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Epizoic algae on *Emys orbicularis* (LINNAEUS, 1758), and *Mauremys rivulata* (VALENCIENNES, 1833), in the Kavak River Delta (Saros Bay, Turkey)

(Testudines: Emydidae, Geoemydidae)

Epizoische Algen auf *Emys orbicularis* (LINNAEUS, 1758) und *Mauremys rivulata* (VALENCIENNES, 1833) im Kavak Flußdelta (Saros Bucht, Türkei)
(Testudines: Emydidae, Geoemydidae)

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KURZFASSUNG

Vier *Mauremys rivulata* (VALENCIENNES, 1833) und 39 *Emys orbicularis* (LINNAEUS, 1758) aus dem Gebiet des Kavak Flußdeltas (Saros Bucht, Provinz Çanakkale, Türkisch Thrakien) wurden hinsichtlich des Algenaufwuchses auf Schwanz und Karapax untersucht. Die Gruppierung der festgestellten Algengattungen nach Schildkrötenart und -größe ließ unterschiedliche Verteilungsmuster der Algen erkennen. Vierzehn Gattungen epizoischer Algen konnten durch Abschaben isoliert und bestimmt werden. Algen der Gattungen *Chamaesiphon*, *Phormidium* und *Oscillatoria* waren am häufigsten. Bei gleicher Karapaxlänge war der Algenbewuchs von *M. rivulata* geringer als bei *E. orbicularis*.

ABSTRACT

Four *Mauremys rivulata* (VALENCIENNES, 1833) and thirty-nine *Emys orbicularis* (LINNAEUS, 1758) collected in the Kavak River Delta (Saros Bay, Province of Çanakkale, Turkish Thrace) were examined for epizoic algae on tail and carapace surfaces. Algae samples were grouped according to turtle species and shell size to detect potential patterns in the distributions of algae. Fourteen taxa of epizoic algae that were collected by scraping were identified from the turtles. Algae of the genera *Chamaesiphon*, *Phormidium* and *Oscillatoria* were found most frequently. The amount of algal growth was less in *M. rivulata* than *E. orbicularis* when turtles of similar carapax length were compared.

KEY WORDS

Reptilia: Testudines: Emydidae, Geoemydidae; *Emys orbicularis*, *Mauremys rivulata*, ecology, epizoic algae, Kavak River Delta, Province of Çanakkale, Thrace, Turkey

INTRODUCTION

Algae can develop on different structures. There are various reports of algae living on stones (DESIKACHARY 1959), in aquatic angiosperm plants (PRESCOTT 1951; TIFFANY & BRITTON 1952) or under the scales of fishes (PRESCOTT 1969) as well as epizoically on aquatic turtles or other aquatic reptiles (ERNST &NORRIS 1978; LINCOLN et al. 1982; ZIGLAR & ANDERSON 2005; TUMLISON & TRAUTH 2006; GARBARY et al. 2007). It was suggested that – in an ecological context – the relationships between ecosystems and epizoic organisms can be neglected because of their small to microscopic size (THORP & COVICH 1991). Albeit, these communities were useful indicators of pollution (ZIGLAR & ANDERSON 2011). Regarding the study of epizoic algae, there is lack of information about species on terrapins. Most common studies dealt with the algae *Basicladia chelonum* and *B. crassa* (PROCTOR 1958), whereas *Cladophora glomerata*, *Rhizoclonium hieroglyphicum*, *Dermatophyton radicans* and *Gongrosira debaryana* remained poorly studied objects (EDGREN et al. 1953; DIXON 1960; BELUSZ & REED 1969; ERNST & BARBOUR 1972; HULSE 1976). In addition to the members of the Chlorophyta, BELUSZ & REED (1969) reported Cyanobacteria of the species *Plectonema tenue*

from the carapace of the Snapping Turtle *Chelydra serpentina* (Linnaeus, 1758). Other cyanobacteria found on turtles were *Oscillatoria* sp., *Trichodesmium* sp. and *Lyngbya* sp. (Ernst & Barbour 1972).

