

Short Note/Kurze Mitteilung

Zoogeographical and ecological comparison of reef fishes of Tobago (Caribbean) and Cape Verde (tropical eastern Atlantic)

Zoogeografischer und ökologischer Vergleich der Riffische von Tobago (Karibik) und Kap Verde (tropischer Ostatlantik)

C. Dieter Zander

Biozentrum Grindel und Zoologisches Museum, University, Martin-Luther-King-Platz 3,
D-20146 Hamburg-Rotherbaum, Germany, cedezet@uni-hamburg.de

Zusammenfassung Im Februar 2008 wurden vor Tobago (Westatlantik, Karibik) und im Oktober 2009 vor der Kap Verde Insel San Tiago (tropischer Ostatlantik) jeweils 14 Tage Unterwasserbeobachtungen zur Artenvielfalt und Häufigkeit der Riffische durchgeführt. Das Ziel war ein zoogeografischer und ökologischer Vergleich der beiden Fischgemeinschaften mit den jeweiligen ökologischen Stellvertretern und der Analyse ihrer Rolle im Ökosystem. Diese wurden anhand von Habitat, Nahrung, Aktivitätszeit und Schwarmbildung gekennzeichnet. Zur Quantifizierung wurden Frequenzen (Vorkommen in den einzelnen Habitaten) verwendet. Die Fischgemeinschaften der beiden Areale bestanden mehrheitlich aus eigenständigen Arten, aber auch der Anteil der gemeinsamen Arten war relativ hoch (Tab. 1). Arten mit hohen Frequenzen waren zahlreicher in San Tiago als in Tobago (Tab. 2 und 3). Dagegen waren in Tobago mehr Arten Höhlenbewohner als in San Tiago, ihre Frequenzsumme war allerdings dort größer (Tab. 4). Die Lebensformen des Nahrungserwerbs wurden in sechs Kategorien eingeteilt, wobei mit 75-79 % große Ähnlichkeiten zwischen beiden Inseln vorhanden waren (Tab. 5). Auffallend war der geringe Anteil der Putzerfische in San Tiago (Tab. 6). Die Addierung der Frequenzen von Arten gleicher oder sehr ähnlicher Lebensweise (Lebensformen) ist eine genauere Möglichkeit, Fischgemeinschaften zu analysieren, als wenn nur die Zahl der Arten summiert wird (KÖPCKE 1956).

The island of Tobago on the margin of the Caribbean to the western Atlantic and the Cape Verde archipelago in the eastern Atlantic have a similar geographic position on the northern hemisphere. Tobago lies on the 12th, Cape Verde on the 17th degree of latitude. Whereas the terrestrial climates are humid tropical and attain very similar temperatures, the maximal values in the water are 26-29 °C at Tobago, but only 23-26 °C at the Cape Verde Islands. The latter are influenced by the cold Canaran stream and prevent the establishment of extensive coral reefs. Both islands lie in an area of great nutrient influx either in the near of the mouth of the Orinoco or at the Westafrican upwelling area, respectively.

Therefore, it seems to be of great interest to make a zoogeographical and ecological comparison of the reef fish fauna of the two areas. The investigations were performed by a SCUBA underwater census during two weeks: at Tobago

in February 2008 and at the island San Tiago which is situated in the south of the Cape Verde archipelago in October 2009. The fish were taxonomically discriminated by comparing photos made underwater with photos and descriptions of special literature (HUMANN 1999, DEBELIUS 2007). A quantitative analysis is made by calculating the frequency of occurrence with a range of 0.1-1 in 10 different habitats in Tobago and 14 in San Tiago. A massive presence of conspecifics was noticed as swarms. Related species in both islands were compared under regard of their ecological equivalence, especially habitat and, basing on literature, of prey. Special analyses were focused on cave dwelling and cleaner fish. The aim of this investigation is to find a mean to judge how the respective community is structured.

