FISHERIES RESEARCH BOARD OF CANADA

Translation Series No. 341

ECOLOGY AND TERRITORIAL BEHAVIOUR OF THE SCRIPT PERCH (*Serranus scriba* Cuv.)

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Original title: Ökologie und Revierverhältnisse beim Schriftbarsch (*Serranus scriba* Cuv.).

From: Osterreichische Zoologische Zeitschrift, Vol. 5, pp. 329-349, 1954.

Translated by the Bureau for Translations, Foreign Language Division, Department of the Secretary of State of Canada

Distributed by the Fisheries Research Board of Canada
Biological Station, St. Andrews, N.B.

1961

I. INTRODUCTION

When diving in the Adriatic Sea I observed, at first occasionally and then later systematically, the behaviour of the "Schriftbarsch" (literally from German: script-perch) (Serranus scriba Cuv.)--a fish encountered often in the littoral zone of the Adriatic coast. I was struck with the fact that the animals remained stationary and separately in spaces among the rocks, near rubble islands, or boulders. From this fact it is possible to deduce that, wherever possible, the fish has a solitary, territorial way of life. As a supplement to field observations of the cichlids which I had just completed, I was interested to learn more about this species of perch, its manner of life and behaviour. My wish was fulfilled when, with the support of the Zoological Institute at the University of Vienna and the Marine Biological Institute in Rovinj, Jugoslavia, I was able to prolong my leave for two more months, and to arrange the field observations at suitable locations along the coast, as well as in the salt-water aquarium of the Institute. To both Institutes I express here my most sincere thanks.

It was obvious from the literature I could obtain on the subject that very little is known about the manner of life and behaviour of this species under natural conditions. Therefore I put great value on the field observations because they give a glimpse into the life of a species and allow one to trace the relations between a species and its biotop. In general, investigations into territories especially can be carried out best in the natural habitat of the animal.

II. METHODS AND TECHNIQUES

This study is based on two parallel series of observations, one of which was carried out in the field and the other in the salt-water aquarium of the Institute.

Whereas observations on the habitat and the territorial structure could be studied first of all in the field, the comparative observations in the aquarium allowed for detailed study of the behaviour of the fish when catching their prey, fighting and defending territories; further they allowed one to observe the distribution of new habitats and the fishes' behaviour in a small space. This supplement of the field observations with observations on the animals in captivity seems to me a favourable synthesis of the working methods for a comparative ethological analysis. Such synthesis reveals and thus eliminates many sources of errors, which would remain hidden when each method is applied separately.

For the field observations I used a diving mask and snorkel with which I was able to lie quietly on the water surface and observe the fish for a long time. Two polished

brass plates, hanging on a string around my neck, allowed me to make notes under water; such notes being necessary for an observer of behaviour. The equipment was completed with a tin filled with sea-water-proof oil paint and a brush (for marking purposes) and a 10 meter long measuring tape.

This somewhat unusual method of making scientific observations of behaviour naturally presupposes certain abilities of swimming and diving for the observer; however these were not the real difficulties. However elementary they may seem, they must be mentioned, for the success of the study depends on the mastering of them. In my case these difficulties were of very discrepant nature: a) to get the fishes accustomed to the observer, b) the chilling of the observer when in the water. a) On account of the fact that I went directly into the natural habitat of the fish and wanted to observe them there, I had to train them to get used to my presence. This is not difficult, but it takes time. Therefore this training time should be accounted for in the planning of the observations, for it could happen that either the time for the observations proper will be too short, or the observations carried out among disturbed animals will be biased. In order to be able to observe during longer periods of time it would be of great advantage to supplement the equipment with a rubber suit. With an ordinary bathing suit the observer must come to the surface approximately each hour at the beginning of the observation period, then each half hour, then each quarter hour, for the body chills faster and faster with time. I had to work without a rubber suit and helped myself to keep warm by covering the body with fat; however the observations on cloudy days and during the last week were not comfortable.

However, if such difficulties are mastered then this method of underwater observation is one of the most pleasant types of work which an animal psychologist can desire.

