ETHOLOGY OF THE ASIAN TELEOST *BADIS BADIS*. I. LOCOMOTION, MAINTENANCE, AGGREGATION AND FRIGHT

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For such a popular aquarium species, the biology of *Badis badis* (Hamilton-Buchanan) is remarkably poorly known. What little information is available, mostly in aquarium journals, is to a large measure erroneous. Even systematically the species appears to have been misplaced. I hope to show in a subsequent paper, primarily on behavioral evidence, that *Badis badis* has been classified in the wrong family and suborder.

The main objective of this paper is to introduce certain aspects of the ethology of *Badis badis*. The topics considered could stand alone, but of more importance, they constitute the foundation for a series of articles to follow. The treatment of locomotion, for instance, centers on descriptions of movements essential to an understanding of social displays and parental care, and their derivation, rather than emphasizing hydrodynamical considerations. It was found practical, however, to discuss some of the topics as they were completed, rather than to defer this to later publications.

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TERMINOLOGY

The behavior of *Badis badis* is first broken down into units and these are given names. No claim is made that these units correspond to Fixed Action Patterns, "acts," or "components," (see Hinde, 1959). Convenience has been the rule in fractionating the behavior. Most of the units, however, approximate Fixed Action Patterns, or subdivisions of them. Where pertinent, the orientation components (Lorenz and Tinbergen, 1938) are described.

The prevailing terminology is usually employed when possible, but no attempt is made to follow priority of usage, nor in most cases are the sources acknowledged. In this article terms both new and old referring specifically to *Badis badis* are *capitalized*. Forselius (1957) has coined many terms to describe behavior patters observed in anabantid fishes. In

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spite of the similarity of the behavior of the anabantids and of *Badis badis,* and of their presumed close relationship, I prefer using my own terminology in the treatment of the behavior of *Badis badis.*

Materials and Methods

Badis badis is a small (maximum standard length about 75 mm) teleost fish occurring naturally in tropical Asia. The stock was obtained from an aquarium shop in Munich, and had been raised in that city. Most of the animals reported on were bred in the laboratory. The fish were kept in aquaria having capacities of 30, 60, and 120 liters; they were thickly planted with a wide variety of aquatic plants, and the bottoms were covered with fine gravel. Water with a hardness of about DH 4-6, a pH of around 6-7, and a temperature of approximately 26° C to 28° C circulated through a large filter reservoir and the aquaria. Illumination was provided by 25-watt fluorescent tubes.

Most of the observations were made directly. Strobe-light photography was employed to supplement observations.

Locomotion

Forward. *Badis badis* swims slowly in comparison to many kinds of fishes. At the slowest speeds, forward thrust is provided by movements of the pectoral fins which undulate, passing vertical waves down and to the rear along the fins; this type of movement will be referred to as sculling. In comparison to the slower tempo of many other teleosts, the sculling by *Badis badis* seems vibratory. The phasing of the waves between right and left fins appears to be alternate.

Swimming fast is accomplished in the normal teleost manner through lateral undulations of the body. The head appears to initiate the waves by turning almost imperceptibly to the right and left. As the waves pass posteriorly through the body they increase progressively in amplitude. The propulsive thrust of this type of movement is derived from the forward component of the force produced by the passage of the leading edges of the waves obliquely through the water (Gray, 1933a). Normally the fish employs both methods for swimming ahead, sculling being implemented by occasional undulations.

While swimming rapidly forward, the spinous portions of the dorsal and anal fins, as well as the pelvic fins, are usually folded against the body. The lobes of the dorsal and anal fins are held loosely open and move in unison with the caudal fin; together they increase the surface area of the posterior end of the fish. This arrangement of the fins refers to swimming movements uncomplicated by interactions with other fishes, predators, or prey.