In Tobago 73 and in San Tiago 43 fish species were encountered, that means 170 % or 59 %



Figs. 1-8: Typical fishes of Tobago and San Tiago. **1** *Sphyraena barracuda* is found worldwide in all tropical oceans and seas – circumtropical distribution. The barracuda is a fish predator. **2** *Melichthys niger* and the attached *Echineis naucrates* are also representatives of a circumtropical distribution. The trigger fish is an epifauna predator, the remora an obligate cleaner. **3** *Myripristis jacobus* is found at both sides of the tropic Atlantic Ocean – amphiatlantic distribution. This species feeds on plankton. **4** *Balistes carolinensis* is also a representative of an amphiatlantic distribution which is also found in the western Mediterranean. This species preys on epifauna. **5** *Epinephelus morio* occurs in the tropical western Atlantic. It is a fish predator.

in relation to the respective other island. Regarding the zoogeographical origin in Tobago the greatest part consists of western Atlantic and Caribbean species (63 %), in San Tiago of eastern Atlantic species including the Mediterranean (51 %) (tab. 1). The category of common Atlantic fish species attain values of 30 % (Tobago) or 42 % (San Tiago). Only 7 or 2 % are distributed worldwide in all tropical waters. Additionally, two

Tab. 1: Zoogeographical origin of fish species (%) in Tobago and Cape Verde.

Tab. 1: Zoogeografische Herkunft von Fischarten (%) in Tobago und Kap Verde.

Distribution	Tobago	Cape Verde
Circumtropical	7	2
Amphiatlantic	30	42
West Atlantic	63	
East Atlantic		35
East Atlantic & Mediterranean		51
Endemic		5

Tab. 2: Compilation of the most frequent reef fish species in Tobago, their habitats, prey, activity time and equivalents in Cape Verde.

Tab. 2: Liste der häufigsten Riffische in Tobago, ihre Habitate, Nahrung, Aktivitätszeit und ihre Stellvertreter in Kap Verde.

Species	Frequency	Habitat	Prey	Time of activity	Swarms	Equivalent in Cape Verde	Frequency
<i>Pomacanthus paru</i>	0.8	Open water	Epibenthos, juv. cleaner	Day		<i>Holocentrus africanus</i>	0.2
<i>Thalassoma bifasciatum</i>	0.8	Open water	Epifauna, juv. cleaner	Day	X	<i>Thalassoma paru</i>	0.8
<i>Myripristis jacobus</i>	0.7	Cave (open water)	Plankton	Night		<i>Myripristis jacobus</i>	0.9
<i>Holocentrus ciliaris</i>	0.6	Open water	Epibenthos	Day		<i>Holocentrus africanus</i>	0.2
<i>Haemulon flavilinctus</i>	0.6	Cave	Epifauna	Night		<i>Paripristoma latifrons</i>	0.1
<i>Chaetodon robustus</i>	0.6	Open water	Epifauna	Day		<i>Chaetodon robustus</i>	0.6
<i>Stegastes partitus</i>	0.6	Open Water (cave)	Algae	Day		<i>Stegastes leucostictus</i>	0.1
<i>Aulostomus maculatus</i>	0.5	Open water	Fish	Day		<i>Aulostomus strigosus</i>	1
<i>Acanthurus coeruleus</i>	0.5	Cave (open water)	Algae	Day	X	<i>Acanthurus monroviae</i>	0.9
<i>Epinephelus morio</i>	0.5	Cave	Fish	Night		<i>Cephalopholis taeniops</i>	0.9
<i>Epinephelus ascensionis</i>	0.5	Cave	Fish	Night		<i>Cephalopholis taeniops</i>	0.9
<i>Gobiosoma evelynae</i>	0.5	Open water	Parasites	Day			

6 *Cephalopholis taeniops* is the ecological equivalent of *Epinephelus morio* in the eastern Atlantic. **7** *Sparisoma cretense* is distributed in the eastern Atlantic and the Mediterranean. It feeds on hard epifauna. **8** *Chromis lubbocki* is an endemic species at the Cape Verde archipelago. It is a plankton feeder.

