

## CONTRIBUTION TO THE HERPETOFAUNA (AMPHIBIANS & REPTILES) OF THE KORNATI ACHIPELAGO, CROATIA

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In this paper, we present data about the herpetofauna of the Kornati islands, with special reference to Kornat and Žut, collected during several field trips in 2009. Together with the personal comments from our colleagues and literature data, 1 amphibian and 11 reptile species were recorded on the islands. There is a possibility that *Emys orbicularis* is now extinct from the island of Kornat, as well as that *Testudo hermannii* has been introduced on the island of Žut.

**Keywords:** Kornat, Žut, Tarac, amphibians, reptiles, distribution, extinction

**Koren, T., Lauš, B., Burić, I. & Kuljerić, M.: Prilog poznavanju herpetofaune (vodozemci i gmazovi) Kornatskog otočja, Hrvatska. Nat. Croat., Vol. 20, No. 2., 387–396, 2011, Zagreb.**

U ovom radu predstavljamo rezultate o herpetofauni Kornatskog otočja, s posebnim osvrtom na Kornat i Žut, sakupljenih tijekom nekoliko terenskih izlazaka u 2009 godini. Zajedno s osobnim komentarima naših kolega i literaturnim podatcima, na Kornatskom otočju zabilježena je jedna vrsta vodozemca i 11 vrsta gmazova. Postoji mogućnost da je barska kornjača, *Emys orbicularis*, u potpunosti nestala s otoka Kornata dok je kopnena kornjača (*Testudo hermannii*) vjerojatno unesena na otok Žut.

**Ključne riječi:** Kornat, Žut, Tarac, vodozemci, gmazovi, rasprostranjenost, izumiranje

### INTRODUCTION

The Kornati islands are a unique, well-indented group of islands situated along the central part of the eastern Adriatic coast, between the Zadar and Šibenik archipelagos (FRIGANOVIĆ, 1995). There are more than 140 islands and islets over an area of 232.40 km<sup>2</sup> (KULUŠIĆ, 1965). All of these islands can be sorted into four smaller groups, depending on the direction of their extension, as well as their geographic position. Those are: the Upper Kornati islands with two groups – Žut and Sit with the pertaining small islands, and the Lower Kornati islands with two other groups

– Kornat and Piškera with pertaining islands. The islands of Kornat (32, 45 km<sup>2</sup>) and Žut (14, 83 km<sup>2</sup>) are the largest in this archipelago, and most of our research was based on them (URL1).

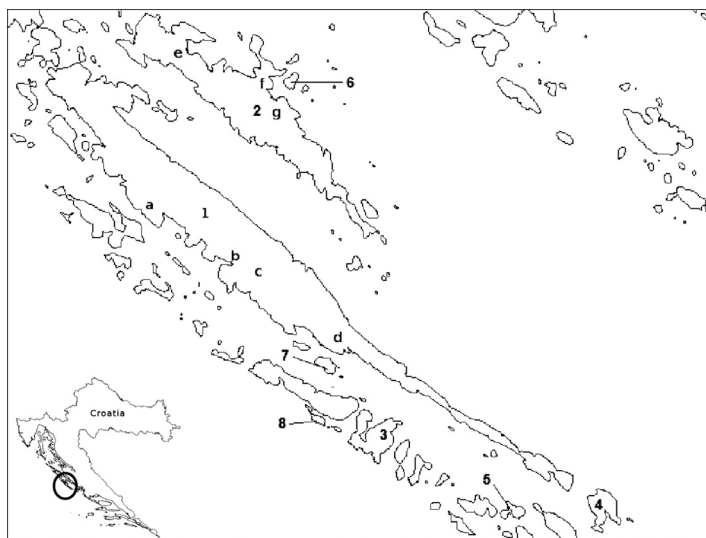
Geologically speaking, these islands are built mostly of Cretaceous limestone and dolomites, as well as of Eocene limestone. The islands can be characterized as a typical karst area, including almost all of the morphological forms, such as karrens, pits, caves, karst sinkholes, karst depressions etc. Because of the secondary carbonate porous geological structure and the adverse annual distribution of precipitation on the islands, there are no very large water bodies on the surface. There are some exceptions in the form of smaller pools, which serve as precious waterholes for livestock. The islands are covered with a thin layer of red soil, which supports a sparse vegetation. Due to the scarce soil and vegetation, dew is usually abundant and partly replaces the rain. A thicker layer of red soil is present only in a few fields and karst depressions; but even then it is mixed with outcrops of dolomite and limestone. Despite that, it is still the only fertile soil suitable for olive groves, vineyards and orchards (URL1).

