeces (spraints) and/ or tracks. The survey sites consist of 600m of river bank, a length demonstrated to yield a reliable assessment on the presence or absence of otters. As soon as otter signs are found, the search stops and the site is confirmed as positive. If no otter signs are found then the site is recorded as negative. The relation of positive sites to the total number of sites surveyed is given as "percentage of positive sites". Using the same methodology, this procedure allows comparisons of distribution development in the same area over time.

According to the 'Standard Method", survey sites are required to be at least 5km away from each other, with that distance measured not in a straight line but along the river corridor. For the purposes of our study, sites were set at (or very close to) this minimum 5km distance, with almost all sites more or less equidistant from each other. This approach provides us with the maximum possible number of sites, allowing for an in-depth understanding of the use of the area's hydrological network by otters.

In total, 50 survey sites were selected. 44 sites were set within the Sarandaporos sub-basin, with further six covering the lower stretches of Aoos and Voidomatis rivers (between the Northern Pindos N.P. and the borders with Albania). This is very close to the standard of 60 survey sites suggested by Chanin (2003b) as a sufficiently large sample size for analyzing distribution development over time.



Map 4. The 50 survey sites selected along the hydrological network of our study area.

In addition to the sign survey, special efforts were made in order to investigate certain river stretches and streams suspected to be used as breeding sites by otters. It is important here to make a distinction between the breeding site and the natal den. The term breeding site is used here to describe a stretch of river large enough to provide a breeding otter with:

- Security from disturbance.
- One or more potential natal den sites.
- No risk of flooding.
- Access to good food supply.

The natal den is taken to be the small space occupied by the female when she gives birth and where the cubs stay for up to three months. (Liles, 2003).

It was clear from very early on that such an undertaking would have to be subject to severe limitations. Almost the whole of the Sarandaporos sub-basin, characterized as it is by kilometers on end of undisturbed rivers in near perfect conservation status, seemingly provides near-ideal conditions for otters' selection of breeding sites, in a way that would meet all the above criteria. In such a respect, attempting to survey all such areas for potential breeding sites, would prove outright impossible and beyond the scope of this study. However, two considerations weighed in favour of selecting a limited number of locations for such an investigation.

Picture 3. The "Sarandaporos' straights", one of the locations considered for the construction of a small hydro power plant. It was confirmed as an otter breeding site.

i. The main course of the Sarandaporos river is characterized by a narrow river channel surrounded by a very wide gravel floodplain, almost completely devoid of vegetation or any other cover. Although Sarandaporos is used by otters all along its length, such an absence of cover means that any female otter looking for a suitable natal den would have to resort to either one of the two existing canyons, or one of the nearby tributary streams.
ii. One of the canyons, as well as some of the nearby tributary streams mentioned above, find themselves under threat from the impending construction of small hydropower dams.

Therefore, both Sarandaporos' canyons and three tributary streams were thoroughly investigated for otter resting places and potential natal dens. All suitable hollows, caves and cavities detected along the banks, were checked for signs of frequent otter visits. Furthermore, the banks were searched for tracks of otter cubs.

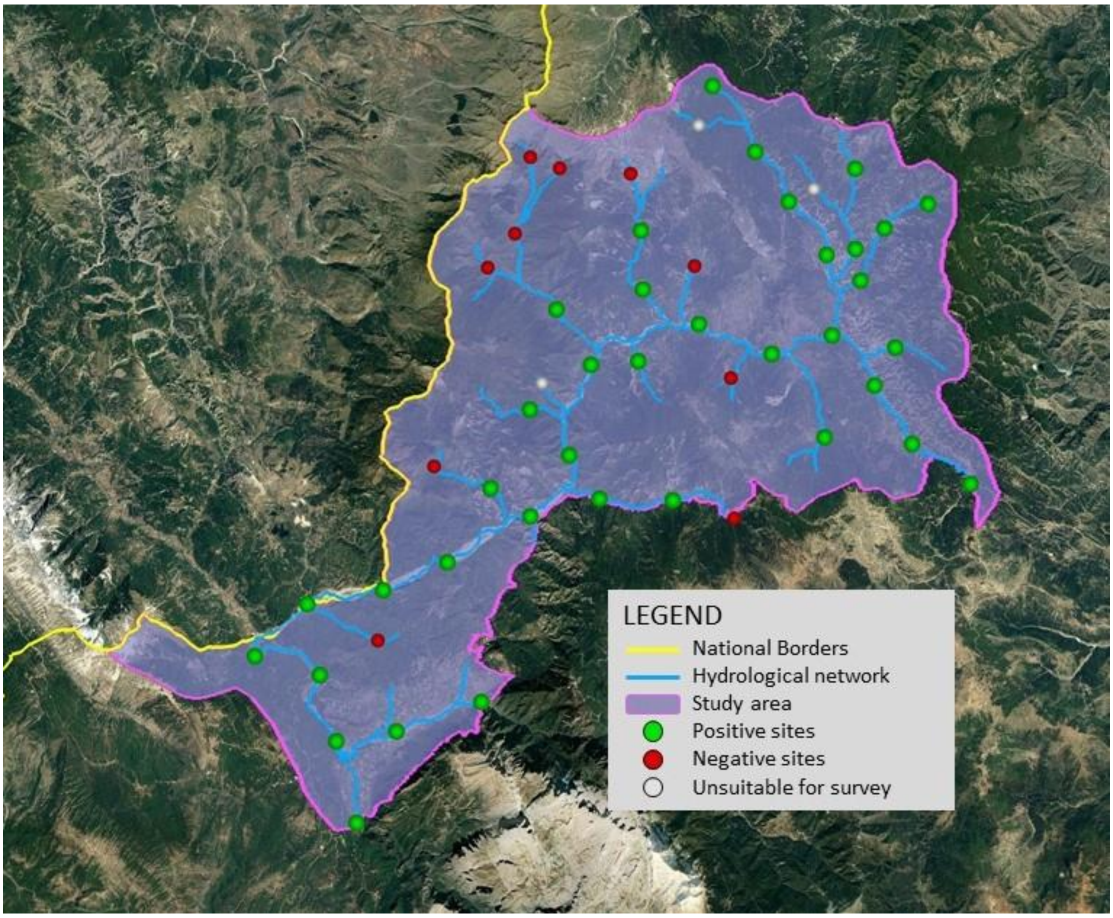
The first part of the survey took place between 26/9 and 04/10. Following a prolonged period of drought, severe rainfall fell between 4-6/10, resulting in an abrupt cessation of the fieldwork. Heavy rainfall and the subsequent flooding resulted in spraints and tracks being washed off. Consequently, sufficient time should be allowed after that for new spraints to be deposited. The survey resumed for two more days between 25-26/10. For the purposes of this study, 1213km and 72km were covered in total by car and on foot respectively within our study area.

Results

Out of the 50 survey sites originally set, three sites proved to be unsuitable for survey since the forbidding terrain made access there precarious. Out of the remaining 47 sites that were thoroughly surveyed, 37 produced reliable otter signs (spraints and/ or tracks). Only 10 sites showed no signs and were assessed as "negative" (Map 5). Therefore, the percentage of "positive" sites came out to be 79%, a percentage deemed to be very high.

Signs of otters were recorded all along the main courses of Sarandaporos, Aoos and Voidomatis rivers. In addition, the survey confirmed that otters also use almost all of the second and third order small mountain streams. Otters were found present in a large variety of riverine habitats, including gentle braided rivers and fast flowing mountain streams, stretches with bare and gravelly banks as well as stretches with dense riparian vegetation, perennial streams with consistently strong flow and intermittent streams with minimal flow.