Fig. 1-8: Typische Fische von Tobago und San Tiago. **1** *Sphyræna barracuda* kommt in allen tropischen Meeren der Welt vor. Er ist ein Fischräuber. **2** *Melichthys niger* und der angeheftete *Echineis naucrates* sind ebenfalls weltweit in den Tropen verbreitet. Der Balistide frisst Epifauna, der Schiffshalter ist ein Putzer. **3** *Myripristis jacobus* ist auf beiden Seiten des tropischen Atlantiks – amphiatlantisch – verbreitet. Er ist Planktonfresser. **4** *Balistes carolinensis* ist ebenfalls ein Repräsentant für eine amphiatlantische Verbreitung, der zudem im westlichen Mittelmeer gefunden wird. Er ernährt sich von Epifauna. **5** *Epinephelus morio* kommt im westlichen Atlantik vor. Er ist Fischräuber. **6** *Cephalopholis taeniops* ist die *Epinephelus morio* entsprechende Lebensform im Ostatlantik. **7** *Sparisoma cretense* ist im Ostatlantik und Mittelmeer verbreitet. Er frisst harte Epifauna. **8** *Chromis lubbocki* ist eine endemische Art an den Kap Verde-Inseln. Er ist Planktonfresser.

Tab. 3: Compilation of the most frequent reef fish species in Cape Verde, their habitats, prey, activity time and equivalents in Tobago.
Tab. 3: Liste der häufigsten Riffische in Kap Verde, ihre Habitate, Nahrung, Aktivitätszeit und ihre Stellvertreter in Tobago.

Species	Frequency	Habitat	Prey	Time of activity	Swarms	Equivalent in Tobago	Frequency
<i>Aulostomus strigosus</i>	1	Cave	Fish	Night	X	<i>Aulostomus maculatus</i>	0.5
<i>Cephalopholis taeniops</i>	0.9	Cave	Fish	Night		<i>Hippichthys morio</i>	0.5
<i>Acantharus monroviae</i>	0.9	Cave	Algae	Day	X	<i>Acantharus oarichus</i>	0.5
<i>Myripristis jacobus</i>	0.9	Cave	Plankton	Night	X	<i>Myripristis jacobus</i>	0.7
<i>Sargocentron hastatus</i>	0.9	Cave	Epifauna	Night		<i>Holentrus vestillanti</i>	0.4
<i>Chromis lubbocki</i>	0.9	Open water (cave)	Plankton	Day	X	<i>Chromis cyanus</i>	0.4
<i>Thalassoma pavo</i>	0.8	Open water	Epifauna, inv. cleaner	Day		<i>Thalassoma bifasciatum</i>	0.8
<i>Sparisoma cretense</i>	0.8	Open water	Epifauna	Day		<i>Sparisoma aurofrenatum</i>	0.3
<i>Chaetodon robustus</i>	0.6	Open water (cave)	Epifauna	Day		<i>Chaetodon ophidiatus</i> 0.6	
<i>Chromis lineolata</i>	0.6	Open water (cave)	Plankton	Day		<i>Chromis multilineata</i>	0.4
<i>Acanthaluteres lucidus</i>	0.6	Open water (cave)	Plankton	Day		<i>Acanthaluteres lucidus</i>	0.3
<i>Sphaeramphys leipodus</i>	0.6	Open water	Epibenthos	Day		<i>Cantharomermis</i>	0.1

In San Tiago 15 species (= 35 %) attained a frequency of more than 0.5 with a mean of 0.7 (tab. 3). *Aulostomus strigosus* was found in all habitats, five other species attained a frequency value of 0.9 and two labrids a value of 0.8. Four of these species were present in swarms: *Aulostomus strigosus*, *Acantharus monroviae*, *Myripristis jacobus* and the endemic *Chromis lubbocki*. Additionally, also *Mulloidichthys martinicus* with a frequency of 0.5 occurred only in swarms. As many as seven species were found in caves, occasionally four other species were also observed there (tab. 3). Only *Aulostomus strigosus* and *Cephalopholis taeniops* which are present in high frequency are fish predators. Beside *Myripristis jacobus* two pomacentrids are also plankton feeder, the rest prey on epifauna and flora. Not all cave dwellers are active at dim light or night, exceptions are *Acantharus monroviae* and *Parupeneus preyeri*. The corresponding equivalents in Tobago attain frequencies of 0.1 to 0.8, e.g. *Thalassoma bifasciatum* corresponds to *T. pavo* from San Tiago with the same value.