For comparative purposes I selected three observation areas, where the stations of the fishes were marked with oil paint. A comparison of these ecologically different coastal zones and of their colonization density allows one to determine the optimum biotop. Besides that I surveyed an area of 400 m^2, made a sketch map of it and plotted the stations and the territories of the fishes occupying these areas (Fig.2,3). The area measured and marked in this way was also the main area of observations.

I covered the bottom of the aquarium with rubble and put in some pieces of rocks covered with algae to provide the fish with cover. Fresh sea-water circulated through the aquarium for long periods of time. Here I kept and observed 4 adult Serranus scriba.

III. DISTRIBUTION, CHARACTERISTICS OF THE SPECIES

Serranus scriba is a representative of the "Zackenbarsch" (literally translated--spiked perch) and has been a well known inhabitant of the Mediterranean since ancient

times. However, it occurs also in the Atlantic along the coast of South France and Portugal and near the Canary Islands (Risso, 1826; Guichenot, 1850; Canestrini, 1872; Boulenger, 1895; Zolezzi, 1939). According to Ninni (1931) this fish has not been encountered near Gibraltar. Günther (1859) mentioned its occurrence in the Black Sea and this was confirmed by Andriashew (1944).

Serranus scriba reaches a length of approximately 20 to 30 cm and a weight of 500 gr (Brehm 1914). Its protruding lower jaw, the toothed front gill cover and the main gill cover provided with three spikes make the fish conspicuous and familiar to everybody; as well as the blue script-like pattern on the head, to which the fish owes its name (in German "Schrift-barsch" means "script-perch"), and the dark bands across the trunk. It has in the dorsal fin 10, in the anal fin two spiny rays. With respect to the morphological details one should consult the works by Brunnich (1768), Cuvier et Valenciennes (1828), Bloch (1790), Günther (1859), Moreau (1881), Döderlein (1889), Boulenger (1895), Ninni (1931), Zolezzi (1939), and Soljan (1948).

Only the colouring will be discussed here in detail because it is closely related to the different patterns of behaviour.

The above mentioned authors are not always in agreement concerning the colour pattern and Ninni (1931) described it as variable. Cuvier et Valenciennes (1828) have established that it does not stay long after the death of the animal and varies with age and the seasons of the year. Döderlein (1889) agrees with this and adds that the colouring depends also on the surroundings. Zolezzi (1939) reports that animals caught on sandy ground are less intensively coloured than others.

In general the following colour patterns are seen: the basic olour of the body is yellow to reddish; the head on the lower side is brown, on the upper side it is covered with azur- and silver-blue lines, which resemble a script pattern. These colours are the most permanent. Five to nine dark lateral cross bands, which are sometimes ramified, are on the body. The unpaired fins, especially in the soft parts, are yellowish with red spots; the pelvic fins are grey blue with red dots; the pectoral fins are yellowish with faded blue cross bands.

I observed the colouring of the adult animals during the summer and could add the following that has not been mentioned or mentioned only briefly in the above-cited papers.

A dark-brown, conspicuous stripe is normally present over the eye, and runs from the upper jaw over the eye to the back and ends slightly before the first dark cross band on the trunk. This stripe is not always intensely coloured. In the literature this head pattern is mentioned only by Boulenger (1895).

Among the dark cross bands the first band crosses the

gill cover entirely. The second is ramified. Its first branch runs partially over the gill cover and then encircles the base of the pectoral (shown by Cuvier, Moreau and Döderlein). When the fish spreads the gill cover during a display this part of the cross band (where three spines are located) is similar to an eye-pattern. The second branch runs slanting downwards. The third and the fourth bands can also be ramified. They end in the centre of the side, while the three or four last bands continue to the anal. All cross bands continue into the dorsal fin.

Below the third to fifth cross bands is located a luminous blue spot, which was always present during my observations. This spot is mentioned only by Brunnich (1768). Zolezzi (1939) describes only faint blue bands on the belly.

When excited the fish can change their colour from dark brown to nearly black. This colour change begins from the head and the back and can spread over the whole body. It appears very fast and can disappear equally fast. This change reminds one of the sudden changes of colour in cichlids, which have been described by Baerends (1950).