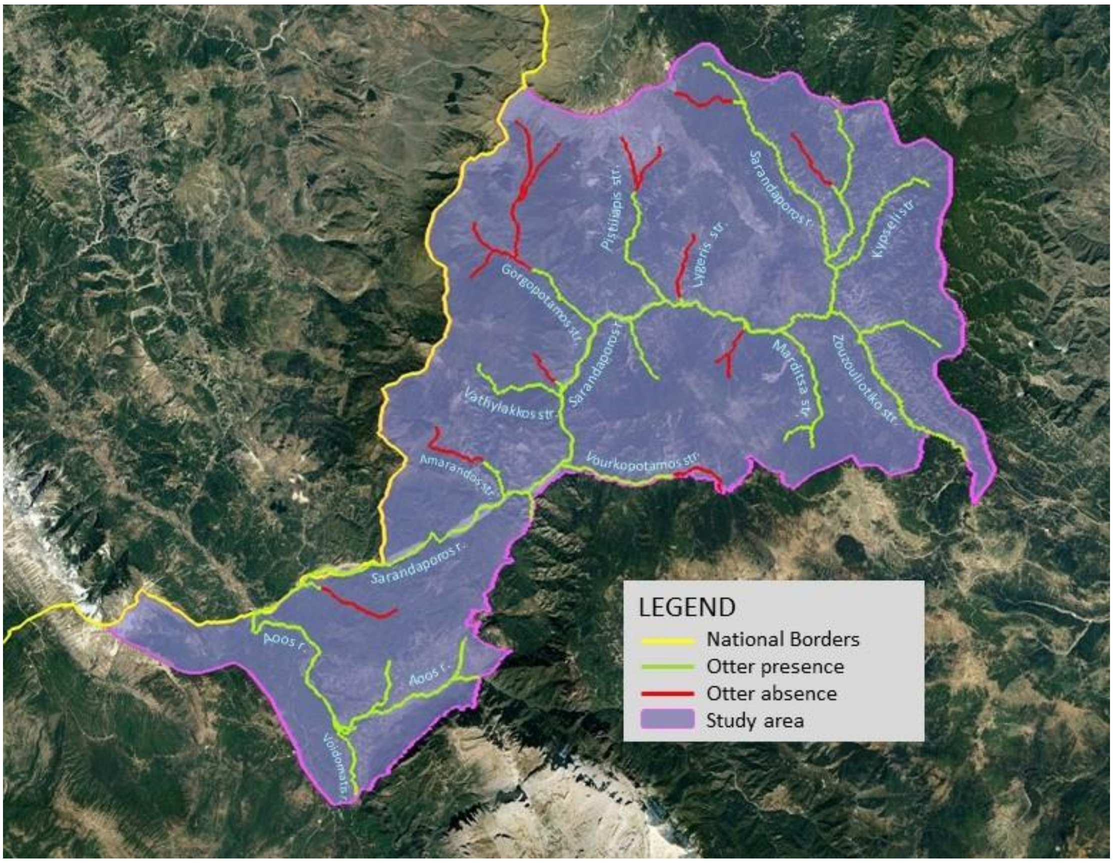
Picture 4. Typical otter spraint. Otters use spraints to mark and defend their territories. Prey remains (in this case, crayfish) are clearly visible.



Map 5. Results of the otter sign survey.

Otters were recorded as absent mainly at highly erosional headwater streams, where gradients are steep and stream beds are completely bare and heavily exposed to the full force of flush floods. A typical example was the largest part of the Gorgopotamos stream drainage basin, that contained 4 negative sites. Three more negative sites were associated with small and steep first order streams that, at the time of the survey, were found either with minimal (in the case of Megas Lakkos and Drosopigi streams) or even nonexistent (in the case of Lygeri stream) surface flow. Finally, the survey site upstream the Vourkopotamos small hydro power plant (the only one currently in operation within our study area) also came out negative (see Chapter 6).

It is important to note that the survey took place after an uncommonly prolonged and severe drought period, even for Mediterranean standards. All streams and rivers throughout the study area were under intense water stress, experiencing losses of some (or even, in some cases, all) surface water, thus creating extreme challenges for all water related species, including the otter. It would be fair to assume that any river corridor stretch yielding otter signs under such conditions, is most probably used by otters on a year-round basis.



Map 6. Distribution of otter (*Lutra lutra*) within our study area.

The investigation for otter breeding sites resulted in the detection of definite signs of reproduction at both of the Sarandaporos' canyons, as well as at two out of the three streams (Amarandos stream and Vathylakkos stream) that were examined. The recording of unmistakable otter cub tracks in all cases, left no room for doubt (see Picture 5). Furthermore, suitable potential holts were located in all the confirmed breeding sites mentioned above. It is, however, important to note that distinguishing between a resting place and a natal den or confirming that an otter holt is used for breeding, is not straightforward without the aid of radio-tracking data (Liles, 2003)..

The results of this otter study (positive sites of 79%) are in general agreement with previous studies in the area: otters seem to occupy practically all suitable available habitats within the study area. Chanin (2003b) suggested that a percentage of over 70% positive sites, should be regarded as an indicator of a healthy otter population. This is more realistic than expecting a 100% positive result, as not all spraint sites will be used all the time.

Picture 5. Otter cub and adult otter tracks: clear evidence of the use of a river stretch for reproduction.

The high percentage of positive sites in the area should not come as a surprise. The hydrological network of the study area evidently meets all of the species habitat requirements: abundant aquatic prey, excellent water quality and adjacent areas offering ample cover and secure locations for breeding. Toxic pollutants, that can potentially have an extremely severe impact on otters, are virtually non-existent here. Finally, human-induced mortality is at a minimum since direct persecution is practically non-existent.

However, this almost optimal picture is under threat by the impending construction of a series of small hydro dams.

Picture. 6. First order stream near the village of Plikati. Such highly erosional headwater streams were among the few stretches of the area's hydrological network that were not used by otters.

Small hydro dams: current situation and brief evaluation

As part of the ongoing effort to break the dependency on fossil fuels, small-hydro power plants (henceforth referred to as SHPs) came into the spotlight in Greece during the last few years. Since the State adopted a financial incentive for the production of such projects, applications for constructions have skyrocketed. According to Greek law, the power capacity of any single SHP cannot exceed 15MW.

In a typical installation, a weir is used to form a headpond for diversion of inlet water through a pipe and into a turbine. As a hydroelectric facility, it requires a dependable flow of water and a reasonable difference in relative height for the water to fall, called the head. To achieve the required head, customarily the water is being transported between the weir (at the top) and the power-house (at the bottom) for a distance of a few hundred to a few thousand meters (see Figure 1). The water is being transported either at a small distance from the river or following the river corridor itself (at least partially). According to the relevant legislation, water abstraction should be designed in such a way as to allow a designated percentage of water – defined as "ecological flow" – to simply flow over the weir and return to the natural watercourse, in order to allow viable conditions to the aquatic environment. Also, where necessary, the construction of a fish ladder is required to allow the ascending and descending movement of fish along the river.

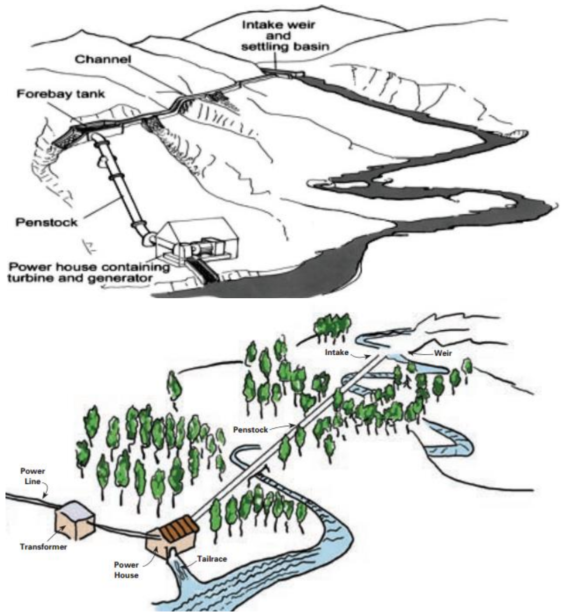
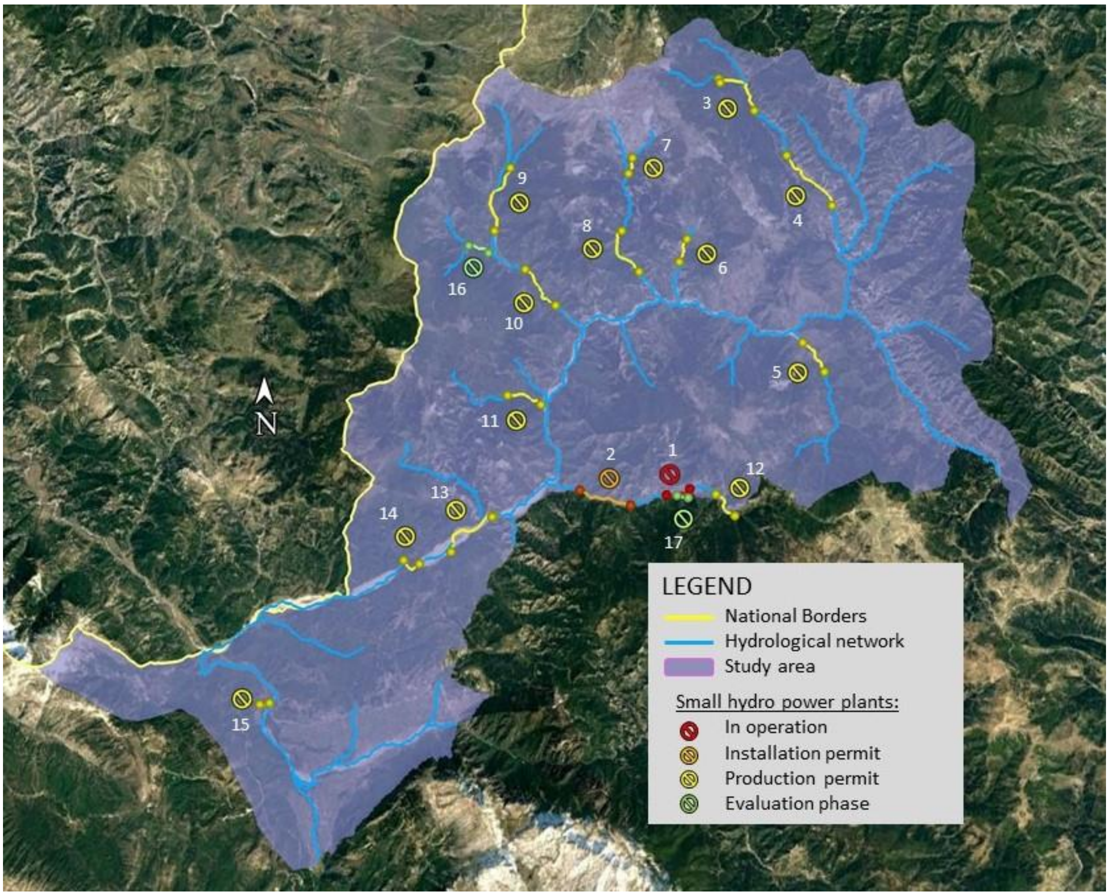


Figure 1. Depiction of typical SHPs configurations.

