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Zoobenthos from sublacustrine springs in Lake Skadar, Crna Gora, Yugoslavia

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With 2 figures and 3 tables in the text

Introduction

The purpose of this investigation was to collect, identify, and determine the vertical distribution of zoobenthos in several springs in Lake Skadar.

A limited number of general zoobenthic studies have been conducted during the early years of exploration on Skadar (NEDELJKOVIĆ 1959) while others have been on specific fauna: oligochaetes (SAPKAREV 1956; KARAMAN 1973), chironomids (JANKOVIĆ 1973), and molluscs (STEIN et al. 1975 b; COVICH 1976). Although faunistic surveys of single springs or spring systems are common (PEARCE 1936; TEAL 1957; ODUM 1959; COLE 1975), no major zoobenthic investigations have been conducted on the sublacustrine springs of Lake Skadar.

Skadar, the largest lake on the Balkan peninsula has a surface area fluctuating between 370 and 600 km² and an average depth of 5 to 7 m. It contains sublacustrine springs, known as cryptodepressions or *.okos*, which are concentrated primarily along the steep southwestern and northern shores. Springs formed by chemical dissolution are important in the water budget and physico-chemical conditions of the lake (BEETON et al. 1974) and make up less than 1 per cent of the lake but yield up to 50 per cent of the large annual catch of fish (STEIN et al. 1975 a).

Study locations

Lake Skadar lies at the southwestern edge of a broad plain, 6 m above sea level, in the Dinaric Alps. between coastal mountains on the southwest and inland mountains on the northeast. Approximately 65 % of the lake lies in Yugoslavia and 35 % in Albania. Although there are numerous springs in Lake Skadar, this study includes the deepest (Raduš, ca. 60 m) and some lesser depressions. The locations of the springs studied are as follows: Raduš, Krnjice, and Modra (II — shallow basin) are on the southwest side of the lake; Morača is on the east side of Vranjina Island in the delta of the Morača River; and Karuć, Volać, Djurovo, and Nema Ime are at the northern end of an embayment known as Karuć (Fig. 1).

Methods and materials

Macro-zoobenthos were collected from several depths around and within each depression using an EKMAN sampler (15 × 15 cm). Collections at each location were composites of two to fifteen samples. Samples were washed with a 0.5 mm mesh screen-bucket and live sorted in the laboratory. Weight estimations were obtained using the volumetric displacement method of MEYERS & PETERKA (1974), i. e., number of ml displaced times a specific gravity of 1.05 g; except for large molluscs which were wet weighed.

Water temperatures from various depths were measured from samples collected with a FRIEDINGER bottle.

