Mimicry of a Bean Seed by the Amazonian Aspredinid Catfish *Amaralia hypsiura* (Kner 1855), with Notes on Vegetative Camouflage by Fishes

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Abstract.

Amaralia hypsiura can modify its typically bunocephalid or aspredinid-catfish shape, hiding many of its features including all of its fins, so that it resembles a large bean or seed of the spermatophyte family Leguminosae or Fabaceae. This is accomplished mainly by adpressing both pectoral fins and folding the tail and caudal fin tightly around one side of the body and head. In so doing, *Amaralia* radically transforms itself from the bilaterally symmetrical form of a vertebrate animal into the radially symmetrical form of a seed. The fish then remains motionless until it unfolds itself. While mimicry of plant parts and camouflage to resemble plants or woody background is well known in fishes, mimicry of a seed apparently has not been reported previously. It possibly facilitates prey capture by *Amaralia*, which feed on the large yolky eggs of orally-brooding or otherwise parentally-guarding loricariid catfishes. It might also be involved in predator avoidance. Mimicry and camouflage involving vegetation is now known in a wide variety of freshwater and marine fishes.

Zusammenfassung

Amaralia hypsiura ist in der Lage, die für Asprenididen oder Bunocephaliden typische Form abzuwandeln; die Flossen und andere Merkmale sind dann verborgen, sodass der Wels einer großen Bohne oder anderen Samen der Hülsenfrüchtler (Leguminosen oder Fabaceen) ähnelt. Erreicht wird das dadurch, dass beide Brustflossen an den Rumpf gepresst und Schwanz und Schwanzflossen dicht um Flanken und Kopf gefaltet werden. Der Fisch bleibt dann so lange bewegungslos, bis er sich selber wieder entfaltet. Während Mimikry von Pflanzenteilen und Tarnung durch Ähnlichkeit mit Pflanzen oder hölzernem Untergrund von Fischen seit längerem bekannt sind, wurde über Mimikry von Samen bisher nicht berichtet. Möglicherweise wird der Beute-Erwerb von *Amaralia hypsiura* dadurch erleichtert, denn die Vertreter dieser Art ernähren sich von Eiern der maulbrütenden oder anderweitig von Eltern behüteten Vertreter der Loricariiden (Harnischwelse). Wahrscheinlich hilft es ihnen auch zu vermeiden, dass sie selber zur Beute werden. Mimikry und Tarnung in Bezug auf Vegetation ist jetzt von einer Vielzahl von Süß- und Salzwasserfischen bekannt.

Résumé

Amaralia hypsiura est en mesure de modifier sa forme typique de Bunocéphalidé ou d'Asprédinidé, en cachant une série de ses caractéristiques, y compris toutes ses nageoires, de façon à ressembler à un grand haricot ou à une semence de la famille des Légumineuses ou Fabacées. Il y parvient surtout en accolant ses deux pectorales et en repliant la queue et la caudale fermement autour de la partie latérale du corps et de la tête. Ce faisant, *Amaralia* se transforme radicalement, passant de la forme de symétrie bilatérale d'un animal vertébré à celle de symétrie radiale d'une semence. Le poisson reste alors immobile jusqu'à ce qu'il se déploie. Alors que l'imitation de parties de plantes et le camouflage évoquant des plantes ou un fond de bois sont bien connus chez les poissons, l'imitation d'une semence ne semble pas avoir été rapportée jusqu'ici. Cela facilite peut-être la capture des proies pour *Amaralia* qui se nourrit des grands oeufs de Loricariidés incubateurs buccaux ou protecteurs parentaux. Ce phénomène pourrait aussi concerner l'évitement des prédateurs. L'imitation et le camouflage impliquant des végétaux sont à présent connus pour un grand nombre de poissons marins et d'eau douce.