SHPs usually have fast environmental and licensing procedures, and since the equipment is usually in serial production, standardized and simplified, and as the civil works construction is also reduced, the projects may be developed rapidly. In Greece there are four licensing stages: all projects must start with an evaluation phase, move through a production permit and an installation permit, before getting an operation permit.

Currently, there is only one (1) SHP in operation within our study area. However, an immoderate number of further 16 are under consideration and at different licensing stages: 2 in evaluation phase, 13 with a production permit and 1 with an installation permit.



Map 7. SHPs (in operation and under consideration) within our study area.

SHPs are often portrayed as eco-friendly and described as nothing more than modern water-mills. Nevertheless, such projects can have a very serious impact on the environment, both at the local (impact on habitats and species) and at the landscape level. Such a claim is not only supported by relevant literature (Kelly- Richards et al., 2017; Pinho et al., 2007), but also from lessons drawn from similar projects elsewhere in Greece. Even though an in-depth impact assessment analysis of SHPs is beyond the scope of this study, some key impacts are summarized here:

- <u>Reduction of flow along the affected riverbed stretches</u>

Either by absence of adequate flow data, misguided assumptions or flawed design/engineering, natural watercourses are often left with insufficient (or even no) surface flow. This affects the health of the stream/ river and its ability to sustain aquatic life (including otters).

- <u>Obstruction of fish and other aquatic organism movements</u>

Fish ladders often prove to be a poor substitute that does not adequately restore the river's continuity. Fish ladders in Greece are often poorly designed/ maintained or even absent altogether. Such barriers can result in the loss of fish and other aquatic species from entire river stretches, severely affecting the trophic network they support (including otters).

- <u>Disturbance of the natural watercourse/ riparian vegetation</u>

Penstocks are typically dug underground; often parts of them cross or even follow the natural watercourses. The associated large-scale earthworks directly degrade natural river corridors and/ or riparian vegetation. This can both affect rivers' trophic networks as well as disrupt/ destroy potential otter resting places/ holts.

- Deforestation, erosion etc. due to related infrastructure

Construction and operation of roads (for access to the weir and the power house, also roads for penstock installation)/ power lines result in direct habitat degradation.

- Interruption of bedload transport

Reduction of sediment load resulting in water course modification and erosion downstream.
Even if through careful design and planning some of the above mentioned concerns could be mitigated, there are additional considerations when the affected area in question is of high natural (and aesthetic) value with no prior encroachment, as is the case in our study area.

- Fragmentation of habitats/ increased accessibility/ disturbance

The impact zone from opening a road and allowing access to previously secluded areas is not limited to the actual width of roads; such an encroachment can affect an area that can vary from a few hundred to a few thousand meters. Previously untouched rivers, even the most striking and valuable river stretches, often critical for the survival of many protected species (including otters), are being affected.

- Landscape impact

SHPs can dramatically change the character of a landscape. For a place such as our study area, a land of previously untouched rivers and crystal-clear wild streams, surrounded by wild mountains and extensive forests, such projects can quickly turn a landscape of outstanding wilderness, to an almost industrial-looking one.

As part of our investigation the SHP at the Vourkopotamos stream (the only currently operational within our study area) was inspected. The plant is using the "Tyrolean intake" method and at the time of inspection the water abstraction from the stream was total; after the weir no water was allowed to run along the natural watercourse, which was simply left dry. Also, no fish ladder has been constructed and it is perhaps not surprising that otters were found to be absent upstream the dam. There are plans for another three SHPs in Vourkopotamos stream alone.

Picture 7. The only currently in operation SHP within our study area (Vourkopotamos stream). No water is allowed to run after the weir; no fish ladder present. No otters upstream the SHP.

Furthermore, at least two of the proposed SHPs are designed in localities that were proven to be otter breeding sites (see Table 1). It is highly probable that a more comprehensive study would confirm many other proposed SHP sites to be associated with breeding sites. What is, perhaps, most alarming is that many of the proposed SHPs are designed in streams that were found to be almost dry at the time of the investigation (Picture 8). This is emblematic of the highly flawed subsidy arrangement that often results in contractors profiting mainly from the construction of the SHP itself, with viable energy production being a secondary consideration.

Picture 7. Marditsa stream, with only minimal surface flow (29/09/2019). A SHP is also designed here!! SHPs are being considered for many other streams with similar characteristics (minimal flow for a large part of the year).

The following Table (Table 1) summarises some of the impacts on the otter estimated to be caused by the SHPs under consideration. It should be clear that this approach concerns only specific otter related impacts and was produced taking into account only the general characteristics and the location of proposed SHPs. It therefore does not in any way attempt to emulate the Environmental Impact Assessment, which is an essential requirement for every SHP.

Conclusion:

The area under investigation was assessed as high value for the otter as it combines optimal foraging habitat with low disturbance and suitable riparian habitat for cover and breeding sites. This assessment is reflected by the identification of otter signs and their breeding sites along many of the watercourses within the study area. The existing favourable conservation status is currently under serious threat due to the impending construction of a large number of small hydro-power plants (SHPs). In order to safeguard the sustainability of the area's otter population, it is imperative that a thorough, complete and from the ground up re-evaluation of all planned SHPs take place, specifically taking into account the aggregate impact of SHPs, at least on a river basin level.

Table 1. Impacts on the otter estimated to be caused by the SHPs under consideration. SHP site numbers correspond with those in Map 7.

a/a	SHP site	Otter presence	Otter breeding site	Large-scale earthworks required (deforestation, watercourse disturbance)	Large-scale additional infrastructure required (roads, power lines)	Previous encroachment	Assessment of overall impact on the otter
Operation permit							
1	Vourkopotamos str. / Karamousi bridge	Already in operation					
Installation permit							
2	Vourkopotamos str.	Yes	?	No	No	Low	**Medium**
Production permit							
3	Sarandaporos springs	Yes	?	Yes	No	Medium	**Medium**
4	Sarandaporos r. (Chrisi)	Yes	?	No	No	Medium	**Medium**
5	Marditsa	Yes	?	No	Yes	Medium	**Medium**
6	Lygeri str. (Kefalohori)	No	No	No	No	Medium	**Medium**
7	Mavro potami	No	No	Yes	No	Medium	**Medium**
8	Pitsiliapis str.	Yes	?	Yes	Yes	Non existent	**High**
9	Gorgopotamos str.	No	No	No	No	Medium	**Medium**
10	Vourbianitiko	Yes	?	Yes	Yes	Low	**High**
11	Vathylakkos	Yes	Yes	Yes	Yes	Non existent	**Extreme**
12	Ellinikou str.	No	No	No	No	Medium	**Medium**
13	Agios Minas	Yes	?	Yes	Yes	Low	**High**
14	Sarandaporos r.	Yes	Yes	Yes	Yes	Non existent	**Extreme**
15	Aidonohori - Bourazani springs	?	?	No	No	High	**Low**
Evaluation phase							
16	Manouras str.	No	No	Yes	No	Medium	**Medium**
17	Mesopotamos str.	No	No	Yes	No	Medium	**Medium**

References

Calzada, J., Delibes-Mateos, M., Clavero, M. & Delibes, M. 2010. If drink coffee at the coffee-shop is the answer, what is the question? Some comments on the use of the sprainting index to monitor otters. Ecological Indicators 10: 560–561.

Chanin P. 2003a. Ecology of the European Otter. Conserving Natura 2000 Rivers Ecology Series No. 10. English Nature, Peterborough.

Chanin P. 2003b. Monitoring the Otter Lutra lutra. Conserving Natura2000 Rivers Monitoring Series No. 10, English Nature, Peterborough.

Chanin, P. 2013. Otters. Whittet Books Ltd, Stansted.

Epirus S.A. 2009 (Editor-in-Chief: Haritakis Papaioannou). Special Environmental Study (SES) of Grammos-Konitsa-Pogoni (precise title: "Update and Completion of the SES of the NATURA 2000 Network Areas: "Koryfes Orous Grammos" (GR 1320002) and preparation of SES for the area: "Oros Douskon, Oraiokastro, Dasos Meropis, Koilada Gormou, Limni Delvinaki" (GR 2130010). Region of Epirus (Directorate of Environment and Spatial Planning).

