ON THE ECOLOGY, BIONOMICS AND SYSTEMATICS OF THE BLENNIID FISHES OF THE GENUS *ANDAMIA* BLYTH.

(Plates VIII-X.)

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I.—Ecology and Bionomics.

By H. Srinivasa Rao.

Contents.

Introduction.

In a study of the Andaman fluviatile fish-fauna published some years ago Annandale and Hora[1] (1925) remarked that this fauna was derived mainly from adaptable marine species in recent times. While working along the coasts of the Andaman Islands in connection with the *Trochus* fishery investigation, the common occurrence of an abundant population of the Blenniid fish, *Andamia heteroptera,* only on the rocks subject to the pounding action of the breakers and nowhere else reminded me of the remarks of these authors, and induced me to record my observations on these animals not only in the field but also in aquaria in the Laboratory. As Mukerji[2] (1933), who had previously made some observations on the fish of the Andamans and published some notes on them, was keenly interested in the problem of the origin of the freshwater fauna of the Andamans, I gladly placed my collections of fish and my notes on them in his hands for study. Unfortunately, owing to his untimely and lamented death last year, the notes and the materials remained untouched. The Blenniid fishes of the genus *Andamia* collected in the Andamans have since been studied by my colleague, Dr. Hora, and his conclusions on the systematic position of the species known from the Andamans are published in the second part (*infra,* pp. 393-400). In view of the scanty observations on the habits of *Andamia,* which is so widely

[1] Annandale, N. and Hora, S. L., *Rec. Ind. Mus.* XXVII, pp. 33-41, pl. ii (1925).
[2] Mukerji, D. D., *Rec. Ind. Mus.* XXXV, pp. 121-123 (1933).

distributed in the Indo-Pacific region, Dr. Hora urged me to publish my field notes on the species observed. My thanks are due to him for this encouragement which has enabled me to bring together my scattered notes on the subject in the form of a more or less connected account.

My observations on the rock-skippers of the Andamans inclined me to the view that, sexual dimorphism apart, there were at least two distinct species within the limits of Port Blair where, mainly, observations were made. The re-examination by Dr. Hora of the material collected by me and my predecessors in charge of the *Trochus* fishery has convinced him that my surmise was correct, and in the following article he has fully described *A. heteroptera* and what, in our opinion, constitutes a hitherto undescribed species of *Andamia*.

Andamia heteroptera and *Andamia raoi* have been observed in the vicinity of Port Blair, and in Rutland I., Cinque Is., and at Port Bonington in North Andaman. My observations in the field are based mainly on the fish occurring on the rocks and piers around Ross I., and on the rocky coasts near North Point, South Point, South Corbyn's Cove (Plate VIII), and Brookesabad, all within the jurisdiction of the Port Blair settlement. The rocky shores at these places are subject to the direct action of breakers. The rocks which are found between tide-marks are uncovered by the sea at low tides, but are kept moist by a more or less constant spray from the dashing waves. The fish obtained from the coasts of Ross I., were also kept under observation in large bell-jars of sea-water in the Laboratory, and were experimented upon variously. The results of these observations and experiments are detailed in these notes.

HABITATS OF *ANDAMIA*.

The general nature of the environment in which *Andamia heteroptera* and *Andamia raoi* live does not, at first sight, appear to differ very much, but the latter species seems to prefer situations exposed to the breakers which strike with full force on the vertical face of the rocks. Under laboratory conditions *A. raoi* appears to be more active than *A. heteroptera*, more particularly the males which frequently dive to the bottom of the jar where they stay for several minutes attached to the stone and often feed on the algae growing on it. *A. heteroptera* is much less active, and rarely stays under water for long periods, but its young ones are as active as those of *A. raoi* and behave in the same way in the aquarium. It would thus appear to be far more terrestrial than *A. raoi*, and the divergence from the aquatic habitat of the closely allied species of the genus *Salarias* appears to have gone on much further in *A. heteroptera* than in *A. raoi*. It lives in groups of not less than 4 or 5, often in larger groups of 10 or more, in the fissures, crevices and pits of large massive rocks facing the surf, or on isolated rocks swept by every wave or constantly covered by the spray of dashing waves. It is found in still larger numbers on the vertical sides of deep gullies (formed by cleavages in rocks) which are within reach of the swell from the sea which rises and falls rhythmically every few seconds. Environments like those described above are common on the shores near Port Blair (Plate X, figs. 5 and 7), Port Bonington, and Cinque Is. On the Rutland I.,

however, the environment is somewhat different. At the time of my landing on the west coast of this island at 5 P.M., the tide was rising on the sandy beach. Between the beach and the jungle close by were several isolated rocks which were kept moist by the gentle rush of the ripples. On these rocks were found several young specimens of *A. heteroptera.* At low tide the following day, the inter-tidal region, which is a sandy stretch of several hundred yards in width with no rocks jutting above the sand, was without a trace of these rock-skippers. When the tide is low, the fish seem to live in crannies and pits in the rocks where, presumably, collections of sea-water are left by the previous high tide. It is probable that they lie quietly in these crevices where the moisture is sufficient to keep them alive, and come out on the surface of the rocks with the next high tide. I was, however, unable to discover any of these small fish at low tide either on or at the base of the rocks. Although cracks in the rocks were evident, I could not find the hiding places of the fish. It is not likely that the fish keep moving with the tides, as at low tide there are no rocks jutting out of the water on which they could skip about ; and experiments with *A. heteroptera* in the Laboratory show that they cannot live immersed in water for more than a few hours at a stretch.