According to the Köppen classification, the Kornati Islands belong to the Csa climate zone, commonly referred to as »the olive climate« (ŠEGOTA, 2003). The Csa climate zone is characterized by dry and hot summers and rainy autumns. The mean annual air temperature is 16°C, and precipitation comes to 791 mm a year (URL2). In such conditions, a Mediterranean vegetation develops, evergreen oak forest and its various degradation phases.

The Kornati islands can be characterized as an anthropogenic landscape. In the past, these islands were covered with Holm oak forests (*Quercus ilex*), which was then degraded to pastures on litho soil over the following centuries, to gain more land for raising livestock. Today, there is significant difference in vegetation on the islands of Žut and Kornat. Although they share the same past (deforestation), mostly karst pastures prevail on the island of Kornat, with rocky ground, low and rare vegetation, and just a few oases in the landscape (olive groves, vineyards and one holm oak grove). The island of Žut is also covered with pastures on lithosol, but with scrub, several groves of holm oak (*Q. ilex*), and Aleppo pine trees (*Pinus halepensis*). Here, olive groves with scattered fig and almost trees are present, as they are on the island of Kornat (MATIĆ *et al.*, 2001).

In the last ten years, a vast amount of new data on the distribution of reptiles and amphibians on Croatian islands has become available (e.g. TOTH, 2006; HILL, 2008; VERVUST *et al.*, 2009). Nevertheless, the most comprehensive study regarding the herpetofauna of Croatia's islands was done by KRYŠTUFEK & KLETEČKI (2007), and it includes 14 islands with surface areas between 15 and 410 km<sup>2</sup>, but it does not include the islands of Kornat and Žut. For the whole Kornati island group only one published paper on general herpetofauna exists – for the island of Kornat by M. Hirtz in the beginning of the 20th century (Hirtz, 1930). Other islands in the archipelago were never surveyed for amphibians and reptiles.

In this paper we reported our observations on amphibians and reptiles of the Kornati islands made during several visits to the islands in the period from April to December 2009. We also took into consideration published data and personal comments, and with them have provided the first systematic review of reptiles and amphibians present on the Kornati archipelago.