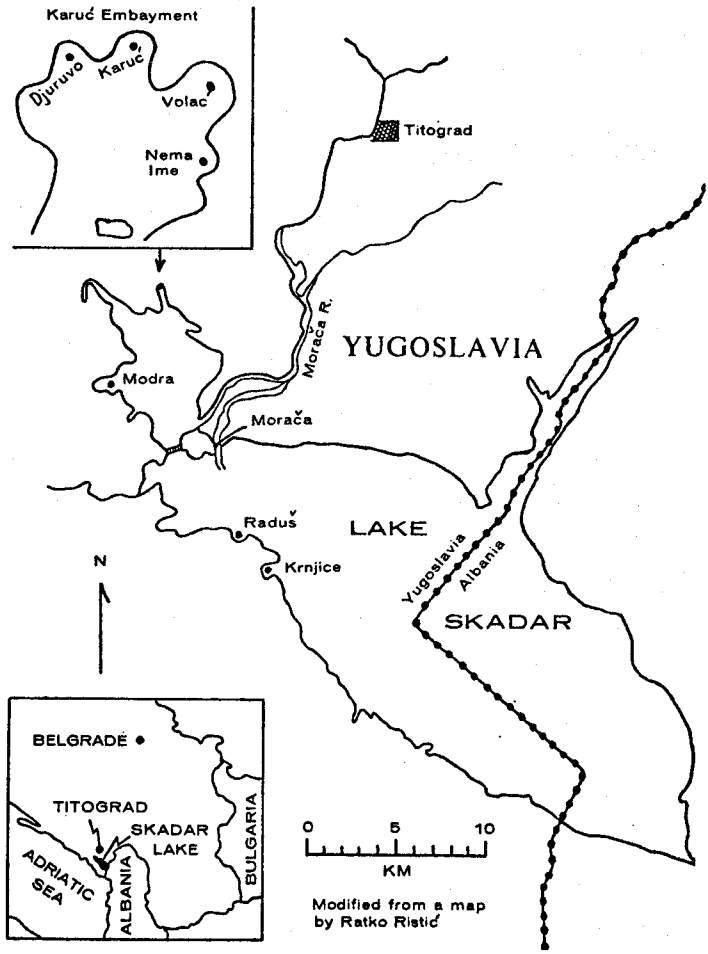

Fig. 1. Lake Skadar sublacustrine springs.

Raduš and Modra were sampled in May, 1975, while Krnjice, Morača, Karuć, Volać, Djurovo, and Nema Ime were sampled in late April and early May, 1976.

Results

Tables 1 and 2 show total taxa, density, biomass, and distribution of zoobenthos from eight springs. Thirty-seven taxa were identifed. The highest number encountered in one sample was 19 at 4 m on the south edge of Raduš. The most dominant were Mollusca, Tubificidae, and Chironomidae, each present in over 85 % of the samples. The most frequently occurring species were a midge *Polypedilum convictum* (78 %), snail *Valvata piscinalis* (50 %), snail *Pyrgula annulata* (44 %), snail *Viviparus viviparus* (42 %), and midge *Chironomus plumosus* and amphipod *Echinogammarus scutarensis* (30 % each).

The highest density of organisms approached 8900/m² in Djurovo at 3 m (99 % — *Viviparus viviparus*) and 6800/m² in Raduš at 17 m (65 % — worms Tubificidae and 18 % — *Polypedilum convictum*). High biomass values of 780 g/m² in Raduš at 6 m and 175 g/m² each in Karuć at 20 m and Morača at 3 m were due to large numbers of *Viviparus viviparus* up to 25 mm in diameter and mean weight of 14 g.

Raduš

A total of 19 depths, varying from 3 to 55 m were sampled from around and within the depression. Recent bathymetric soundings indicate that Raduš is at least 60 m deep (Ristic et al. 1975).

The deepest portion appears to lie approximately 20 m from shore at the southwest end of a trough beginning at the northeast edge of the embayment (Fig. 2). Slope is moderate (with a slight rise midway) until a depth of 20 m, at which point the depression quickly narrows and deepens to become steep-sided with scattered shelves or plateaus where sediments accumulate. Irregularly shaped sides of the main passage after 30 m afford many crevasses in which sampling equipment has been caught (V. Milasević pers. comm.).

On the north and east edges, between 3 and 8 m, the vegetation was primarily *Valliseneria* sp. and *Ceratophyllum demensum* overlying coarse partially decomposed organic matter. Inshore, to the south, the vegetation was more dense and consisted of *Ceratophyllum, Myriophyllum spicatum,* and *Potamogeton* sp. Dominant zoobenthos included Mollusca, worm Lumbricidae, Tubificidae, Chironomidae (*Polypedilum convictum* and *Chrionomus plumosus*), and biting midge Ceratopogonidae. Others present, leech Hirudinea, crayfish Decapoda, scud Amphipoda (endemic *Echinogammarus scutarensis*), sow bug Isopoda, opossum shrimp Mysidacea, mayfly Ephemeroptera, and caddis fly Trichoptera (Table 1), are typical fauna from the lake bottom.

Between 10 and 20 m, no living vegetation was found. The substrate was composed of fine organic matter, with numerous mollusc fragments, or hard rock. Here *Chironomus plumosus* was first collected. Other dominant taxa included Mollusca and Tubificidae.

Most of the substrate between 23 and 33 m consisted of coarse organic matter; although one sample at 25 m contained a large amount of *Ceratophyllum.* As in the shallows portions, the benthos was composed of Mollusca, Tubificidae, and Chironomidae.