On the western side of Ross I. there are no rocks, isolated or massive, but there is a wall of granite slabs against which the wharf and the pier rest. On this wall *A. heteroptera* occurs in fairly large numbers. When the tide is high and the wall is bathed by spray from the waves, the fish skip about on the granite slabs, resting always a few inches to 3 feet, above the water-level. When the tide is low, and the wall is not covered by a column of water, the fish seem to hide themselves in the crevices between the slabs which contain sufficient moisture to keep the fish alive till the next rise of the tide. This device of concealing themselves in fissures and crevices observed on the west coast of Rutland and Ross Is. seems to be adopted by the fish as the inter-tidal region does not provide an environment suitable for their active life when the tide is low. Their behaviour on the rocky coasts and in open bays studded with isolated rocks or massive dead corals is different. A dozen or more of the fish occupy the surface of the rocks or corals, and when disturbed they dodge cleverly from the seaward face of the rocks to the landward and *vice versa.* But when continually disturbed and cornered they skim the surface of water or swim through water to a distant rock more than a yard or so away. If the distance from one rock to another is less than a yard they jump directly from the surface of one rock to that of the other employing the tail to propel themselves in the air, and thus avoid getting into the water. As far as my observations go, these fish never seem to jump deliberately into the water, or swim, or seek food under water in their natural surroundings. When a wave suddenly strikes the rocks on which they live, the fish stick firmly to the rock-surface by means of the labial sucker and the pectoral fins which are fully spread out in the form of an open fan (Plate IX, figs. 3-5). If they are on the vertical face of a rock the head is directed upwards when sticking to it. When the sea water has completely streamed down the sides of the rock, the fish begin to move about, and continue as usual to keep well within the

area constantly kept moist by the spray. On the vertical walls of deep gulleys into which the sea water rushes in and out with every rise and fall of the wave, the fish are found in much larger numbers, often more than a hundred or so, quietly sticking to the surface of the walls and moving slowly up and down with every rise and fall of the level of sea water. When disturbed they jump into the water and swim to a more distant part of the rock-surface or skip off from one face of the gulley to the other on the opposite side. The behaviour of the fish is very similar to that of the mud-skippers, *Periophthalmus* and *Periophthalmodon.*

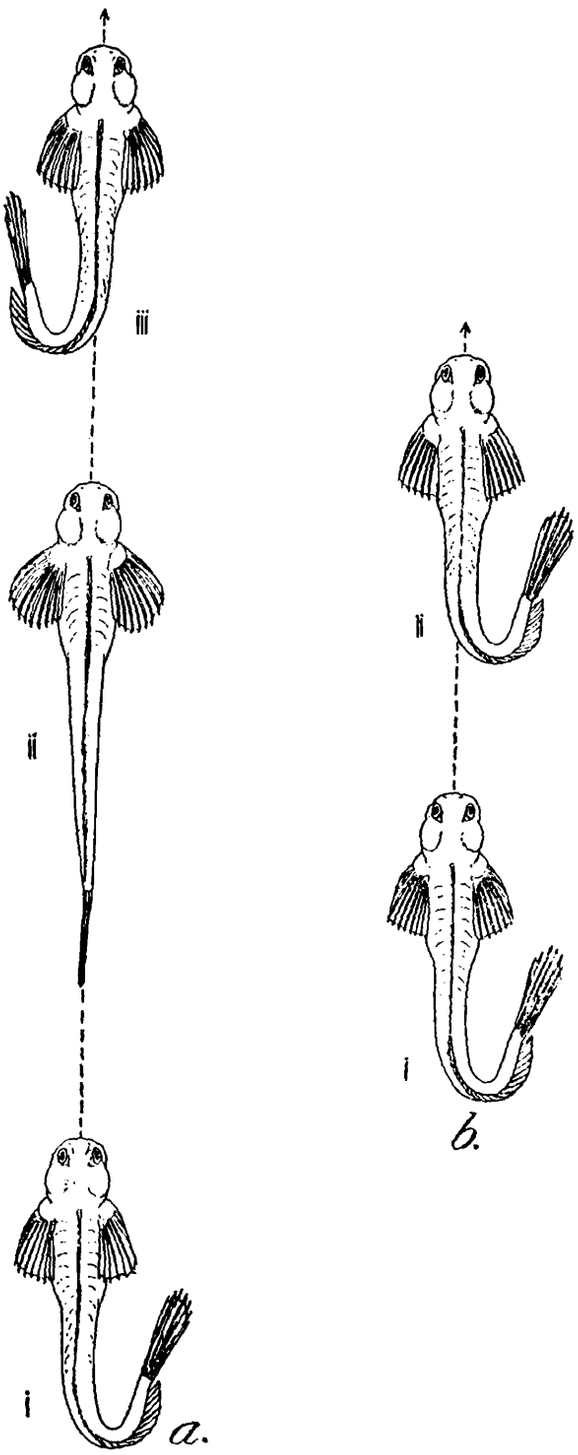
LOCOMOTION.

The locomotion of *Andamia* is of various types according to the circumstances in the environment in which they find themselves. Their active movements such as skipping, skimming the surface of water, or swimming, when disturbed by waves, by the rise of the tide, or by human beings have been referred to above. In the absence of disturbances their movements are quite different. They often adopt a shuffling gait which curiously resembles that of some of the larger reptiles or mammals. In this movement the whole of the tail takes part, and enables the fish to move either from side to side or forward. Forward progression may be effected by the flexure of the tail either on one side only (text-fig. 1*b*), or on both the sides alternately (text-fig. 1*a*), but this flexure does not involve any zig-zag movement on the part of the fish, that is to say, the new positions reached in this kind of progression are nearly always in a straight line in front of them. The pectoral and ventral fins and the ventral sucker probably assist the fish in holding on to the new positions attained, but they seem to come into full action when there is a rush of water from the sea washing the rocks or a strong surf breaking on them. This must result in dislodging them from their positions were it not for the powerful action of the fins and sucker as adhesive organs. These probably also serve as a leverage for the body of the fish in the act of skipping from place to place. Annandale and Hora (*loc. cit.*) rightly believed that the structure of the fish as a whole is modified as in hill-stream fishes to resist the swift and violent movements of water.

FEEDING HABITS.