Sommario

Amaralia hypsiura può modificare la sua tipica forma di pesce gatto aspredinide o bunocefalide nascondendo molte dei suoi tratti morfologici, comprese tutte le pinne, così da assomigliare a un grande fagiolo o a un seme di leguminosa o di fabacea. Questo avviene principalmente ripiegando strettamente le pinne pettorali, la coda e la pinna caudale attorno ad un lato del corpo e alla testa. In questo modo *Amaralia* si trasforma da un animale vertebrato a simmetria bilaterale ad un essere a simmetria radiale a forma di seme. Il pesce rimane poi immobile fino a quando non si dispiega. Mentre l'imitazione delle parti di piante e il camuffamento per assomigliare a piante o a uno sfondo legnoso sono ben noti nei pesci, il mimetismo di un seme non è stato finora mai segnalato. Probabilmente facilita la cattura delle prede da parte di *Amaralia,* costituite da grandi uova ricche di tuorlo dei pesci gatto Loricaridi che hanno l'abitudine di covare le uova in bocca o di proteggere in altro modo la covata. Questo comportamento potrebbe anche essere un meccanismo di difesa dai predatori. Il mimetismo e il camuffamento in elementi vegetali è diffuso in un'ampia varietà di pesci marini e d'acqua dolce.

INTRODUCTION

The aspredinid genus *Amaralia* Fowler 1944, generally treated as including only a single species, is widely distributed in the Amazon and Plata basins. An undescribed species reportedly occurs in the Parana and Paraguay watersheds of the Plata basin (Friel 1994: 83) and has even received a name, but the abstract in which it is mentioned is not available for purposes of zoological nomenclature (Friel 1992). The only available nominal species taxon within the genus is *Amaralia hypsiura* (Kner 1855). The species is represented by relatively few museum samples from widely scattered localities in Bolivia, Brazil, Colombia, Ecuador, and Peru.

Biological camouflage is the ability of a plant or an animal to blend with its vegetable, animal, or inanimate background, usually to hide its presence from potential predators or prey. In some instances both advantages are involved. Mimicry is when an animal or plant resembles another creature or inanimate object, for comparable advantages. Like camouflage, mimicry often involves morphological and physiological modifications in body shape, coloration, color pattern and color change as well as in behavior, including but not limited to habitat selection, body posture, and locomotion or other movements.

Resemblance to plants and plant parts is well documented in marine fishes and less well documented in freshwater fishes (Breder 1946; Randall & Randall 1960; Randall 2005). The selective advantage of such camouflage apparently is most often defensive, i.e. to escape detection by predators, but it may also be offensive, to hide a predator from its prey, or in some species, it could be both. The Amazon provides numerous examples of freshwater fishes that hide among plants. At least three Neotropical catfish families, Aspredinidae, Auchenipteridae, and Loricariidae, include numerous species that partially resemble tree trunks, branches or leaves. All or nearly all of these examples probably should be regarded as camouflage rather than mimicry. The nandid *Monocirrhus polyacanthus* mimics dead leaves (Eigenmann & Allen 1921; Catarino & Zuanon 2010). So far as I am aware, no species or generic identification of the leaves mimicked has been made. *Monocirrhus* and virtually all of the neotropical catfishes that hide among plants are essentially brown or brownish, often with a mottled or otherwise disrupted color pattern. Such fishes tend to have variable coloration, and sometimes the ability to change coloration. The small Amazonian characiform fish *Ammocryptocharax elegans* turns bright green when it perches immobile on green plant stems or leaves so that it becomes nearly invisible (Zuanon et al. 2006). This again is best regarded as camouflage or protective coloration rather than mimicry.

Young Amazonian pacu, *Myleus* sp., have modified coloration and behaviour and deep-bodied morphology enabling them to resemble darkened dead leaves and fragments of branches. This has been interpreted as protective camouflage. The coloration, similar to that in juveniles of many Serrasalmidae, involves a uniformly dark coloration of the entire head and body and basal portions of the dorsal, anal, and pelvic fins, while the rest of these fins, the pectoral fin, and the caudal fin are entirely clear or colorless, thus effectively invisible. The little fish tend to occur as isolated individuals rather than in schools characteristic of the young of many species in other characoid taxa. They remain relatively motionless, typically with the head slightly down and the body slightly oblique, in a rather uncharacteristic posture for fish (Zamprogno & Andrade 1986).