Though in Tobago were more species (19) cave dwellers than in San Tiago (12), their respective parts of all observed fish species attain almost equal values, 26 or 28 %, respectively (Table 4). The cave fish of San Tiago comprise eight of the most frequent species including four species with a maximal value of 0.9 whereas in Tobago only six species attain a value of more than 0.5 of which *Myripristis jacobus* dominated by 0.7. Regarding preying behaviors one third of species in both fish communities comprise fish predators, only one sixth plankton feeder, all other species exploit benthos organisms (tab. 4).

A more exact analysis of predator types presents table 5 where the respective species are arranged to seven categories and where the single frequency values are summed up. These values presented the fish predators to be the greatest group in caves of both islands, followed by algae feeder in Tobago and plankton feeder in San Tiago. The identity of prey categories was between both islands high (78 %) though great differences appeared in algae and endofauna feeder (Table 5). In comparing frequencies of cave fish with those from all reef habitats of the respective island identity was in both cases similar (Table 5). A minor role played obligate

Tab. 4: Frequencies and prey of cave dwelling fish in Tobago and Cape Verde.

Tab. 4: Frequenzen und Nahrung von Höhlenfischen in Tobago und Kap Verde.

Tobago			Cape Verde		
Species	Frequency	Prey	Species	Frequency	Prey
<i>Haemulon flavilineatus</i>	0.7	Epifauna	<i>Acanthurus monrovae</i>	0.9	Algae
<i>Acanthurus caeruleus</i>	0.6	Algae	<i>Cephalophis taeniops</i>	0.9	Fish
<i>Epinephelus morio</i>	0.5	Fish	<i>Priacanthus orientatus</i>	0.2	Plankton, fish
<i>Epinephelus ascensionis</i>	0.5	Fish	<i>Aulostomus strigatus</i>	1	Fish
<i>Epinephelus guttatus</i>	0.1	Fish	<i>Myripristis jacobus</i>	0.9	Plankton
<i>Serranus tigrinus</i>	0.4	Fish	<i>Sargocentron hastatus</i>	0.9	Epibenthos
<i>Mycteroperca interstitialis</i>	0.1	Fish	<i>Chromis lubbocki</i>	0.9	Plankton
<i>Priacanthus orientatus</i>	0.1	Plankton, Fish	<i>Chaetodon robustus</i>	0.6	Epifauna
<i>Myripristis jacobus</i>	0.7	Plankton	<i>Chaetodon marcellus</i>	0.1	Epifauna
<i>Holocentrus marianus</i>	0.2	Epibenthos	<i>Pseudupeneus preyeri</i>	0.5	Endofauna
<i>Holocentrus vexillaris</i>	0.4	Epibenthos	<i>Mulloidichthys martinicus</i>	0.5	Endofauna
<i>Holocentrus rufus</i>	0.1	Epibenthos	<i>Scorpaena madeirensis</i>	0.1	Fish
<i>Stegastes partitus</i>	0.1	Algae			
<i>Microspathodon chrysurus</i>	0.1	Algae			
<i>Chaetodon aculeatus</i>	0.4	Epifauna			
<i>Pomphersis schomburgkii</i>	0.1	Plankton			
<i>Echineis naucrates</i>	0.1	Cleaner			
<i>Giglyostoma cirratum</i>	0.1	Endofauna, Fish			
18 species = 25 %			12 species = 28 %		
	Σ =	5.6		Σ =	7.6
Mean		0.3 ± 0.2	Mean		0.6 ± 0.3

cleaners but if facultative cleaners are added the ratio raised to 37 % in Tobago and of still 7 % in San Tiago (Table 6) where the only cleaner were young *Thalassoma pavo*. In Tobago two obligate cleaners, *Gobiosoma evelynae* and *Echineis naucrates*, could be observed.