The mode of feeding in *Andamia heteroptera* and *Andamia raoi* is of some interest. The rocks on which they live are usually covered with growths of algae. When the fish applies the mouth to the surface of the rock, it appears to expand the fleshy lips to their fullest extent so as to permit the rows of very fine golden yellow teeth in each jaw to come into contact with the algal growth. It raises its head, when the opposing rows of teeth come together holding between them a small quantity of algae which is taken into the mouth. The head is thus repeatedly moved up and down as the fish moves along on the surface of the rock. The curious movements of the head of the fish in the act of feeding suggest those associated with cattle grazing on a meadow and moving

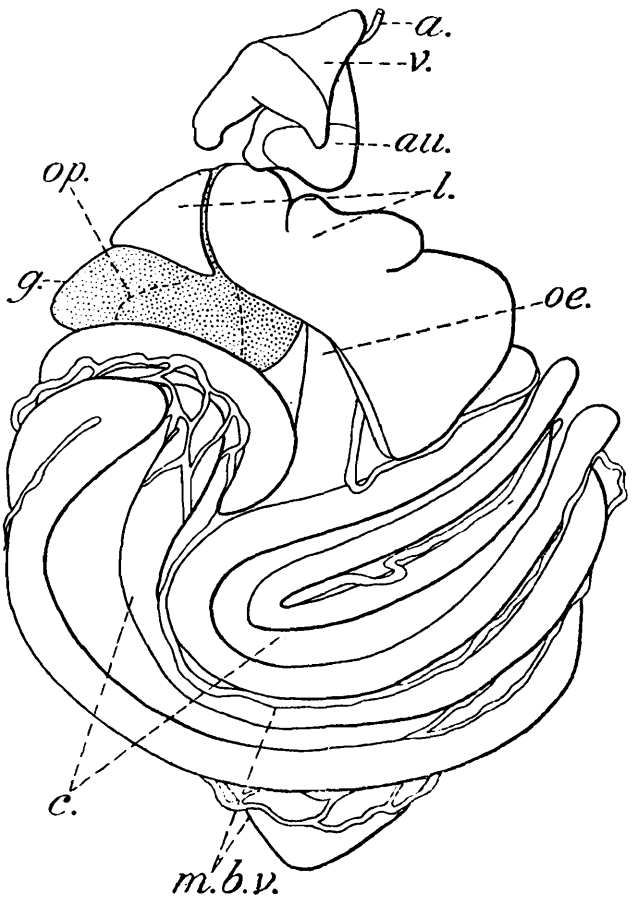
slowly along pulling wisps of grass. Another voluntary movement of these fish is also of considerable interest. While the fish are resting on



Text-fig. 1.—Sketches to show the positions assumed by *Andamia* in forward progression on rocks washed by the spray or waves from the sea. *a* (i to iii). Progression by flexure of the tail on the right and on the left alternately; *b* (i and ii). Progression by flexure of the tail on one side only.

the rocks they occasionally hold firmly the rock-surface by the tail, and roll the anterior part of the body from side to side so that the sides of the head come into close contact with the rock. This rolling movement is repeated twice or thrice in quick succession before the position of rest

is resumed. This action has again a curious resemblance to the act of scratching which one observes in mammals, and probably represents a process of cleaning or of scratching.



TEXT-FIG. 2.—View of the viscera of *Andamia heteroptera* (Bleeker) *in situ* dissected from the ventral surface. (Diagrammatic).

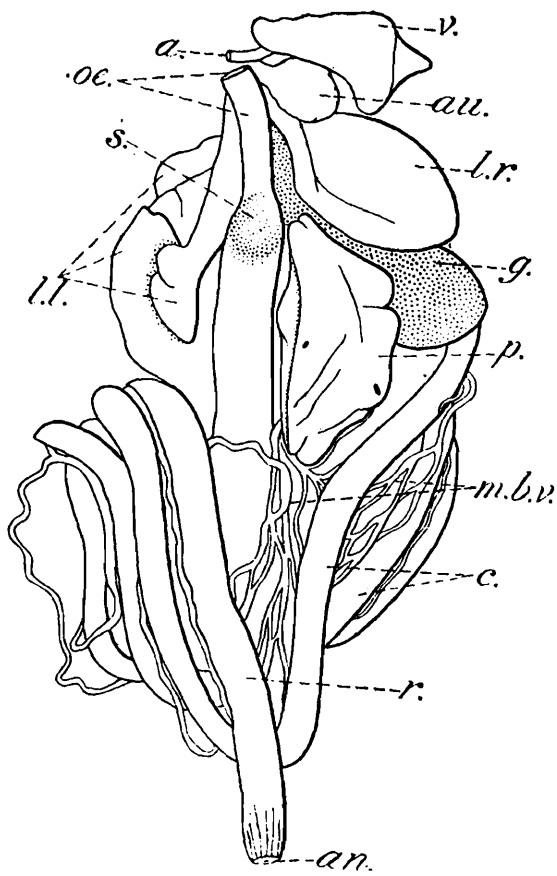
a. aorta ; *au.* auricle ; *c.* coils of the intestine ; *g.* gall-bladder ; *l.* lobes of the liver, *m.b.v.* mesenterial blood-vessels ; *oe.* oesophagus ; *op.* outline of pancreas seen through the transparent wall of gall-bladder ; *v.* ventricle.

The fish, which should be classed as a scraper, seems to feed mainly on minute algae, but microscopic animals which are found in association with the algae are also taken in while feeding. Thus among the gut-contents of several fish examined were found filamentous or lamellar algae of green, brown or pink colour, minute particles of sand, tests of Foraminifera, spicules of sponges, small Gastropod shells, small Crustacea, and worms.

While dealing with the feeding habits of the fish it will be appropriate to mention some features of the visceral organs which I have been able to observe by dissection of the freshly captured fish. The relationship of the various organs forming part of the viscera is shown in text-figures 2-5. As in all vegetable-feeding vertebrates the intestine is very long, about 3 times the body-length of the fish, and forms a complicated coil overlying the oesophagus and the rectum.[1] The heart and the aorta

[1] Ishida, J. (*Annot. Zool. Japon.* XV, pp. 158-160, 1935) records the occurrence of a band of ciliated epithelium lining a part of the intestine of the Blenniid fish, *Salarias enosimae* of Japan. The function of the ciliated part is not known. I have not been able to study the histology of *Andamia* to institute a comparison with this author's observations.

are seen immediately in front of the lobes of the brownish liver, while there are much-branched mesenterial blood-vessels lying on and between the coils of the intestine. The gall-bladder, which is a transparent green conical sac, lies concealed by the lobes of the liver and the coils of the intestine. The pancreas is a reddish body lying concealed below the gall-bladder. The stomach is a small rounded dilatation of the oesophageal part and is not seen when the fish is dissected from the ventral



Text-fig. 3.—View of the viscera of *Andamia heteroptera* (Bleeker) as seen when dist sected from the dorsal surface. (Diagrammatic).