Reported here for the first time is a fish that mimics a seed. This came to my attention when a single specimen of *Amaralia hypsyura* was collected by seine in the Rio de Las Piedras, a tributary of the Rio Madre de Dios in the Upper Amazon of Peru near Puerto Maldonado. The specimen was collected in shallow water near the shore of the Rio de las Piedras a few km upstream from where it is entered by its tributary the Rio Pariamanu, on 15 Sep 2010.

The specimen, now in the fish collection of the Smithsonian Tropical Research Institute catalogued as STRI 08513, is 41.0 mm standard length. This is far below maximum size for the species, and it is presumably immature. Sex undetermined. The portion of the fish that mimicked a bean, from snout tip to vent, is 25 mm long and 15 mm wide. Its stomach contents consisted of a uniform oval mass of partially digested orange colored yolk.

Amaralia Fowler 1954

Amaralia Fowler, 1954: 40 (type species by original designation and monotypy *Bunocephalus hypsiura* Kner 1855).

Amaralia differs from all other aspredinids in that the abdomen is lengthened at the expense of the tail and is distensible; dorsal fin greatly reduced with a very short stout spine and only 2 or 3 short rays (vs. dorsal fin relatively large with 3 or more rays) (Friel 1994: 47); and caudal peduncle deep and laterally compressed, with a low mid-dorsal tuberculated ridge. Caudal fin with 5+4=9 principal fin rays and with procurrent rays thickened and S-shaped unlike those in other aspredinids (Friel 1994: 82). Postabdominal part of body or tail exceptionally flexible. As in *Bunocephalus* (Friel 1994: 193, fig. 39) and most aspredinids, body extensively covered with unculiferous tubercles.

Morphological modification of *Amaralia* are related to two unusual adaptations, its characteristic egg-eating or oophagy so far unknown in other aspredinids, and its ability to wrap the tail tightly around the sides of the abdomen, thus disguising its fish shape and helping it to mimic a bean seed. Other bunocephalids have a less flexible tail that would prevent them from doing this.

In resting or immobilized *Amaralia* the dorsal fin is depressed, so that it is virtually invisible and cannot be detected by moving a finger gently forwards over the dorsal surface. When specimens are preserved the dorsal fin usually becomes erect and firmly locked in place. It is then obvious despite its very small size. It seems possible that in seed-mimicking mode the dorsal fin with its spine may be withdrawn entirely below the skin.

Knobby skull ornamentation well developed, dorsal surface of head rugose. This ornamentation pattern is due to "bony knobs which often form above bifurcation points of the *lateralis* system of the skull." Among Aspredinidae this pattern is most highly developed in *Bunocephalus verrucosus* and *Amaralia hypsiura* (Friel 1994: 30). Coracoid processes of pectoral girdle readily visible as prominent rib-like structures on the sides of the abdomen (typical for aspredinids). One of these coracoid processes apparently is covered when the tail is tightly wrapped around one side of the body. It is unclear how the process of the other side is hidden. It seems that the other bony knobs vary in the extent that they project from the body. Perhaps they also can be can be voluntarily exposed or retracted below the skin. When the 41.0-mm alcohol preserved specimen was dried a bit, the tubercles on the dorsal surface of the head became much more pronounced than they are in Fig. 1b.