IV. ECOLOGICAL

1. Information up to the present time

The littoral zone of the rocky coast is given by different authors as the habitat of this fish. Risso (1826) and Cuvier et Valenciennes (1828) reported that it could be encountered throughout the entire year, and that it prefers rocks covered with vegetation. Also Canestrini (1872) indicates that the animal can be found among the rocks next to the beach in sparsely populated areas. According to Brehm (1914) the stony coastline which has plenty of small fish and crayfish and has cavities and depressions for hiding is the favourite habitat of this fish. Zolezzi (1939) established that the fish can be found often on sandy bottom also, and gives details on its food.

2. Observation areas

My main observation district was the Kap Montauro, a land spit approximately 3 km south from Rovinj, a location avoided by bathers on account of the roughness and brokenness of the beach. One comparison district was in Valdibora, an inlet one and a quarter km north of Rovinj, and the second comparison district was near Punta corrente, 4 km south of Rovinj (Fig. 1).

At Kap Montauro the cliff coast, divided into many projections, descends 1.5 to 2 m into the sea and there at a depth of 0.5 m forms a terrace, which in its turn slopes and, going over into the rocky projections, forms a second terrace, located deeper in the sea. This terrace sinks to the sea bottom, here 4 to 6 m deep (Fig. 3). The whole terraced coastal slope is 10 to 18 m wide and reaches the rubble sand of the

sea ground. Between the single rock cliffs and the projections run channels filled with rubble. Besides that there are many kettle-like depressions of various size, in the centre of which lie boulders. In the walls of the broken rock are many small cavities. The abundance of algal vegetation, among which Zystosira occurs most frequently, is quite conspicuous (Fig. 2).

I was able to establish that Serranus scriba inhabits these phytal bands nearly exclusively. The natural caves and cracks form its stations. Often it shares them with representatives of the Labridae and Gobidae. Also I found crabs and anemones as co-inhabitants of the caves. On the whole the littoral zone at this location was especially rich in fish and I could regularly encounter swarms of Sargus vulgaris Geoffr., S. annularis Geoffr., and S. rondeletti Cuv.. Occasionally I observed Box salpa and Chrysophris aurata Cuv., Belone acus Risso and Charax puntazzo C. V.; also I always observed the solitary living Gobidae, Labridae and Plenidae, which were impossible to identify to species. From time to time swarms of Heleastes and "Seebarben" passed through the region.

In comparison with the other coast lines the Kap exhibits rather extreme features. Here and near Punta corrente relatively strong sea currents prevail. On account of its exposed position bad weather is felt more strongly here than elsewhere. During a storm the surf splashes far over the shore and floods it. Days after the storm, when the water has become calm, a strong wave-motion is still present all around here. In contrast, Valdibora is nearly always quiet, as its location protects it from the frequent southern winds.

During calm days at Kap Montauro the water was clear and transparent and it was possible to make good observations.

The conditions of the terrain at Punta corrente were slightly different from those at Kap Montauro; the phytal zone here descends and projects into only one flat terrace, over 20 m wide, which slopes to the sea bottom. This terrace is cut in all directions with narrow, deep grooves gilled with rubble. There are fewer kettle-like depressions and cavities. The algal vegetation is dense. Zystosira is encountered very frequently. The water is exceptionally clear.

In Valdibora the phytal zone is 15 m wide and is sparser. Zystosira is almost completely absent. The coast consists of artificially piled up boulders. The slope into the water is flat and extends far into the inlet. The sea bottom is less subdivided, the numerous rock projections, grooves filled with rubble, caves and rock fragments typical for the other districts are absent here. Instead there are large stone plateaus and enormous boulders without fissures. The water is very often turbid.

3. The colonization density, optimum biotop

At Kap montauro I counted 24 fishes in a coastal strip 90 m long and up to 20 m wide. At Punta corrente in the 50 m long observation area I found 8, and in the 200 m long area of Valdibora, 3 fishes.

The comparisons of these data shows that Kap montauro and Punta corrente are populated more densely than Valdibora, The districts can be ranked as: Kap montauro, Punta corrente, Valdibora.