Studies of epizoic algae on Turkish turtles are rare (e.g., Soylu et al. 2006). The aim of this study was to determine algal species on *Mauremys rivulata* (Valenciennes, 1833) and the threatened Red List species (IUCN 2013) *E. orbicularis* (Linnaeus, 1758) syntopically living in the Kavak River Delta (Province of Çanakkale, Turkish Thrace) and to compare the distribution patterns of the algae on the turtles' carapace. Potential differences were expected from the observation that *E. orbicularis* prefers the soft surfaces of slow-flowing fresh water systems that are clean and rich in vegetation (Ernst & Barbour 1989; Baran & Atatür 1998; Ayaz & Budak 2007) whereas *M. rivulata* is less specialized and thus also found in stagnant and slow flowing fresh waters including those polluted by domestic and industrial waste (Gasith & Sidis 1983, 1984, 1985).

MATERIALS AND METHODS

As a study site, the authors selected, the Kavak River Delta (40°38'N, 26°50' E), an important wetland, home to a rich herpetofauna and a number of different habitats (Özcan et al. 2008; Uysal & Tosunoğlu 2013). It covers approximately 21 km² at the Gulf of Saros in the Province of Çanakkale, southwest Turkish Thrace (Saner 1985) (Fig. 1).

Between April 30, 2011 and May 27, 2011 algae samples were collected from the carapace and tail surfaces of 39 *E. orbicularis* and four *M. rivulata*, which were caught sunbathing or from within the estu-

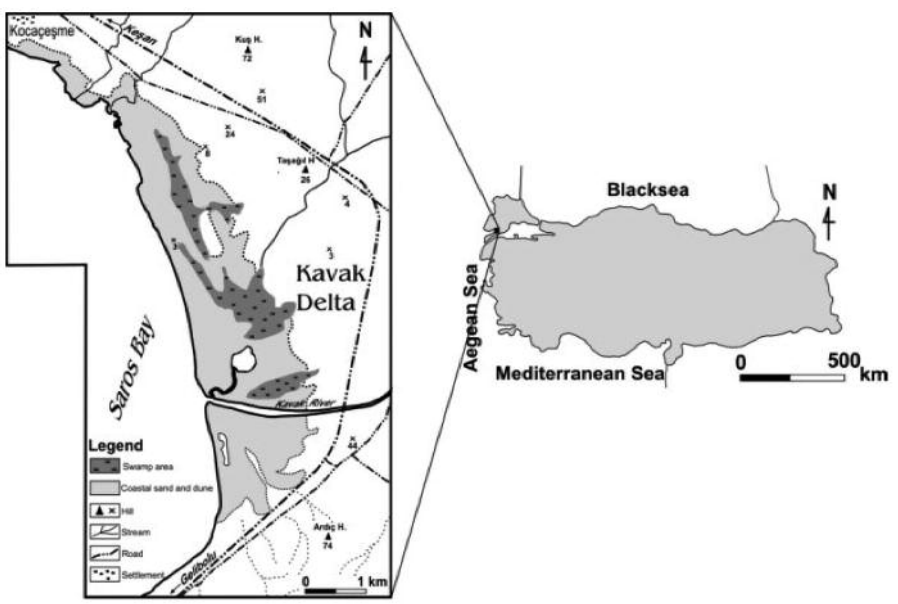

Fig. 1: Study area at the Kavak River Delta (40°38' N, 26°50' E), Saros Bay, Province of Çanakkale, Turkish Thrace.

Abb. 1: Das Untersuchungsgebiet am Kavak Flußdelta (40°38' N, 26°50' E), Saros Bucht, Provinz Çanakkale, Türkisch Thrakien.

arine fresh water by hand-picking. The algae were scraped from the shells with a scalpel, fixed in 4 % formaldehyde, examined under an Olympus BX51 microscope and identified to genus level with the help of the pertinent literature (KOMAREK & ANAGNOSTIDIS 1986, 1989, 1999; ANAGNOSTIDIS & KOMAREK 1988; KRAMMER & LANGE-BERTALOT 1991a, 1991b, 1999a, 1999b; JOHN et al. 2003; GUIRY & GUIRY 2013).