OBSERVATIONS (Fooled by a Fish) – Figs 1-3

Only a single seed-mimicking *A. hypsiura* was observed by me, and it was not photographed in mimicry mode. Its initial resemblance to a large water-logged dead seed completely fooled me. The incident occurred following a seine haul on the Rio de las Piedras, about an hour by motor boat upstream from its mouth into the Rio Madre de Dios at Puerto Maldonado, Peru, on 19 January 2010. Felix Yucra, whom I engaged to help me do an ichthyological survey of the Rio de Las Piedras and its tributary the Rio Pariamanu, handed me a seemingly inanimate semi-flattened oval object and asked "is this a fish?" I examined the object closely, turning it over several times, observing all aspects in good daylight at about 4 PM. Impressed by its symmetric oval shape and strong resemblance to a dead water-logged seed, I pronounced it a seed. Noticing on the side of the oval what appeared to be the slightly raised edge of a seed coat and something lighter colored inside, I gently prized it open, fully expecting to reveal a seed leaf and endosperm. To my amazement the prized edge straightened out into a fish tail complete with rayed caudal fin, and only after that did the familiar shape of an aspredinid snout with its tiny eyes and short barbels, and the dorsal, pectoral, pelvic, and anal fins become apparent (Fig. 1). To avoid loss of the unique specimen it was immediately preserved. No photographs were taken during the short time it resembled a seed.

The following points should be noted with regard to the seed-like object I had held in my hands. Until its tail was prized open, it remained completely immobile despite the handling it had been subjected to by Felix and me. It was somewhat depressed or flattened but relatively thick and otherwise perfectly oval in shape in its dorsal and ventral aspects (and thus completely unlike the relatively elongate shape of the actual fish). What turned out to be the dorsal and ventral or abdominal surfaces of the fish were nearly identical in their oval shape, coloration, and finely granulated surface. There were no signs of eyes, mouth, barbels, epidermal knobs, or fins. The lateral surface of the head, abdomen and tail formed the thick flattened circumference of the oval. The dull brownish or tan seed-like color was similar dorsally and ventrally. When gently squeezed the object felt squishy or spongy like a dead waterlogged seed but remained immobile.

Steps were taken after observation of this specimen to obtain additional relevant observations in the field. The large seine net in which the specimen was caught was carefully searched for more specimens and for comparable seeds from actual plants, and several more sweeps were made with it in the area to no avail. No additional specimens of *Amaralia* were collected during the 14 days of the survey, nor were seeds resembling the fish found.

An attempt was made to recreate the bean mimicry position observed in the living fish by manipulation of the preserved specimen. The part of the body, from the snout tip to the vent, involved in mimicking a bean, is 25 mm long, 15 mm wide, and a maximum of 11 mm deep. The tail, its full length from vent to tip of caudal fin 23 mm, could be bent around one side of the abdomen and adpressed pectoral fin, effectively hiding them, until the tips of its caudal fin reached the corner of the mouth. This left the pectoral fin of the opposite fully exposed, but it was somehow hidden when I observed it alive in bean mimicry mode. Other problems of concealment apparently solved by the fish in bean seed mimicry mode involve the eyes, barbels, keratinous knobs, and the dorsal, pelvic, anal, and caudal fins.