Naturally these scanty numerical data can not express anything final, however, they show quite obvious differences in the colonization density of single observation areas. This fact, associated with the ecological differences, gives food for thought.

The district at Kap montauro (the most subdivided and differentiated district) shows the densest colonization. The numerous rock projections, grooves filled with rubble, boulders and cavities, and the vegetation subdivide the district quite naturally and provide the fish with good cover. The dense algal meadows provide additional cover, as well as fertile hunting grounds. Both features, the numerous subdivisions of the district and the dense algal vegetation are absent in Valdibora as are the current and the clear water.

On the other hand there is a rich algal vegetation at Punta corrente, also there is clear water and current, but the district is not so well subdivided.

Comparing these observations with the earlier ones one might think that among the numerous factors determing colonization density the most important are those of space subdivision (or variety of the landscape) and of the intensity of the vegetation. Breder (1936) with the black perch, and Wunder (1930) as well as Ter Pelkwijk and Tinbergen (1937) with the stickleback, observed that more animals could be kept and made to breed in an aqurium if it had plenty of vegetation or was subdivided so as to provide cover. As far as I could establish in the "Oasis" pools at Gafcas the size of the mating territory of the male cichlid (Haplochromis desfontainesii) depended on the structure of the bottom among other factors. The territories on a uniformly flat bottom were larger than those at boundaries with water plants, or near shore, or those including stones and tufts of plants (Kirchshofer, 1953). For many territorial fish the cover between neighbours plays a significant role in colonization density and in the size of territories, two factors which are closely associated.

The territory of Serranus scriba is a hunting or feeding territory (here the term is used in contrast to the exclusively breeding and mating territories). This means that its size is a function of the amount of food available. According to Brehm (1914) and Zolezzi (1939) and my own

observations Serranus scriba feeds on small animals (preferably crustaceans, fish and molluscs) that feed on algae. Thus, vegetation plays two important roles: that of cover and that of providing food.

Summarizing: The more varied the habitat and the denser the vegetation the higher the colonization density. The size of the territory increases with uniformity of the bottom and the sparsity of vegetation. The example of Punta corrente shows that districts well covered with vegetation but less subdivided are more sparsely populated than those where both these prerequisites are fulfilled. Thus, as an optimum biotop for Serranus scriba, i. e., the biotop, which allows dense colonization in the smallest possible area and offers high development possibilities, should be defined as a rocky, well subdivided part of the littoral zone where there is dense plant growth.

V. THE STRUCTURE OF A TERRITORY

1. The restriction to one area

The question of the fidelity of the fish to their stations can be studied by observing marked fishes. This was impossible in my case. However, my method (marking of the stations, prolonged observation of small areas) also allowed me to draw reliable conclusions. Again and again, day after day, one encounters the animals at the same places, which they do not leave even when being observed continuously for long periods of time. In time I became so familiar with the daily routine of individual animals that if I did not see one near its cave I knew where I could find it.

Each animal actually has a permanent station, in a cave or under stones, often with two or more exits. This station is the centre of its territory, which is inhabitied only by this particular individual. I would like to designate such a station after Hediger (1946) as a home of the first order (H.1.O.). From this place the fish carries out all its activities, to this place it flees when in danger and here it stays for hours (during the night, bad weather or for rest).

As territories of Serranus scriba, with respect to all their features, could be compared very well with those of mammals, I wish to give them the very general definition, given by Hediger, according to which a territory is an area defended by an individual or by an organized group of individuals.

At Kap montauro the areas are 50-60 m^2. They do not have sharply defined boundaries as, e. g., the mating areas of cichlids do, but overlap each other. These overlapping strips, where neighbouring fishes hunt in turn also represent neutral zones. They can be compared with the neutral zones, or the "cross country roads" (Hediger, 1949) of mammal territories. Here neighbours tolerate each other or

limit their conflicts to only a weak threatening attitude, so that they do not pursue the fish which swims away. Besides this, the intensity of defence, and of the fight decreases as the distance from the centre of the territory increases; a fact well known for other territorial animals. The "ready to fight attitude" is replaced by a "ready to flee attitude".