The structure of the fish communities of Tobago and San Tiago is very similar as is evidenced by the analysis of feeding categories. Because here quantitative results are used this comparison seems to be more exact as that of KÖPCKE (1956). Tobago can be characterized to present more species than San Tiago which in

contrast conspicuously attains higher population densities. Species richness may be caused by warmer temperatures as prevail in the Caribbean which promote the highly structured coral reefs with many diverse habitats and also means less density of the populations (principle of MARGALEF 1968). The populations in San Tiago profit not only from the nutritional effect of upwelling but also from the presence of many large and middle sized caves. As consequence, in San Tiago one third of all observed fish were cave dwellers which, additionally, appeared in high frequencies, in Tobago were only one sixth.

Tab. 5: Comparison of prey categories of fish in caves and all reef habitats in Tobago and Cape Verde.

Tab. 5: Vergleich der Nahrungsorganismen von Fischen in Höhlen und allen Riffhabitaten von Tobago und Kap Verde.

	Tobago				Cape Verde				Caves
	Cave		All habitats	Minimal	Cave		All habitats	Minimal	
	Frequency	%	%	Frequency	Frequency	%	%	Frequency	Minimal Similarity
Plankton	0.9	15	9.7	9.7	7	25	19.1	19.1	15
Algae	1.2	20	15.3	15.3	0.9	11.7	8.2	8.1	11.7
Epibenthos	0.9	15	19.4	15	0.9	11.7	18.2	11.7	11.7
Epifauna	1	16.6	27.9	16.6	0.7	9.1	28.1	9.1	9.1
Endofauna	0.1	1.7		0	1	13	9.2	9.1	1.7
Fish	1.8	30	20.8	20.8	2.2	28.5	17.2	17.2	28.5
Parasites	0.1	1.7	6.9	1.7					0
Σ =	6	100	100	79.1	7.7	100	100	75.3	77.7

Tab. 6: Frequencies of cleaner fish in Tobago and Cape Verde.**Tab. 6:** Frequenzen von Putzerfischen in Tobago und Kap Verde.

Tobago		Cape Verde	
Species	Frequency	Species	Frequency
<i>Gobiosoma evelynae</i>	0.5		
<i>Thalassoma bifasciatum</i> juv.	0.8	<i>Thalassoma pavo</i> juv.	0.8
<i>Halichoeres garnoti</i>	0.4		
<i>Bodianus rufus</i> juv.	0.1		
<i>Pomacanthus paru</i> juv.	0.8		
<i>Echineis naucrates</i>	0.1		
	$\Sigma =$ 2.7		$\Sigma =$ 0.8
Total frequency from table 2	7.2	Total frequency from table 3	11
Percentage of cleaner frequency	37%	Percentage of cleaner frequency	7%

Frequencies of fish predators are unexpectedly high in the two fish communities of caves whereas plankton feeder play a slight lower role (San Tiago) or make only up the half of fish predators (Tobago). This difference may lie on a better growth of algae in the free littoral near the caves of Tobago and to sessile epifauna of which some may be competitors on plankton. The special category of cleaner fish is represented in Tobago by two species of obligate and four species of facultative cleaners that is more than one third of all observed fish whereas in San Tiago only one species clean as young. Possibly, in East Atlantic appropriated species for this task are missing because this role is taken over by shrimps (VAN TASSELL et al. 1994). An exception is the circumtropical distributed *Echineis naucrates* which is rather a visitor of large vertebrates but was not observed in San Tiago during this investigation.

The way of analysis on the basis of frequencies reveals the advantage of this method in contrast to the way of KÖPCKE (1956) who added solely the number of species with the respective ecological attributes. In comparing these two methods, KÖPCKE would have attained a result of only 13 or 16 % regarding the fish predators in caves which mean a lesser importance than 28 or 30 % found here.

An accordance of 78 % of ecological equivalents among predators in caves reveals a very high similarity of the reef fish communities of both islands. Frequency values of ecological equivalents demonstrate that niches can easily be quantified

and compared. Because niches describe the role that an organism play in the ecosystem (PIANKA 1994, ZANDER 2006) one can better judge what group of ecological equivalents is dominant or what is less important. Thus, both islands may be characterized by fish communities which are dominated by epibenthos (algae, sessile and mobile epifauna) feeders followed by fish predators in Tobago and plankton feeders in San Tiago whereas in caves fish predators dominated.

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