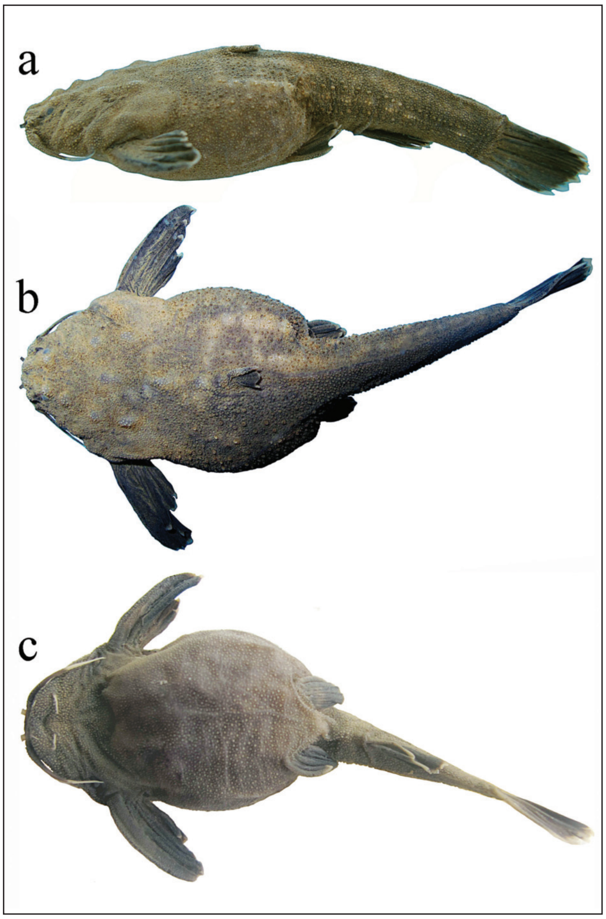

Fig. 1. *Amaralia hypsiura*, 41.0 mm standard length, Rio de las Piedras near Puerto Maldonado, Peruvian Amazonas. **A**. lateral view; **B**. dorsal view; **C**. ventral view. This is the specimen I mistook for a bean seed when it was collected in the Rio de las Piedras. Photo by T. R. Roberts.

Peeling back the abdominal wall of the *Amaralia* specimen from the Rio de las Piedras revealed an oval mass of bright orange yolk 13 mm long and 15 mm wide (Fig. 2). Horizontal hemisection of the mass with a scalpel revealed a uniform or homogeneous composition (with no sign of individual eggs). This presumably is the partially digested remains of a single meal of loricariid eggs.

Twelve specimens 70-200 mm standard length were obtained from aquarium fish traders and maintained alive in my apartment in Iquitos for several weeks in February and March 2010, in the hope of observing them mimicking seeds. They were kept in plastic lined wooden flat boxes 37x37x8 cm in standard use in the Iquitos aquarium trade in three groups of four specimens according to their stated collection localities Rio Itaya, Rio Momon, and Rio Uritiyacu. The following observations were made on behavior of these three lots of *A. hypsiura* which was essentially similar. The Itaya lot included one *Bunocephalus coracoideus.* None of the specimens was observed to change from its catfish form into the seed or bean form reported above.

Immobility: Individually and collectively the fish in each flat would remain in fixed positions on the bottom, isolated from each other, lightly touching each other, or piled up on each other for periods as long as six to 12 hours. Occasionally the three or four fish in each lot would separate widely, sometimes one occupying each corner of the flat. More often they were scattered seemingly randomly or formed a pile. Sudden splashes in the flat would indicate that at least one fish had made a sudden movement, but such occurred at infrequent intervals and were not visually observed. Movement of one or more fish would result invariably in a new immobile configuration of all of them. The *Bunocephalus* often remained immobile for equally long periods.

Piling up: While individual fish often remained by themselves immobile on the bottom of a flat for prolonged periods, as often two, three or four fish would pile up on each other and remain in the same position for periods of six to 12 hours. The piled-up configurations were very diverse, seemingly haphazard, but with substantial fin and body contact among individuals. The *Bunocephalus* often participated in the pile-ups.

Maintenance of upside-down position: When gently overturned and released so that the belly was upwards, individual fish would remain immobile in upside position for periods up to several hours. On one occasion a group of three individuals left to their own devices piled up on top of each other with the uppermost individual upside down (i.e., belly-up), and maintained this position for at least six hours. Otherwise fish left on their own maintained upright positions. When gently turned upside down, the *Bunocephalus* would immediately right itself. It was never observed in an upside-down position.

Thigmotropism: Thigmotropism is when an organism moves, remains stationary, or grows in response to touch or contact stimuli. Most fish are bottom dwellers, and the commonest thigmotropism among them involves contact with the substrate. This probably is true of *A. hypsiura*. In the specimens observed in captivity, this substrate was the plastic lined bottom of a wooden flat. In nature the substrate presumably is often the wood of a tree trunk or branch. Whether *Amaralia* stay inside hollowed out tree trunks, as do some ageneiosid, auchenipterid and loricariid catfishes, apparently is unrecorded. They may also seek contact with dead leaves, especially large broad ones. Catfish thigmotropism may be mediated mainly by the barbels, the ventrally-located paired fins and caudal fin, or by the dorsal and ventral body surfaces as a whole. Many catfishes avoid body contact with other individuals of the same species, but intraspecific body contact thigmotropism is highly developed in *A. hypsiura*, which spend much of the time piled up on each other. In this species the structures most important in thigmotropism or touch behavior appear to be the pectoral and caudal fins and the body surface generally. The barbels apparently are unimportant.

