

## **Amphibians of the Eastern Julian Alps (Slovenia) with special attention to endemic forms of the Alpine newt (*Mesotriton alpestris*)**

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### **Die Amphibien der östlichen Julischen Alpen (Slowenien) unter besonderer Berücksichtigung der endemischen Formen des Bergmolchs (*Mesotriton alpestris*)**

Verbreitung und Status der Amphibien der östlichen Julischen Alpen wurden in den Jahren 2005 und 2006 untersucht. Fünf Arten konnten festgestellt werden: Bergmolch (*Mesotriton alpestris*), Alpensalamander (*Salamandra atra*), Gelbbauchunke (*Bombina variegata*), Erdkröte (*Bufo bufo*) und Grasfrosch (*Rana temporaria*). Vor allem natürliche Seen und Tümpel sowie vom Menschen angelegte Viehtränken dienen in dieser Region als Fortpflanzungsgewässer. In einigen Seen sind die Amphibienbestände durch eingesetzte Fische erloschen, während einige der Viehtränken nicht mehr bewirtschaftet werden und trocken gefallen sind. Drei endemische Bergmolch-Formen kamen oder kommen noch in dem Gebiet vor. Die lacustris-Form ist ausgestorben, weil Fischbesatz das Vorkommen in einem einzelnen See vernichtete. Die lacusnigri-Form existiert in einem See in einer kleinen Anzahl neben normal aussehenden Bergmolchen. Kürzlich eingesetzte Fische bedrohen allerdings das Überleben der Tiere. Eine dritte Form, die hier beschriebene »gebleichte« Form, kommt in einigen Tümpeln und kleinen Seen vor, zusammen mit normal aussehenden Bergmolchen.

**Schlüsselbegriffe:** Amphibien, östliche Julische Alpen, Slowenien, Bergmolch-Formen.

#### **Abstract**

The distribution and status of amphibians in the Eastern Julian Alps was surveyed in 2005 and 2006. Five species of amphibians were observed: Alpine newt (*Mesotriton alpestris*), Alpine salamander (*Salamandra atra*), yellow-bellied toad (*Bombina variegata*), common toad (*Bufo bufo*) and grass frog (*Rana temporaria*). Breeding sites in this region are largely limited to natural lakes and ponds as well as man-made cattle drinking ponds. Introduced fish have caused extinction of amphibians in some of the lakes while some of the cattle drinking ponds are no longer maintained and contain no water. Three endemic forms of the Alpine newt occurred or still occur in this area. Of these, the lacustris-form is extinct because of fish introduction in the single lake where it occurred. The lacusnigri-form occurs in small numbers alongside normal looking Alpine newts in a single lake but a recent introduction of fish into this lake threatens its future survival. A third form, the »bleached form« occurs in several ponds and a small lake, also alongside normal looking Alpine newts.

**Key words:** Amphibians, Eastern Julian Alps, Slovenia, Alpine newt, different forms.

## Introduction

In the last years, the global decline of amphibians has received increasing attention. The decline is often caused by intensification of human land use for agriculture, including destruction of amphibian breeding habitats, and an increased use of pesticides and fertilizers. Additional causes are diseases spread by human activities (OHST et al. 2006), and an increase in UV-B radiation (but see SCHMIDT 2006). Declining amphibian populations and local extinctions have not only been reported from lowland areas, which are extensively used for agriculture, but also from seemingly natural regions like mountain ranges (for a review see ALFORD & RICHARDS 1999 and COLLINS & STORFER 2003). Amphibians in such areas have often evolved special adaptations to the local climatic conditions and may differ morphologically from other populations of the same species (NAVAS 2006). The Eastern Julian Alps in Slovenia are an example of such a high altitude area. Already in 1935 two forms of the Alpine newt (*Mesotriton alpestris*) were described in this region: the lacusnigri-form from Črno jezero and the lacustris-form from Jezero na Planini pri jezeru (»Jezero« is Slovene for »Lake«) (SELIŠKAR & PEHANI 1935). Both forms are considered extinct according to the Slovene red list (National Gazette of Republic of Slovenia 82/2002). In 2003 we found a large number of Alpine newts in Črno jezero, the type locality of one of these forms. This was the reason to start a systematic survey of potential amphibian breeding sites in the Eastern Julian Alps. With this survey we intended to answer two questions: (1) Are human actions affecting amphibian populations in this region? (2) What is the current status of the endemic forms of the Alpine newt in this region?