Backward. The pectoral fins push water forward by means of alternate paddle-like beats. On the recovery stroke, the fin is feathered, the superior margin leading. In a well developed backing, all the other fins are folded except the lobe of the dorsal fin. The caudal fin frequently is compressed and held to one side partially cupped; it often beats to that side, probably having a greater steering than propulsive effect. Also, the fish may feel its way in the burrow with the caudal fin. The loosely expanded lobe of the dorsal fin is brought into use as a rudder. Rarely the entire dorsal fin, as well as the caudal fin, may remain loosely spread, particularly when backing up is incompletely expressed.

Hovering. The fish stands in the water nearly motionless. The pectoral fins, and often the lobe of the dorsal fin, perform sculling movements. The pectoral fins tend to be cupped with the concave surface directed anteriolaterally. Presumably the pectorals exert a backing thrust, resisting the forward thrust of the opercular jets (see Breder, 1926). The medium and pelvic fins may be either spread or depressed. *Badis badis* spends much of its time Hovering.

In subsequent articles, the tempo of Hovering will be compared to those of Fanning, Digging, and Shuddering, as the origins of these behavior patterns are considered. Table I lists the extreme range, and median, of the tempo of Hovering seen in various *Badis badis*. At the slowest tempos, the fish barely maintained themselves in midwater; at the fastest tempos, the fish often contacted some firm object, as though using it as an anchor.

The tempo of the pectoral fin movements while Hovering seems to indicate the state of excitation of the fish. Ripe ♀♀ were observed as they approached and withdrew from the ♂ in his burrow. In each instance the slowest speeds were recorded when the ♀ was furthest from the ♂, and had been so removed for some time. Approaching produced an acceleration of the tempo. The maximum invariably was achieved when the ♀ actually confronted the ♂. Fleeing was followed by a gradual deceleration. Among sub-adults the fastest tempos were always seen during encounters with other sub-adults, the slowest when unmolested and full of food. Hence the faster the tempo, apparently the greater the excitation.

Starting. In slow starting, the fish appears to change the pitch of the sculling pectoral fins slightly,

TABLE 1.—Tempo of Pectoral Fin Beats While Hovering.[1]

Estimated Standard Length (mm.)	Temperature (°C)	Range (Beats/Sec.)	Median (Beats/Sec.)
25	26.3	4.6-6.1	5.4
27.5	26.3	4.5-5.2	4.9
30	26.3	4.5-5.4	5.0
20	26.5	3.9-4.5	4.2
22.5	26.5	4.1-4.6	4.4
25	26.5	4.0-4.3	4.2
		Grand Range 3.9-6.1	Grand Median 5.0

[1] The upper three sets of data were taken from three ripe ♀♀ in aquaria with mature ♂♂, the lower three from sub-adults in an aquarium with other sub-adults. For each fish 10 samples of 50 beats each were tallied.

directing the water current to the rear. If a faster start is required the head initiates lateral trunk undulations in the manner typical for most fishes (Gray, 1933b), and the spread pectoral fins are clapped against the sides in unison. In either case the fins take on the arrangement described for Forward Swimming.

In certain situations the fish starts with an abrupt burst of speed. The most typical preparatory posture for a fast start in *Badis badis,* and a great number of other kinds of fishes, is the sigmoid, or S-shape (Fig. 1A), an arrested swimming undulation. From this position the fish can deliver the maximum instantaneous forward thrust. The head is in a position enabling it to move through the greatest arc possible. Consequently the largest lateral amplitude is produced in the tail-beat. The posterior part of the fish has at the outset the proper angle for utilizing the greatest possible forward component of the beat.

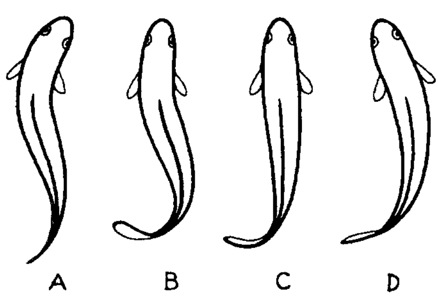

Fig. 1.—Characteristic body postures derived from locomotory movements, seen from above. A, S-shape; B, Sickle-shape; C, L-shape; D, C-shape.