Tail-bending: Individual fish would sometimes remain with the body fully extended for prolonged periods of time, then respond to a light touch of the finger by immediately coiling the tail loosely around the body. *Bunocephalus* can bend the tail, but not nearly so much as *Amaralia*, and they cannot bend it around the body like *Amaralia*. *Amaralia* but not *Bunocephalus* are capable of bending the tail in an S-shape, or of bending the tail so that it nearly doubles around itself and is applied to one or the other side of the head and abdomen. In *A. hypsiura* this may contribute to the ability of a fish to disguise its true shape and enhance its camouflage without resulting in true mimicry. If lightly touched or gently removed from the water and immediately replaced, the response of all twelve *A. hypsiura* was to bend the tail. This had the immediate effect of lessening their overall fishlike outline. Sometimes the outspread pectoral fins were adpressed, which also lessened the fishlike outline. Otherwise the fish remained immobile. In marked contrast was the response of the *Bunocephalus*, which could only bend its tail partially compared to the *Amaralia*, and when gently replaced in the water would dash about madly for several seconds.

Shedding of keratinized epidermis and color change: Periodical shedding of the keratinzed epidermis is characteristic of Aspredinidae (Friel, 1994). Individual *A. hypsiura* fish occasionally shed a thin layer of the epidermis. Unlike in some amphibians and snakes and reportedly in some other aspredinids in which the epidermis is shed as a unit, the shedding observed in my captive aspredinids resulted in numerous small flakes of discarded epidermis. The process occurred at night and apparently required several hours. At the end of the shedding the fish was changed from an overall dark brown or chocolate brown with some underlying darker markings to

Fig. 2. *Amaralia hypsiura*, 41.0 mm, with abdominal wall peeled back to reveal an oval mass of digested yolk. Photo by T. R. Roberts.

Fig. 3. Seeds of *Mucuna* cf. *fawcettii* from the Upper Amazon of Peru. These resemble the specimen in Fig. 1 when it was in seed-mimicking mode. The granular surface of the seeds and the color of some of them as well as their overall shape is closely similar to the tuberculation and coloration of the *Amaralia*. Photo courtesy of P. Mikkelson, SeaBean.com.

nearly black with prominent silvery or pale whitish markings on the top of the head and on the tail. The four fish reportedly collected in the Rio Uritiyacu all had the same black and silvery coloration when first observed, so that initially they looked like they might belong to a different species. Only after a fish from Momon shed its cuticle did it become clear that the specimens from all three rivers were the same species. The Uritiyacu specimens did not attain the more usual brown overall color associated with a mature cuticle during the observation period. No short-term color change was observed in any other of the individual fish.

Sound production: *Bunocephalus coracoideus* is able to make a fairly loud grating or grinding noise, apparently by stridulation of its pectoral fin spines. Sound production was not observed in my captive *Amaralia*.

DISCUSSION

Given the lack of photographic evidence, this report of seed mimicry may be met with scepticism. Nevertheless, I prefer to report the phenomenon as it was observed and interpreted by me, with the expectation that this unusual and possibly unique behaviour of *Amaralia* will be fully confirmed and more adequately documented by future investigations, which are more likely to occur if the facts are recorded.

My observations on captive specimens in Iquitos suggest that the usual cryptic behavior of *Amaralia* involves camouflage so that it resembles a background of dead wood. Well known ichthyological examples of camouflage are provided by flatfishes, coloration of the dorsal surfaces of many of which changes to blend with differently colored substrates on which they stay. The deceptive coloration of flatfishes is effective partly due to their extremely flattened morphology and the behavior common to many species of burying themselves in the substrate. Fishes with cryptic resemblances to plants or plant parts are well known (Breder 1946; Randall & Randall 1960: Randall 2005). Objects likely to provide the background for the camouflage of *A. hypsiura* are tree trunks or branches and large broad dead leaves.

