Acta Musei Nationalis Pragae, Series B, Historia Naturalis, 61 (1–2): 77–80 issued June 2005
Sborník Národního muzea, Serie B, Přírodní vědy, 61 (1–2): 77–80

ALGAL FLORA OF KRŠKA JAMA CAVE, SLOVENIA

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Krivograd Klemenčič, A., Vrhovšek, D. (2005): Algal flora of Krška jama Cave. – Acta Mus. Nat. Pragae, Ser. B, Hist. Nat., 61 (1-2): 77–80. Praha. ISSN 0036-5343.

Abstract. This paper represents the first report of the Krška jama Cave algae. A total of ten algal species and subspecies were found in subaerial samples from the Krška jama Cave in Slovenia. Most algae were typical aerophilic species, with *Trentepohlia aurea* being the most abundant. The flora was species-poor compared with other caves, probably due to weak lighting. *Navicula harderii* is new species for Slovenia.

■ algae, cave, subaerial habitat

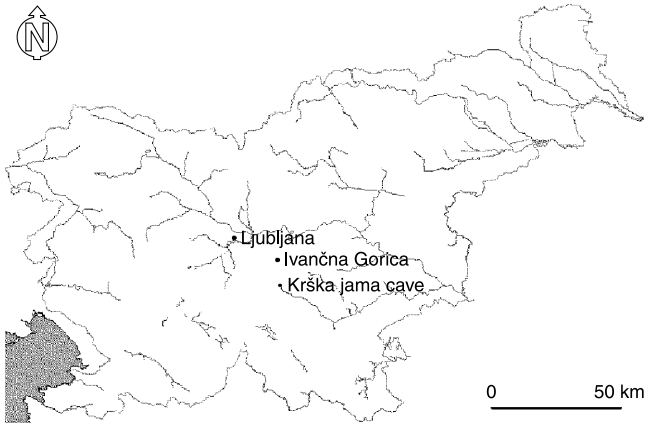
Received: May 11, 2004

Introduction

Algal floras have been studied for a number of different subaerial habitat types by various researchers throughout the world. These habitats have drawn attention because of their marked differences from aquatic habitats usually studied by phycologists. The studied sites include wet walls associated with waterfalls or springs (Johansen et al. 1983a), soils (Johansen et al. 1983b) and caves (Golubič 1967, Dobat 1973, Martinčič et al. 1981, Rushforth et al. 1984, Dayner and Johansen 1991, Georgoudaki et al. 1993, Vinogradova et al. 1998, Garbacki et al. 1999). Of these habitats, caves are perhaps the most unusual because of their very reduced seasonality and limited light conditions (at the mouth; artificial light).

Three studies have considered subaerial algal floras in caves of Slovenia. Dobat (1973) found 7 algal species in different caves with artificial light. Martinčič et al. (1981) found algal floras in six caves with artificial light: Postonjska jama, Pivka jama, Črna jama, Taborska jama, Škocijanske jame and jama Pekel. Altogether with the other authors they found a total of 44 algal species, most of which were Cyanophyceae with most abundant genera *Gloeocapsa* and *Aphanocapsa*. Golubić (1967) studied 13 karst caves in the area of former Jugoslavia. He found in total 115 algal species, most of which were assigned to Cyanophyceae with 103 species.

The Krška jama is a karst limestone cave formed by water flow, thus it does not have the stalactite and stalagmite formations of the caves previously studied. During winter it is open from 11 am to 3 pm and during summer from 9 am to 7 pm. The lights are switched on only when visitors are in the cave. Mosses are present on many substrates around the lights and moisture from groundwater seeps into the cave year-round. At the end of the cave (about 150 meters from the mouth) there is a small siphon pool. The map of Slovenia with marked the Krška jama Cave is presented in Text-fig 1.