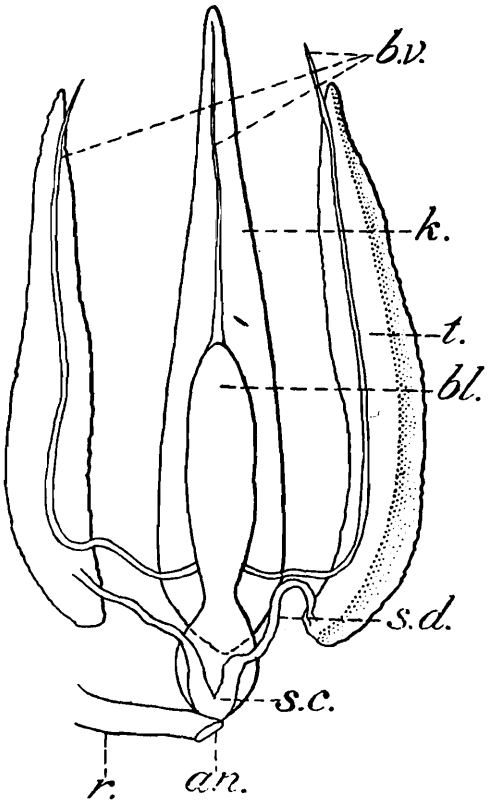
a. aorta ; *an.* anus ; *au.* auricle ; *c.* coils of the intestine ; *g.* gall-bladder ; *l. l.* left lobe of the liver ; *l.r.* right lobe of liver ; *m.b.v.* mesenterial blood vessels ; *oe.* oesophagus ; *p.* pancreas ; *r.* rectum ; *s.* stomach ; *v.* ventricle.

surface. The kidney and the gonads are lanceolate bodies lying closely packed near the vertebral column at the lower end of the peritoneal cavity. The gonoducts and the ureters are adherent to each other and to the bladder and seem to open into a small common chamber which opens into the rectum very near the anal opening. In the gravid female the ova bulge out from within on the surface of the ovary. The kidney, gonads and bladder are well supplied with blood-vessels.

Longevity, and Habits under Laboratory Conditions.

The behaviour of the rock-skippers when kept in ordinary bell-jars full of sea water was studied in the laboratory. As there were no supports for them to perch on they all repeatedly tried to adhere to the smooth, curved surface of the jar, but nearly all of them slipped

down and dropped into the water in which they swam and came back to the sides. It seemed at first that the fish congregated on the lighted

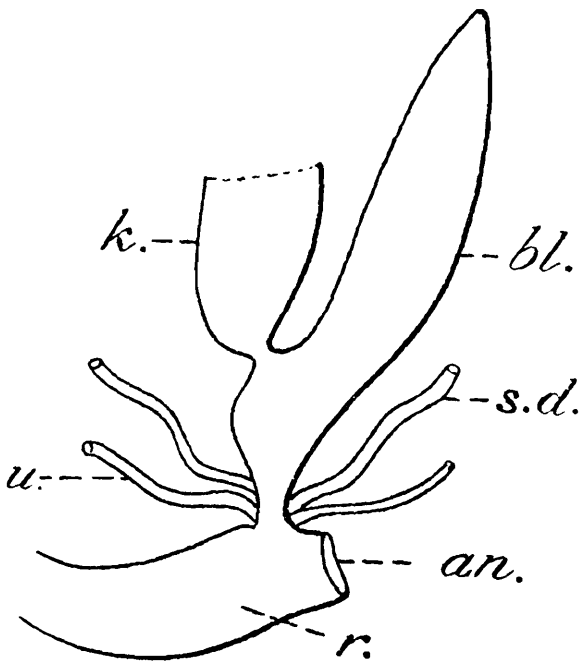


TEXT-FIG. 4.—The urino-genital system of the male *Andamia heteroptera* (Bleeker) as seen when dissected from the dorsal surface. (Diagrammatic).

an. anus ; *bl.* bladder ; *b.v.* blood-vessels ; *k.* kidney ; *r.* rectum ; *s.c.* common chamber into which spermduct and ureters open ; *s.d.* spermduct ; *t.* testes.

side of the aquarium, but on hanging a piece of wet cheese-cloth on the darker side all the fish jumped on to the cloth which presented a rough surface facilitating adhesion by means of their pectoral fin and the labial sucker. The action of the pectoral fin and the sucker when the fish were trying to stick to the glass surface was more pronounced than when the fish were perched on the cheese-cloth. The cloth was removed and small pieces of wood about 2″-3″ square were floated on the water, and small masses of algae scraped from rocks were placed on them and at the bottom of the jar. The fish promptly jumped on to the floating pieces of wood and settled in such a way that the water was just touching the anterior end of the body. They began to suck in the water by the mouth and let it out by the gill-aperture. When the cheese-cloth was hung on the sides again many of them left their positions on the wood and jumped on to the cloth. After a while they wriggled slowly and reversed their position on the cloth so that the head was again touching the surface of water. One or two of them occasionally dived to the bottom of the aquarium and nibbled at the algae. When the fish were not near the surface of water they usually lifted their head and kept it at an angle to the rest of the body. In that position the opercular chamber ceased its rhythmic pulsating movements and was bulged with air, and the fish remained quiet for several hours. In aquaria with a large mass of coral covered with algae kept in the centre with a portion

projecting above the water, the fish usually preferred to sit on the coral mass at the edge of the water, but a few occasionally jumped into the



Text-fig. 5.—The terminal portion of the rectum of the male *Andamia heteroptera* (Bleeker) showing the relationship of the various parts of the urinogenital system to one another and to the rectum. (Diagrammatic). The structures are shown slightly displaced to one side.

an. anus; *bl.* bladder; *k.* kidney; *r.* rectum; *s.d.* spermduct; *u.* ureter.

water and swam to the sides of the jar apparently in an attempt to escape from confinement, where they stuck to the glass sides by their labial sucker and pectoral fins. When exhausted by the effort of sticking to the glass they returned to the coral mass again. Some occasionally scraped the algal growth on the coral. Under the temperature and atmospheric conditions in the laboratory, the fish did not seem to live for more than a month. What the longevity of these fish is in their natural environment on the rocks washed by the spray and waves is not known. In May 1932 twenty-four large and small fish were kept in bell-jars full of sea-water and provided with an abundant supply of algae growing on pieces of coral mass, and the sea-water was changed daily. The bell-jars were placed near open windows where plenty of light and air was available. Within a fortnight they all looked famished and thin, and one by one began to die until the last survivor was found dead exactly a month later. This experiment of keeping the rock-skippers in aquaria in the laboratory was continued till the first week of August 1932, and as a rule, all the fish died within three weeks to a month.