Algae samples were grouped according to terrapin species and carapace length (CL). *Emys orbicularis* included four size groups (CL = 80-100 mm [*n* = 6], 101-120 mm [*n* = 6], 121-140 mm [*n* = 22], and 141-160 mm [*n* = 5]) and *M. rivulata* two (120-160 mm [*n* = 2], 161-200 mm [*n* = 2]).

The concentrations of algae on the carapace were compared among these groups using a quadrinomial rating scale. Four categories roughly quantifying the extent of the algal plaques cover were determined: almost absent - sparse - moderate - rich.

RESULTS

Fourteen epizoic algal taxa were identified on the carapace and tail surfaces of *M. rivulata* and *E. orbicularis* (Table 1). The most frequently found taxa belonged to the genera *Chamaesiphon* A. BRAUN in RABENHORST (1864), *Phormidium* KÜTZING ex GOMONT (1892) and *Oscillatoria* VAUCHER ex GOMONT (1892) (Fig. 2). In a single case algae of the genus *Gyrosigma* HASSALL, 1845 were observed on the tail of *E. orbicularis*. The epizoic algal taxa detected were assigned to four higher systematic categories (Cyanobacteria, Chlorophyta, Ochrophyta and Charophyta); their frequencies on *E. orbicularis* and *M. rivulata* are shown in Fig. 3.

Variable densities of algal plaques were typical to the shells of all size classes of *E. orbicularis* (Fig. 4) (CL = 80-160 mm). In the smaller size classes (CL = 80-120 mm) however, the algal plaques were almost absent to sparse and restricted to few circumscribed areas of the carapace except in one moderately overgrown individual.

In larger animals (CL = 121-160 mm) all stages of algal growth were present and the borders of the algal plaques were frequently ill-defined and merged to form an almost continuous layer. Overall, the smaller the terrapins, the lesser was the extent of the algal plaques (Table 2).

The comparatively small sample of *M. rivulata* displayed sparse to moderate algal growth with clearly circumscribed algal plaques in the latter case. The number of algal taxa and the extent of algal growth found in this species was less than in *E. orbicularis* (Tables 1, 2, Figs. 3, 4).

Representatives of five to zero algae genera were observed per turtle (Table 1).

DISCUSSION

In his doctoral thesis AYAZ (2003) found that the accumulation of algae was dense on the carapace of *E. orbicularis* whereas only localized algal plaques were present on the shell of *M. rivulata*. This is fully in accordance with the present observations. A study by SOYLU et al. (2006) which examined epizoic algae on different populations of *E. orbicularis* from great parts of Anatolia defined 53 algal taxa belonging to the groups Chlorophyta, Cyanoprokaryota, Bacillariophyta, Euglenophyta, Dinophyta and Cryptophyta.

Previous studies indicated that, as regards the shell of terrapins, the type of hunting, physical stress, parasites, migration and competition affected the specific composition and distribution of algae, and that eating habits correlated with their frequency. Studies also showed that turtle species, which usually prey on insects, tadpoles and fishes, were more often camouflaged by epizoic algae than, e.g., herbivores, suggesting advantages in ambush hunting strategies (NEIL & ALLEN 1954; SOYLU et al. 2006).

Table 1: Algal genera found on the carapace of four *Mauremys rivulata* (Valenciennes, 1833) and 39 *Emys orbicularis* (Linnaeus, 1758) at the study site in 2011. CL – Carapace Length, M – Male, F – Female, J – Juvenile.