The samples from 40 to 55 m were from either the walls of the depression or shelves containing fine organic matter with mollusc shell fragments and coarse organic matter (large plant fragments). Representative benthic organisms included Mollusca, Tubificidae, Amphipoda (*Echinogammarus scutarensis* and *Synurella ambulans),* and Chironomidae (*Chironomus plumosus* and *Polypedilum convictum).*

Modra

Only the shallower basin (8 m deep and 20 m wide) was sampled; this was not thermally stratified like other depressions (Table 3). The sediments from all depths were composed of very fine organic matter. Tubificidae, Chrionomidae, and the phantom midge *Chaoborus crystallinus* were the only taxa collected. At 5 m, only *Chaoborus* was present.

Karuć

This is also the name of a region which consists of four shallow sublacustrine springs — Karuć Volać, Djurovo, and Nema Ime (Fig. 1). The spring Karuć was approximately 30 m across and 20 m deep, with steep sides, although not as rocky as

Table. 1. Distribution, density, and biomass of zoobenthos in sublacustrine spring Raduš, Lake Skadar, Crna Gora, Yugoslavia.

Taxa	Depth 3 m	4 m	5 m	6 m	8 m	10 m	15 m	17 m
MOLLUSCA								
Theodoxus fluviatilus	176 (23.33)	81 (5.77)	66 (1.16)	110 (10.63)	0	22 (1.62)	0	0
Valvata piscinalis	330 (15.25)	154 (5.08)	154 (11.78)	374 (13.86)	198 (5.08)	242 (4.85)	44 (0.69)	0
Pyrgula annulata	0	152 (1.54)	0	0	0	22 (0.69)	22 (0.23)	22 (0.23)
Viviparus viviparus	88 (13.63)	0	15 (0.15)	44 (632.50)	0	0	0	0
Dreissena polymorpha	22 (0.70)	381 (55.32)	0	286 (22.64)	0	22 (1.39)	22 (32.11)	0
Unio sp.	0	0	0	0	0	0	22 (22.18)	0
Pisidium sp.	44 (1.16)	88 (0.38)	0	0	0	0	0	0
OLIGOCHAETA								
Lumbricidae	0	22 (1.23)	22 (2.77)	0	330 (0.46)	0	0	0
Tubificidae	352 (0.46)	271 (1.77)	0	44 (0.23)	0	352 (1.85)	0	6732 (14.09)
Potamothrix hammoniensis	0	0	110 (0.70)	0	0	0	198 (1.20)	0
Psammoryctes barbatus	0	0	22 (0.12)	0	220 (0.12)	0	66 (0.42)	0
Hirudinea	66 (1.16)	29 (0.92)	0	0	0	0	0	0
DECAPODA								
Paleomonetes antennaris	0	14 (4.00)	0	0	0	0	0	0
AMPHIPODA								
Echinogammarus scutarensis	0	7 (0.08)	0	0	0	0	0	0
Syneurella ambulans	0	0	0	0	0	0	0	0
ISOPODA								
Assellus aquaticus	0	7 (0.08)	0	0	0	0	0	0
MYSIDACEA								
Diamysis bachirensis	44 (0.23)	0	0	0	0	0	0	0
HYDRACARINA	0	0	0	22 (0.12)	0	0	0	0
DIPTERA								
Chironomidae	0	0	0	0	0	0	0	0
Chironomus plumosus	0	0	0	0	0	22 (0.69)	0	22 (1.39)
Polypedilum convictum	176 (0.35)	37 (0.15)	132 (0.12)	88 (0.23)	330 (0.46)	66 (0.12)	22 (0.12)	22 (0.23)
Clinotanypus	0	44 (0.39)	22 (0.23)	0	0	0	0	0
Ceratopogonidae	110 (0.35)	7 (0.08)	22 (0.12)	22 (0.12)	44 (0.12)	22 (0.23)	0	0
EPHEMEROPTERA								
Caenis sp.	66 (0.23)	29 (0.23)	0	22 (0.23)	0	0	0	0
Baetidae	22 (0.46)	0	0	0	0	0	0	0
TRICHOPTERA								
Triaenodes sp.	0	15 (0.31)	0	0	0	0	0	0
Athripsodes sp.	0	15 (0.31)	0	0	0	0	0	0
Ecnomus sp.	0	44 (0.31)	44 (0.35)	22 (0.23)	0	0	0	0
LEPIDOPTERA (pupae?)	0	7 (0.08)	0	0	0	0	0	0
Total taxa	12	19	10	10	5	8	7	4
Numbers /m²	1496	1404	609	1034	1122	770	396	6798
Weight (g/m²)	57.31	78.03	17.50	680.79	6.24	11.44	56.95	15.94

Table 1, continued.