## Methods

### Research area

The Eastern Julian Alps form the easternmost part of the Alps. They are situated in north-western Slovenia, between the Soča River in the west and the Upper Sava River in the east. The whole region Eastern Julian Alps is protected as Triglav National Park. Due to a combination of steep slopes and a predominantly karstic underground, natural surface water is largely limited to glacial lakes. In the past summer grazing with cows and sheep was common practice, and for this purpose cattle drinking ponds were made. Nowadays grazing is carried out only in part of the area and part of the ponds is no longer maintained. The Eastern Julian Alps are a popular destination for mountain tourism. For this purpose many mountain huts were built, of which four are situated in the immediate vicinity of lakes (Planina pri jezeru, Dvojno jezero, Dupeljsko jezero and Kriška jezera). Two of these huts cause visible eutrophication of the lakes while for a third (Kriška jezera) drinking water is extracted from the lakes. A more extensive description of the lakes is provided by BRANCELJ (2002).

Because the possible presence of endemic forms of the Alpine newt, the survey was mainly focused on aquatic habitats in the surroundings of Črno jezero and Jezero na Planini pri jezeru, the type-localities of the endemic forms of the Alpine newt. The

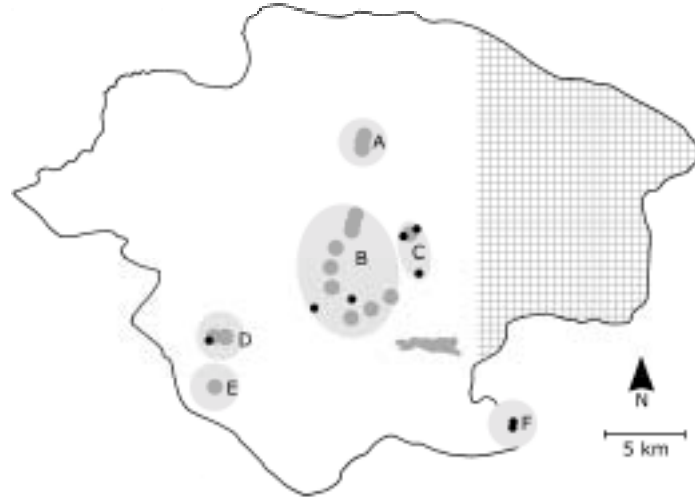


Fig. 1: Research area. --- = border of Triglav National park, Slovenia, ● = natural lake or natural pond, ■ = man made cattle-drinking pond, ● A–F = cluster of lakes and/or ponds, ▨ = area within Triglav National Park, not covered by this survey, ▨ = Bohinj Lake (not included in this survey).  
 Untersuchungsgebiet. --- = Grenze des Triglav Nationalparks, Slowenien, ● natürlicher See oder Tümpel, ■ angelegte Viehtränke, ● A–F = Ansammlung von Seen und Tümpeln, ▨ = Bereich des Nationalparks, der nicht untersucht wurde, ▨ = Bohinj-See (nicht untersucht).

survey was later extended to cover all lakes, natural ponds and man-made ponds above 1 000 m a. s. l. and within a distance up to 9 km from Črno jezero. The only way to reach most localities is by hiking over mountain trails or by helicopter. The lakes and ponds can be logically grouped in six clusters, which are isolated from each other by high mountain ridges (fig. 1). The northernmost cluster consists of three high altitude lakes known as the »Kriška jezera« (A). Between these lakes and lowland amphibian breeding sites there are slopes with low vegetation and without surface water for at least 4 km.

The central, and largest cluster (B), consists of a valley with ten lakes and natural ponds (»Triglavska jezera«), a nearby natural pond (Mlake pod Studorjem) a nearby lake (Jezero na Planini pri jezeru) and four man-made ponds. During periods with high water level, two of the lakes and a small pond join together to form one larger lake (Dvojno jezero).

The third cluster (C) is situated immediately east of the »Triglavska jezera« and consist of a small natural lake and three man made ponds, all of which are still in use as cattle drinking places.