Effect of Desiccation.

The observation of Mukerji (*op. cit.*) that *Andamia heteroptera* bask in the sun on the rocks on which they live led me to try the effect of desiccation. A fairly large specimen was kept in a dry bell-jar at 11 A.M. The fish stuck to the sides for several minutes with the opercular chamber

pulsating fairly quickly. After 3 hours the mucus on the head of the fish had dried up, and the fish slowly began to relax its hold on the sides until it dropped down to the bottom of the jar. It was gently removed to a petri-dish where it showed signs of feeble movement of the tail and the body. On placing a few drops of sea-water on the head and body, the opercular chamber began to pulsate again, but after a few minutes the fish showed signs of collapse. Immersion of the fish in a jar of fresh sea-water failed to revive it, and death ensued at 2·30 P.M., that is, after $3\frac{1}{2}$ hours of the commencement of the experiment. Probably, the process of desiccation within that period had gone on so far that recovery to normal conditions was impossible. Whatever the purpose of the basking habit observed by Mukerji, basking cannot be prolonged too long, for moisture seems to be an essential condition for all air-breathing species of fishes.

The minute ridges and grooves which form a meandrine pattern on the head, operculum, and parts of the body of *Andamia* are a characteristic feature, and it seems to me that these grooves serve to hold moisture for a much longer period than if the skin were smooth (Pl. IX, fig. 6, Pl. X, fig. 6). For fish living always outside water in the inter-tidal region, it would be a disadvantage to have a smooth skin over which the water will flow down and leave it dry in a much shorter time. These grooves and ridges are best seen, in fact, in preserved fish when the skin has been allowed to dry. The nature of these grooves in *A. heteroptera* and *A. raoi* seems also to differ. In the former species the ridges are thick and the grooves narrow, whereas in the latter the ridges are thin and the grooves broad. The skin of *A. heteroptera* seems, therefore, better fitted for holding water for a longer period, and this condition should be regarded as an advanced stage in adaptation for terrestrial life. Curiously enough, the grooves and ridges which are so characteristic of *Andamia* are absent in the closely allied Blenniid fish *Salarias* which nearly always lives in pools of sea-water.

The much-branched superficial blood-vessels forming a kind of plexus on each side of the operculum, which may be seen on the surface even in preserved specimens, suggest the possibility of a certain amount of skin respiration as well. As interchange of gases can take place only in the presence of moisture, the retention of water in the grooves would serve to maintain a certain degree of moisture on the skin of the head and operculum and assist in the process of respiration.

AERIAL AND AQUATIC RESPIRATION.

A series of simple experiments was conducted to observe the behaviour of the fish when confined in small or large quantities of sea-water in closed jars, then in open jars, and when prevented from coming up to the surface of the water. Six specimens of rock-skippers, three large and three small, were confined in a closed jar (7 lb. capacity) of sea-water. The three small ones died in one and a half hours, one large fish in three hours and 40 minutes, the second in five hours and ten minutes, and the third in five hours and fifty minutes. A specimen of *Andamia heteroptera* was kept in a large jar (7 lb. capacity) full of sea-water and the mouth of the jar was closed with a piece of mosquito-netting. This jar

was lowered into a plunger jar (18″ high and in 18″ diameter) containing sea-water which was changed every day. The fish which had gone down to the bottom of the jar did not make any attempt to come up to the netting, but remained at the bottom vigorously taking in water through the mouth and letting it out through the opercular opening. In the afternoon the fish was observed to come up to the net and attach itself by the pectoral fins and the ventral sucker. In this position it remained till late in the evening when it descended to the bottom again. On the following morning, however, the fish was found dead. In a similar experiment with three examples of fish the following were observed : The fish made several excursions from the bottom of the jar to the netting and descended to the bottom immediately, finding exit impossible. One of them, after several attempts, seemed exhausted and dropped down passively to the bottom of the jar. In all of them the movements of the operculum in the act of drawing water through the mouth and opercular chamber were unusually rapid. After seven hours of confinement in the jar the fish were removed to an open jar containing sea-water and a large piece of coral was placed in the centre with a portion projecting out of the water. The movements of the operculum had then become less rapid and finally ceased, but occasional reversion to the habit of pulsating the opercular chamber was observed in some of them. After some time the fish found convenient positions of rest on the coral mass, and the opercular movements were no longer observed. The same fish were confined in a jar on the following day. The rapid opercular movements were renewed, and after a lapse of $8\frac{1}{2}$ hours two fish died, while the third one died in the course of the night. It seems to me that in the circumstances detailed above the fish can tolerate atmospheric air normally dissolved in sea-water only for a short time, probably not exceeding 24 hours. As to what would be the behaviour of the fish if the water inside the 7 lb. jar were kept well aerated can only be conjectured. Presumably it would be similar to that observed by Hora (1935, p. 9) in the case of *Periophthalmodon schlosseri* (Pallas). The intake of atmospheric air through the medium of a moist skin and the inner vascular lining of the mouth and the pharynx does not involve any physical exertion like that observed in fish confined under water, and the aerial mode of respiration being physiologically the more advantageous, owing to the richness of oxygen in air, seems to have been adopted. In their natural habitat, atmospheric air is, therefore, another essential condition of life for these rock-skipping fish in addition to moisture that has already been mentioned.

The simple experiments of Ghosh[1] (1934) on the asphyxiation of various air-breathing fishes of Bengal show that the prevention of access to free atmospheric air was not the actual cause of the death of the fish, but the insufficiency of the volume of water containing an optimum quantity of dissolved air. Those that have retained the aquatic mode of respiration to a considerable extent survived in his experiments, although they had at the same time become adapted for aerial respiration by the development of accessory respiratory organs which enable them to live out of water for considerable periods. Fishes of the genus

[1] Ghosh, E., *Journ. As. Soc. Bengal*, (N. S.) XXIX, pp. 327-332, 1933 (1934).