The Sickle-shape (Fig. 1B) is a specialized expression of S-shape. By keeping the anterior part of the body straight the fish achieves greater control of the forward movement. But it is placed in a less favorable position for the initiation of another beat, and also sacrifices some force. The Sickle-shape is usually used only when the fish intends to dart forward a short distance (at least less than its own body length), but when considerable accuracy in the course is necessary.

Sickle-shape and S-shape are two extremes and all degrees of intermediacy occur. Some of the other postures derived from locomotory movements are shown in Figures 1C and 1D; these occur regularly in certain displays and will be discussed in another article.

Turning. The mechanics of turning are difficult to observe without resorting to high speed cinematography. Turning seems to consist of merely bending the head in the direction of the turn while swimming. Among the fins, the pectorals appear to exert the most control in turning both in the horizontal and in the vertical. Unfortunately the pectoral fins are too transparent to be observed well. In some fishes, one extreme being the pomocentrids of the genus *Dascyllus,* the pelvic fin, on the side toward which the fish is turning, is lowered and serves as a pivot, or brake. In *Badis badis* the pelvic fins are abducted now and then, though usually together. Evidently this is done mostly as a partial stopping and/or stabilizing movement. Although *Badis badis* can raise and lower the right and left pelvic fins independently, it does not do so to any great extent in turning. The median fins of *Badis badis* take no special part in turning other than assisting in propulsion and stabilization.

Opening and closing the fins. A definite way of folding or raising the fins is observable when the movements are done slowly. In a fish whose fins are tautly spread the anterior-most elements of the dorsal fin even incline slightly forward. In folding the dorsal fin against the body the rays first incline somewhat to the rear. This imparts a relaxed appearance to the fin, termed loosely spread.

The dorsal fin collapses from front to rear, and is erected in reverse order, from posterior to anterior. Under certain circumstance, however, the fish is able to erect the dorsal fin from front to rear. The folding of the anal fin is similar to that of the dorsal. Because of the short length of its base, the anal fin folds more as a unit. When folded, the rays of the caudal fin may press together until the fin forms a point. The pelvic fins are simply brought in against the abdomen.

The sequence of folding the fins slowly can be seen best in a fish preparing to back up. The pelvic fins are adducted first followed by the anal, caudal, and dorsal fins in that order. The sequence is usually the same for swimming forward; of course, the caudal fin is not folded. The fins are abducted in reverse order, *i.e.*, the pelvics are the last to be spread. Most of the time the folding movements overlap broadly. As an example, when the pelvics fold, the dorsal fin rays begin to incline more to the rear.

In opening and closing the fins the excitation runs along the perimeter of the body, so to speak. The same holds for the onset of fanning movements where the beat starts in the dorsal, then the caudal, and then the anal fin, extinguishing in the reverse order.

Respiration in Oxygen Deficient Water

The response to oxygen-deficient water by *Badis badis* is similar to that of many teleost fishes lacking the ability to utilize air directly. In order to observe this response, twelve *Badis badis,* juveniles to young adults, were placed in a small plastic dish containing water from their aquarium. As the oxygen content of the water presumably decreased, the fish moved upward and stood directly under the surface of the water. Their bodies were tilted upward anteriorly about 45°, just enough to bring their mouths into contact with the surface. The oxygen-rich surface film was then inhaled and passed over the gills. The opercular movements appeared to be the same as those seen in normal aquatic respiration. At no time did a *Badis badis* entrap air bubbles in, or pass them through, the gill chamber.

Comfort Movements

Included here are those movements that are used in removing irritants, or seem to be stretching movements (Baerends and Baerends-van Roon, 1950, for a discussion of Comfort Movements).

Fin flickering. The pelvic fins rarely are opened and closed together rapidly once or twice. Sometimes one pelvic fin alone is moved through the full arc, and the other opens only partially. The elements of the dorsal and anal fin can be raised and lowered rapidly in a flicker-like movement that may be repeated in bursts. The pectoral fins can be rubbed against the body in various ways; these movements are exceedingly difficult to observe.