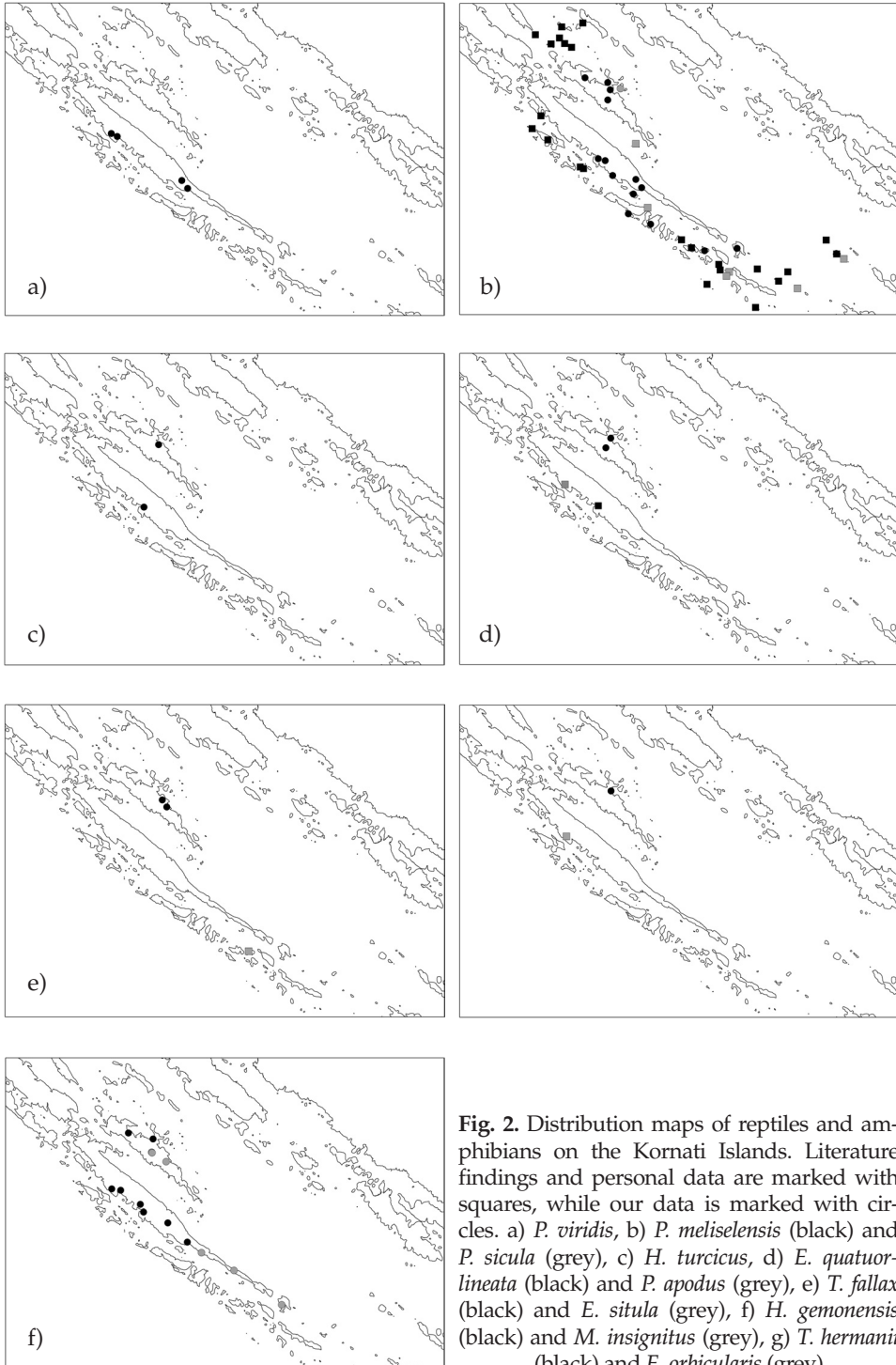
**Fig. 1.** Surveyed locations on Kornati Islands. 1. Kornat (a – Tarac field, b – Vrulje, c – Trtuša field, d – bay Ropotnica and Knežak field). 2. Žut (e – bay Podražanj, f – Dragišina, g – Pristanišće-V.Grba-Lukovnjak), 3. Lavsa, 4. Smokvica Vela, 5. Ravni Žakan, 6. Gustac (near Žut), 7. Gustac (near Kornat), 8. Vela Panitula

## MATERIAL AND METHODS

The data for this study was gathered during four field trips to Kornati and Žut in April, May and September 2009. The positions of the main surveyed locations are given in Fig. 1. A few of the records were provided by our colleagues doing fieldwork at the same time and they are in that case located outside the main localities, but for the more complete overall picture, these are also presented in the distribution maps (Fig. 2).

The number of search man-hours varied per island, depending on the time we spent on each island, from seven days to just several hours. Habitats on the islands of Kornat and Žut were surveyed both during the day and at night, but the smaller islands were visited in daytime only. Due to the limited time for research and the accessibility of the terrain, we selected only the areas that are the most probable habitats of amphibians and reptiles, such as karst fields, olive groves and grassy fields, all temporary and anthropogenic aqueous habitats (water cisterns) and ponds.