Both clusters in the south-western part of the area (D and E) are smaller, consisting of two lakes and a pond and a single lake respectively. In addition, there is a cluster of four man-made ponds in the south-eastern corner of Triglav National Park (F). According to mountaineering maps, several further ponds and other water bodies should be located between clusters D, E and F. However, these could not be found in the field and it is likely that they no longer exist.

Although the large Bohinj Lake is situated within the research area, it was not included in the survey. This touristic lake naturally contains large populations of fish,



Fig. 2: Jezero v ledvicah in Triglav National Park (Slovenia). A small number of Alpine newts was observed in this lake.

Jezero v ledvicah im Triglav Nationalpark (Slowenien). Eine kleine Anzahl an Bergmolchen wurde in diesem See beobachtet.

and has relatively steep shores with little aquatic vegetation. Due to these characteristics it is unlikely that it contains significant amphibian populations of any species.

### Sampling methods

According to SELIŠKAR & PEHANI (1935), VOGRIN (1998) and our own preliminary observations, the following amphibian species could be expected in the research area: smooth newt (*Lissotriton vulgaris*), Alpine newt, Italian crested newt (*Triturus carnifex*), Alpine salamander (*Salamandra atra*), yellow-bellied toad (*Bombina variegata*), common toad (*Bufo bufo*) and grass frog (*Rana temporaria*). Except for the Alpine salamander all species have an aquatic larval stage. Therefore, the survey was focused on potential breeding sites like lakes, ponds and temporary pools. Although we observed several Alpine salamanders, this species is not included in the analysis. The localities were visited in June to September in the years 2005 and 2006. At higher altitudes the larval development of amphibians tends to be delayed (GRILLITSCH et al. 2001) and also in the late summer we observed common toad tadpoles. The water was mostly clear with a visibility to the bottom; therefore visual inspection could be used as the main survey method. Sampling with a dipnet was used as an additional method in shallow pools, a lake with turbid water and in places with dense aquatic vegetation. All water bodies were photographed for documentation.

In order to determine the status and distribution of the endemic forms of the Alpine newt, at least ten males and ten females of this species were photographed at each water body, or all individuals when less than 20 could be found. On the basis of preliminary visits to Črno jezero and literature (SELIŠKAR & PEHANI 1935) it was expected that both described forms could be recognised from photographs of living newts.

## Results

### Observed amphibian species

Most numerous were Alpine newts, which were observed in 17 out of 38 surveyed localities. Other observed species were common toads (8 localities), yellow-bellied toads (5 localities) and grass frogs (4 localities). SELIŠKAR & PEHANI (1935) observed smooth newts and Italian crested newts in Jezero na Planini pri jezeru. As recently as 1997, M. VOGRIN observed an adult and a larval Italian crested newt in this lake (pers. comm). However, we did not observe these species in the research area. Since Jezero na Planini pri jezeru contains very large populations of introduced fish species, it is likely that smooth newts and Italian crested newts no longer occur in the higher parts of the Julian Alps.

### Lakes and natural pools

21 lakes and natural pools were surveyed (fig. 1, tab. 1). One natural pool in the area was not included in this survey because of its remote location. Amphibians were observed in eight lakes and natural pools. The remaining lakes and pools contained large numbers of introduced fish (4), were dried up (2), were situated several kilometres from the closest other locality with amphibians (4) or may be unsuitable for amphibians due to a combination of high altitude and few hours of sunlight (3).

### Fish introductions

Historically no fish occurred in any of the lakes because of their isolated location. However, introduced fish were observed in five lakes. Historical data on amphibians are available only for Jezero pri Planini pri jezeru and Črno jezero. However, considering the habitat characteristics, we can assume that amphibians were present in the other three lakes as well. In the two lakes that are together called »Dvojno jezero« we observed numerous Alpine charr (*Salvelinus umbla*), which were introduced in 1991 (BRANCELJ et al. no year). In addition we observed minnows (*Phoxinus phoxinus*) in these lakes, which were not previously recorded (D. ZABRIC, Fisheries institute of Slovenia, pers. com). In 2000 there was an attempt to remove fish from this lake. Although many Alpine charr were caught, some remained and the population quickly returned to the former abundance (BRANCELJ 2001). Because Dvojno jezero is situated between two lakes in which amphibians were found (Črno jezero and Veliko jezero), it is likely that amphibians occurred in Dvojno jezero as well.

