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## ECOLOGICAL CHARACTERIZATION OF A MEDITERRANEAN FRESH WATER POOL ON THE MERAG PENINSULA, CRES (CROATIA)

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### ABSTRACT

In 1997, fauna, flora and water chemistry of a persisting fresh water pool was investigated on the Merag Peninsula of the Kvarner island of Cres. The pond was threatened to become totally covered by *Typha angustifolia* L. Different methods to remove parts of the *Typha*-stand have been therefore engaged. Effectiveness of the methods has been controlled qualitatively in the consecutive years 1998-2001. Water chemistry was determined before and after the removal of the phytomass. Two species were new records for the island of Cres: *Orchis laxiflora* Lam., which is endangered throughout the Mediterranean region, and the Water Rail *Rallus aquaticus* L., which was found breeding successfully in the reed belt. Moreover, the water beetle *Hygrobia tarda* (Herbst), a species considered to be extinct in central Europe, was collected.

**Keywords:** fresh water pool, fauna, flora, first records, *Typha angustifolia*, floating mat, Cres

## CARATTERISTICHE ECOLOGICHE DI UNO STAGNO MEDITERRANEO SULLA PENISOLA DI MERAG, ISOLA DI CHERSO (CROAZIA)

### SINTESI

Nel 1997 gli autori hanno studiato la fauna, la flora e le caratteristiche fisico-chimiche dell'acqua di uno specchio d'acqua dolce permanente sulla penisola di Merag dell'isola quamerina di Cherso. Sullo stagno combeva la minaccia di venir completamente ricoperto da *Typha angustifolia* L. Nel tentativo di rimuovere parte della copertura a *Typha* sono stati usati metodi differenti. L'efficacia di tali metodi è stata controllata qualitativamente negli anni consecutivi 1998-2001. Le caratteristiche fisico-chimiche dell'acqua sono state determinate prima e dopo la rimozione della fito-massa. Due specie sono state inoltre segnalate per la prima volta sull'isola di Cherso: *Orchis laxiflora* Lam., minacciata nell'intera regione mediterranea, e il porciglione *Rallus aquaticus* L., che nidificava con successo nel canneto. È stata inoltre raccolta *Hygrobia tarda* (Herbst), specie considerata ormai estinta nell'Europa centrale.

**Parole chiave:** specchio d'acqua dolce, fauna, flora, prime segnalazioni, *Typha angustifolia*, intrico galleggiante, Cherso

INTRODUCTION

In semi-arid regions like the Mediterranean, permanent freshwater pools constitute important "cells" that increase the biodiversity of the region. Various species of insects, amphibians, reptiles and waterfowl depend on the pools and the surrounding marsh (Raab *et al.*, 1996; Silveira, 1998). On Cres, more than 70 medium-sized and small pools exist and many of them never dry up (Mavrović, 1994). Some are of natural origin and some are man-made. In the times when the island was more densely populated than today, the Cres inhabitants increased the number of natural pools by artificial ones. Natural or man-made hollows were made impervious by clay. In the past, these pools have been an essential factor in the general water supply particularly for the livestock.

Since the population density has decreased due to migration, livestock has decreased as well. Hence, watering places are used infrequently, they may become heavily infested by cattail and succession to terrestrialisation may start. Since permanent fresh water pools are especially important in semi-arid regions, it is essential to maintain the still existing ones.

The investigated pond of Sveti Vid on the Merag Peninsula was threatened by total coverage of the narrow leaved cattail *Typha angustifolia*, indicating a decreasing utilization and care for the pool by man. The aim of the study was, first of all, to characterize the pool by its flora and fauna in a half-quantitative and qualitative manner in order to document its importance for the local biodiversity. Secondly, it should serve as a basis for finding effective methods to reduce the cattail belt and to achieve the recommended 50:50 ratio of open water and vegetation (Sojda & Solberg, 1993) and to counteract eutrophication (Blab, 1993). This paper shall give the first impression of the life community in and around the pond and studies will be continued in the following years.

MATERIAL AND METHODS

Location of the pool

The pond is situated near the deserted village of Sveti Vid on the Merag Peninsula (Fig. 1) and embedded in a formerly intensively cultivated area (vineyards, mulberry trees, laurel groves). Today, the area is only used as sheep pasture. The soil-type is a flat, the stony Terra Rossa and two thirds of the pool are surrounded by stonewalls at a distance of 3-5 m, the rest is fenced by a wire net. Shape and exposition are shown in Fig. 2. Water samples for chemical analysis were taken 30 cm below the water surface and parameters were determined using a Merck outdoor Test (Art. Nr. 111151). Additionally, temperature was measured in the free water-body.