Chafing. The fish slowly approaches an object such as a plant, the bottom, or an aquarium wall. With a quick movement one side of the fish apparently near the head, is placed against the object, and it darts forward two to three body lengths; the rebound may be arcing, or straight ahead; the fins are folded. In cichlid fishes the median and pelvic fins, in contrast, are normally spread during the rebound (pers. observ. on *Etroplus maculatus* and *E. suratensis*).

Flexing. An exaggerated lateral flexure is made in the body, often as the fish reverses directions. It may immediately straighten out again, or the flexure may pass down the body as a wave.

Coughing. The gill covers are clamped down in a quick movement and the mouth is thrown open. Further details are not available. Apparently a counter-current of water is flushed through the buccal cavity.

Yawning. In the most complete expression of this movement all the fins are fully spread, the mouth is opened maximally, and the opercular chamber is expanded (See Fig. 8 of *Eupomotus gibbosus* in Breder, 1936). Then (1) the mouth is snapped shut as (2) the floor of the mouth is depressed and quickly recovered, and immediately (3) the operculae are adducted. This sequence is rapid and passes a large volume of water quickly from the mouth out through the gills. Concurrently with (3) the fins relax. In a less complete performance the sequence remains the same, but the gaping is less, the floor of the mouth is not so conspicuously depressed, and the fins are only partially, or barely, spread. Intention yawning, consisting of slight gaping and partial erection of the fins, may precede complete yawning.

Feeding Behavior

Badis badis is strictly carnivorous. The post-larvae forage at first on the microfauna in the aquarium, probably rotifers and large protozoans. Within a few days after swimming they capture and eat small cyclops and *Daphnia*; these are caught in the open water. The post-larvae also forage along the bottom and over the surfaces of plant leaves where doubtless they find small benthonic animals. As soon as the fish are large enough they feed on small worm-like animals. They seem to prefer these "worms," such as *Tubifex, Enchytraeus,* and many aquatic insect larvae, to crustacea. If sufficient "worms" are available to the juveniles and adults, crustacea are taken only sporadically. Adults also have been seen to seize and attempt to eat large leeches, but the leeches escaped. Small leeches are probably eaten.

Feeding appears to be visually mediated since only moving objects are taken. Even post-larvae, which have been swimming well for only a few days, have been observed to turn the head to one side and fix on tiny moving particles.

The movements employed in feeding are similar at all stages in the life history of *Badis badis.* Younger animals feed on a different type of prey (nektonic) than do the larger fish (benthonic), so their way of foraging at first seems different.

A young, not recently fed, *Badis badis* catches a *Daphnia* in the following way. It approaches the prey slowly by sculling forward. When the prey lies directly ahead about one head length away the fish stops and commences Hovering while continually adjusting to maintain its position relative to the prey. The already raised dorsal fin now becomes taut. Slowly the trunk forms a Sickle-shape (Fig. 1B). During this brief period while the fish fixes on the prey, its movements are slow and scarcely noticeable. Suddenly it darts forward with folded fins in a single snap of the trunk, and engulfs the *Daphnia*. The prey is chewed a few times, apparently by the pharyngeal teeth, before swallowing.

A young *Badis badis* that has already eaten some *Daphnia* shows less complete feeding behavior. It approaches and fixes on the prey in nearly the same manner. The body of the fish, however, remains straight. Furthermore, the fish may move forward and to the side until the prey is lateral to its snout at a distance about one-half of a head's length. Then the fish snaps its head laterally toward the prey. The fish seems to "inhale" the prey by suddenly enlarging the mouth cavity, but this cannot be reported with certainty. It is also not certain whether this sideways snapping of the head appears as early in ontogeny as the forward dart.

An even less complete performance of the prey-capturing behavior is commonly observed after the fish has devoured several crustacea in quick succession. The fish simply swims directly to the prey and takes it into its mouth. All intermediates are seen in the degree of completeness of prey-capturing behavior.