We used several methods during field research. Those included methods of general collecting, that typically involve searching and collecting amphibians and reptiles in all possible (appropriate) microhabitats both during the day and night and result in modest habitat modification (dismantling rotten logs for example). These general collecting techniques have been used for both long-term and short-term sampling projects (HEYER *et al.*, 1994). The animals were caught by hand, net and loop. We also used opportunistic surveys that require an active search for animals over large areas (i.e., up to several square kilometers), in order to increase the probability of encountering as many different species as possible. This method is effec-



**Fig. 2.** Distribution maps of reptiles and amphibians on the Kornati Islands. Literature findings and personal data are marked with squares, while our data is marked with circles. a) *P. viridis*, b) *P. meliselensis* (black) and *P. sicula* (grey), c) *H. turcicus*, d) *E. quatuorlineata* (black) and *P. apodus* (grey), e) *T. fallax* (black) and *E. situla* (grey), f) *H. gemonensis* (black) and *M. insignitus* (grey), g) *T. hermanii* (black) and *E. orbicularis* (grey)

tive for sampling species richness, but because not all individuals encountered are recorded, and cryptic or inactive individuals may be easily overlooked, the method is inappropriate for comparing densities (WATLING & NGADINO, 2007). In addition, a frog call survey was used, which is extensively used to record the presence of species. Males use it to advertise their presence and it is generally restricted to the breeding season and when conditions are conducive to calling. Calling may still occur outside this period but is unpredictable. Static or point call survey is listening to and recording calls at a particular site. This method is suitable for areas where species breed in farm dams or small ponds, and can be conducted while doing a nocturnal search (LEMCKERT & MAHONY, 2008). All the caught animals were identified, photographed and released in the same location where they were found.

## RESULTS

During our research on the Kornati islands we found 1 amphibian, *Pseudepidalea viridis* (Laurenti, 1768), and 8 reptile species, including 3 species of lizards: *Podarcis melisellensis* (Braun, 1877), *Podarcis siculus* (Rafinesque, 1810), *Hemidactylus turcicus* (Linnaeus, 1758), 4 species of snakes: *Hierophis gemonensis* (Laurenti, 1768), *Malpolon insignitus* (Geoffroy Saint-Hilaire, 1827), *Telescopus fallax* (Fleischmann, 1831), *Elaphe quatuorlineata* (Lacépède, 1789) and one tortoise species, *Testudo hermanni* (Gmelin, 1789).

In addition, we gathered data on the occurrence of one additional lizard species, *Pseudopus apodus* (Pallas, 1775) and one snake species, *Zamenis situla* (Linnaeus, 1758) through communication with our colleagues. The presence of the pond turtle, *Emys orbicularis* (Linnaeus, 1758) on the island of Kornat was known from previous research (HIRTZ, 1930) but we were not able to confirm this.

A systematic list of found species, along with their presence on each island and the source of data is given in Tab. 1. The distribution of each species on the researched islands is given in Fig. 2.

## DISCUSSION

For amphibians, Žut is completely unsuitable because of the lack of permanent water of any type. Only few closed or half closed concrete cisterns are scattered across the island. Even if the island were to be colonized by amphibians, the cisterns could not be utilized as breeding pools because their vertical walls prevent the exit of amphibians (and all other animals) from them. On the island of Kornat, there is one permanent pond in the Tarac field [polje] which is regularly utilized as a breeding site by the only amphibian on the island, *P. viridis*. There are also a few temporary ponds that can be active long enough for toads to lay eggs and for tadpoles to develop, depending on seasonal precipitation and temperatures. We also noticed the presence of tadpoles in one small concrete watering place for livestock.

Two lizard species, the Dalmatian wall lizard (*P. melisellensis*) and the Mediterranean gecko (*H. turcicus*) were present on both islands. *H. turcicus* was mainly located in and around rural settlements, with a few exceptions of some specimens in the ol-

**Tab. 1.** The presence of amphibian and reptile species on different islands in the Kornati island group.

SPECIES	Kornat	surrounding islands	source*	Žut	surrounding islands	source*
1. <i>Pseudepidalea viridis</i> (Laurenti, 1768)	+		A			-
2. <i>Podarcis melisellensis</i> (Braun, 1877)	+	+	A/LIT	+	+	A/LIT
3. <i>Podarcis siculus</i> (Rafinesque, 1810)		+	LIT		+	A/LIT
4. <i>Hemidactylus turcicus</i> (Linnaeus, 1758)	+		A	+		A
5. <i>Pseudopus apodus</i> (Pallas, 1775)	+		P			-
6. <i>Hierophis gemonensis</i> (Laurenti, 1768)	+		A	+		A
7. <i>Malpolon insignitus</i> (Geoffroy Saint-Hilaire, 1827)	+		A	+		A
8. <i>Telescopus fallax</i> (Fleischmann, 1831)			A	+		A
9. <i>Elaphe quatuorlineata</i> (Lacépède, 1789)	+		P	+		A
10. <i>Zamenis situla</i> (Linnaeus, 1758)		+	P			-
11. <i>Testudo hermanni</i> (Gmelin, 1789)			-	+		A
12. <i>Emys orbicularis</i> (Linnaeus, 1758)	+		LIT			-
Total number of species:	8	1	/	7	1	/