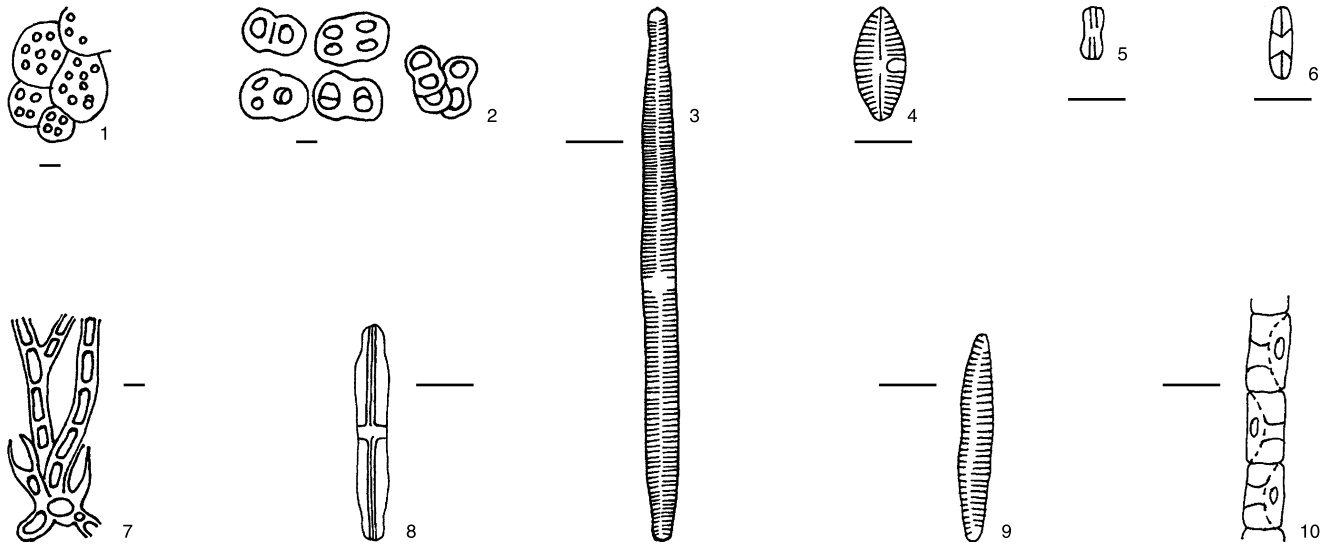


Text-fig. 1. Map of Slovenia with marked sampling site the Krška jama Cave.

The aim of the investigation was to establish the species structure and relative abundance of the algal flora in the Krška jama Cave in Slovenia.

Materials and methods

Four samples were taken seasonally in the years 1998, 1999 and 2000. The samples were brushed from the rock below the light that is most distant from the cave mouth. This sampling site was the wettest site in the cave. The samples were immediately bottled and preserved in a solution of 4 % formaldehyde. Each sample was treated by concentrated HNO_3 for the identification of diatom species (APHA 1985).



Text-fig. 2. Species determined in the Krška jama Cave in the years 1998, 1999 and 2000. Legend: 1 – *Gloeocapsa compacta*, 2 – *G. minuta*, 3 – *Fragilaria ulna* var. *ulna*, 4 – *Achnanthes lanceolata*, 5 – *Navicula contenta*, 6 – *N. harderii*, 7 – *Trentepohlia aurea*, 8 – *Neidium septentrionale*, 9 – *Nitzschia amphibia*, 10 – *Klebsormidium flaccidum*. Scale bar = 10 µm.

Species and subspecies of algae were determined with the use of a light microscope and the following identification monographs were used: Golubić (1967), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b). Relative abundance was estimated using numbers 1, 3 and 5 (1-single, 3-customary, 5-dominate) (Grbović 1994).

Results and discussion

A total of ten algal species and subspecies were determined. These included six Bacillariophyceae, two Cyanophyceae and two Chlorophyceae (Tab. 1). The most common species were *Gloeocapsa minuta*, *Navicula contenta*, *Navicula harderii* and *Trentepohlia aurea*, which occurred in all four samples. *Trentepohlia aurea* was also the most abundant species. The sample taken on 1.7.2000 had the highest species diversity, possessing all the species encountered in the cave. The winter sample (13.2.2000) had the lower species diversity, which can be explained with dimmer lighting during winter compared with other seasons.