Judging from these limited observations on *Amaralia*, camouflage may be a precondition, preadaptation or intermediate stage for evolution of more advanced forms of mimicry, such as leaf mimicry and seed mimicry. From this perspective it seems that many if not all resemblances of neotropical catfishes to wood or leaves should be considered as examples of camouflage rather than mimicry. There do not seem to be any catfish equivalents of the various groups of twig- and branch-mimicking insects that evidently have evolved through a stage of camouflage to one of genuine mimicry. Camouflage usually is possible only in the presence of the appropriate background. In mimicry the object resembled need not be present. Instances of camouflage in fishes evidently greatly outnumber those of mimicry. Mimicry of a seed by a fish is perhaps very unusual.

The primary importance of camouflage and mimicry in *Amaralia* may be to hide them from potential predators. The ability to hide may also contribute to their success as predators on the eggs of egg-brooding loricariids. Observations in support of either hypothesis are presently unavailable. Observations of stomach contents of *A. hypsiura* in museum collections indicate that they may feed almost exclusively on the eggs of loricariids (Friel 1994: 59, 197, fig. 43). It has not been determined whether the eggs are those of the buccal egg guarding Loricariinae, of the substrate laying Hypostominae, or of both kinds. If the seed mimicry of *Amaralia* permits it to deceive the loricariids on the eggs of which it preys, then it represents an instance of aggressive mimicry. Predators of *Amaralia* have not been identified but it seems likely that the seed mimicry of *Amaralia.* also is defensive.

Seed mimicry of *Amaralia* evidently is facultative, in that the fish apparently can change rapidly from a fish-like shape to a seed-like shape and back again. This statement is qualified because although the rapid change from seed-like to fish-like was observed, the change from fish-shape to seed-shape was not.

Immobility itself can serve to hide an organism from a potential predator or prey. In *Amaralia* it may also be associated with a relatively low metabolic activity and prolonged fasting, with intermittent periods of activity, especially when taking food. Inactivity and fasting may be preadaptive for the evolution of camouflage and mimicry in many other fishes as well. Loss of the alarm cells and fright reaction (Friel, 1994: 59) might be another characteristic of Aspredinidae related to their immobility and supposed reduced metabolic activity. Loss of sound production, otherwise widespread in Aspredinidae, might also be related to the excessive immobility and advanced hiding behavior of *Amaralia*.

Although the Amazonian leaffish *Monocirrhus polyacanthus* mimics leaves and not seeds, a brief comparison of the behavioral and other attributes contributing to its mimicry with those of *Amaralia* is instructive. I observed several hundred *Monocirrhus* maintained in a large aquarium in Iquitos in February 2010. The most obvious similarity in behavior is immobility. In *Amaralia* this is achieved while the fish are resting on the substrate, while in *Monocirrhus* it occurs while the fish are suspended in the water or with only their median chin barbel (resembling a leaf-stem) barely touching the bottom. While in *Amaralia* the orientation of the body is extremely variable but nearly always horizontal or nearly so, the leaf fish orient uniformly with the body at an angle of about 60% with the head downwards. Hundreds of fish similarly oriented at once is a striking sight. Such large aggregations, however, probably do not occur under natural conditions. *Monocirrhus* are able to remain quite stationary in mid water without any evident swimming movements. While *Amaralia hypsiura* actively seeks contact with conspecifics, *M. polyacanthus* avoids contact. The mimicry of *Monocirrhus* is obligatory, rather than facultative: it cannot change its leaf-like shape into any other shape. Since it is a percomorph rather than an ostariophysan, *Monocirrhus* – like *Amaralia* – does not have alarm cells or fright reaction.