Figure 3 shows the territories of 6 fishes inhabiting the district at Kap montauro. This sketch illustrates the selection of stations, the sizes, and the overlapping of the separate territories.

The animals almost never leave their territories and if they do so they never go far enough to cross neighbouring territories. They are tied firmly to a place once it is acquired.

In this respect it would be interesting to study the question of incorporation of a new generation. However, for such a study a long period of time would be necessary.

As one can see from the above Serranus scriba is a solitary-living fish, where this expression should be understood as "living singly" and not as "isolated from others, or lonely". For on its territory boundaries the fish comes into contact with its neighbours and responds to them. This kind of "solitary living" life, when one territory adjoins another so that practically the entire biotop of the species is subdivided into such territories, I should like to describe as a "territorial society". Baerends (1950) defines such an association as a community where all members are of equal rank and where all possess territories where they tolerate only their partners. Only in the case of Serranus scriba it seems that such a community exits over the whole year, while according to the majority of earlier observations (mostly carried out on fish and birds) and on which Baerends based his conclusions, such communities were formed only during the reproductive period and occupied only a part of the whole biotop, while usually the animals lived in schools.

Among other things Baerends, and many authors before him, discussed the function of territories. Similar thoughts occurred to me during my field observations of the cichlids and also during these observations on Serranus scriba. In the case of cichlids and also of the thoroughly investigated Centrarchidae (Breder, 1936) the formation of a territory is exclusively the concern of the male. It is closely timed with the reproductive period so that breeding can proceed undisturbed.

With Serranus scriba the territoriality extends to all individuals, a fact which might be ascribed to the hermaphroditism of the species. As supplementary advantages the territoriality of Serranus scriba provides them with food reserves and regulates the population, two points which Meise (1936) has already considered in his definition of a territory.

2. The subdivision of a territory by an individual

Inside of the territorial community each animal occupies its territory and meets others of the species only at its boundaries. They are not much interested in each other; their interest is mostly of a hostile nature. The same was observed in the aquarium, where the fish, after being put in, immediately sought the darkest corners. There they remained close together ignoring each other. As soon as they had settled down a little they began to threaten each other to fight during feeding and finally to defend small areas, which were, so to speak, only the "centres" or the "homes of the first order".

The fish is best oriented in its own territory. Wherever it is within its territory it finds immediately its bearings and the shortest way to the centre. Observations have shown that when swimming to the home of the first order the same routes were used, e. g., around a certain rock projection, and so on. Besides the "centre" the fish has in its territory other places which it visits for a rest or for cover. Such places represent homes of the second and third order (Hediger, 1946). Similarly the hunting grounds, the algal meadows in the territory, are of different importance to the owner; some places are especially preferred, while others are visited only seldom or briefly. In this way the fish subdivides its territory into places for cover and places for hunting; these places are connected by fixed routes and each of them has a different value for the fish. Here we find much similarity with the territory subdivision of many mammals, which Hediger (1946/49) describes in detail. Serranus scriba lives in a "fixed area" system. To what extent this is connected with a "fixed in time" system not much can be said at present. In order to investigate this question, more thorough observations are necessary; the observer must stay under water for many hours. It seems striking to me that the animals frequent their hunting places more often in the evening than in the day.

I would like to illustrate these general results with some concrete examples:

Fish 1 (see Fig. 3) occupies a relatively large cave in its territory, which goes approximately 40-50 cm deep into the rock. This cave is the home of the first order. There the fish can hide itself completely. Mostly the fish rests with its head partially out of the cave, looking around and quietly moving its fins. When someone approaches, the fish swims backwards into its cave, disappears suddenly and completely. If the fish was not in its cave, or on its hunting grounds, then I saw it often in a small groove in the rock on the bottom of a pit just under the cave. This groove is also a valuable refuge place, providing good cover, but does not allow the fish to survey the whole territory as does the home of the first order (H.1.O.). This groove is thus a subarea (or home) of the second order (H. 2.O.). The