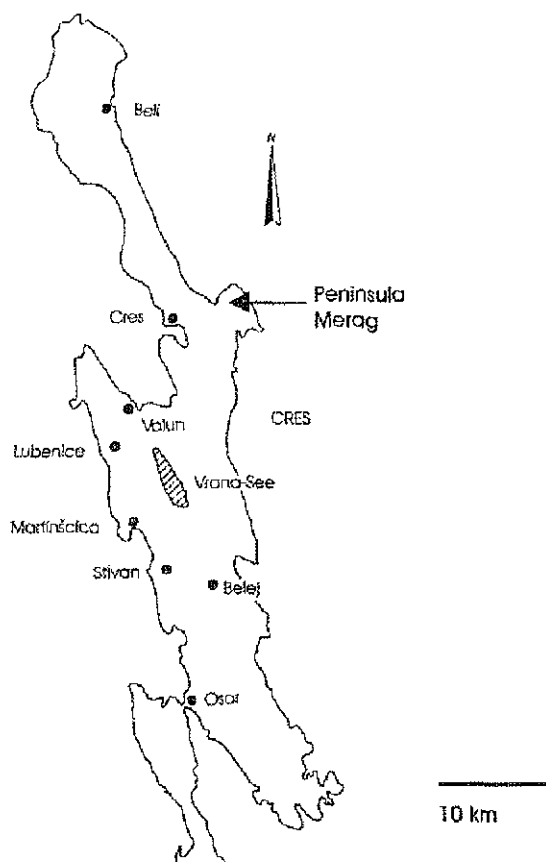


Fig. 1: Study area - location of the Merag Peninsula on the island of Cres (Kvarner, Croatia).

Sl. 1. Raziskovano območje - lokacija Meraškega polotoka na otoku Cresu (Kvarner, Hrvaška).

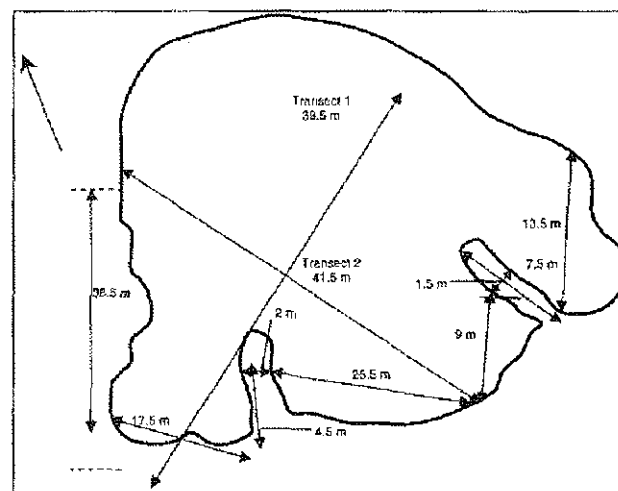


Fig. 2: Dimensions of the pond at Sv. Vid.

Sl. 2: Dimenzije kala pri Sv. Vidu.

- *Typha* stand before reduction; - - - - - *Typha* stand after reduction; x Dead wood; O *Salix alba*
- *Salix cinerea*; ▨ *Ceratophyllum demersum*; ▩ *Orchis laxiflora*;
- ▤ *Potamogeton natans*
- Rogozov sestoj pred skrčenjem; - - - - - Rogozov sestoj po skrčenju; x Plavajoči les