The same fish species, minnow and Alpine charr, are introduced to Krnsko jezero, where no amphibians were observed. However, Alpine newts and common toad tadpoles were numerous in the smaller lake Dupeljsko jezero, situated approximately 1 km from Krnsko jezero. During our preliminary site-visit in 1999, minnows were also observed in Dupljsko jezero. As Dupljsko jezero is only about 1 m deep and freezes to the bottom in winter, minnows went extinct before the fish could cause extinction of local amphibian populations.

Tab. 1: Amphibians in lakes and ponds of the Eastern Julian Alps. N = natural lake or pond. H = man-made pond, Lv = *Lissotriton vulgaris*, Ma = *Mesotriton alpestris*, Tc = *Triturus carnifex*, Bv = *Bombina variegata*, Bb = *Bufo bufo*, Rt = *Rana temporaria*.

Amphibien in Seen und Tümpeln der östlichen Julischen Alpen. N = natürliche Gewässer, H = angelegte Gewässer.

Cluster	Name of locality	altitude [m]	Origin	Amphibian species	Comments
A	Spodnje Kriško jezero	1880	N	-	
	Srednje Kriško jezero	1950	N	-	
	Zgornje Kriško jezero	2150	N	-	
B	Jezero na Planini pri jezeru	1430	N	Lv†, Ma†, Tc†, Bv†	all amphibians extinct due to fish introductions
	Mlaka pod Studorjem I	1489	N	Ma, Rt	
	Mlaka pod Sturorjem II	1499	N	-	dry
	Črno jezero	1325	N	Ma, Bb	introduced fish
	Planina na kalu (2 ponds)	1642	H	Ma	nearly overgrown
	Planina Ovčarija, pond at trail	1660	H	Ma	nearly overgrown
	Planina Ovčarija, second pond	1679	H	-	dry
	Dvojno jezero (2 lakes)	1669	N	-	introduced fish
	Dvojno jezero (pond between lakes)	1669	N	Bb	
	Pond between Dvojno j. & J. v Ledvicah	1764	N	-	dry
	Jezero v ledvicah	1830	N	Ma	
	Zeleno jezero	1983	N	Ma	
	Jezero pod Vršacem	1993	N	-	
	Mlaka v Laštah	2000	N	-	
Rjavo jezero	2002	N	-		
C	Planina krstenica	1628	H	Ma	
	Planina pod Mišel vhom	1698	H	Ma	
	Mlake pod Mišel vhom	1655	N	Ma, Bb	
	Velo polje	1680	H	Ma	
D	Dupeljsko jezero	1340	N	Ma, Bb	
	Krnsko jezero	1383	N	-	introduced fish
	Planina na polju	1542	H	-	dry
E	Jezero v Lužnici	1800	N	-	
F	Planina za liscem (northern pond)	1324	H	Bv, Bb	
	Planina za liscem (3 other ponds)	1382	H	-	dry

In Jezero pri Planini pri jezeru we observed numerous chub (*Squalius cephalus*) and Crucian carp (*Carassius carassius*), which were introduced in 1951 (POVŽ 1997) or 1954 (ARSO 2001).

Only in Črno jezero fish currently co-occur with amphibians. The presence of minnows in Črno jezero were first recorded in 2001 (BRANCELJ 2002). In 2005 and 2006 this species was numerous and we observed several hundreds during our survey. According to literature, extinction of the lacusnigri-form of Alpine newt was caused by the introduction of salmonids in the lake in 1930s' (c. f. ARSO 2001). However, there are neither other historical records nor recent observations that indicate the presence of salmonids in this lake.

From these observations it appears that amphibian populations can survive the short-term presence of small fish species (minnows grow to a maximum size of 12 cm), but

when larger fish species are present for a longer time, amphibian populations go extinct. It is unlikely that minnows can predate on adult amphibians, but they predate on amphibian eggs and larvae and on large copepods, which are the main food source of Alpine newts in high altitude lakes (SCHABETSBERGER et al. 2006). Alpine newts are typically long-lived at high altitudes (SCHABETSBERGER et al. 2001) and any effect of the presence of minnows on the amphibian populations may only become visible in a longer period after the introduction of fish. Indeed, SCHABETSBERGER et al. (2006) conclude that the absence of Alpine newts in two lakes is a direct consequence from the introduction of minnows in these lakes.