hunting grounds are on the first and the second terrace. One can see the fish most frequently in the centre of the deeper terrace, lying in wait and hunting. Frequently it stays for a quarter of an hour among the tufts of plants, where it is difficult to see (its colouring making an excellent camouflage). In order to get to the second terrace the fish may use three routes. If it travels from the H. 1. 0. and wants to be in the central favourite part of the second terrace, then it swims directly from the centre of the area over the lower barriers to the lower hunting ground. From the H.2.0. to the same place it swims around the barriers. The third route runs along the rock projection in which the H. 1. 0. is located and leads in the overlapping zone to fish 2. The second hunting ground is visited less frequently than the first; the algae stock is much thinner here, and what might be also of importance, the location is much shallower. The pit itself is not used very much for hunting.

The area inhabited by fish 3 is similarly subdivided. This fish's H. I. 0 is located approximately 12 m from the shore in a pit filled with rubble under a boulder covered with vegetation. This fish hunts most frequently in the Zystosira meadows above the pit. The second favourite hunting ground is located in the first terrace next to the shore, in a crevice partly covered with dense vegetation. There the fish has a cave under a large boulder. It visits this place, which also represents a H. 1. 0., very often. Thus this fish has two centres. The route from the first to the second centre is precisely fixed. It leads over terrace 2 to the second pit located a little higher. There among the boulders the fish seeks cover, in an area which represents a H. 2. 0. From here a route goes to the crevice near the shore via a third pit, filled with the rubble, and located in terrace 1. This route provides very good cover and it is always used. It is interesting to observe how well the fish is able to use the surroundings to the best advantage. A similar situation has been found among all observed animals. Fish 2, for example, also has two centres in its territory. The home of the first order (H.1.0.) is deep in the bottom of a pit filled with rubble; the pit itself is in a fissure in a rock projection. The H.2.0. is in a cave of the same rock projection approximately 2 m higher. This cave passes nearly through the whole rock projection and has two exits. Here one can often find this fish which, when frightened, flees immediately to H. 1. 0. at the bottom of the pit. It may be that the H. 2.0. offers a better survey over the territory, but not the best protection, whereas in the case of fish 1 the H. 1. 0. provides both, and in the case of fish 3 no such survey is provided at all, but both H. 1. 0's offer good cover and allow to a partial survey of the area.

These few examples show that in general the organization of the territories is the same. However, the animals understand how to use the surroundings to the best effect in each particular case.

VI. DAILY ROUTINE IN THE TERRITORY

1. Control of the territory

Serranus scriba has either the entire area or a large part of it under permanent control, and everything that happens there is watched and notice in the truest sense of the word is taken of everything. If something foreign or unusual appears then, if it is moving, it is observed and judged from a distance of approximately 2-3 m.. The fish swims towards it, turns sideways, and twists so that the blue spot faces the intruder. This threatening position allows the Serranus scriba to fix its opponent with one eye. This position reminds one very much of the way a grey goose watches an enemy of its flock. Strange motionless objects are also investigaed from near by in great detail. For example, when I was marking the stations, the animals would immediately approach the red stones, swim around them and push them with the nose. One can attract them at once simply by changing something in the territory even if it is difficult to notice from where they come. A fin-shaped bowl dropped into the water as an experiment was first noticed by the monkfish school. Suddenly a Serranus scriba, who was owner of this territory swam near, chased the monkfish away, and then investigated the bowl at close quarters. Although they are curious about anything new, they quickly get used to it, if they are convinced that it is harmless. In this connection, one observation I made might be of interest. The fishes were already used to my presence, and fish 2, after a few days, did not flee when I swam near, but continued its activities unperturbed, except when I moved too close. When one of my colleagues swam with me fish 2 fled immediately into its home of the first order and remained there in a threatening attitude in the entrance of the cave. As soon as I was alone again the fish came out and lay in wait in its Zystosira ground. The fish was used to one human being in its area, but two was something new and thus caused anxiety.