Gaethlich, M. 1988. Otters in Western Greece and Corfu. IUCN Otter Spec. Group Bull. 3: 17 - 23

Galanaki, A. and Gaethlich, M. 2009. Lutra lutra (Linnaeus, 1758). In: Red data book of the threatened animal species of Greece. Legakis, A. & Maragou, P. (eds.), pp. 380-382, Hellenic Zoological Society, Athens.

Kelly-Richards, S., Silber-Coats, N., Crootof, A., Tecklin, D., & Bauer, C. 2017. Governing the transition to renewable energy: A review of impacts and policy issues in the small hydropower boom. Energy Policy, 101, 251–264.

Krawczyk, A.J., Bogdziewicz, M., Majkowska, K. & Glazaczow, A. 2016. Diet composition of the Eurasian otter Lutra lutra in different freshwater habitats of temperate Europe: a review and meta-analysis. Mammal Review 46 (2): 106-113.

Kruuk, H. 1995. Wild Otters: Predation and populations. Oxford University Press, Oxford.

Kruuk, H. 2006. Otters: Ecology, behaviour and conservation. Oxford: Oxford University Press.

Kruuk, H., Carss, D.N., Conroy, J.W.H. & Gaywood, M.J. 1998. Habitat use and conservation of otters (Lutra lutra) in Britain: a review. In: Behaviour and ecology of riparian mammals. Dunstone N. & Gorman M. (eds.), pp. 119-134, Cambridge University Press, U.K.

Lenton E.J., Chanin P.R.F. & Jefferies D.J. 1980. Otter survey of England 1977-79. Nature Conservancy Council, London: 1-75.

Liles, G. 2003. Otter Breeding Sites. Conservation and Management. Conserving Natura 2000 Rivers, Conservation Techniques Series No. 5. English Nature, Peterborough.

López-Martín, J.M., Jiménez, J. & Ruiz-Olmo, J. 1998. Caracterización y uso del hábitat de la Nutria Lutra lutra (Linné, 1758) en un río de carácter mediterráneo. Galemys 10 (N.E.): 175-190.

Mason, C. 1990. An introduction to the otters. In: Otters an Action Plan for their Conservation. Foster-Turley P., Macdonald S. & Mason C. (eds.), pp. 4-7, IUCN/SSC Otter Specialist Group. Gland, Switzerland.

Mertzanis, G. (ed.) 2008. Monitoring programme on the fauna of the Northern Pindos National Park. Final report, Callisto, p. 808 + maps.

Pinho, P., Maia, R. & Monterroso, A. 2007. The Quality of Portuguese Environmental Impact Studies: The Case of Small Hydropower Projects. Environmental Impact Assessment Review. 27. 189-205.

Remonti, L., Balestrieri, A. & Prigioni, C. 2009. Altitudinal gradient of Eurasian otter (Lutra lutra) food niche in Mediterranean habitats. Can. J. Zool. 87: 285–291.

Reuther, C., Dolch, D., Green, R., Jahrl, J., Jefferies, D., Krekemeyer, A., Kucerova, M., Madsen, A.B., Romanowski, J., Roche, K., Ruiz-Olmo, J., Teubner, J., Trindade, A. 2000. Surveying and Monitoring Distribution and Population Trends of the Eurasian Otter (Lutra lutra). Habitat 12, 152pp.

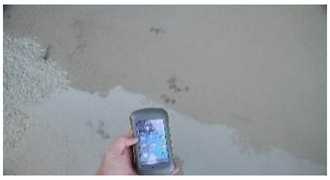
Roos, A., Loy, A., de Silva, P., Hajkova, P. & Zemanová, B. Lutra lutra. The IUCN Red List of Threatened Species 2015: e.T12419A21935287. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12419A21935287.en. Downloaded on 23 November 2019.

Theodoropoulos, Y. 2006. The otter (Lutra lutra) in the river system of Aoos - Voidomatis (Northern Pindos National Park). MSc thesis. University of Ioannina.

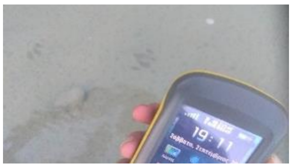
3rd National Six-Year Report on the Implementation of Directive 92/43/EEC. 2014.

Annex I – Survey sites

Site No	Otter sign	Coordinates	Assesment
1		N: 40.060710	Positive
		E: 20.588610	
2		N: 40.050850	Positive
		E: 20.633310	
3		N: 40.015900	Positive
		E: 20.644740	
4		N: 39.973020	Positive
		E: 20.658760	
5		N: 40.021140	Positive
		E: 20.686220	
6		N: 40.036680	Positive
		E: 20.744780	
7		N: 40.069000	Negative
		E: 20.673310	
8		N: 40.088100	Positive
		E: 20.624630	

Site No	Otter sign	Coordinates	Assesment
9		N: 40.095530	Positive
		E: 20.677020	
10		N: 40.110220	Positive
		E: 20.721270	
11		N: 40.149200	Positive
		E: 20.751170	
12		N: 40.160655	Negative
		E: 20.712053	
13		N: 40.134370	Positive
		E: 20.778620	
14		N: 40.143561	Positive
		E: 20.826303	
15		N: 40.142698	Positive
		E: 20.877022	
16		N: 40.133217	Negative
		E: 20.919268	
17		N: 40.166498	Positive
		E: 20.805429	

Site No	Otter sign	Coordinates	Assesment
18		N: 40.190495 E: 20.778263	Positive
19		N: 40.204443 E: 20.786543	Unsuitable for survey
20		N: 40.214063 E: 20.820514	Positive
21		N: 40.243250 E: 20.796810	Positive
22		N: 40.265218 E: 20.749174	Negative
23		N: 40.283080 E: 20.768065	Negative
24		N: 40.323385 E: 20.778731	Negative
25		N: 40.317508 E: 20.799018	Negative
26		N: 40.215901 E: 20.853264	Positive

Site No	Otter sign	Coordinates	Assesment
27		N: 40.253750	Positive
		E: 20.856488	
28		N: 40.284660	Positive
		E: 20.855291	
29		N: 40.314620	Negative
		E: 20.848160	
30		N: 40.265981	Negative
		E: 20.892306	
31		N: 40.235380	Positive
		E: 20.895310	
32		N: 40.207026	Negative
		E: 20.917199	
33		N: 40.219620	Positive
		E: 20.945590	
34		N: 40.175590	Positive
		E: 20.982040	
35		N: 40.229340	Positive
		E: 20.987410	

Site No	Otter sign	Coordinates	Assesment
36		N: 40.202900	Positive
		E: 21.016720	
37		N: 40.171990	Positive
		E: 21.042640	
38		N: 40.150830	Positive
		E: 21.083010	
39		N: 40.222820	Positive
		E: 21.031270	
40		N: 40.258187	Positive
		E: 21.007334	
41		N: 40.285670	Positive
		E: 21.024040	
42		N: 40.298390	Positive
		E: 21.054430	
43		N: 40.274750	Positive
		E: 21.003940	
44		N: 40.306505	Unsuitable for survey
		E: 20.975063	

Site No	Otter sign	Coordinates	Assesment
45		N: 40.317100	Positive
		E: 21.003890	
46		N: 40.271760	Positive
		E: 20.983900	
47		N: 40.299840	Positive
		E: 20.957790	
48		N: 40.326160	Positive
		E: 20.934690	
49		N: 40.340180	Unsuitable for survey
		E: 20.895320	
50		N: 40.360840	Positive
		E: 20.905270	

Annex II – Further photographic documentation

Picture 8. Zouzouliotiko stream.

Picture 9. Vourbianitiko stream. A SHP is considered here.

Picture 10. View of the Sarandaporos river valley at the point of confluence with the Pistiliapis stream. SHPs are under consideration for both the main course of the Sarandaporos river and the Pistiliapis stream.