### **Climate and geographic isolation**

No amphibians were found in Kriška jezera (cluster A), or in Jezero v Lužnici (cluster E), which could be caused by a combination of geographical isolation and a relatively high altitude (1800–2150 m). The surrounding habitat consists mainly of alpine pastures and bare rocks, and it is possible that amphibians were unable to colonize these lakes.

Lakes of the central cluster (B) are situated successively through the valley, with the maximum distance between lakes of 2.5 km. Because of this, geographic isolation does not explain the absence of amphibians in some of the lakes. Absence of amphibians in the highest three lakes is probably caused by unfavourable climatic conditions, as they are all situated under steep rocky walls and are in shadow large part of the year. Jezero pod Vršacem, was even covered with ice for several years until 1992 (BRANCELJ 2002). In the nearby lake Zeleno jezero, which is much more exposed direct sunlight, a small population of Alpine newts was recorded. In Dvojno jezero amphibians are probably secondarily absent as a result of fish introductions. All other lakes of the central cluster are inhabited by at least one amphibian species.

### **Cattle drinking ponds**

Twelve man-made ponds were located on the basis of mountaineering maps. Only four of these were still in use as cattle-drinking ponds. Three ponds are no longer in use and are overgrown with peaty vegetation, but still contain some water. The remaining five ponds were completely dry and only slight depressions in the landscape indicated their former presence. Amphibians were observed in all ponds which contained water, but overall numbers were low in the overgrown ponds (tab. 1).

### **Other amphibian breeding sites**

In addition to lakes and ponds, smaller numbers of amphibians were observed in very small water bodies like pools on unpaved forest roads (4), small pools in wet meadows (2), a small stream and in a small spring. In the eastern part of the research area small pools on unpaved roads are formed because the soil contains some clay. In other parts of the research area the soil is more permeable and such small water bodies are apparently absent.

## Endemic forms of the Alpine newt

### Lacustris-form

The lacustris-form of the alpine newt was described from Jezero na planini pri Jezeru (SELIŠKAR & PEHANI 1935; fig. 3) as differing from 'normal' Alpine newts in that about 71 % of the population was paedomorphic (neothenic). Paedomorphic alpine newts normally co-occur with metamorphosed alpine newts and are not recognized as separate subspecies (SOTIROPOULOS et al. 2001). The paedomorphic forms of the alpine newt can be seen as a special adaptation to a deep water habitat in lakes (DENOËL et al. 2001). The type locality of this form is currently inhabited by large populations of introduced chub and crucian carp. Neither during this survey nor at several other visits did we observe any amphibians at this locality. Since paedomorphic newts tend to stay in the water throughout their life, they are especially vulnerable for the impact of introduced fish. In this survey special attention was paid to the possible occurrence of paedomorphic Alpine newts in other localities, especially in the lakes, however none were observed. In the Slovene red list (National Gazette 82/2002), the lacustris-form of Alpine newt is placed in to the category »extinct« as a subspecies »*Triturus alpestris lacustris*«. On the basis of findings of this survey, we can agree with its status in the red list. Even though the status of »subspecies« is not warranted, this special form should certainly be seen as a separate conservation unit, which would require special attention if it were still extant.

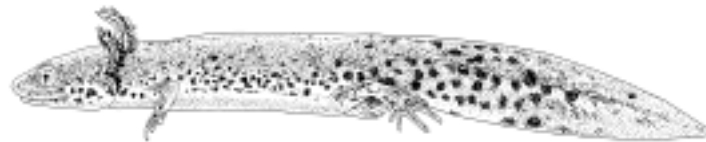


Fig. 3: Paedomorphic adult male of the lacustris form of the Alpine newt. Illustration made by PAUL VEENVLIET after a photograph from SELIŠKAR & PEHANI (1935).

Pädomorphes adultes Männchen der lacustris-Form des Bergmolchs. Zeichnung PAUL VEENVLIET nach einem Foto von SELIŠKAR & PEHANI (1935).