They are, repeating the words of Lorenz, animals which learn through curiosity. A biological explanation of this fact may lie in the milieu of the littoral zone, which does not allow an unobstructed view of the area. It is an environment which demands that its inhabitants be constantly on guard and ready to adjust quickly to all events. Lorenz (1954 and earlier) expressed the opinion that animals which inhabit a subdivided habitat, must be better able to orientate and have faster reactions than animals inhabiting a uniform area. As illustration he gives a littoral fish compared with a deep sea fish. He sees in the higher ability to orientate in space and in faster reactions the first steps in the development of a higher "sensible" intelligence. Serranus scriba, a typical littoral fish with its good orientation in space and fast reactions presents an excellent test-case for these ideas of Lorenz.

2. The defence of the territory

It has already been mentioned that the territory centre is defended first. However, it seldom comes to a fight in the territory proper, for the intruder is much more ready to flee than to fight. Mostly as soon as the owner threatens the intruder flees, giving to the former only the opportunity to pursue.

In general only fellow-members of the species are fought. No attention is paid to the other littoral fishes which may co-inhabit the area or pass again and again through the territory of a Serranus scriba. They are suffered even in the home of the first order, so that the latter can be, for example, a territory centre for a Serranus scriba and at the same time a territory centre for a "Meergrundel" or a "Lippfisch" (literally--lip-fish), and in such way several territories may overlap. Only three times during my observations was notice taken of individuals of another species: once the above-mentioned chasing away of the school of monkfish, once the driving away of a lip-fish with a ramming blow and also of another lip-fish by a lateral threat. It is evident that the threat is "understood" unambiguously by the other species.

This species has a rich repertoire of behaviour patterns which it uses during a fight. The degree of aggressiveness is expressed by different colouration and motions.

The lateral threat is shown by:

1. Spreading of the dorsal fin: the attacker spreads the whole dorsal fin or only its spiny part; the attacked spreads only the posterior soft part of its dorsal fin.

2. Spreading of the dorsal fin and simultaneously lying on its side, so that the belly faces the opponent and freezing in this position. A higher degree is shown by dark colouration (see colour pattern), and delivering blows with its tail to the opponent.

3. Spreading of the non-paired fins; the bellies are brought closer together, the flanks with blue spots are very close, heads and tails are turned away from each other, the fish is stationary on the spot.

4. Spreading of the non-paired fins, dark colouration, the backs brought closer together, at the same time sliding along each other.

The frontal threat is shown in the following way:

Threatening with open mouth and spreading of the gill covers.

Behaviour during the fight

All the threats described above can be the introduction to a serious fight. The type of threat determines in most cases the course of the fight.

The threat described under No. 1 is only an indication of aggression, while the others lead to real fights. Three forms of fighting were observed again and again, although the fights in single cases did not always take exactly the same course.

1. Lateral threat.
(Spreading of the spiny part of the dorsal fin) ----------> Lateral threat (Spreading of the soft part of the dorsal fin; lateral display of the blue spots).

<---------- Likewise lateral bending, displaying of the blue spots; approaching the opponent from the side, encircling the other, while swimming over the blue spot from above or below ----------> More intensive bending, encircling of the opponent.

<---------- The same (can be repeated several times) ----------> Swimming away

<---------- Pursuit

2. Frontal threat (widely opened mouth, unpaired fins spread) ----------> Lateral threat (lying on the side, the soft part of the dorsal fin sprawled, dark colouration, blows with the tail toward the opponent).

<---------- Attack with ramming blow (with widely opened mouth against the mouth or gill covers (of the other) ----------> Spreading of the gill covers, opening of the mouth, a ramming blow.

The same will be repeated until the threatening and the fighting of one of the partners stops and it flees.

3. The lateral threat described under items 1 and 2 can develop into circling, with the fish swimming, in a small circle, each with its head at the tail of the other, and also delivering blows with the tail to the head of the opponent, and trying to ram with open mouth into the tail. This part of a fight reminds one very much of the intraterritorial fights of cichlids (Baerends, 1950). On the whole the elements of behaviour of Serranus scriba are very smiliar to those of the cichlids, however the combinations of these elements are different. Most important for the threat attitude and fight actions is the sight of the fellow member of the species in the territory; the degree of intensity depending on the distance from the home of the first order.