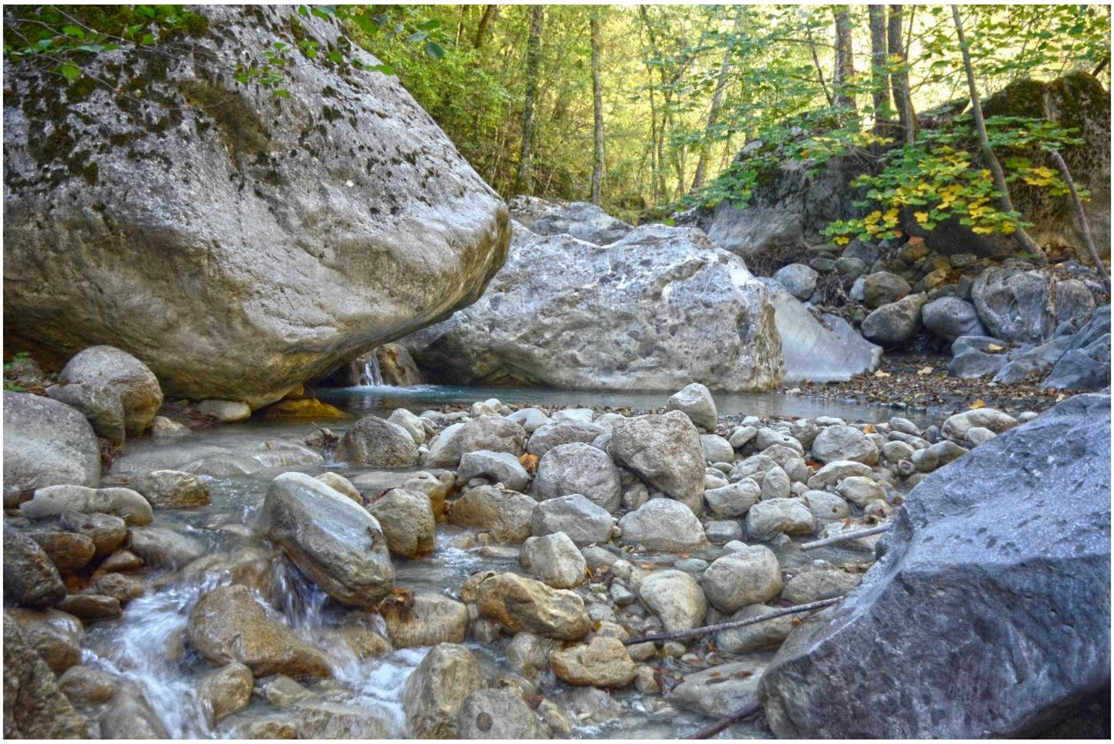
Picture 11. The wide gravel floodplain of the Sarandaporos river.

Picture 12. Vourkopotamos stream. The construction of three additional SHPs is considered here.

Picture 13. Lash riparian vegetation along the Amarandos stream.

Picture 14. The Aoos river just after exiting its gorge, next to the town of Konitsa (seen in the background). This area is under pressure from large-scale gravel extraction.

Picture 15. The confluence of Aoos and Voidomatis rivers. The only significant area of arable land within our study area. Important riparian forests still stretch for much of the distance between here and Bourazani bridge.



Picture 17. Vathylakkos stream, an otter breeding site. A SHP is considered here.

Picture 16. Potential otter holt at Vathylakkos stream.

Contribution to the knowledge of Odonata fauna from Aoos catchment

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Abstract

Aoos/Vjosa is one of the last intact river systems in Europe of significant biodiversity value. Odonata fauna is a key element of wetland habitats, as an insect group dependent on aquatic environments. At the same time, Odonata is one of the less studied orders in Greece and the aim of our study is to highlight the importance of Aoos' catchment area for Odonata species and to investigate their most important habitats. A number of 22 stations and the most representing habitats including ponds, streams, gravel riversides, rich riparian vegetation riversides and banks of reservoir were surveyed, following the methodology of time constrain visits of 15 minutes and line transects. A total number of 29 Odonata species were reported (37,7% of the Greek Odonata fauna known). Species like *Lestes dryas*, *Lestes parvidens*, *Ischnura pumilio*, *Enallagma cyathigerum*, *Coenagrion scitulum*, *Aeshna cyanea*, *Cordulia aenea* and *Sympetrum pedemontanum* are newly reported for the area, while the reported species *Caliaeschna microstigma* and *Cordulegaster bidentata* have a conservation concern as their global population trend is decreasing. Ponds and streams hosted the highest number of species and abundances, while gravel riversides and reservoirs' banks hosted the lowest number of species. Additionally, reservoir's banks were the only habitat without Odonata species observed in the majority of stations.

Keywords: Odonata, Dragonflies, Greece, catchment area, biodiversity, species richness, species composition

Introduction

The insect order Odonata is consisted of species dependent on aquatic environments and mainly on freshwater habitats at all stages of their life cycle. Both larvae and adults are predators. Many previous studies suggest the importance of this group of insects as bioindicators of water quality in many different aquatic habitats (Corbet 1999; Catling 2005). Many studies conclude that the composition and richness of Odonata species may be changed due to different water quality (Catling 2005; Villanueva 2010), but also due to small hydroelectric power plants (Klein et al. 2018) or the construction of a reservoir (Fulan et al. 2010).

The order is relatively well studied, with at least 5860 different species globally (Kalkman et al. 2008). In Greece, a number of 77 species have been reported (Kalkman et al. 2010) but very few studies have been conducted in the majority of Greek wetlands that can pose new scientific data on distribution and status of the different species of Odonata. Respectively, the Aoos/Vjosa catchment area is a poorly studied area in European level with reference to this insect order.

Materials and methods

The study area is the greek part of river Aoos and its main tributaries, Voidomatis and Sarantaporos. The river Aoos is located in northwestern Greece in the region of Epirus. Its total length is about 272 Km, of which the first 80 Km are in Greece and the remaining 192 Km in Albania. Its sources lays in the Pindus mountain range, where a big dam for hydroelectric power production has been constructed, creating an artificial lake (or reservoir). The river flows through the North Pindos National Park, the valley of Konitsa, enters Albania near the village of Molivdoskepastos and flows into the Adriatic sea, north of the Narte lagoon. In Greece a significant area of the river is protected by a network of protected areas (Natura 2000). During the field survey, a total number of 22 Sampling stations were surveyed. The stations were set including the main different habitats of Odonata species within the catchment area of Aoos. 4 stations (5,6,7,16) were set in small ponds with stagnant water, 4 stations (2,3,14,20) in streams, 5 stations (1,4,8,11,22) in riversides with rich riparian vegetation, 5 stations (9,10,12,13,21) in riversides with gravel, without vegetation and 4 stations (15,17,18,19) in the banks of the artificial lake in the springs of the river (Fig.2). The minimum distance between the stations was 1 Km. Stations were surveyed monthly during the period June-September 2019. A total number of 12 field days were conducted and 4 repetitions for each station. The method that was followed in each station was the time constraint visits of 15 minutes duration. Odonata species and their numbers were recorded using the method of Line transects for a distance of 150m. Equipment that was used for the recording of specimens was a Nikon D-slr camera equipped with a macro lens 105mm and binoculars (Pentax 8,5X21). For the identification of each species that appeared identical by using field characteristics (like genus *Pyrrhosoma*), specimens were collected using entomological aerial nets, placed in entomological envelopes labeled with date, station of capture and analyzed in Stereo-Microscope Bresser researcher ICD/WF 10X in the laboratory.

Fig 1: Typical habitats of Aoos catchment area, riverside with rich riparian vegetation (top left), stream (top right), riverside with gravels (bottom left) and ponds (bottom right).

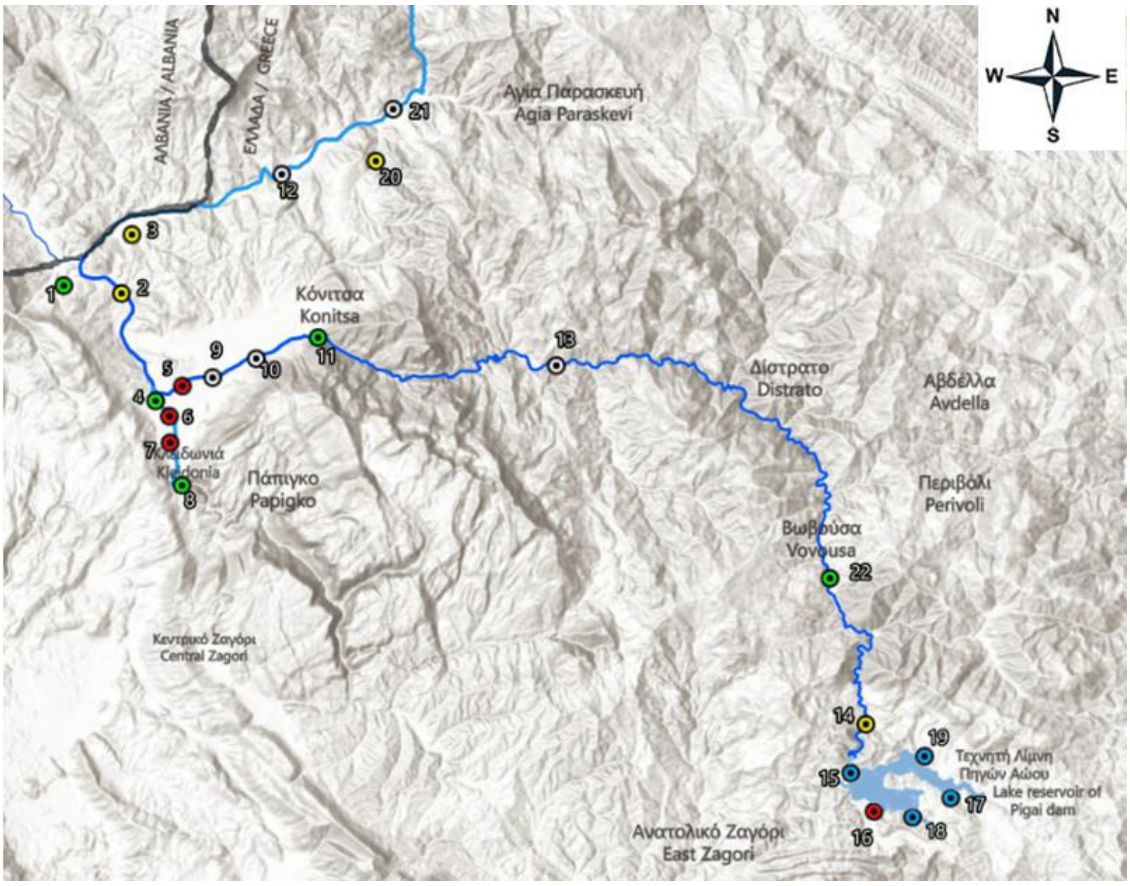

Fig.2: Sampling stations in the catchment area of Aoos. Stations of small ponds are indicated with red coloured circle, stations of streams are indicated with yellow, stations of rich riparian vegetation with green, stations of gravel riversides with white and stations of artificial lake's banks with blue.