Depth										
20 m	23 m	25 m	28 m	32 m	33 m	40 m	42 m	48 m	53 m	55 m
0	0	0	0	0	0	0	0	0	0	0
308 (5.08)	22 (0.23)	88 (0.46)	59 (0.93)	198 (2.54)	0	0	103 (2.46)	88 (0.93)	0	0
44 (0.92)	0	0	29 (0.62)	22 (0.23)	44 (0.46)	0	0	22 (0.23)	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	88 (3.23)	0	0	0	44 (38.35)	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	44 (0.69)	44 (0.46)	0	0	0	11 (0.23)	0
0	0	0	0	0	0	0	0	0	0	0
1408 (1.39)	0	88 (0.92)	0	0	1980 (8.32)	0	0	22 (0.23)	0	22 (0.23)
0	286 (3.03)	0	543 (3.39)	600 (3.33)	0	0	543 (1.26)	0	0	0
0	22 (0.23)	0	74 (0.08)	38 (0.83)	0	0	381 (0.85)	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	44 (0.46)	0
0	0	0	0	0	0	0	0	0	11 (0.19)	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	11 (0.12)	0
132 (3.70)	0	0	15 (0.13)	22 (0.46)	88 (3.23)	0	0	0	11 (0.19)	0
0	44 (0.12)	0	0	0	748 (1.39)	0	0	22 (0.23)	99 (0.11)	0
0	0	0	0	0	0	0	0	0	0	0
0	22 (0.12)	0	0	0	44 (0.46)	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
4	5	3	5	6	6	1	3	4	6	1
1892	396	264	720	924	2948	44	1027	154	187	22
11.09	3.73	4.61	5.15	8.08	14.32	38.35	4.57	1.62	1.30	0.23

Table 2. Distribution, density, and biomass of zoobenthos in selected sublacustrine springs in Lake Skadar, Crna Gora, Yugoslavia.

Taxa	Modra		Karuc				Volac	
	3 m	5 m	5 m	10 m	15 m	20 m	5 m	13 m
MOLLUSCA								
Lymnaea (Radix) auricularia	0	0	0	0	0	0	0	0
Theodoxus fluviatilus	0	0	0	0	0	0	0	0
Valvata piscinalis	0	0	0	0	22 (0.23)	0	0	0
Pyrgula annulata	0	0	0	26 (0.09)	22 (0.12)	9 (0.09)	0	0
Viviparus viviparus	0	0	669 (2.31)	748 (2.31)	330 (1.16)	26 (170.81)	519 (30.46)	0
Dreissena polymorpha	0	0	0	0	0	0	0	0
Pisidium sp.	0	0	0	0	0	0	0	9 (0.09)
OLIGOCHAETA								
Lumbricidae	0	0	0	0	0	18 (0.56)	0	0
Tubificidae	0	0	90 (0.28)	238 (1.20)	1782 (8.78)	0	44 (0.14)	414 (1.02)
Potamothrix hammoniensis	121 (2.08)	0	0	0	0	475 (3.42)	0	0
Psammoryctes barbatus	0	0	0	0	0	0	0	0
Hirudinea	0	0	9 (0.09)	0	0	26 (0.28)	0	0
AMPHIPODA								
Echinogammarus scutarensis	0	0	174 (0.92)	27 (0.09)	88 (0.46)	0	9 (0.09)	9 (0.09)
MYSIDACEA								
Diamysis bachirensis	0	0	0	0	0	0	0	0
OSTRACODA								
Herpetocypris reptans	0	0	55 (0.01)	18 (<0.01)	26 (0.01)	0	9 (<0.01)	0
ODONATA								
Coenagrionidae	0	0	0	0	0	0	0	0
ELMIDAE	0	0	0	0	0	0	0	0
DIPTERA								
Chironomidae	0	0	0	0	0	0	0	0
Chironomus plumosus	0	0	0	9 (0.09)	0	0	0	0
Polypedilum convictum	33 (0.12)		926 (0.56)	554 (0.56)	616 (0.69)	44 (0.09)	79 (0.14)	79 (0.18)
Clinotanypus nervosus	11 (0.12)	0	0	0	0	0	0	0
Procladius sp.	0	0	0	0	22 (0.23)	0	0	0
Chironomus sp.	0	0	0	0	0	0	0	0
Ceratopogonidae	0	0	0	0	0	0	0	0
Chaoboridae								
Chaoborus crystallinus	11 (0.12)	99 (1.04)	0	0	0	0	0	0
EPHEMEROPTERA								
Caenis sp.	0	0	0	0	0	0	0	0
Ephemera vulgata	0	0	9 (0.09)	79 (0.56)	0	0	26 (0.18)	9 (0.09)
TRICHOPTERA								
Triaenodes sp.	0	0	0	0	0	0	0	0
LEPIDOPTERA (larvae)	0	0	0	0	0	0	0	0
Total taxa	4	1	7	8	8	6	6	5
Numbers /m²	176	99	1932	1699	2908	598	686	520
Weight (g/m²)	2.44	1.04	4.26	4.91	11.68	175.25	31.02	1.47