\* Source of information: A – the authors of this paper; LIT – literature; P – personal communication

ive groves, but not far from settlements. As geckos colonized the Adriatic coast with human help this kind of distribution is expected and usual. *P. melisellensis* is a very common and numerous lizard on both islands. On Kornat, we often found this species close to paths, olive groves and houses, which indicates that the combination of karst and sparse vegetation, as well as a small amount of annual precipitation and a high number of sunny days (URL2) is not a good habitat even for them. On some parts of Kornat, the lizards are not afraid of humans and do not try to hide when approached. Other species of wall lizard present in the area, for example the Italian wall lizard (*P. siculus*), was found only on Gustac, a small island near Žut. This is not an unusual finding, considering the patchy distribution of these two species of wall lizards (*P. melisellensis* and *P. siculus*) on the eastern Adriatic islands (RADOVANOVIĆ, 1956; RADOVANOVIĆ, 1959; RADOVANOVIĆ, 1960), as well as the fact that only six small islands were surveyed. Taking into account that *P. siculus* is an excellent colonizer, and can easily be transferred to new locations by humans and drive local populations of *P. melisellensis* to extinction (PODNAR *et al.*, 2005), it would be interesting to make a survey of all the islands in the archipelago and compare them to the findings of Radovanović.

The Balkan whip snake (*H. gemonensis*) and eastern Montpellier snake (*M. insignitus*) were the most common snakes found on both islands; in greater numbers on Žut than on Kornat. The food preferences of both snakes are mainly lizards, but also small mammals, other snakes and insects. The European cat snake (*T. fallax*) was found only on the island of Žut, around the village of Pristanišće. Because it is a crepuscular and nocturnal snake, it can easily be overlooked during surveys. *T. fallax* and *M. insignitus* are the only half-venomous snake species that live in Croatia, and

both were found on the researched islands. The four-lined snake (*E. quatuorlineata*) was confirmed only on the island of Žut, but data from the National Park employees (Z. Ružanović, pers. comm.) suggest that it is also present on Kornat, in the village of Vrulje.

The number of snake species and their abundance was noticeably higher on Žut than on Kornat. Although the island of Žut is smaller than Kornat (LEDER *et al.*, 2004), it has a greater snake abundance and even diversity. This can be explained by differences in habitat and microclimate conditions on these islands. The island of Kornat is almost completely covered in pastures on litho-soil, with some exceptions of green, grassy fields, and olive groves which are scattered across the island. On the other hand, the island of Žut is more or less entirely covered with vegetation of different types. Pastures on litho-soil which were maintained by livestock in the past are most abundant. Olive groves are located mainly around rural settlements, which are a perfect habitat for reptiles, because of the insulation sites and shelter they offer when temperatures are high. Apart from the pastures and olive groves, there are patches of forest vegetation in different degradation stages (*P. halepensis* and *Q. ilex*) on Žut that provide great habitats for reptiles. All recorded snake species, (with the exception of *T. fallax*) are large snakes which need to consume large prey to meet their energy needs. During our fieldwork of Žut, we encountered a great number of small mammals, such as the black rat, *Rattus rattus* (Linnaeus, 1758), the house mouse, *Mus musculus* Linnaeus 1758, and the wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758) which are, besides birds and their eggs, the main food for *E. quatuorlineata* but can also be taken by other snake species. Lizards and insects are present in great numbers on both islands. It can be argued that besides habitat and microclimate differences, food availability is also a restricting factor on snake abundance and diversity on different islands from the Kornati group. Due to our limited research time, we cannot exclude the presence of certain species from the surveyed islands (i.e. *Z. situla* and *T. fallax* on Kornat and *Z. situla* on Žut). During his research into Kornat, HIRTZ (1930) found two specimens of the European pond turtle (*E. orbicularis*) in the Tarac pond (Kornat Island). According to him, the possibility that this population was introduced to the island does exist, but is quite unlikely because local people claim that the turtles were indigenous there, and present for more than 70 years. During our study we visited Tarac pond several times and did not observe any specimens of *E. orbicularis*. But we have to point out that most parts of the pond were inaccessible from the shore, due to the pond edges being covered in dense vegetation, so the presence of this species on Kornat is still possible.