The descriptions of activities concerned with seizing worms apply to juvenile fish capturing worms that are already imbedded in the bottom. Long before the fish reach maturity they learn to catch the worms as they fall from the surface of the water, or to pick up worms on the bottom before they dig in. The adults seem to be "spoiled" by the easy life in the aquarium and complete feeding behavior is seldom manifested even when the worms are well dug in. In the adults, social interactions also frequently modify the behavior. For instance, a fish may fix on a worm from outside of another's territory, then suddenly dart from its hiding place and snatch the worm, all in one circling dash.

Normally two slightly different techniques for grasping onto worms are observed; in both cases the fish first swims to the protruding tip of the worm. It pauses there when its mouth is roughly one head length from the worm. In the more complex method of grasping a worm the fish rolls over onto one side, simultaneously forming an S-shape; the head points down at the worm, and the dorsal fin is usually spread as much as the body curvature allows (Fig. 2, Top). After briefly fixing on the prey the *Badis badis* lunges and seizes the worm. Most of the time this method is seen only when the fish has not recently caught a worm.

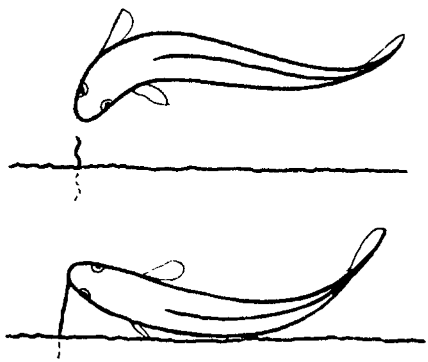

Fig. 2. Top—fixing on a worm in the bottom. Bottom—pulling on the worm.

In the less elaborate technique of worm catching the body remains in the normal upright position, though its long axis becomes inclined downward anteriorly at an angle of about 45°; the already raised fins become tautly spread. While thus fixing on the worm the fish forms a slight Sickle-shape, and then strikes forward grasping the free tip of the worm. Hence this maneuver is the same as that used in capturing free-swimming prey, except it has a different orientation. The upright approach is often used in catching the first worm. However, if both the upright and on-the-side approaches occur in the same feeding bout the on-the-side technique more often appears first and subsequently is replaced by the upright method.

The techniques used to pull worms free of the substrate can be grouped into three characteristic types, swimming backward, swimming forward (including circling), and lying on one side. Swimming backward and forward are largely self-explanatory; the variation lies in the amount of force exerted, and the number of times the fish pulls on the worm. By lying on one side the fish is able to use its body as a lever (Fig. 2, Bottom). The head is raised, pulling the worm free, while a counteracting force is exerted downward by swimming movements of the tail. Swimming forward or backward with the worm usually follows fixing in an upright position. Side leverage normally follows fixing from the on-the-side S-shape. All combinations, however, are seen.

The completeness of the observed behavior seems to be influenced by exogenous, as well as endogenous, factors. This can be documented by observations on the activities involved in pulling a worm free of the substrate after grasping onto it. It often happens that the fish backs up with the worm, the pulling movement that commonly seems the last to drop out, but finds the worm will not yield. This may evoke darting forward. And if the worm still remains fastened, the fish may resort to lying on the side, or to making stronger lunges forward. The environmental feed-back seems to play a smaller role in the movements used in stalking the prey.

Once a juvenile *Badis badis* succeeds in pulling a worm free from the bottom, it swims a distance of several body lengths up into the water with the worm dangling from its mouth. But a fully grown *Badis badis* with a cluster of worms protruding from its mouth usually backs away slowly; a single worm simply disappears into the mouth. Backing up apparently serves to keep the free ends of the worms from touching the face.

The most significant characteristic of hunting behavior in *Badis badis* is that catching and eating each prey produces steadily increasing parsimony of behavior in capturing the next, if this is done at once. The most complete expressions of this behavior contain the most movements and positions deviating most from the norm. In short, they require the greatest expenditures of energy. Hence increasing energy requirements appear to be positively correlated with progressively higher thresholds of the motor patterns of hunting behavior (see also van Iersel and Bol, 1958).