Andamia, being almost terrestrial in their habits, are fully adapted for aerial respiration in the presence of moisture, but under adverse conditions can remain alive for short periods through aquatic respiration, as detailed in the above experiments. In the latter case the organs of aerial respiration presumably subserve aquatic respiration also. The spaciousness of the opercular chamber and the extraordinarily well-developed discrete gill-lamellae and pseudobranch appear to be factors concerned in this increased capacity for aerial respiration. A comparative morphological study of the opercular chamber and its structures in the Blenniid fishes would probably explain the considerable differences in the modes of respiration in different species which live in slightly varying habitats on the rocky coasts of the Indo-Pacific seas.

Hora's[1] (1935) observations support Ghosh's conclusions, but Das[2] (1937) seems to think that deprivation of the free atmospheric air is the primary cause of asphyxiation. In this connection Howell's[3] observations (1915) on the Ophicephalid fishes in the Punjab are of great interest. He has shown that the *Murral* need not come to the surface of the water to take in air if the temperature of the water remains sufficiently cold, for it is well known that water areas are saturated with air when exposed to the atmosphere and the degree of absorption varies inversely with temperature.

The buccal cavity, gill chambers, and gills in the marine and estuarine air-breathing Gobioid fishes of the genera *Apocryptes*, *Pseudapocryptes*, *Taenioides*, *Periophthalmus* and *Periophthalmodon*, and in the Blenniid fish *Andamia* act as organs of aerial respiration. Hora (*loc. cit.*, 1935) thinks that the air-breathing habit in these fish has been induced not because of the lack of oxygen in the inshore waters but by the action of the tides. The closely allied Blenniid fishes of the genus *Salarias* of which a number of species occurs on the coasts of the Andamans, seem to be in a state of transition between the aquatic and aerial modes of respiration. On the same rocks on which *A. heteroptera* live, species of *Salarias* are found in small pits on the vertical face of the rocks, in large rock-pools in which the range of temperature is between 30° C. to 33°C. in the months of March and April, and in sandy pools between coral rocks from which they never seem to come out to the exposed surface of rock masses on the shore. So, among species of *Salarias* there are those which never leave the water and consequently have aquatic respiration, and others which, although they come out of water and live in crannies, crevices and pits constantly bathed by spray from the sea, are still to be classed among fishes having aquatic respiration. The difference between these species and *Andamia*, if any, in the mode of respiration, can only be a matter of degree. No experiments have been made with these species of *Salarias*, but presumably they will suffer no ill-effects under water as do species of *Andamia*, provided it is well aerated. The fishes of the latter genus seem to have developed to a higher stage in the evolution of the air-breathing habit, and their capacity to tolerate insufficiently aerated water is distinctly inferior to that

[1] Hora, S. L., *Trans. Nat. Inst. Sci. India* I, p. 13, pl. i (1935).
[2] Das, B. K., *XIIth Congr. Internat. Zool.* II, pp. 888, 889 (1937).
[3] Howell, G. C. L, *Journ. Bombay Nat. Hist. Soc.* XXIV, pp. 195, 196 (1915).

of *Salarias*. The members of the Blenniidae are generally inhabitants of rock-pools or sandy pools in the intertidal region. The increasing deficiency of dissolved air in these pools, especially at the high temperatures which prevail during the low-tide periods, must have been a powerful factor in inducing some species to leave their stable environment in the pools for the unstable but better aerated conditions of the spray and surf which beat the rocks on the coasts. The two species of *Andamia* and one or two species of *Salarias* appear to be the few Blenniids which have left their original environment in the inter-tidal pools. In the reference cited Hora (1935) has, I believe, rightly surmised " that the conditions in the rock pools may, however, necessitate aerial respiration at times as is the case with torrential fishes"

The curious habit of *Andamia* lying passively in groups on rocks with the opercular chamber bulging out prominently on the sides suggested to me the possibility of atmospheric air being confined in the chamber and used up by the fish when they are not active at all and make no movements of the operculum such as are observed when they are confined in water. Two examples of fish freshly obtained from the rocks on Ross I. were brought to the laboratory, and with a sharp, sterilised mounted needle a tiny hole was made through the opercula on both sides of the fish. A large bell-jar with fresh sea-water was set up on a bench in the open air under the shade of a tree. Small masses of coral with growths of algae on them were heaped in the centre of the jar so that a portion of the mass was projecting above the water. The fish with the punctured opercula were left in the jar. They took up convenient positions on the coral mass facing the surface of water and made no effort to escape or to swim in the water. One of them died after an hour and a half, while the other died 4 hours after it was put into the jar. Examination of the dead fish showed that the pricking of the hole in the opercula had not caused any haemorrhage, but the bulging of the opercular chamber was not so prominent at their death as it was when they were introduced into the aquarium. Death might have ensued as a result of the escape of air from and the non-retention of fresh air in the opercular chamber. The proximity of the sea-water in the jar from which the fish, in their emergency, could have obtained their supply of dissolved air for respiration by gills was apparently no inducement for a species of fish which deliberately avoids submergence under water.

Respiration in Diluted Sea-water and in Freshwater.

The capacity of *Andamia* to tolerate dilutions of sea-water and to live in freshwater was tested by experiment. Six individuals of fish collected from the rocks on Ross I. were thrown into a bell-jar containing freshwater from the tap. All except one went down to the bottom of the jar where the pulsating action of the opercular chamber was observed. The one that remained above the surface of water made repeated attempts to stick to the sides of the jar. Pieces of wood thrown into the water did not serve as an inducement for the fish to cling to Later, a piece of cheese-cloth was hung on the sides of the jar. After a few more futile attempts to stick to the jar the fish jumped on to the cheese-cloth. Two gravid females which went down to the bottom of

the jar showed signs of exhaustion after ten minutes. The pre-anal portion of the body of the fish was observed to have swollen, and both the fish died exactly half an hour after they were in freshwater. The other three fish also indicated distress as the opercular movements were getting visibly slower, and they ceased all activity 35 minutes after being in freshwater. When the fish were touched or the water in their neighbourhood stirred, the reactions seemed to be of a reflex kind, only a few twitchings of the body being observed. All the fish under experiment were removed to a jar of sea-water. Within 5 minutes the opercular movements were resumed, and in an hour and a half the fish were able to come up to the surface and remain attached to the sides of the jar. When they had revived completely in the sea-water they were again transferred to a jar of freshwater. In about an hour the two gravid females began to show signs of distress and did not revive on retransference to fresh sea-water. One male specimen died in two hours. The last survivor, a male, was transferred to a jar of sea-water and left there over-night, but was found dead on the following morning. The specific gravity of the coastal waters of the Bay of Bengal is known to be about 1·0270 but in the Andamans which receive considerable rainfall during both the monsoons, it may vary from 1·015 to 1·027.