On the island of Žut we encountered one Hermann's tortoise (*T. hermanni*), close to the village called Dragišina. The specimen was an adult, but its age could not be determined by counting the grained scales on the carapax or on the plastron. Because it was the only tortoise found, our opinion is that it probably was not indigenous to the island, but rather introduced as a pet and was then released or else escaped into the wild.

The data on two species, which were not found during this research, were obtained through personal communication with colleagues. One specimen of the European glass lizard (*P. apodus*) was found by Vedran Lucić (LUCIĆ, pers. comm.) in 2004 during a visit to the island of Kornat, at the edge of Tarac field. Considering the

harsh habitat on Kornat they are probably very rare and maybe even confined to several »vegetation oases« on the island (i.e. the plains of Tarac and Knežak). It is interesting to note that we did not find any specimens on the island of Žut despite its good habitats for this species.

The leopard snake (*E. situla*) was found during mining for a cistern on the island of Ravni Žakan – unfortunately it was dead (Z. RUŽANOVIĆ, pers. comm.). The presence of that species on the small island could not be confirmed, but because it is a secretive species and taking into consideration the small amount of time that we spent there, we cannot exclude its presence. It could also be present on other islands in the archipelago, especially bigger ones.

This research and personal data from our colleagues and literature data of the Kornati islands, resulted in the recording of one amphibian and 11 reptile species.

The habitats on both islands are in a fairly good state and generally not threatened by human activities such as development of infrastructure and intensive agriculture. This is because the Kornati islands have never had many permanent inhabitants, and because most of the area is protected as the Kornati National Park. Still, at the present time, there are several threats to the herpetofauna of the area. In the past people used to clean ponds of overgrown vegetation, but these activities have recently ceased and overgrown ponds do present a problem – the pond in Knežak field has already disappeared and the pond in Tarac field is shrinking. This is a problem for the green toad because of the shortage of breeding sites. Big problems for reptiles are the very numerous feral cats around the settlements. Cats are well fed during the summer season by the many restaurants and tourists, but depend on wildlife to survive throughout the rest of the year. Snakes are also threatened by being killed deliberately and outright by humans.

Comparison of the richness and the composition of reptile and amphibian fauna between other Adriatic islands (KRYŠTUFEK & KLETEČKI, 2007) and Kornati archipelago is rather difficult, due to the significant difference in size, position and history of research. Nevertheless, it seems that the biggest islands in the Kornati archipelago (Kornat and Žut) have a diversity of reptile species similar to that of some other islands of the same size. For example Žut (14.8 km<sup>2</sup>) has 7 and Silba (14.3 km<sup>2</sup>) has 8 reptile species, but they have somewhat different species composition (KULJERIĆ, pers. data). We can compare the island of Kornat with some slightly bigger islands (such as Ugljan and Lastovo), which also have a similar number of reptile species: Kornat 7, Lastovo 7 and Ugljan 7 (KRYŠTUFEK & KLETEČKI, 2007; VERVUST *et al.*, 2009). Amphibian fauna in the Kornati archipelago consists of only one toad species (on Kornat island), which is the characteristic and the only amphibian inhabitant of many Adriatic islands. Only islands with more water bodies and/or humid habitats have also some other amphibian species present (HIRTZ, 1930; KRYŠTUFEK & KLETEČKI, 2007; KULJERIĆ & LUKIN, 2002; TOTH *et al.*, 2006; VERVUST *et al.*, 2009).

Further studies should be aimed at confirming the presence of doubtful species on both islands and monitoring possible species immigration onto the islands, especially those of *P. sicula*. We also think that this area is a suitable place to do further population research into both *Podarcis* species, *H. gemonensis* and *M. insignitus*, because of their high frequency.



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