Tab. 1: Die Algengattungen, welche im Jahr 2011 im Untersuchungsgebiet auf den Rückenpanzern von vier *Mauremys rivulata* (Valenciennes, 1833) und 39 *Emys orbicularis* (Linnaeus, 1758) festgestellt wurden. CL – Carapaxlänge, M – Männchen, F – Weibchen, J – Jungtier.

ALGAE GENERA	*Chamaesiphon* sp.	*Phormidium* sp.	*Oscillatoria* sp.	*Aphanocapsa* sp.	*Calothrix* sp.	*Aphanothece* sp.	*Oedogonium* sp.	*Cladophora* sp.	*Amphora* sp.	*Nitzschia* sp.	*Gyrosigma* sp.	*Navicula* sp.	*Cosmarium* sp.	*Coleochaete* sp.	CL, Sex	Date / Datum
	Cyanobacteria						Chloro-phyta		Ochrophyta				Charo-phyta			
Mauremys rivulata																
1	+	+					+								16.4, M	4.V.
2	+	+						+							11.3., J	4.V.
3		+	+		+										20.0, M	4.V.
4															18.0, M	4.V.
Emys orbicularis																
1	+	+							+						14.3, F	17.V.
2	+		+	+			+								11.5, F	17.V.
3			+		+		+								11.2, F	17.V.
4			+							+					13.1, F	17.V.
5			+							+	+		+		12.8, F	17.V.
6	+					+									11.9, F	17.V.
7			+			+									12.8, F	17.V.
8	+	+	+			+									13.8, F	17.V.
9		+				+									13.3, F	17.V.
10	+														12.1, F	17.V.
11		+													11.5, F	17.V.
12	+											+			13.3, F	17.V.
13	+		+												12.2, M	17.V.
14	+	+		+	+					+					12.5, M	17.V.
15									+						11.2, M	17.V.
16															12.0, M	17.V.
17	+	+	+												12.7, M	17.V.
18	+	+	+												12.2, M	17.V.
19		+	+												11.0, M	17.V.
20	+	+										+			11.1, M	17.V.
21	+		+			+	+					+			11.5, M	17.V.
22															12.2, M	17.V.
23	+		+					+							10.2, M	17.V.
24	+														11.5, M	17.V.
25	+					+	+			+					11.3, M	17.V.
26	+														11.2, M	17.V.
27		+													11.5, M	17.V.
28	+	+												+	10.6, M	17.V.
29			+												12.6, M	17.V.
30	+			+											11.5, M	17.V.
31		+													8.3, J	17.V.
32															8.7, J	17.V.
33															8.6, J	17.V.
34															8.0, J	17.V.
35	+														9.5, J	17.V.
36	+	+	+						+						8.1, J	17.V.
37	+	+	+												8.0, J	17.V.
38	+		+			+				+					12.1, F	17.V.
39	+	+							+						11.3, F	17.V.