Prey-capture behavior may persist in an animal that has fed to repletion (Lorenz, 1937, 1939; Räber, 1950; Thorpe, 1956). *Badis badis* was never observed to hunt after it stopped eating, even if no hunting had been involved. Although the motor patterns of hunting drop out quickly, *Badis badis* may continue to eat if it can pick up loose worms. Thus the threshold of hunting seems to rise faster than that of eating. In nature the animal probably never, or seldom, has the opportunity to capture several worms in quick succession. The elimination of the more elaborate elements of the hunting behavior would be adaptive, allowing the animal to capture more worms in a given amount of time, and to conserve energy as well.

Aggregating Behavior

Badis badis is throughout its life an essentially non-aggregating species. The post-larvae seem to be entirely solitary. At about the time they begin developing a barred color pattern (*ca.* 8-10 mm standard length) they can be observed approaching and interacting with other *Badis badis* juveniles. Other than between juveniles, and perhaps there as well, aggregating appears to result only from special circumstances.

Immature fish. The congregating of juveniles is a weakly developed type of aggregating. The fish come together, usually by one approaching the other, fight briefly, and separate. One often appears to be driving the other way, or the two merely withdraw from each other. The spacing out is not so great as to keep the fish from continually interacting with one another. Dispersal seems to be counteracted by some degree of attraction between them. This conclusion, however, is highly tentative. If the fish actively disaggregated as a result of fighting one would expect them to become uniformly spread out, and the fighting to be reduced thereby. Such was not the case even though food was not confined to one place, and the fish were not crowded. Aggregating in this fashion might not occur in nature. And if it did, it would be difficult to rule out selection of some common environmental factors, which is also the case in the aquarium.

That juveniles probably are not really solitary is indicated by one feature of their color pattern. The region embraced by the first few elements of the dorsal fin is dark; this is followed by a white bar, then dark again. As the juveniles, otherwise cryptically colored, move about this white patch with dark borders flashes on and off with the opening and closing of the fin. There probably is a reason for the elaboration of such a striking feature, and the reason may lie in the intraspecific signal value of the structure.

Sexually motivated females. Aggregating between two gravid ♀♀ is clear cut. The ♀♀, though, must be deprived of contact with a ♂. Such ♀♀ will then spend most of their time together, only separating occasionally. Infrequently they may fight, but this almost never proceeds beyond initial displays. Two ♀♀ not sexually motivated, on the other hand, will enter into well developed fights. Thus the aggregating of two gravid, ♂-deprived ♀♀ probably results from substituting one another for a ♂, and is made possible through the suppression of fighting behavior.

Frightened fish. The last type of aggregating behavior could be called schooling behavior. It has only been observed in ♀♀ and sub-adults. Males might be capable of schooling if properly manipulated. The following description applies to ♀♀. When placed in a small, relatively bare aquarium (but provided with hiding places), the fish at first become motionless on the bottom, a typical fright response. After several minutes one usually makes a short dart toward another. In this way they gradually assemble in a loose aggregation resting on the bottom. Then, little by little, they move in one direction, each swimming in short hops. Eventually they travel several times around the aquarium together in this saltatory fashion. The behavior is infectious. If one or two residents are present they soon behave as the introduced fish. As the fish seem to become accustomed to their new surroundings the schooling behavior gradually disappears.

From the increased disposition of the fish to show fright behavior (see below), the appearance of the schooling behavior itself, and a consideration of the stimuli provoking it, it seems reasonable to assume fright is the predominant motivation of schooling in *Badis badis*.

Fright Behavior

Flight. In forward flight the fish darts away at top speed with folded fins. The course taken is often toward the cover of plants, burrows, or aquarium corners. When shelter is too far away, or when the fish is temporarily too disoriented to find a suitable hiding place, an adult *Badis badis* may dart down to the bottom and sit there motionless (see below). Juvenile *Badis badis* in the same situation are more apt to swim upward. If badly harassed by another *Badis badis*, an adult will swim upward as a last resort. Then it usually stands in a corner (head down or up) or among plants (often head up). When a juvenile swims upward or forward in flight, the body normally swings down posteriorly at the end of the flight if the fish is not in contact with the substrate. The body angle, with respect to the bottom, ranges between 45° and 80°.