### Lacusnigri-form

14 adult male and 12 adult female Alpine newts were photographed at Črno jezero on 28th July 2005. The individuals were selected in order of capture. One female was readily identified as belonging to the lacusnigri-form. The other individuals show a large variation in all characters. In addition to these 26 photographed newts several tens were caught and investigated in the field. None of these showed all characters of the lacusnigri form. This confirmed our (unpublished) observations from July 2003, where out of 18 photographed and over 50 investigated newts also only one female had all characters of to the lacusnigri form (fig 4). Both females showed the relatively angular shaped head, slender body shape, long tail, dark dorsal coloration, large eyes and strongly developed labial fold. In addition, the female photographed in 2005 also had a slightly protruding lower jaw. SELIŠKAR & PEHANI (1935) reported that some individual alpine newts had a spotted belly, which is confirmed by ROČEK (1976). Of

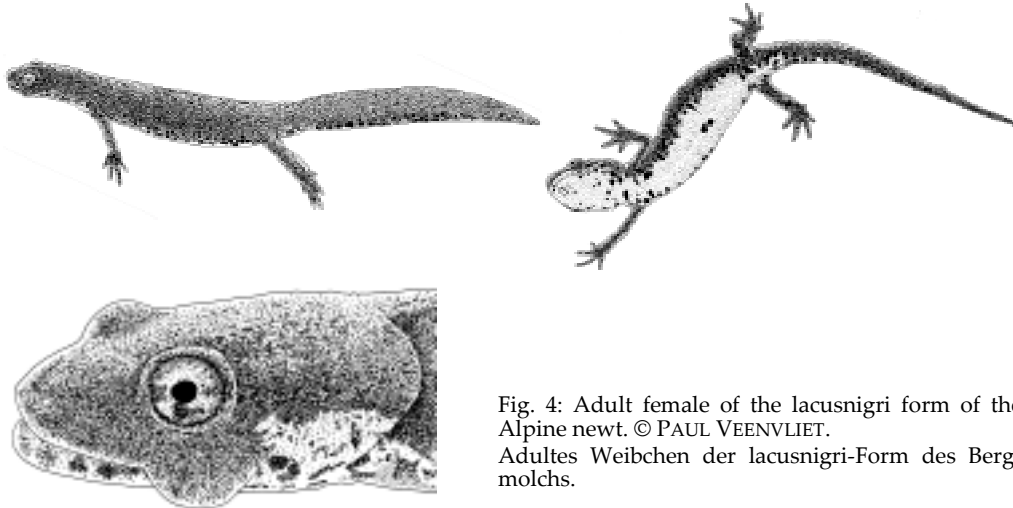


Fig. 4: Adult female of the lacusnigri form of the Alpine newt. © PAUL VEENVLIET.  
Adultes Weibchen der lacusnigri-Form des Bergmolchs.

all Alpine newts caught during this survey, only one, which also had other characters of the lacusnigri-form, had a small dark spot on the belly. An adult male, photographed by M. DENOËL in 1995, also appears to belong to this form. From these observations we confirm that the lacusnigri-form is distinctive and can be recognized in the field. However, only a small part of the population shows all characters of this form, while most individuals are either similar to »normal« alpine newts from other localities or show at most some of the characters of the lacusnigri-form. As a consequence, the lacusnigri-form cannot be regarded as a separate subspecies because, by definition, subspecies should be allopatric. However, the lacusnigri-form is a distinct variety of the Alpine newt, which is adapted to the environment of Črno jezero. We did not observe any lacusnigri-like Alpine newts in any other locality. The long-term presence of minnows in Črno jezero is likely to severely affect the reproduction of newts and may lead to the extinction of this form in the near future. Therefore it is best to revise the red list status of the lacusnigri-form of the Alpine newt from category »extinct« to »critically endangered«.

#### »Bleached« form

Already SELIŠKAR & PEHANI (1935) noted that »in summer, individuals are found that appear strongly bleached«. They did not propose a specific name for these »bleached«



Fig. 5: Adult females of the bleached form with angular dark patches. © PAUL VEENVLIET.  
Adulte Weibchen der »gebleichten« Form des Bergmolchs mit winkligen dunklen Mustern.