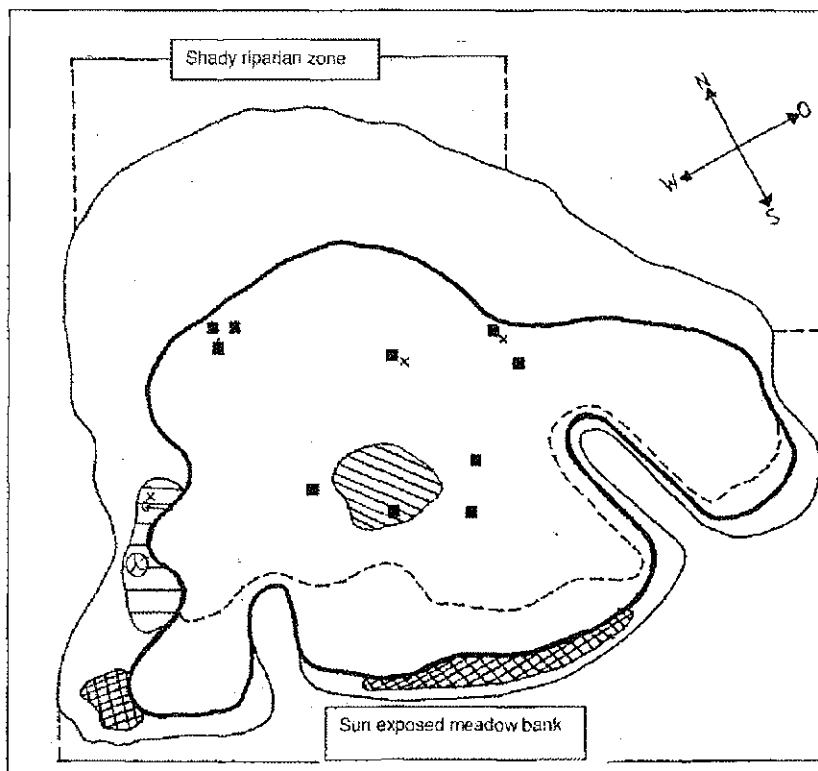


Fig. 3: Sketch of the *Typha* layer before and after reduction of the herbaceous plant layer and woody plants.

Fig. 3: Skica plasti ozkolistnega rogoza pred in po odstranitvi rastlinske mase in olesenelih rastlin.

Tab. 1: Water chemistry of the fresh water pool at Sv. Vid on the Merag Peninsula (Cres Island, Croatia). n.d.= below detection limit of the test, -- not measured.

Tab. 1: Kemijske lastnosti vode v kalu pri Sv. Vidu na Meraškem polotoku (otok Cres, Hrvatska). n.d.= pod mejo detekcije, -- neizmerjene.

	1997		1998	1999		2000		2001
	before <i>Typha</i> removal	after <i>Typha</i> removal	June	June	September	June	September	May
temperature (°C)	20	21	22.8	--	25	22.5	25.5	20
pH	7.5	7.8	7.5	--	--	7.7	8.5	7.0
oxygen (mg/l)	4.9	3.65	3.0	--	2.0	--	1.7	5.0
phosphate (mg/l)	0.25	0.25	<0.25	--	<0.25	--	0.25	0.25
nitrate (mg/l)	n.d.	0.1	<10	--	10	10	10	0
nitrite (mg/l)	n.d.	n.d.	0.025	--	0.25	0.04	0.3	0
ammonium (mg/l)	0.1	0.2	n.d.	--	n.d.	--	0.2	0.1
total hardness (°dH)	17.1	15.2	18.1	--	--	18.4	18.1	14.7
carbonate hardness (°dH)	17	15.5	16.4	--	--	--	16.8	4.6
residual hardness (°dH)	>0.5	>0.5	>0.5	--	--	--	>0.5	--

### Vegetation

Vegetation within and around the pool was recorded. The marsh flora was investigated along two transects (Fig. 2). For the reduction of the cattail, the *T. angustifolia* stems rooting in the bottom of the pond near the shore were either pulled out by hand or cut below the water surface due to damage rhizomes infiltrated by water. A part of the floating rhizome mat in the centre of the pond was sawed into squares and, after estimating its biomass, removed from the water (Fig. 4a). The development of the *Typha* layer was documented photographically in spring and autumn/winter from 1997 to 2001.

### Fauna

The fauna associated with the pond was recorded qualitatively considering the different habitats: free water body, benthos, *Typha*-stand (standing crop and floating mat). Population densities of two vertebrate species were estimated for an area of about 250 m<sup>2</sup>: *Gambusia affinis* was caught in a constrained area for 30 min by hand nets. Projection of the number of individuals caught yielded an estimation for the total population size. Population density of *Rana ridibunda* was estimated by observing the sunny shore of the pond for several times during June 2<sup>nd</sup> – 14<sup>th</sup> 1997.

## RESULTS AND DISCUSSION

### Biotope parameters of the pond

The surface area of the pond is approximately 1,200 m<sup>2</sup> and its maximum depth is 2.18 m. Further dimensions are shown in Figure 2. Water chemistry parameters are summarised in Table 1. The pH value of 7.5 and the low values for nitrate and nitrite indicate rather good water quality. Removing of *Typha* did not influence water chemistry neither immediately nor in longer term. Slight differences between the years may be due to differences in water level and temperature: during the season, the water level of the pool changed between high water after winter rainfall and extensive desiccation during the summer. Seasonal fluctuations between 130 cm and 170 cm are apparently normal. During the study period, the highest water level in the pool of Merag rose up to approximately 215 cm (November 1998, see also Fig. 4f) and the lowest level fell down to 40 cm (August 2000, see also Fig. 4j). Under the extreme summer conditions, the water line could recede along the East-West-line down to 9.5 m from the shore with a reduction of the water volume of about 85%. At that time, it is particularly the fish population that gets very crowded in the highly restricted zone of life.