In the aquarium where the animals were shy and without territories at first, the fellow member of the species was considered an opponent only during feeding or at such external disturbances to which the fish could not respond directly, e. g., when the table on which the aquarium stood was violently shaken. In the latter case the fighting had a strong displacement character and resembled the behaviour of Haplochromis desfontainesii during disturbing situations (Kirchshofer, 1953).

Flight and pursuit

When the intruder turns to flee, it will be immediately pursued if it is close to the centre; the defender of the territory tries to ram it from the side. The fleeing fish beats strongly with its tail, with which, as is known in the case of cichlids (Baerends, 1950), it forces water against the head of the pursuer.

When the fish retreats to the overlapping zone in front of its neighbour, it swims away with highly conspicuous swimming motions: it bends its body strongly to the left and right, so that each time the blue spot flashes brilliantly. This display swimming differs fundamentally from fleeing or from normal swimming.

3. Catching of prey

It never occured to me to observe these fish hunting in the open water of the sea. However, I observed them catching little animals in the algal meadows. For this purpose they lay in wait among the tufts of water plants. Their colour pattern makes it difficult to see them. A certain plant will be rigidly fixed, frequently for several minutes. Then suddenly the fish will rush there and the prey will be immediately swallowed. Hunting in the algae contradicts the assumption that they are fish eaters. However, in the aquarium they took to fish from the very beginning and ate them immediately, starting from the head. When offered different pieces of fish they preferred the heads. A small fish moving on the outside of the aquarium released in hungry animals all their prey-catching actions (fixing, slight spreading of the dorsal fin, lunging).

Pieces which fell to the bottom and were motionless were never taken. After being in captivity for a while the ground was sometimes searched for food, but only by very hungry animals.

These observations indicate that Serranus scriba probably considers fish as its prey also, and that it is accustomed to hunt living prey. Further these observations show that it recognizes fish from their heads and that it learns to eat motionless food.

With these conclusions the present observations become a further small contribution to the nutrition biology of this species and confirm the conclusions by Zolezzi (1939) who, on the basis of analysis of the stomach contents of 150 animals, compiled a list of the prey animals, and proved experimentally that Serranus scriba has a special liking for young anchovies, and does not spare even its own young, besides eating different molluscs and crustacea.

4. PROPAGATION

Since ancient times the hermaphroditism of the species has repeatedly given rise to research in this direction, although of course only of morphological and histological nature. In one of these Ancona (1949) indicates that July and August is the breeding period of this species for the upper Adriatic (Rovinj, Istria).

Nothing is known of the reproductive behaviour and it remains for further research to discover the details of this subject.

SUMMARY

The present work is the first on the behaviour of a marine fish (Serranus scriba Cuv.) carried out by field observations under water and in aquaria.

Observations are presented on the ecology of this species; it was established that its optimum biotop is well-subdivided and dense phytal. Such a biotop allows a dense colonization with the smallest possible, separate territories and gives the species favourable development chances. Further, the structure of the area is described: Serranus scriba is a territorial animal. The entire biotop of the species is subdivided into single territories adjoining each other. Thus the individuals form a "territorial society". A territory, the size of which depends on the structure of the ground and on the vegetation, represents the habitat of one animal. Such a territory provides it with cover and food. Each territory is subdivided by its owner into subareas: places for rest, hunting grounds, etc. These subareas are of different value to the owner. The centre of the area is a cave or crevice in the rock. "Fixed routes" are used for communication between this centre and other subareas.

The territory is defended against other members of the same species, and the repertoire of fighting behaviour is complex.

Serranus scriba is a rapacious feeder on small animals. Nothing is known with respect to its reproductive behaviour.

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FIGURE LEGENDS

Fig. 1. Sketch of Rovinj and surroundings. Crosses denote the observation districts.

Fig. 2. The main observation district at Kap montauro. Distribution of rubble and vegetation.

Fig. 3. The main observation district at Kap montauro: separate territories with stations. The segments of the arcs indicate the range of the territories; the radii serve only to give some idea of closeness of the territories. The large fishes indicate the homes of the first order (H.1.0); the small fishes subareas of the second order (H.2.0). Terrace 1 is dotted sparsely, terrace 2 more densely, and the sea-bottom is dotted most densely.