Flight backwards is performed as described for normal backward swimming. The movement is done slowly and the distance travelled is seldom more than one body length. There are two flight situations in which backing up is commonly observed. The less common occasion is when one fish avoids another; this is sometimes observed when a juvenile *Badis badis* is confronted by a larger one. The behavior most often observed is the fish backing into some shelter. This frequently goes over smoothly into a type of behavior called Nestling (see below).

Forward and backward flight appear to have different thresholds, that for backward being lower than that for forward, particularly when the fish is in its burrow. Bringing a strange object progressively nearer to the shelter releases first backing, then swimming forward to the entrance and fleeing forward. Sometimes the threshold of forward flight is extremely high; touching, entering, or even lifting away the burrow may not produce immediate flight.

Nestling. The performance of Nestling, though species-typical, is variable because it depends upon the shape and light conditions of the shelter, as well as the disposition of the fish. The fish backs up while seemingly probing for a crevice with its tail. Then it presses its body, especially the posterior part, against the rear-most region of the shelter where the light intensity is low. The median and pelvic fins are folded until the fish assumes a "satisfactory" position. Then these fins are usually spread, and the fish becomes almost motionless (Fig. 3).

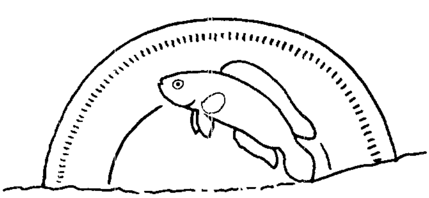

Fig. 3.—A male nestling in the rear of a flower-pot.

Movement suppression. The fish is almost motionless, and the median and pelvic fins most often are spread, but sometimes are folded. Rarely just the anterior-most elements of the dorsal fin are erected. If Hovering in the water, the transparent pectoral fins continue to scull.

When the animal is resting on the bottom the pectorals continue to scull with a fast tempo if the cause of the fright is relatively weak (far away, smaller, etc.). As the strength of the stimulus increases the pectoral fins cease moving and the amplitude of the opercular beats diminishes perceptibly. The already abducted fins become even more tautly spread.

For convenience, the situations evoking suppression of movements may be considered under five groups: (1) predator near (or any novel object), (2) open spaces, (3) attack from a conspecific, (4) mating behavior, (5) stalking food object. Only numbers one and two will be taken up at this point; number five has already been dealt with, and numbers three and four will be treated in later articles.

The protection afforded through inhibition of movements in the presence of a potential predator, and when in the open where *Badis badis* is vulnerable, seems clear. Movements both attract the attention, and elicit the feeding behavior of predators.

Two things deserve to be mentioned about the inhibition of movements in exposed places when no predator is actually present. First, the animal must already have a low fright threshold, as when in new surroundings. Second, the inhibition is often incomplete. The fish moves extremely slowly across open spaces, most of the time just over the bottom. When cover is finally at hand, the fish darts into it. Once inside, it may turn around, probe the bottom, and so forth. The presence of cover (= fish out of predator's view) removes the suppression of movement.

Defense. Fleeing could be considered as a type of defense in the negative sense, as could also hiding. Positive defense consists of spreading the fins. This may be accompanied by rotating the body slightly, presenting the erect dorsal fin spines to the object eliciting the behavior.

Interactions. Andrew (1957) uses the term Fear as, " . . . the tendency to give fleeing and related responses." Figure 4 should make clear what is meant by Fright in the present article; it is roughly equivalent to Andrew's usage of Fear.

There has been an inclination in investigators to use the terms Escape or Flight, or Flight (Escape) Tendency, in preference to Fright or Fear. For one thing Flight Tendency is considered more objective because it is founded on overt behavior. Yet the notion of Flight is used freely in situations when Flight is not manifested, but is only deduced. When Flight is inferred from non-Flight behavior, the term is no longer used objectively. The second difficulty in using Flight arises when one attempts to unravel the complex motivational causes of social behavior, particularly displays. Flight in itself lies further down in the hierarchical chain than do Sexual or Aggressive behavior, against which it is usually compared. A more balanced comparison of motivations lies in the application of the higher level concept of Fright, or Fear.