Results

During the present study a number of 27 Odonata species were reported in all stations and 2 more species outside the stations, summing up to a total number of 29 different Odonata species for the catchment area of Aoos, which covers a share of 37,7% of all known species inhabiting Greece. Of these, 14 species belong to the suborder of Zygoptera and 15 species belong to the suborder of Anisoptera. The observed species inventory is listed below:

Suborder Zygoptera

Family Calopterygidae: *Calopteryx splendens, Calopteryx virgo*

Family Euphaeidae: *Epallage fatime*

Family Lestidae: *Lestes dryas, Lestes virens, Lestes parvidens*

Family Coenagrionidae: *Ischnura elegans, Ischnura pumilio, Enallagma cyathigerum, Coenagrion puella, Coenagrion scitulum, Erythromma lindenii, Pyrrhosoma nymphula*

Family Platycnemididae: *Platycnemis pennipes*

Suborder Anisoptera

Family Aeshnidae: *Aeshna cyanea, Anax imperator, Caliaeschna microstigma*

Family Gomphidae: *Gomphus vulgatissimus, Onychogomphus forcipatus*

Family Cordulegastridae: *Cordulegaster bidentata, Cordulia aenea, Somatochlora meridionalis*

Family Libellulidae: *Libellula depressa, Orthetrum cancellatum, Orthetrum brunneum, Sympetrum pedemontanum, Sympetrum fonscolombii, Sympetrum striolatum, Crocothemis erythraea*

Concerning the selection of habitats from the species it was found that stations of small ponds with stagnant waters (''Ponds'') hosted the highest species number, a total of 22 species and on the opposite, stations at riversides with gravels, without vegetation (''Gravel'') and stations on the banks of the artificial lake (''Reservoir'') hosted the lowest numbers, a total of 2 and 5 species, respectively as shown in table 1. Species like *Calopteryx splendens*, *Calopteryx virgo*, *Onychogomphus forcipatus* were present in a wide variety of habitats and species like *Lestes dryas*, *Lestes virens*, *Caliaeschna microstigma*, *Erythromma lindenii* were restricted only to a single type of habitat.

Table 1: Presence of Odonata species in the different types of habitats. The species *Cordulia aenea* and *Sympetrum pedemontanum* are not included as they were observed outside the stations.

Species	Ponds	Gravels	Riparian	Streams	Reservoir
Calopteryx splendens	+	+	+	+	-
Calopteryx virgo	+	-	+	+	-
Epallage fatime	-	-	+	+	-
Lestes dryas	-	-	-	+	-
Lestes virens	-	-	-	+	-
Lestes parvidens	+	-	-	-	-
Ischnura elegans	+	-	-	+	-
Ischnura pumilio	+	-	-	-	-
Coenagrion puella	+	-	-	+	+
Coenagrion scitulum	+	-	-	-	-
Erythromma lindenii	+	-	-	-	-
Pyrrhosoma nymphula	+	-	+	+	-
Enallagma cyathigerum	+	-	-	-	-
Platycnemis pennipes	+	-	-	+	+
Aeshna cyanea	+	-	-	+	-
Anax imperator	+	-	-	-	+
Caliaeschna microstigma	-	-	-	+	-
Gomphus vulgatissimus	-	-	-	+	+
Onychogomphus forcipatus	+	+	+	+	-
Cordulegaster bidentata	+	-	+	+	-
Somatochlora meridionalis	+	-	-	-	-
Libellula depressa	+	-	-	+	-
Orthetrum cancellatum	+	-	-	-	+
Orthetrum brunneum	+	-	-	+	-
Sympetrum fonscolombii	+	-	-	-	-
Sympetrum striolatum	+	-	-	+	-
Crocothemis erythraea	+	-	-	-	-
Total	**22**	**2**	**6**	**17**	**5**

Fig. 3: 1. *Aeshna cyanea* in flight (left); 2. Side view of male's appendages of *Pyrrhosoma nymphula* (right).

Platycnemis pennipes was the most abundant Odonata species at the majority of stations at small ponds during the period June-August, while *Sympetrum striolatum* was the most abundant species during September (Fig. 4). Additionally, *Calopteryx virgo*, *Coenagrion puella* and *Orthetrum brunneum* were also abundant species in this type of habitat. Species like *Lestes parvidens*, *Ischnura pumilio*, *Coenagrion scitulum*, *Erythromma lindenii*, *Enallagma cyathigerum*, *Somatochlora meridionalis*, *Sympetrum fonscolombii* and *Crocothemis erythraea* were present only in this type of habitat.

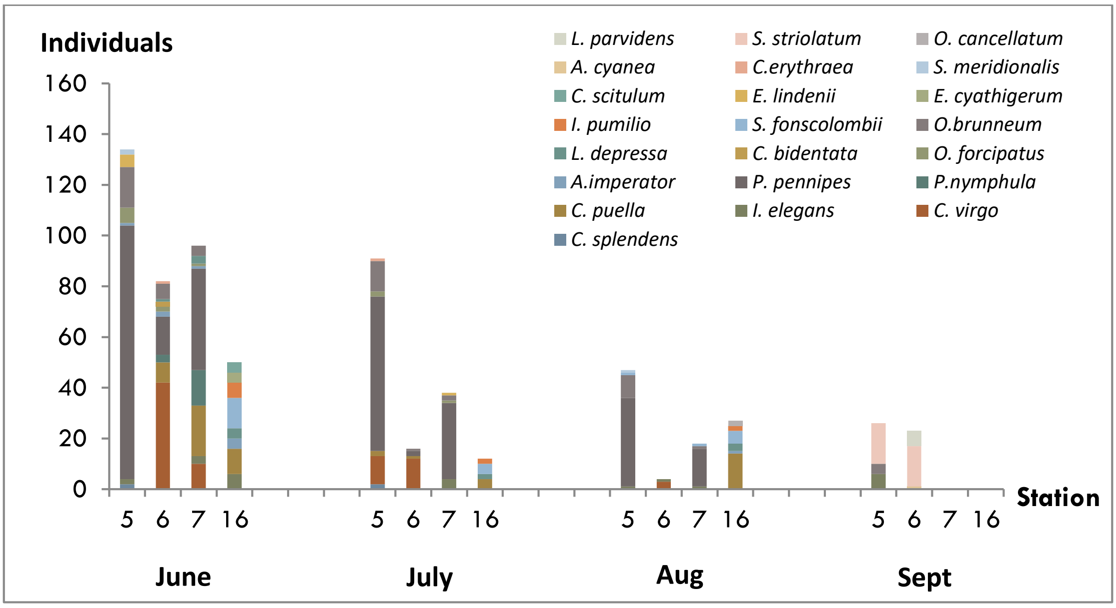

Fig. 4: Number of individuals of different species that were observed in stations of ponds with stagnant water (''Ponds'') during the surveys of June, July, August and September.

Calopteryx virgo, *Caliaeschna microstigma*, *Platycnemis pennipes* were the most abundant species in stream habitats especially during the period June-August, while *Lestes virens* was the most abundant during September. *Lestes dryas, Lestes virens* and *Caliaeschna microstigma* were restricted only to this type of habitat (Fig 5).