Tab. 2: List of the most abundant plant species growing on the *Typha*-rhizome mat in the fresh water pool at Sv. Vid on the Merag Peninsula (Cres Island, Croatia).  
Tab. 2: Seznam najštevilnejših rastlinskih vrst, rastočih na plavajočem rogozu v kalu pri Sv. Vidu na Meraškem polotoku (otok Cres, Hrvatska).

Bryophyta	<i>Calliergonella cuspidata</i> <i>Aulacomnium palustre</i> <i>Plagiomnium undulatum</i> <i>Drepanocladus aduncus</i>
Ranunculaceae	<i>Ranunculus lingua</i>
Cyperaceae	<i>Carex sylvatica</i> <i>Carex cf. acutiformis</i> <i>Carex vulpina</i>
Typhaceae	<i>Typha angustifolia</i>
Rubiaceae	<i>Galium album</i>
Rosaceae	<i>Potentilla reptans</i>
Polygonaceae	<i>Rumex conglomeratus</i>
Salicaceae	<i>Salix cinerea</i> <i>Salix alba</i>
Orchidaceae	<i>Orchis laxiflora</i>
Asteraceae	<i>Eupatorium cannabinum</i> <i>Pulicaria dysenterica</i>
Onagraceae	<i>Epilobium hirsutum</i>

Very low water does not only cause general problems for the aquatic fauna, it also influences the ecological balance by changes of the hydrochemical and – physical life conditions, especially by a low rate of oxygen combined with high water temperatures (Tab. 1). The water surface in the summer is also covered with a dense algae mat (see also Fig. 4i), which hinders the exchange of oxygen. Values for ammonium (0.1–0.2 mg/l) and oxygen indicate a water quality of 2–3 and this corresponds to the occurrence of *Potamogeton natans* and *Ceratophyllum demersum* (Bellmann, 1988). The presence of *Potamogeton natans* indicates β-mesosaprobe water quality (Strebile & Krauter, 1988) and *Ceratophyllum demersum* is typical for eutrophic shallow waters and a resistant species of eutrophic lakes (Toivonen & Bäck, 1989).

Phosphor rates of 0.05 mg/l are considered critical. The measured phosphate and nitrite values of 0.25 mg/l in autumn 1999 and 2000 are relatively high and may result from a sheep cadaver, which was found lying in the water in the autumn.

### Vegetation

The northern shore of the pool is shaded by trees of *Acer campestre* and *A. monspessulanum*, whereas the southern shore is treeless and heavily grazed by sheep. Typical herbs of this sun-exposed area are: *Stachys erecta*, *Marrubium peregrinum*, *Galactites tomentosa*,

Tab. 3: Animal community associated with the permanent fresh water pool at Sv. Vid.  
 Tab. 3: Živalska združba, povezana s sladkovodnim kalom pri Sv. Vidu.

Gastropoda	Acroloxidae	<i>Acroloxus lacustris</i>	
Araneae	Lycosidae	<i>Pirata</i> sp.	
	Tetragnathidae	<i>Tetragnatha</i> sp.	
Odonata	Coenagrionidae	<i>Coenagrion puella</i>	
		<i>Coenagrion scitulum</i>	
		<i>Ceragrion tenellum</i>	
	Aeshnidae	<i>Ischnura elegans</i>	
		<i>Enallagma cyathigerum</i>	
Libellulidae	<i>Anax imperator</i>		
Ensifera	Gryllotalpidae	<i>Orthetrum cancellatum</i>	
		<i>Crocothemis erythraea</i>	
	Tettigoniidae	<i>Libellula depressa</i>	
			<i>Gryllotalpa gryllotalpa</i>
Caelifera	Acrididae	<i>Pteronemobius heydeni</i>	
		<i>Pholidoptera littoralis</i>	
Heteroptera	Notonectidae	<i>Notonecta</i> sp.	
	Nepidae	<i>Nepa</i> sp.	
Coleoptera	Carabidae	<i>Oodes helopioides</i>	
		Dytiscidae	<i>Cybister laterimarginalis</i>
			<i>Noterus</i> sp.
	Hygrobiidae	<i>Scirtes</i> sp.	
		Hydrophilidae	<i>Cyphon</i> sp.
			<i>Hygrobia tarda</i>
Diptera	Stratiomyidae	<i>Enochrus testaceus</i>	
		<i>Stratiomys longicornis</i>	
		<i>Stratiomys potamida</i>	
		<i>Lasiopa villosa</i>	
	Syrphidae	<i>Odontomyia ornata</i>	
		<i>Eristalis similis</i>	
		<i>Eurimyia lineata</i>	
Pisces	Poeciliidae	<i>Gambusia affinis</i>	
Amphibia	Hylidae	<i>Hyla arborea</i>	
	Ranidae	<i>Rana ridibunda</i>	
Reptilia	Lacertidae	<i>Podarcis melisellensis</i>	
	Colubridae	<i>Natrix natrix</i>	
		<i>Elaphe situla</i>	
Aves	Rallidae	<i>Elaphe quatuorlineata</i>	
		<i>Rallus aquaticus</i>	