In comparison to other studies of cave algae, the Krška jama Cave samples had very low algal diversity. For example, Vinogradova et al. (1998) found 42 species of Cyanophyceae in Mount Carmel Cave in Israel. Dayner and Johansen (1991) found 25 species of algae in Seneca Cavern in Ohio, USA, most of which were Bacillariophyceae. The diatoms were the largest group of algae with six species in the present study. Dayner and Johansen (1991) found 14 diatom species in Seneca Cavern in Ohio. Rushforth et al. (1984) found 49 diatom species in Thurston Lava Tube.

Gloeocapsa compacta, *Navicula contenta*, *Klebsormidium flaccidum* and *Trentepohlia aurea* are all aerophiles typically found in subaerial habitats. *Trentepohlia aurea* is the most common algal species of subaerial habitats in caves with artificial light in Slovenia (Lazar 1960). *Navicula harderii* is a new species for Slovenia.

There are several possible explanations for such low diversity in the cave. First, we did not sample any standing water in the cave, but only one subaerial site. This method differs from other studies. Second, light intensity was very low in the Krška jama Cave, lights were switched on only when visitors were in the cave and visitors came mostly on Saturdays and Sundays.

The diatom assemblage observed in the Krška jama Cave was very different from that observed in other caves throughout the world. For example, of the 25 species reported from Seneca Cavern, only *Klebsormidium flaccidum* was present in the Krška jama Cave. Of all algal species found in jama Pekel, Škocijanske jame, Pivka jama, Taborska jama and Črna jama (Martinčič et al. 1981) only *Trentepohlia aurea* was found in our samples. Of the species treated by Golubić (1967) in the caves in Slovenia and nearby surroundings, only two are also present in the Krška jama Cave: *Gloeocapsa compacta* and *Gloeocapsa minuta* = *Chroococcus minutus*. The most similar subaerial habitat reported in the literature is that of Postonjska jama in Slovenia (Martinčič et al. 1981), which shared 4 species with the Krška jama Cave, including *Gloeocapsa compacta*, *Navicula contenta*, *Klebsormidium flaccidum* and *Trentepohlia aurea*.

Table 1: Algal species list with estimation of abundance (1-single, 3-customary, 5-dominate) from the Krška jama Cave in the years 1998, 1999 and 2000.

Taxa	date of sampling			
	20.9.98	12.9.99	13.2.00	1.7.00
PROKARYOTA CYANOPHYTA CYANOPHYCEAE				
Gloeocapsa compacta Kütz.		1		1
Gloeocapsa minuta (Kütz.) Holler.	1	1	1	1
EUKARYOTA HETEROKONTOPHYTA BACILLARIOPHYCEAE				
Achnanthes lanceolata (Bréb.) Grun.				1
Fragilaria ulna var. *ulna* (Nitzsch) Lan.-Bert.				1
Navicula contenta Grun.	1	1	1	1
Navicula harderii Hust.	1	1	1	1
Neidium septentrionale Cleve-Euler				1
Nitzschia amphibia f. *amphibia* Grun.	1	1		1
CHLOROPHYTA CHLOROPHYCEAE				
Klebsormidium flaccidum (Kütz) Silva, Mattox and Black.	1			1
Trentepohlia aurea (L.) Martius	1	3	3	3

Summary

The Krška jama Cave is a karst limestone cave formed by water flow. During winter it is open from 11 am to 3 pm and during summer from 9 am to 7 pm. Lights are switched on only when visitors are in the cave. The aim of the investigation was to establish the species structure and relative abundance of the algal flora in the Krška jama Cave in Slovenia.

Four samples were taken seasonally in the years 1998, 1999 and 2000, from the rock below the light that is most distant from the cave mouth. Species and subspecies of the algae were determined with the use of a light microscope.

A total of 10 algal species and subspecies were determined. These included six Bacillariophyceae, two Cyanophyceae and two Chlorophyceae. The most common species were *Gloeocapsa minuta*, *Navicula contenta*, *Navicula harderii* and *Trentepohlia aurea*, which was also the most abundant species. *Navicula harderii* is a new species for Slovenia.

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