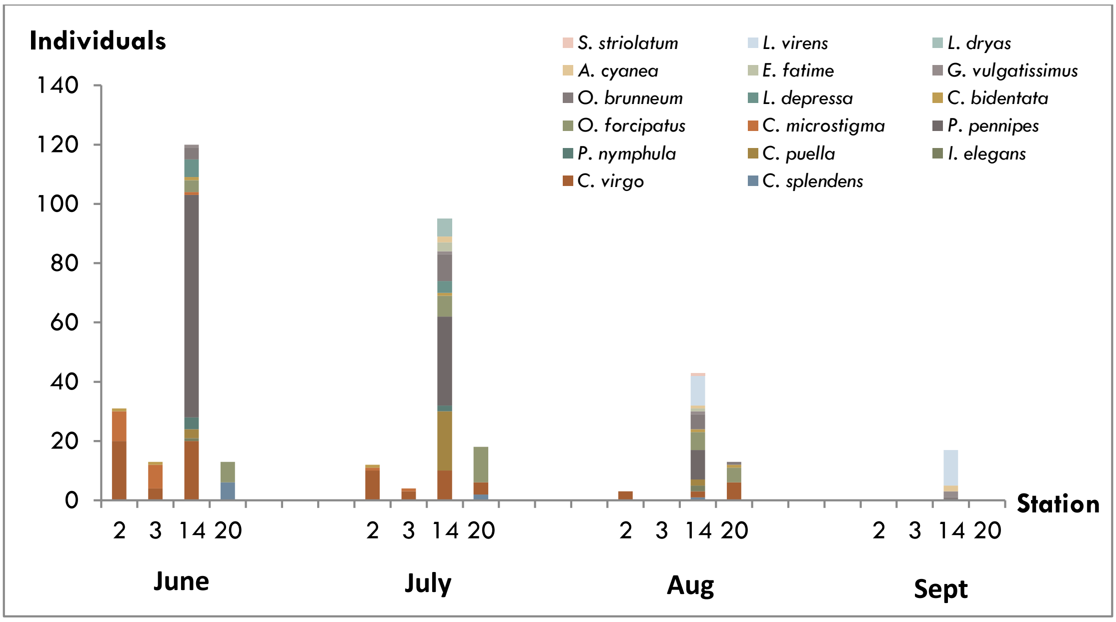

Fig. 5: Number of individuals of different species that were observed in stations of streams (''Streams'') during the surveys of June, July, August and September.

A lower number of species was present riverside habitats with rich riparian vegetation and at riverside habitats with gravel. *Calopteryx virgo* was the most abundant species in all 5 ''Riparian'' stations especially during June (Fig. 6), and *Onychogomphus forcipatus* was present and abundant in all 5 ''Gravel'' stations (Fig. 7).

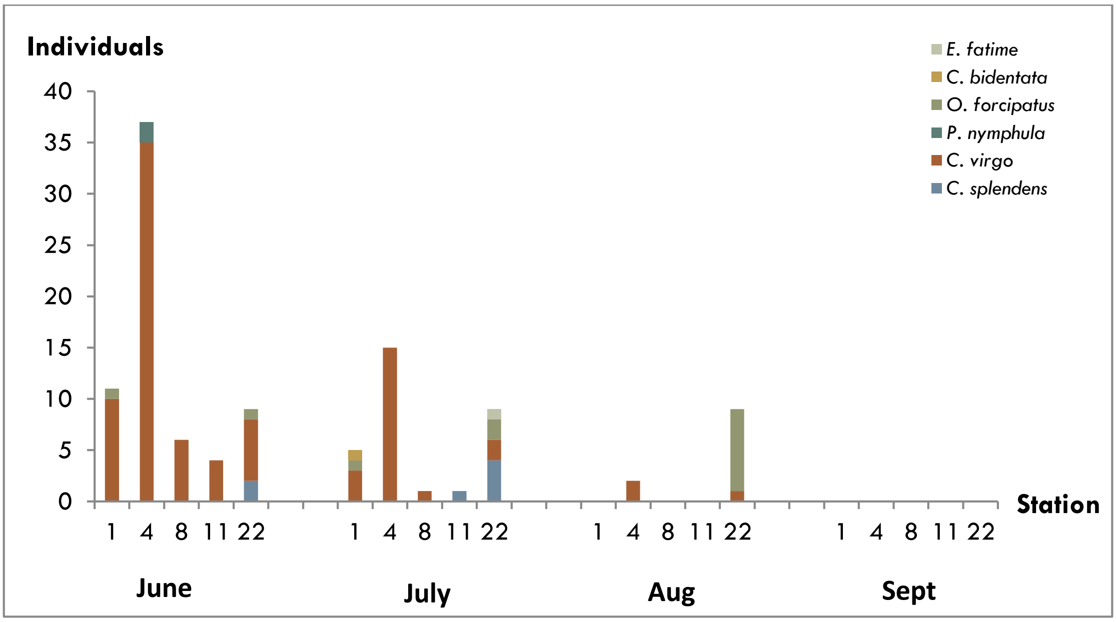

Fig. 6: Number of individuals of different species that were observed in stations of riversides dominated with rich riparian vegetation (''Riparian'') during the surveys of June, July, August and September.

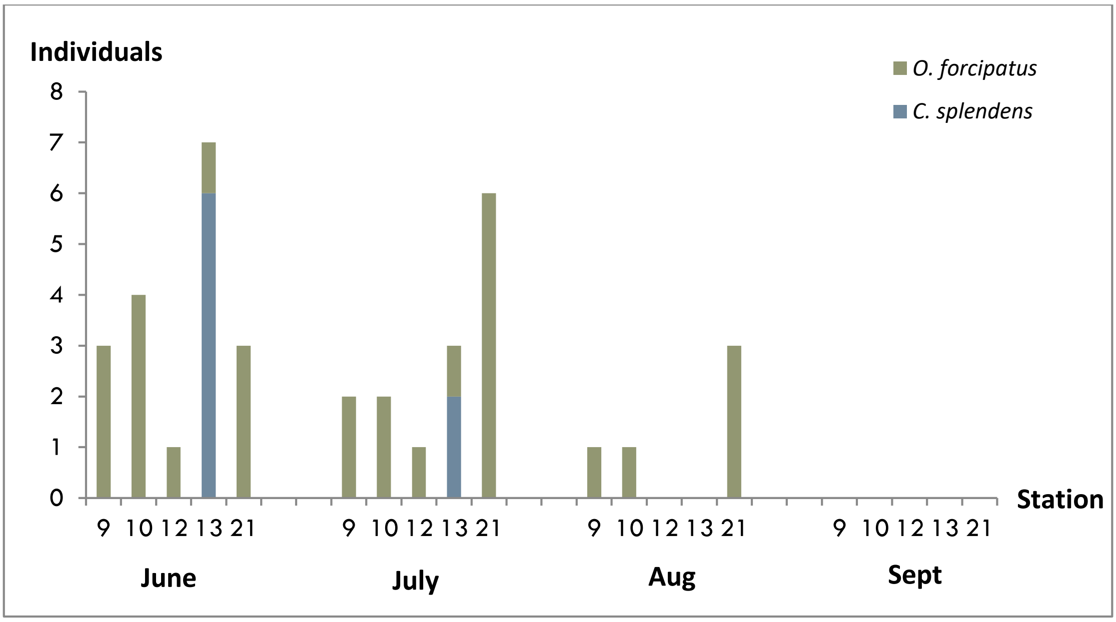

Fig. 7: Number of individuals of different species that were observed in stations of riversides with gravels and without vegetation (''Gravels'') during the surveys of June, July, August and September.

At most stations on the banks of the artificial lake there wasn't any Odonata species observed and only one station (station 18) hosted a significant number of species during June. *Coenagrion puella* was the most abundant species in this type of habitat only for a short period, during June (Fig 8).

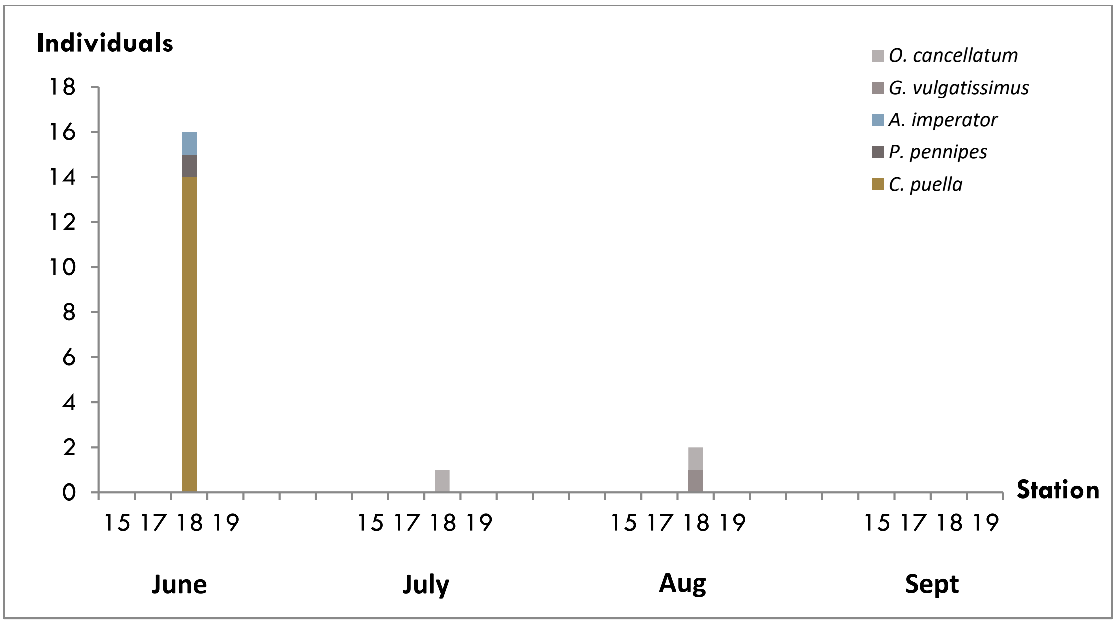

Fig. 8: Number of individuals of different species that were observed in stations on the banks of the artificial lake (''Reservoir'') during the surveys of June, July, August and September.