In the next experiment with five more individuals the effect of gradual dilution of a known quantity of sea-water with freshwater was observed. Three litres of sea-water were taken in a bell-jar and a coral rock with algal growth was placed in the centre so that a portion was projecting above the water. The experiment was commenced on November 4, 1932 and concluded on December 10, 1932. The volume of sea-water was kept constant, but that of the freshwater added everyday was increased as shown below :—

Dates of Experiment.	Quantities of freshwater in cubic centimetres.	Remarks.
NOVEMBER.		
4	20	
5	30	The volume of freshwater added was increased by 10 c. c. everyday.
6	40	
7	50	
8	70	The volume of freshwater added was increased by 20 c. c. everyday.
9	90	
10	110	
11	130	
12	150	
13	170	
14	190	
15	210	
16	230	
17	250	
18	270	Colour of fish paler than usual.
19	300	The volume of freshwater added was increased by 30 c. c. everyday.
20	330	
21	360	

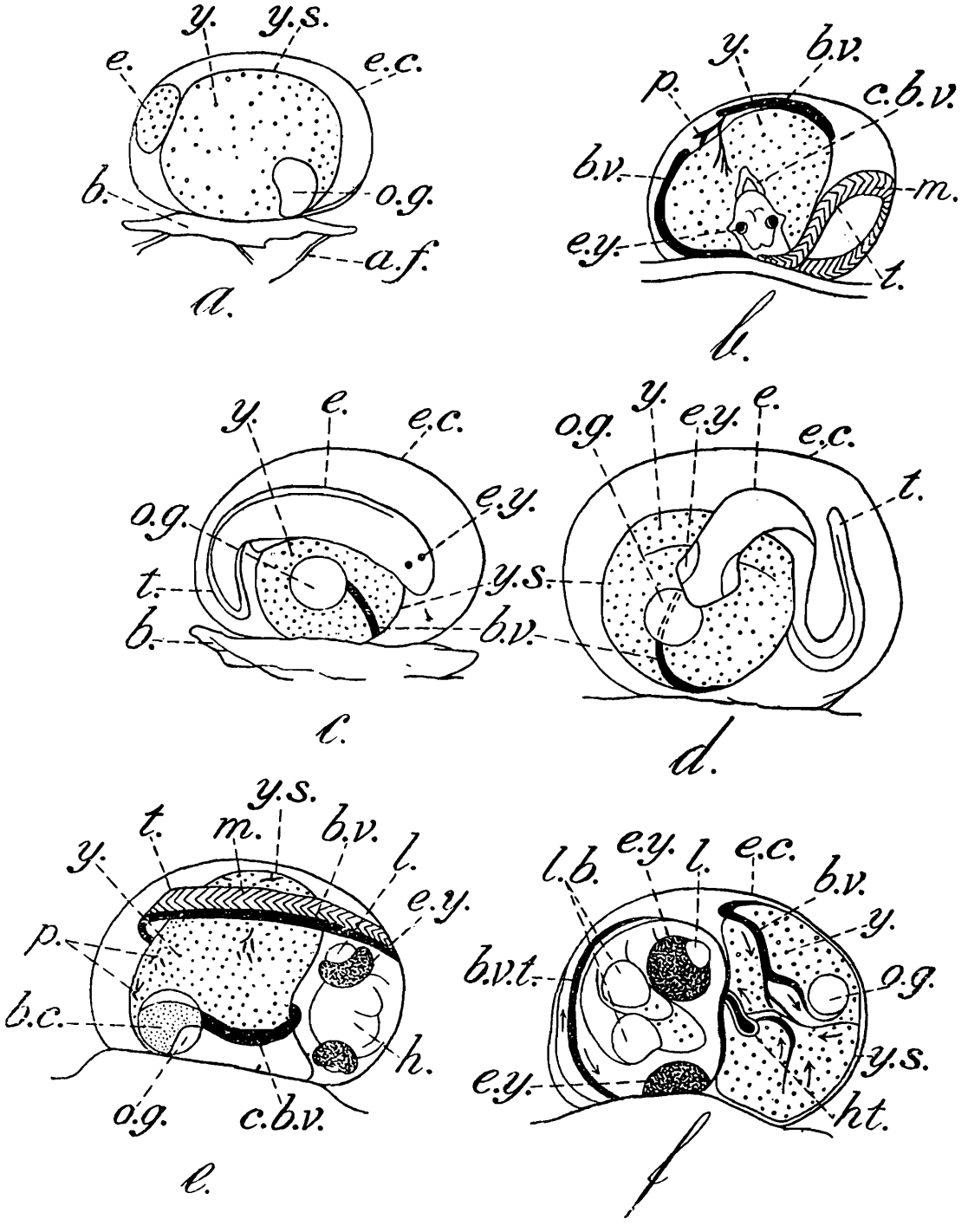
Dates of Experiment.	Quantities of freshwater in cubic centimetres.	Remarks.
NOVEMBER.		
22	400	The volume of freshwater added was increased by 40 c. c. One fish died.
23	450	The volume of freshwater added was increased by 50 c. c.
24	500	Second fish died.
25	560	The volume of freshwater added was increased by 60 c. c. Third fish died.
26	630	The volume of freshwater added was increased by 70 c. c. everyday.
27	700	
28	780	The volume of freshwater added was increased by 80 c. c.
29	880	The volume of freshwater added was increased by 100 c. c.
30	1,000	The volume of freshwater added was increased by 120 c. c.
DECEMBER.		
1	1,100	The volume of freshwater added was increased by 100 c. c. everyday.
2	1,200	
3	1,300	
4	1,400	
5	1,500	
6	1,600	
7	1,700	
8	1,800	Fourth fish died.
9	1,900	
10		Last fish found dead.