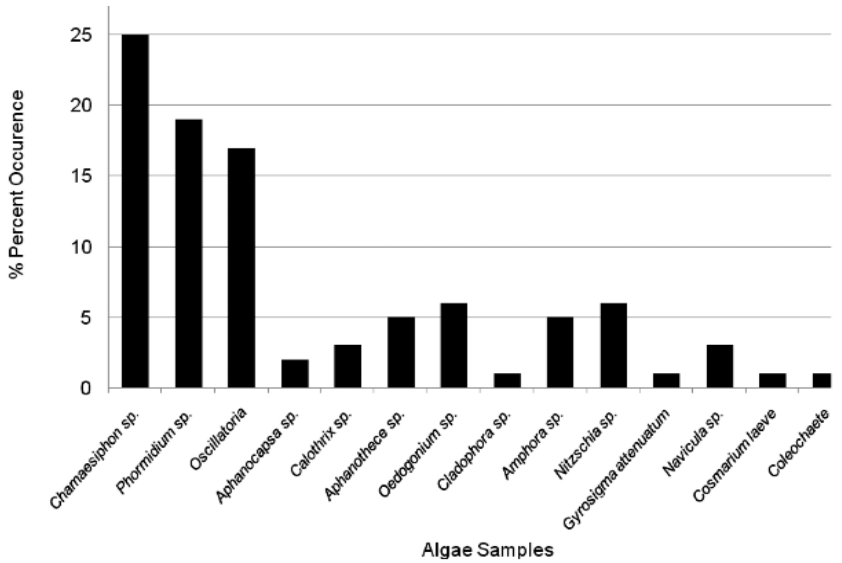

Fig. 2: Frequency (%) of 14 genera of algae on the carapace of 39 *Emys orbicularis* (LINNAEUS, 1758) and four *Mauremys rivulata* (VALENCIENNES, 1833) at the study site.

Abb. 2: Die Häufigkeit (%) des Auftretens von 14 Algengattungen auf dem Rückenpanzer von 39 *Emys orbicularis* (LINNAEUS, 1758) und vier *Mauremys rivulata* (VALENCIENNES, 1833) im Untersuchungsgebiet.

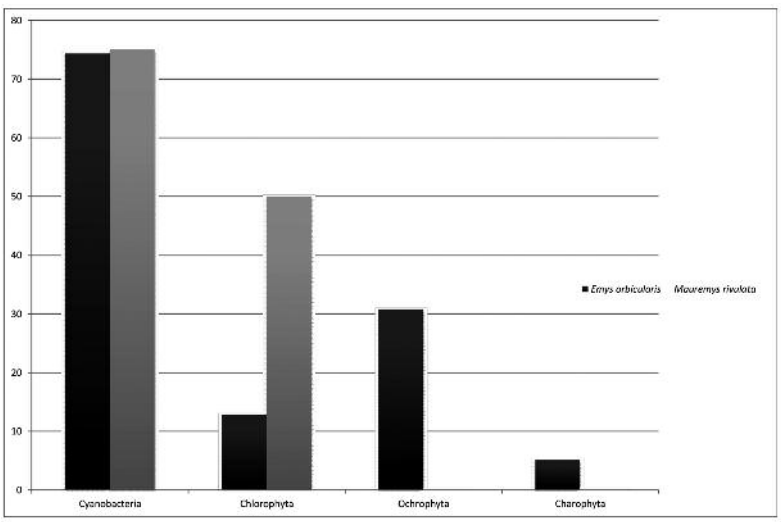

Fig. 3: Frequency (%) of four gross systematic units of algae (Cyanobacteria, Chlorophyta, Ochrophyta and Charophyta) on the carapace of 39 *Emys orbicularis* (LINNAEUS, 1758) and four *Mauremys rivulata* (VALENCIENNES, 1833) at the study site.

Abb. 2: Die Häufigkeit (%) des Auftretens von vier großsystematischen Gruppen der Algen (Cyanobacteria, Chlorophyta, Ochrophyta and Charophyta) auf dem Rückenpanzer von 39 *Emys orbicularis* (LINNAEUS, 1758) und vier *Mauremys rivulata* (VALENCIENNES, 1833) im Untersuchungsgebiet.

Among the main algal groups Cyanobacteria, Chlorophyta, Ochrophyta and Charophyta identified on *E. orbicularis* and *M. rivulata*, Cyanobacteria were equally common (about 75 %) in both species, whereas Chlorophyta were frequently observed (50 %) in *M. rivulata* and rare (12 %) in *E. orbicularis*. Ochrophyta (31 %) and Charophyta (5 %) were found exclusively on *E. orbicularis*.

ZIGLAR & ANDERSON (2005) did not find a correlation between the quantity of epizoic algae and carapace length in upper Mississippi turtles. The results of the present study however suggest that there is a positive correlation between the extent of algal growth and carapace length (i.e., age) in *E. orbicularis* and *M. rivulata*, at least under the ecological conditions prevailing in the study area.