Table 2, continued.

Djurovo		Nema Ime		Moraca	Krnjice			
3 m	10 m	5 m	8 m	3 m	3 m	8 m	13 m	15 m
0	0	0	0	0	44 (0.69)	44 (0.23)	0	0
0	0	0	0	0	0	0	0	44 (1.39)
0	0	0	0	0	110 (1.62)	22 (0.46)	0	44 (0.92)
440 (2.77)	9 (0.09)	0	0	0	110 (1.62)	0	0	88 (0.92)
5808 (16.63)	352 (1.11)	801 (4.25)	246 (1.57)	66 (169.23)	0	0	44 (0.92)	88 (5.08)
0	0	0	0	0	44 (4.16)	0	0	0
176 (0.92)	9 (0.09)	0	0	22 (0.35)	22 (0.23)	66 (1.39)	0	44 (0.46)
0	0	0	0	0	0	0	220 (15.25)	0
0	528 (1.67)	0	0	792 (1.27)	550 (1.73)	2530 (15.94)	1188 (5.54)	2244 (11.55)
508 (1.71)	0 0	326 (0.46)	141 (0.74)	0	0	0	0	0
284 (0.88)	0	0	0	0	0	0	0	0
0	0	0	0	33 (2.31)	22 (2.78)	0	44 (0.92)	0
0	0	9 (0.09)	141 (0.65)	44 (0.46)	22 (0.12)	0	0	0
0	0	9 (0.18)	0	0	22 (0.23)	0	0	0
0	0	35 (0.03)	18 (<0.01)	0	0	0	0	0
0	0	9 (0.28)	9 (0.05)	11 (0.58)	0	0	0	0
0	0	0	0	22 (0.06)	0	0	0	0
0	0	0	0	0	242 (0.23)	0	0	0
0	0	0	0	0	0	770 (14.32)	44 (0.92)	528 (14.78)
1619 (0.92)	282 (0.28)	1144 (2.59)	158 (0.18)	154 (0.12)	110 (0.23)	1760 (2.78)	4048 (8.32)	220 (0.46)
0	0	0	0	0	0	0	0	0
26 (0.05)	0	18 (0.05)	0	0	0	22 (0.12)	0	44 (0.23)
0	0	176 (0.18)	70 (0.18)	0	0	0	0	0
36 (0.09)	9 (0.05)	0	0	0	0	0	0	0
0	0	0	0	0	0	22 (0.23)	0	0
0	0	0	0	0	0	198 (0.69)	0	0
0	26 (0.05)	9 (0.28)	0	22 (0.35)	0	0	0	0
0	0	0	0	0	0	66 (0.23)	44 (0.23)	44 (1.39)
0	0	0	0	0	0	0	0	0
8	7	10	7	9	11	10	7	10
8897	1215	2536	783	1166	1298	5500	5632	3388
23.97	3.34	8.39	3.38	174.73	13.64	36.39	32.10	37.18