Another noteworthy character of *Monocirrhus* relevant to the present discussion is remarkable variation in overall coloration of the entire head, body and fins. These may be uniformly rich brown, reddish brown, gray, beige, or even yellow (never green), like the changing shades of dead leaves. Part of this variation may be due to individual ability to change color, but it might also have a genetic basis, therefore representing color polymorphism. *Amaralia* also varies considerably in color, depending at least partially on how recently it has molted, although it does not exhibit the range of hues present in *Monocirrhus*

It is opportune to report here an instance of leaf mimicry in fishes that might otherwise remain unpublished. The following observations on mimicry of a dead leaf by an anabantoid of the genus *Ctenopoma* were reported to me verbally by a Ghanaian limnologist many years ago whose name I regretfully cannot recall. The fish, possibly *C. kingsleyae*, was observed in a mangrove area of the Abi lagoon in southwest Ghana near the border with Ivory Coast. It was floating on the surface on its side, with the uppermost side partially out of the water and dried, resembling a dead fish or a floating leaf. At first it appeared to be immobile and floating passively, but it then made slight swimming movements so that it came to rest against the leafy branch of a mangrove tree. At this point a number of ants walked from the branch and leaves onto the exposed surface of the fish and started feeding on the dried mucus. The fish then swam slowly away from the branch, suddenly righted itself in the water, and ate the ants which had been dislodged.

Death feigning is a common form of mimicry in many vertebrates including humans, and can be aggressive or protective mimicry. It is not so well known among fishes, but probably more widespread than reported. Tiago Carvalho advised me he has observed *Amaralia* engage in apparent death feigning (pers. commun., 30 Jan 2015). This agrees well with my observations on captive *Amaralia* reported above, particularly about individuals remaining immobile for many hours while lying upside down. This could be either aggressive or protective death feigning in Amaralia. A classical example of aggressive death feigning in fishes is that of the predatory Malawi cichlid *Haplochromis livingstonii* reported by McKaye (1981).

Leaf mimicry apparently has not been reported previously in any anabantoid fish. This is surprising, since the shape and coloration of *Ctenopoma acutirostre* and *C. oxyrhynchus* (both endemic to the Congo basin) are nearly as leaf-like as those of *Monocirrhus polyacanthus* and much more leaf-like than in *C. kingsleyae* or any other West African species. No example of camouflage or plant mimicry is known among the numerous Amazonian species of the percomorph fish family Cichlidae. None of them resembles a dead leaf like *Monocirrhus polyacanthus*, and none have young that are green in color like the green color phase of the small darterlike crenuchid *Ammocryptocharax elegans*. I observed green young of a cichlid *Etroplus* sp. dwelling amidst green sea weed on reef flats in Sri Lanka in 1970. Several of the colorful endemic cichlids of the spring-fed clear-water Rivière Fwa in SE Congo have bright green young that hide in large masses of large aquatic green plants (mostly *Vallisneria aethiopica)* (Roberts & Kullander 1994). It is surprising that young neotropical cichlids are unknown to exhibit similar green cryptic coloration for hiding in the midst of green plants. Initially I hypothesized that *Amaralia* was mimicking the seeds of a particular species of plant, presumably of the family Leguminosae or Fabaceae. A survey of websites and literature on seeds in the STRI Library in Panama did not reveal any exactly similar seeds, but those of the *Mucuna fawcettii* Urban 1908 are reasonably close (Fig. 3). This bat-pollinated bush of the family Fabaceae is widely distributed in the Amazon basin. I am now inclined to consider the alternative hypothesis for *Amaralia* of generical mimicry, i.e. mimicry of a general type of bean seeds, averaging the characteristics of a variety of seeds without precisely matching any of them. In this way *Amaralia* could effectively mimic bean seeds in areas where a particular species of bean does not occur.

Finally, Flávio Lima has communicated to me that a large *Bunocephalus verrucosus* he observed and collected in an igapó forest tributary of Lago Amanã in the middle. Solimões basin in March 2003 looked strikingly like the pit of a drupe or a peachstone. He is going to prepare an account of it, and suggests that mimicry of plant seeds might occur in additional Aspredinidae.

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