Table 2: Extent of the algal plaques on the carapace of 39 *Emys orbicularis* (LINNAEUS, 1758) and four *Mauremys rivulata* (VALENCIENNES, 1833). 1 – almost absent, 2 – sparse, 3 – moderate, 4 – rich (compare Figure 4). CL - Carapace Length.

Tab. 2: Ausmaß des Algenaufwuchses auf den Rückenpanzern von 39 *Emys orbicularis* (LINNAEUS, 1758) und vier *Mauremys rivulata* (VALENCIENNES, 1833). 1 - nahezu fehlend, 2 - schütter, 3 - mäßig, 4 - reichlich (vergl. Abb. 4). CL - Carapaxlänge.

CL (mm)	1	2	3	4
Emys orbicularis				
80-100	1	5	-	-
101-120	1	4	1	-
121-140	5	7	2	8
141-160	2	-	-	3
Σ = 39	9	16	3	11
Mauremys rivulata				
120-160	-	1	1	-
161-200	-	2	-	-
Σ = 4	-	3	1	-

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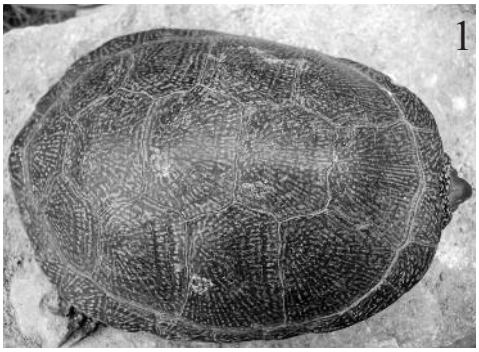
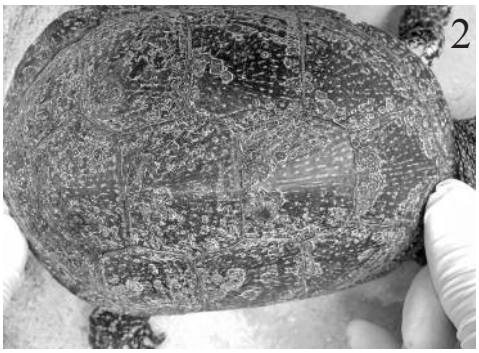
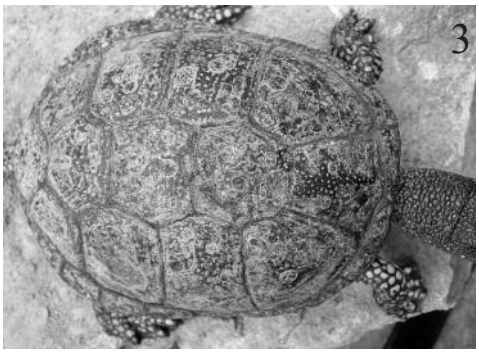
Fig. 4: (opposite page) / Abb 4: (gegenüberliegende Seite)

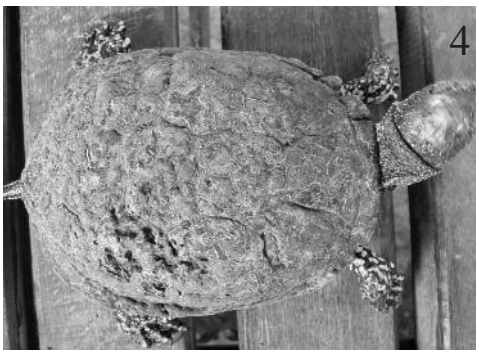
Distribution of algal plaques on the carapace of *Emys orbicularis* (LINNAEUS, 1758). Four categories roughly quantifying the extent of the algal plaques were determined: 1 - almost absent, 2 – sparse, 3 – moderate, 4 – rich.

Ausmaß des Algenaufwuchses auf dem Rückenpanzer von *Emys orbicularis* (LINNAEUS, 1758). Vier Kategorien zur groben Quantifizierung wurden unterschieden: 1 - nahezu fehlend, 2 - schütter, 3 - mäßig, 4 - reichlich.









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