*Plantago media*, *Trifolium repens*, *Dactylis glomerata*. Willows (*Salix alba*, *S. cinerea*) of 0.3 m (min.) to 2.75 m (max.) circumference grow in the northern part of the pool (Fig. 3).

About three quarters of the water surface were covered by *T. angustifolia*, the rest of the surface partly by *Potamogeton natans* and *Ceratophyllum demersum* (Fig. 3). In the centre of the pond, *T. angustifolia* forms a floating rhizome mat on which marsh flora is growing (Tab. 2). The mat of the cattail has its maximum thickness in the central part, which suggests that it originated in the centre of the pool, and expands towards the shore. Since the mat works as a physical and chemical filter (Ennabili et al., 1998), other plant species were found in a characteristic distribution pattern. However, factors like light condition, interspecific competition and nutrient supply may also be responsible.

All four recorded moss-species are widely distributed and typical for marshy habitats. *Aulacomnium palustre* is typical for weakly to strongly acidic bogs (Frahm & Frey, 1983; Jahns, 1987). *Epilobium hirsutum* is typical of terrestrialisation communities and eutrophic species like *Rumex conglomeratus*, *Pulicaria dysenterica* and *Eupatorium cannabinum* indicate nitrification.

Noteworthy is the first record of *Orchis laxiflora* on the island of Cres. This endangered orchid is distributed throughout the northern Mediterranean, but rare due to loss in habitats (Baumann & Künkele, 1982). In 1997, the population of 150-200 individuals bloomed in the centre of the rhizome mat. From 1998 to 2000, no orchids were found blooming. This may be due to sheep grazing in the central part of the *Typha*-stand during the low water level. In May 2001, around 150 orchids were found blooming again.