Fright in *Badis badis* finds expression in three more or less conflicting kinds of behavior, Avoiding, Concealing, and Aggregating (Fig. 4); defending is compatible with all three expressions. The most extreme type of Avoiding is panicky flight; the behavior has negative valence since the only taxis is away from the stimulus, if the stimulus is located. The extreme manifestation of Concealing is complete absence of movements. Goal directed flight already contains an element of Concealing, since its goal is usually a hiding place. Backward flight may

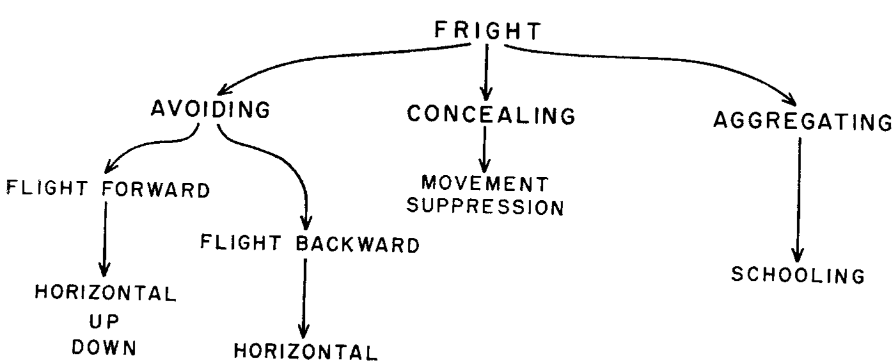

Fig. 4.—A hypothetical construct of the hierarchy of fright induced behavior.

be simple Avoiding, but often it is influenced by a need for Concealing. Actions still more intermediate between Avoiding and Concealing are Nestling (see above) and perhaps Digging (M.S.). Aggregating could be considered as flight behavior, but with positive valence because the transport is toward the fellow *Badis badis*. Concealing also enters in; the individuals in the aggregation show considerable suppression of movement. Aggregating, however, should be recognized as a factor on a par with Concealing and Avoiding once schooling behavior emerges fully.

The change in valence of fright orientation in social behavior is particularly relevant to motivational analysis. Movement away from another individual is often accepted as an expression of flight tendency. As just pointed out, however, fright behavior may have a positive valence, under proper conditions, bringing the individuals closer together. This does not cause much confusion in analyzing the displays of *Badis badis*, but it becomes an important consideration when studying the behavior of more complex fishes, such as the Cichlidae.

It is possible to demonstrate the conflict between fleeing, backward or forward, and suppression of movement in a *Badis badis* by placing it in a small aquarium with inadequate shelter. Tapping on the glass with one's finger, varying the strength and distance of the tapping, causes the fish to lie still, suddenly jump forward and immediately back, and so forth. Thus the behavior switches back and forth rapidly between the possible outlets of Fright.

Fright behavior in *Badis badis* is usually an integrated performance involving both Avoiding (flight) and Concealing (movement suppression), or Aggregating (schooling).

Summary

Badis badis spends much of its time hovering by means of pectoral fin undulations. This sculling action of the pectorals also propels the fish backwards, and forwards. Lateral trunk undulations may appear when swimming forward. In general, the median and pelvic fins are folded while swimming, and spread while stopping.

Comfort movements recorded include fin flickering and rubbing, chafing, flexing the body, coughing, and yawning.

Badis badis eats only live, moving prey. The fish approaches the prey slowly, pauses, flexes the body, then darts forward, grasping the prey with its mouth. If the prey is imbedded in the substrate the fish may lay on its side and use leverage to pull it loose.

Usually *Badis badis* is solitary. Some attraction between juveniles, and between ripe ♀♀, is apparent. Strong fright sometimes induces schooling behavior.

Fright is indicated by three types of behavior: flight (avoiding), movement suppression (concealing), and schooling (aggregating).

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