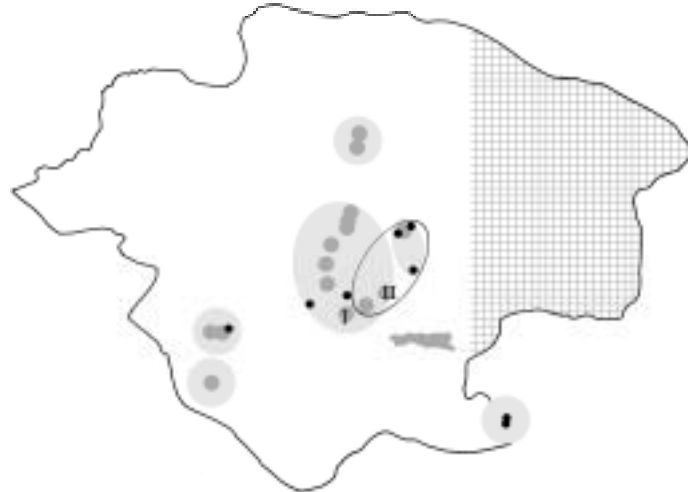


Fig. 6: Distribution of endemic forms of the Alpine newt in the Eastern Julian Alps. I Črno jezero (lacusnigri-form). II Jezero na Planini pri jezeru (extinct lacustris-form). O Distribution of the »bleached« form. For an explanation of other symbols see figure 1.

Verbreitung der endemischen Bergmolch-Formen in den östlichen Julischen Alpen. I Črno jezero (lacusnigri-Form). II Jezero na Planini pri jezeru (ausgestorbene lacustris-Form). O Verbeitung der »gebleichten« Form. Zur Erklärung der anderen Symbole siehe Abbildung 1.

Alpine newts. We observed such »bleached« looking Alpine newts (fig. 5) at five localities (fig. 6, tab. 2) four of which are situated in cluster C. The two other known localities, Jezero na Planini pri jezeru (which currently has no newts because of fish introductions) and Mlake pod Studorjem are situated in cluster B, at the closest distance to cluster C. At all these localities the »bleached« individuals co-occur with normal coloured alpine newts and intermediately coloured individuals (tab. 1). Based on their appearance in the field, these »bleached« Alpine newts are also a distinctive form which is easily recognized in the field. Interestingly, all bleached individuals observed during this survey were females. The dorsal coloration is uniform grey, without any trace of a marble-pattern. Lateral spots are nearly or completely absent, but there is a pale zone between the grey dorsal colour and the ventral colour. The ventral side is uniform orange, similar to normal alpine newts. On the lower part of the tail there can be some dark spots. Some individuals at these localities, both of the bleached form and individuals that otherwise appear normally coloured, have large angular dark patches on the dorsal and lateral sides (fig. 6). We did not observe any

Tab. 2: Number of normal coloured, bleached looking and intermediate female Alpine newts. Anzahl normal gefärbter, »gebleichter« und intermediär gefärbter weiblicher Bergmolche.

Locality	normal	»bleached« form	intermediate	total
Velo polje	3	3	4	10
Mlake pod Mišel vhom	9	1	1	11
Pl. pod Mišelj vrhom	8	4	2	14
Planina Krstenica	6	2	1	9
Mlake pod Studorjem I	4	3	3	10
Total all localities	30 (56 %)	13 (24 %)	11 (20 %)	54 (100 %)

bleached looking Alpine newts in the »Valley of the seven lakes«, nor elsewhere in Slovenia. Because of the local distribution in only few localities, the status of this form can best be described as »vulnerable«.

## Conclusions

Amphibians are strongly affected by human actions in the Eastern Julian Alps. It is likely that fish introductions led to extinction of amphibians in four out of twelve natural amphibian breeding sites (lakes and natural ponds) and may lead to extinction of amphibians in one more lake. Cattle drinking ponds form a suitable secondary habitat, but due to lack of maintenance only four out of twelve cattle drinking ponds are still in a good state for amphibians.

The paedomorphic lacustris-form of the Alpine newt became extinct in Jezero na Planini pri jezeru after fish were introduced. No paedomorphic Alpine newts were observed in any other site. The lacusnigri-form still occurs in low numbers between normal-looking Alpine newts in Črno jezero, but was not found in other localities. The recent introduction of minnows into Črno jezero may lead to extinction of this form in the future. A third distinctive form, the »bleached« Alpine newt is present in at least five water bodies in the Eastern Julian Alps and co-occurs with normal-looking Alpine newts.

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