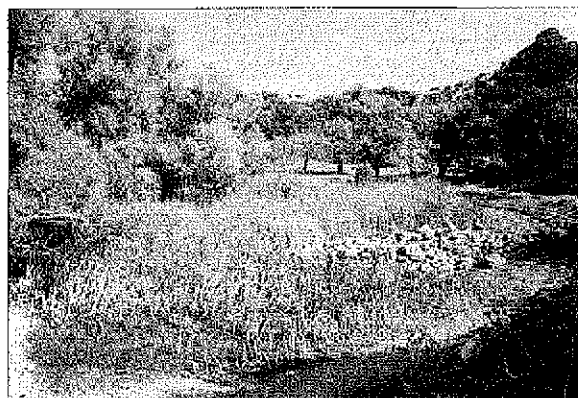
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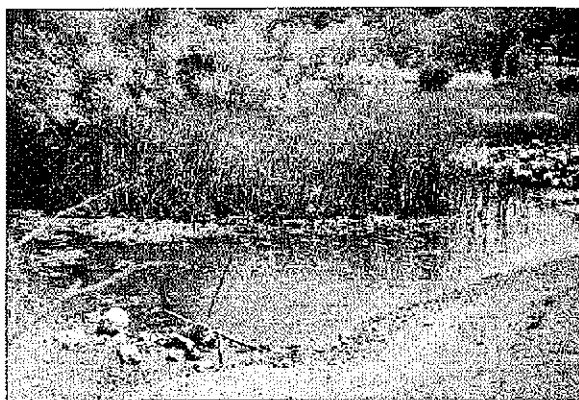
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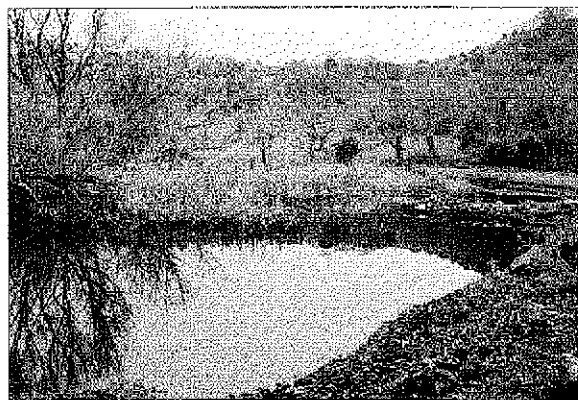
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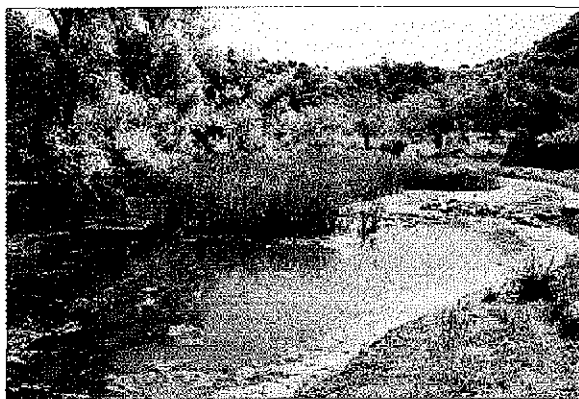
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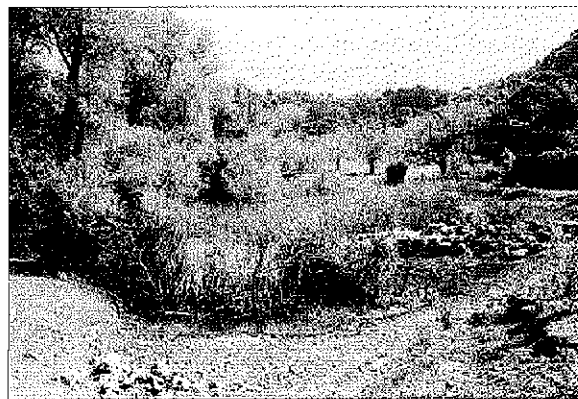
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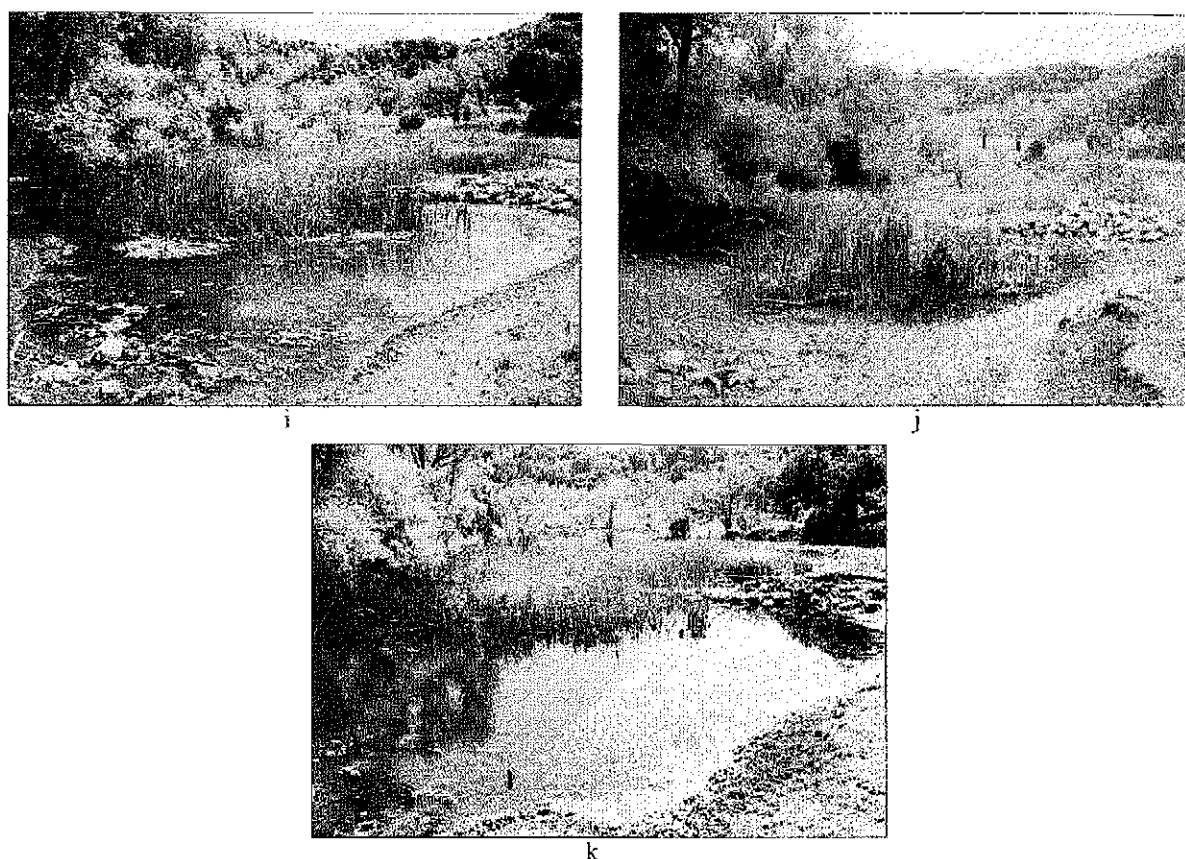
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**Fig. 4: Documentation of the removal of the cattail belt and its recovery in 4 consecutive years at the pond at Sv. Vid, Merag:**