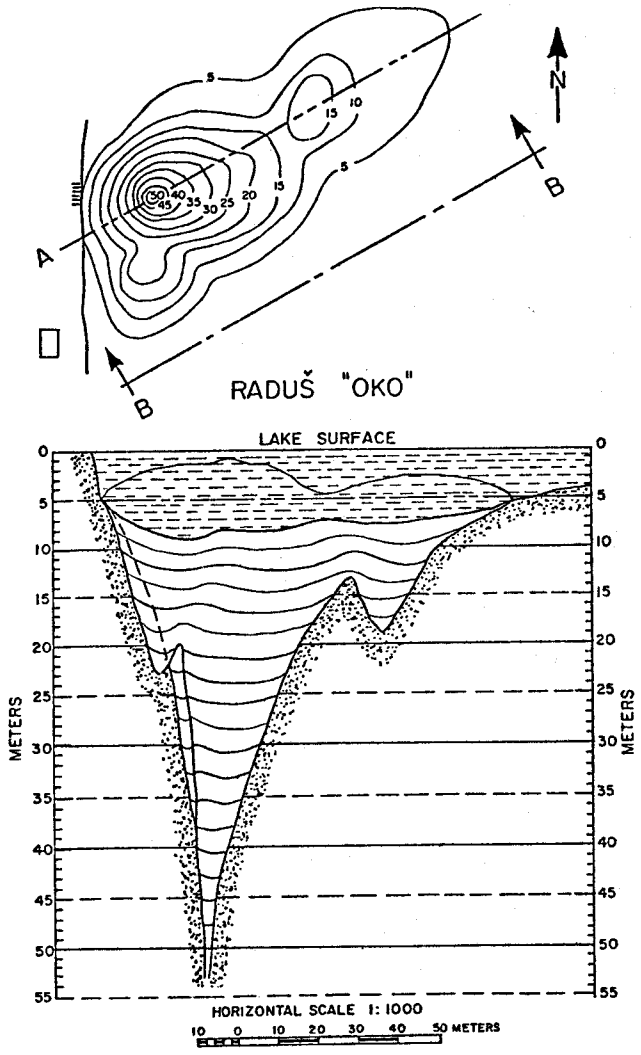

Fig. 2. Depth contours and bottom profile of sublacustrine spring Raduš, Lake Skadar, Crna Gora, Yugoslavia (drawn by RATKO RISTIĆ).

Raduš. At 5 m vegetation consisted of *Ceratophyllum* and *Myriophyllum*, lying over partially decomposed organic matter and red clay. Red clay and sand were the dominant substrate at 10 and 15 m, while at 20 m the substrate consisted of either hard rock, partially decomposed organic matter, sand with mollusc shell fragments, or sand with 3—4 cm long pieces of willow *Salix* sp. Common zoobenthos were Mollusca, Tubificidae, Hirudinea, Amphipoda, seed shrimp Ostracoda, and Chironomidae. At 5 and 10 m, the burrowing mayfly *Ephemera vulgata* first appeared and immature worms, Lubricidae were collected at 20 m.

Volać

This spring was 20 m wide and 13 m deep. The northern side was rocky and steep while the southern side was gently sloping with a substrate of sand and organic matter,

Table 3. Temperatures of Lake Skadar sublacustrine springs.