Discussion

Based on the results of this study, a total number of 29 Odonata species was recorded in the Greek part of the Aoos/Vjosa catchment area, nearly half the number of the total Odonata fauna in Greece. Also, if we take on account previous studies that were conducted on the Albanian part of the river (Shkëmbi et al. 2018) the whole river system hosts a significant number of 41 species. *Lestes dryas*, *Lestes parvidens*, *Ischnura pumilio*, *Enallagma cyathigerum*, *Coenagrion scitulum*, *Aeshna cyanea*, *Cordulia aenea* and *Sympetrum pedemontanum* are newly reported in the area. The Aoos' catchment area hosts species that are restricted only to the southeastern Balkan at European level, like *Epallage fatime* and *Caliaeschna microstigma*. Also, the area hosts species of conservation concern and according to the European Red List for Dragonflies the species *Epallage fatime*, *Caliaeschna microstigma* and *Cordulegaster bidentata* are listed as Near Threatened (NT) with a Decreasing population trend.

Additionally, it is clear that habitats of small ponds along the riverside and streams host a rich diversity and populations of Odonata species. They are the most critical habitats for species of conservational importance. On the other side, reservoir's banks host low diversity and few numbers of Odonata species and the majority of stations are unsuitable for Odonata species throughout the year. Changes of water level due to damming have significant impacts on physical, chemical, geomorphological, and hydrologic modifications that affect biodiversity dependent on aquatic habitats (Brendenhand & Samways 2009; Lessard & Hayes 2003). Concerning the installation of a big scale dam, an additional negative impact is habitat change and dominance of the artificial lake type of habitat with fluctuating water levels and lack of riparian vegetation, creating an unfavorable environment for many benthic macroinvertabrates (Petts et al. 1993). Negative effects of dams for hydroelectric power production on biodiversity must be taken into account prior to their installation.

Acknowledgment

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References

Bredenhand E. & Samways M.J., 2009: Impact of a dam on benthic macroinvertebrates in a small river in a biodiversity hotspot: Cape Floristic Region, South Africa. Journal of Insect Conservation 13, 297–307.

Bulankova E., 1997: Dragonflies (Odonata) as bioindicators of environment quality. Biologia 52(2), 177-180.

Catling P.M., 2005: A potential for the use of dragonfly (Odonata) diversity as a bioindicator of the efficiency of sewage lagoons. Canadian Field-Naturalist 119(2), 233-236.

Chovanec A. & Raab R., 1997: Dragonflies (Insecta, Odonata) and the Ecological Status of Newly Created Wetlands-Examples for Long term Bioindication Programmes. Limnologica 27(3-4), 381-392.

Chovanec A. & Waringer J., 2001: Ecological integrity of river-floodplain systems - assessment by dragonfly surveys (Insecta: Odonata). Regul. Rivers: Res. Mgmt 17, 493-507.

Corbet P.S., 1999: Dragonflies Behaviour and Ecology of Odonata. Harley Books, Essex, England.

D'Amico F., Darblade S., Avignon S., Blanc-Manel S. & Ormerod S.J., 2004: Odonates as indicators of shallow lake restoration by liming: comparing adult and larval responses. Restoration Ecology 12, 439–446.

Dijkstra K.-D.B. & Lewington R., 2006: Field Guide to the Dragonflies of Britain and Europe. 320, Britisch Wildlife Publishing, Gillingham.

Dumont H.J., Mertens J., Miho A., 1993: A contribution to the knowledge of the Odonata of Albania. Opusc. zool. flumin., 113, 1–10.

Fulan J.A., Raimundo R., Figueiredo D. & Correia M., 2010: Abundance and diversity of dragonflies four years after the construction of a reservoir. Limnetica 29(2), 279-286.

Kalkman V.J., Boudot-P.J., Bernard R., Conze -J.K., De Knijf G., Dyatlova E., Ferreira S.,

Jović M., Ott J., Riservato E. & Sahlén G., 2010: European Red List of Dragonflies. Luxembourg: Publications Office of the IUCN.

Kalkman V.J., Clausnitzer V., Dijkstra K.-D.B., Orr A.G., Paulson D. R. & van Tol J., 2008:

Global diversity of dragonflies (Odonata) in freshwater. Hydrobiologia 595, 351–363.

Kalkman V.J. & Lopau W., 2006: Identification of Pyrrhosoma elisabethae with notes on its distribution and habitat (Odonata: Coenagrionidae). International Journal of Odonatology 9(2), 175-184.

Klein C.E., Pinto N.S., Spigoloni Z.A.V., Bergamini F.M., De Melo F.R., De Marco P. & Juen L., 2018: The influence of small hydroelectric power plants on the richness and composition of Odonata species in the Brazilian Savanna. International Journal of Odonatology 21, 33-44.

Lessard J.L. & Hayes D.B., 2003: Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. Regul. Rivers 19, 721-732.

Muranyi D., 2007: Contribution to the Odonata fauna of Albania. Folia Entomologica Hungarica 68, 41-53.

Petts G.E., Armitage P.D. & Castella E., 1993: Physical habitat changes and macroinvertebrate response to river regulation: the river Rede, UK. Regul. Rivers 8 (1-2), 167-178.

Riservato E., Boudot J.P., Ferreira S., Jovic´ M., Kalkman V.J., Schneider W., Samraoui B., Cuttelod A., 2009: The Status and Distribution of Dragonflies of the Mediterranean Basin. IUCN, Gland, Switzerland and Malaga, Spain. 33 pp.

Sahlén G., Bernard R., Rivera A.C., Katelaar R. & Suhling F., 2004: Critical species of Odonata in Europe. International Journal of Odonatology 7(2), 385-398.

Samuel F.M., Ernest K., Gideon A., Felix B.B.C. & Thomas N., 2012: Impact of dam construction on the diversity of benthic macroinvertebrates community in a periurban stream in Cameroon. International Journal of Biosciences 11(2), 137-145.

Shkëmbi E., Gerken B., Pepa B., Kiçaj H., Misja K. & Paparisto A., 2018: Contribution to the knowledge of Odonata from Vjosa catchment. Acta ZooBot Austria 155: 239-250.

Smith J., Samways M.J. & Taylor S., 2007: Assessing riparian quality using two complementary sets of bioindicators. Biodiversity and Conservation 16, 2695-2713.

Villanueva R.J.T., 2010: Adult Odonata community in Dinagat Island, The Philippines: Impact of chromium ore mining on density and species composition. Odonatologica 39(2), 119-126.

Annex I – Photographic documentation of Odonata Species

Figure 23: *Calopteryx splendens*, a species recorded in a variety of habitats (streams, gravel banks, lakeside lakes, and ponds

Figure 24: *Calopteryx virgo*, a species recorded in a variety of habitats (streams, gravel banks, lakeside lakes, and ponds).

Figure 25: *Onychogomphus forcipatus*, one of the most characteristic species on the sunny pebbles of the river.

Figure 26: *Gomphus vulgatissimus*, a species with a limited distribution, found mainly at stations near the artificial lake of the Pigai dam.

Figure 27: *Sympetrum striolatum*, a species mainly present in stagnant ponds, with the most important populations observed in September.

Figure 28: *Aeshna cyanea*, species present until late September, mainly in stagnant ponds.

Figure 29: *Pyrrhosoma nymphula*, a species present in a variety of habitats during the first summer months (ponds, lakeside banks and streams).

Figure 30: *Ischnura elegans*, species present in a variety of habitats (ponds, lakeside lakes and streams).

Figure 31: *Coenagrion puella* during the mating stage.

Figure 32: *Lestes parvidens*, a species with very limited distribution, as it was located in only in 1 sampling station.

Figure 33: *Epallage fatime*, one of the most important species in the region, as the European distribution of the species includes exclusively the Southeast Balkans. In the area of Aoos it was observed at stations mainly within the first few kilometers of the river.

Figure 34: *Crocothemis erythraea*, a small species in stations with small stagnant lakes.

Figure 35: *Cordulegaster bidentata*, a species mainly present in streams.

Figure 36: *Sympetrum pedemontanum*. This is a first report of the species in the Aoos region. It was located in an area outside the sampling stations, near a canal in the Konitsa plain.

Figure 37: *Orthetrum brunneum*, common species in stagnant waters.

Figure 38: *Enallagma cyathigerum*, a species with limited distribution and presence in small lakes with stagnant waters.