**a. removal of the rhizome; b. *Typha* stand before reduction in spring 1997; c. *Typha* stand after reduction in spring 1997; d. autumn 1997; e. spring 1998; f. winter 1998; g. spring 1999; h. autumn 1999; i. spring 2000; j. autumn 2000; k. spring 2001.**

**Sl. 4: Dokumentacija o odstranitvi pasu ozkolistnega rogoza in njegovi ponovni rasti v 4 zaporednih letih v kalu pri Sv. Vidu na Meraškem polotoku:**

**a. odstranitev rizoma; b. sestoj ozkolistnega rogoza pred krčenjem spomladi 1997; c. sestoj ozkolistnega rogoza po krčenju spomladi 1997; d. jesen 1997; e. pomlad 1998; f. zima 1998; g. pomlad 1999; h. jesen 1999; i. pomlad 2000; j. jesen 2000; k. pomlad 2001.**

### ***Typha***

During the last years, the open surface of the pond decreased dramatically due to the expansion of *T. angustifolia*. Total coverage would threaten the existence of the pond. Therefore it was decided to remove some parts of the cattail belt. Just by doing that, it was discovered that the centre of the *Typha*-stand consisted of a floating rhizome mat. The original margins of the *Typha*-stand and the margins after removing the cattail are given in Figure 3. Cattail rooting near the shore was pulled out by hand or cut beneath the water surface and about 25 m<sup>2</sup> of the floating mat with an average thickness of 40 cm, which corresponds to a biomass of 5.1 t fresh weight (3.1 t dry weight), were removed. Controls

in the following years (1998-2001) showed that the rhizome layer did not expand where it had been cut (see also Fig. 4). In September 1997, only cattails removed by hand sprouted again, whereas nearly none recovered amongst those that had been cut below the water line. Hence, the rhizomes may have been damaged by penetrating water. In June 1998, the cattail was cut again and by September 1998 nearly none of the cut cattail had recovered (see Fig. 4f).

### **Fauna**

*Gambusia affinis holbrooki* (Poeciliidae) was introduced to Europe at the beginning of the 20<sup>th</sup> century especially for mosquito control (Kinzelbach & Krupp,

1982) and is established throughout S-Europe since 1930. As *G. affinis* prefers shallow sun-exposed water regions, the population density was estimated on the sunny part of the pond. The projection yielded about 5000 individuals/250 m<sup>2</sup> surface of the pool. The population size indicates that even a small body of water exists during the whole year. *G. affinis* is capable to tolerate water temperatures up to 40°C (Al Habbib & Yacoub, 1993), which is far more than the pool temperature measured on several occasions in late spring and in September.

Seven amphibian and twenty-one reptilian species are known for Cres (Sehnač & Schuster, 1999). In total, five species were found at the pond at Sv. Vid (Tab. 3). The abundance of *Rana ridibunda* was estimated, and yielded 20 adults and 3 sub-adults. Several times, individuals of *Natrix natrix* and *Elaphe quatuorlineata* were recorded swimming, whereas 4 juvenile individuals of *E. situla* were observed in the surrounding stone wall. Many specimens of *Podarcis melisellensis* were recorded resting on stones near the shore.