Spring	Depth (m)	Temperature (°C)
Raduš[1]	0	25.0
	10.0	13.0
	47.0	11.5
Modra[2]	0	25.5
	3.5	24 5
Karuč[3]	0	15.0
	20	11.0
Volač[3]	0	16.0
	12	11.0
Djurovo	0	20.0
	3	11.0
	10	11.0
Nema Ime	0	20.0
	5	11.0
Krnjice	0	20.0
	8	13.0

[1] G. Z. Jacobi, unpubl. data (June, 1973)
[2] A. M. Beeton, pers. comm. (July, 1975)
[3] After 3 days of overcast sky

After heavy precipitation, this spring has a very high volume of water coming up through the bottom; enough to cause surface disturbance (V. Kostić pers. comm.). Zoobenthos consisted of *Viviparus viviparus,* Tubificidae, *Echinogammarus scutarensis, Polypedilum convictum,* and *Ephemera vulgata.*

Djurovo

This depression, west of the spring Karuč, was 20 m wide, 15 m deep, steep sided, with an irregular rocky bottom. At 5 m the substrate consisted of fine organic matter, mollusc shell fragments, and *Salix* leaves. At 10 m the substrate was sand with shell fragments and some coarse plant material. Zoobenthos included Mollusca, Tubificidae, *Polypedilum convictum,* Ceratopogonidae, and *Ephemera vulgata.*

Nema Ime

This was the smallest depression sampled in the Karuč embayment. It was 10 m across and 8 m deep and had a temperature difference of 9 °C between the surface and 5 m. The substrate at 5 m contained filamentous green algae and *Myriophyllum* overlying partially decomposed organic matter with mollusc shell fragments. At 8 m, the sediment was very fine organic matter, brown overlying black. In addition to common benthos such as *Viviparus viviparus, Potamothrix hammoniensis, Echinogammarus scutarensis,* and *Polypedilum convictum,* an oppossum shrimp *Diamysis bachirensis, a* seed shrimp *Herpetocypris reptans,* a damsel fly Coenagrionidae, two other midges *Procladius* sp. and *Chironomus* sp., and *Ephemera vulgata* were found.

Morača

This depression receives spring flow as well as flow from the Morača River. It has been sounded to 9 m but samples were collected only from 3 m. In addition to typical lake fauna, Hirudinea, Coenagrionidae, and a riffle beetle Elmidae were collected.

Krnjice

This depression south of Raduš was 15 m deep and approximately 100 m across; consequently the bottom had a gentle slope. The substrate consisted of the following: at 3 m, coarse organic matter and some *Ceratophyllum;* at 8 m, coarse organic matter with *Trapa longycarpa* pods and mollusc shell fragments; at 13 m, coarse organic matter with *Ceratophyllum;* and at 15 m, coarse organic matter. Benthic fauna included Mollusca, Tubificidae, *Chironomus plumosus, Polypedilum convictum, Caenis* sp., *Triaenodes* sp. and Lepidoptera (larvae).

Discussion

The maximum depth of occurrence for several Lake Skadar zoobenthos have been extended: *Teodoxus fluviatilus* (15 m), *Valvata piscinalis* (48 m), *Pyrgula annulata* (40 m), *Unio* sp. (15 m), *Pisidium* sp. (53 m), Tubificidae (55 m), *Potamothrix hammoniensis* (42 m), *Psammoryctes barbatus* (42 m), Hirudinea (20 m), *Echinogammorus scutarinsis* (53 m), *Chironomus plumosus* (53 m), *Polypedilum convictum* (53 m), *Procladius* sp. (15 m), Ceratopogonidae (33 m), *Ephemera vulgata* (13 m), and an unidentified larvae of Lepidoptera (15 m). The only taxa found in a deep sample (53 m), was an amphipod, *Synurella ambulans.*

Even though a temperature differential of up to 13.5 °C existed between the surface water and depths except for non-stratifying Modra oko (II) (Table 3), this is no greater than the seasonal variations which exist in the major lake basin. Low dissolved oxygen, e. g., 1.95 mg/l in August, 1975, in Radus at 42 m (A. M. Beeton per. comm.), in addition to other factors, may limit colonization by other lake zoobenthos.

A large number of truly endemic spring fauna have not been found. This may be due in part to the "non-isolated" nature of the springs, i. e., they are merely extensions of the lake.

The oligotrophic nature of the lake (Nedeljković 1959) may be changing. It is interesting to note that the midge *Chironomus plumosus* was not found by Nedeljković but was very common in my samples as well as those of Janković (1974). Also, the average weight of zoobenthos for samples taken from 8 m or less and 10 m or more averaged 70.5 g/m² and 25.3 g/m², respectively. These values exceed those of Nedeljković (1959).

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