A peculiarity of the pond is the first evidence of a brood of the Water Rail *Rallus aquaticus* for Cres in 1997. Ten eggs hatched successfully in May 1997 and in September of the same year the pond was still used by these birds.

The pool of Sv. Vid is also a life zone of an interesting invertebrate-biocoenosis, which includes common species along with endangered and rare ones (Tab. 3). The fauna of soldier flies (Stratiomyidae) with aquatic larvae feeding on algae is relative rich in species and individuals. *Stratiomys longicornis*, *S. potamida*, *Lasiopa villosa* and *Odontomyia ornata* were recorded. High numbers of larvae of Stratiomyidae were found in the benthos. The maggots of two species of hover flies, *Eristalis similis* (= *E. pratorum*) and *Eurimyia lineata*, were found developing in the pond.

The largest dytiscid beetle is *Cybister laterimarginalis*. This species occurs in lakes with deep water and is not common in Europe with tendency to recede (Schmidl, 1995). Remarkable is the presence of *Hygrobia tarda* (Hygrobiidae), the only species of this water beetle family in Europe, which is considered to be extinct in Central Europe (Sondermann, 1990). Both species were also found near Osor (Franciscolo, 1978).

High numbers of *Gryllotalpa gryllotalpa* in different developmental stages escaped from the *Typha*-rhizome mats, which were removed from the pond. Several

specimens of the hygrophilic and warm loving (Ingrisch & Kohler, 1998) grasshoppers *Pteronemobius heydeni* and *Pholidoptera littoralis* were also found near the water.

Twenty-one dragonfly species are known from the island of Cres (Sušić & Perinčić, 2000), 9 of which were identified at the pond of Sv. Vid (Tab. 3). Typical Mediterranean species like *Coenagrion scitulum*, *Ceriagrion tenellum* and *Crocothemis erythraea*, which also was abundant as larvae in the benthos, occur with species distributed throughout Middle Europe like *Enallagma cyathigerum* and *Ischnura elegans*. *Ceriagrion tenellum* is abundant in the Mediterranean region and mostly found along flowing waters, whereas *C. scitulum* is considered to be rare throughout its distribution area (Bellmann, 1993). The same author often reported *C. scitulum* from very small, densely vegetated pools, which were rather isolated in a dry landscape of Istria. The fauna of freshwater snails is very poor and only *Acroloxus lacustris* was found in a small population under stones along the shore and within the cattail belt. Especially the appearance of the Emperor Dragonfly *Anax imperator*, a species that is missing at desiccating ponds (Bellmann, 1993), is an evidence that the pool does not dry up during the year.

## CONCLUSIONS

The pond at Sv. Vid was heavily threatened to dry up completely due to the extensive growth of the *Typha* rhizome. During our investigations, this pool showed to be an important cell of biodiversity within the old cultivated area. This was underlined by the first records of two species for the island of Cres. Furthermore, a remarkable number of endangered and rare plant and animal species live around or in the pond. The removal of the *Typha* rhizome was apparently the right way to save the water level and to guarantee the existence of the water body for many years. A continuation of the described management would be desirable.

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## EKOLOŠKE ZNAČILNOSTI SREDOZEMSKEGA KALA NA MERAŠKEM POLOTOKU NA OTOKU CRESU (HRVAŠKA)

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### POVZETEK

Leta 1997 so avtorji članka na Meraškem polotoku na otoku Cresu raziskovali favno, floro in fizikalne ter kemijske lastnosti vode v kalu, ki ga je čedalje bolj preraščal ozkolistni rogoz *Typha angustifolia* L. To je bil razlog za odločitev, da se z različnimi metodami poskusi odstraniti rogozov sesto. Učinkovitost metod je bila kvalitativno nadzorovana med letoma 1998 in 2001. Fizikalne in kemijske lastnosti vode so bile ugotovljene pred in po odstranitvi rastlinske mase. Sicer pa sta bili na otoku Cresu odkriti dve novi vrsti: *Orchis laxiflora* Lam., ki je ogrožena v celotni sredozemski regiji, in mokož *Rallus aquaticus* L., ki je uspešno gnezdil v trstičevju. Poleg tega je bil odkrit tudi potapnik *Hygrobia tarda* (Herbst), za katerega domnevajo, da je v Srednji Evropi že izumrl.

**Ključne besede:** kal, favna, flora, prvi podatki, *Typha angustifolia*, plavajoče rastlinje, Cres

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