After two weeks in the gradually diluted sea water in the jar, the fish had turned paler in colour, and grown appreciably thinner. After 18 days the fish began to die one after the other, the first after 18 days, the second and third after 20 and 21 days respectively. The fourth fish died on the 34th day and the fifth on the 36th day. The normal activities of the fish of seeking food on the coral mass, or of splashing into the water at intervals, presumably, to moisten the opercular chamber, and of the assumption of a quiescent attitude for longer intervals did not seem to have been in any way interfered with by the dilution of sea-water, and two at least of the five fish with which the experiment was started lived for over a month which is the normal period of the life of this species under laboratory conditions.

Breeding and Development.

The breeding season of *Andamia* seems to be fairly extended. I have observed eggs being laid in the laboratory from September to December, gravid females from December to March, and young ones of various sizes practically throughout the year. It is quite probable that *Andamia* is a continuous breeder. Eggs laid in the laboratory in the months of September and October failed to develop. In November 1932 several freshly caught *Andamia heteroptera* from the rocks on Ross

I. were kept in laboratory aquaria. On the day following their confinement in jars several small groups of eggs, two to twelve or more in a group,



TEXT-FIG. 6.—Diagrams of the developing embryos of *Andamia heteroptera* (Bleeker) inside eggs.

The eggs were laid on 23.xii.32, and the embryos were sketched on the 5th and 6th days after the eggs were laid. Stages *a*, *b* and *e* were sketched on 28.xii.32, and stages *c*, *d* and *f* on 29.xii.32.

a. f. algal filaments attached to the basal chitinous plate of the egg; *b.* basal chitinous plate by which the egg is attached to the rocks; *b.c.* blood-corpuscles; *b.v.* blood-vessel; *b.v.t.* blood-vessel of the tail; *c.b.v.* contractile portions of blood-vessel; *e.* embryo; *e.c.* egg-case of chitinous material; *e.y.* eye; *h.* head; *ht.* heart; *l.* lens of the eye; *l.b.* lobes of the brain; *m.* myotomes; *o.g.* oil globule; *p.* branching streaks of black pigment; *t.* tail; *y.* yolk granules; *y.s.* yolk sac.

were found deposited amongst the algal growths on the coral mass. They were firmly sticking to the algal strands by a broad basal chitinous plate. Each egg was enveloped by an outer tough minutely sculptured membrane

and an inner thin covering within which yolk granules and a large yellow oil-globule were present. Four days after the laying of the eggs, development was noticed in some of them. One was apparently an early stage : the large oil-globule in the egg had been broken up into finer globules and the yolk granules had turned opaque ; the other was a more advanced stage in which the embryo had fully developed head and tail, large eyes, and the yolk granules were greatly reduced in number and occupied only half the space inside the ovum. In the month of December 1932 again the fish kept in the laboratory laid 30-40 eggs in groups of three or more. The embryos were in different stages of development (text-fig. 6). In the more advanced stages the eyes were prominent, the heart was tubular and contractile, the veins and arteries on the tail could be distinguished by the direction of the flow of blood, and the lobes of the brain were prominent. Streaks of black pigment were found here and there on the body. Some embryos were seen to turn occasionally over the yolk sac. Some of the stages observed are shown in text-figure 6.

II.—Systematics.

By Sunder Lal Hora.

Contents.

Introduction.

In 1858, Blyth described a small collection of fish made at Port Blair, Andaman Islands, and remarked that among the fishes " the most remarkable is a curious new genus of the Blenny group, with broad expanded pectorals, thrown out as in the loaches of the genus *Homaloptera* " The new genus was christened *Andamia*, and characterised as follows :—

" Form elongated, with large expanded pectorals and caudal, and a long serrated anal which is also permanently expanded ; the ventrals short, even with the pectorals, and consisting each of an outer simple ray and an inner divided ray, which are separated nearly to the base. Head depressed, with rather small eyes, placed vertically, and distantly apart ; the mouth opening downward, and furnished with a remarkable labial apparatus : in front it is covered by a thin overflapping upper lip, which is connected laterally by a plicature with a fold or flap of membrane underneath, at a short distance from the mouth behind it : minute marginal teeth in both jaws, which are perceptible to the touch as a slight asperity. Dorsal fin extending the whole length of the back, becoming higher on its posterior half ; its spinous and soft rays not easily distinguishable, and the second and third rays are a little elongated in the males (at least of the species described, which also has a small palmated appendage over each eye)."

Günther (1861, p. 294) recognised *Andamia* as a distinct genus among the Blenniidae, but he characterised it after Blyth and remarked that he had no opportunity of seeing any specimens of this genus.

Day (1869) also recognised Blyth's genus and species as valid, and redescribed the latter from " Many specimens, up to $3\frac{1}{2}$ inches in length,

exist in the Calcutta Museum. All were received from the Andaman Islands" Later he (1870, 1873) extended its range to the Nicobar Islands, but in his *Fishes of India* (1876, p. 336) he assigned Günther's (1861, p. 253) *Salarias aequipinnis* to the synonymy of *Andamia expansa* Blyth, and thus further extended the range of the genus from "Andamans and Nicobars to Amboina" Day also noted that Blyth's species "appears to be nearly related to *Salarias* or *Alticus heteropterous*, Bleeker, which however is said to have D. 14/21, A. 26-27, and no mention is made of the labial sucker. There are specimens from Amboina both in the British and Berlin Museums. Some of those in the former are the types of *Salarias aequipinnis*, Günther." In the *Fauna* volume, however, he (1889) definitely recognised Bleeker's species and assigned both Blyth's *expansa* and Günther's *aequipinnis* to its synonymy. Weber (1909, 1913), in his description of the new species, *Andamia cyclocheilus* from West New Guinea, refers to the systematic position of Bleeker's *Salarias heteropterus* and agrees with Day that it is synonymous with *Andamia expansa* Blyth. He distinguished his new species from that of Blyth mainly on the form of the disc, but Mukerji (1933) showed that Weber's species is identical with the Andaman form. Annandale and Hora had previously, on the authority of Mr. J. R. Norman, combined *Salarias heteropterus* Bleeker, *Andamia expansa* Blyth and *Salarias aequipinnis* Günther into one species. It would thus appear that *Andamia*, as recognised at the present day, is a monotypic genus.

Mr. Norman has very kindly re-examined the typical specimens of *Salarias aequipinnis* Günther with the help of the key given below and favoured me with the following report :—

"Unfortunately the matter is not too easy as the two type specimens of *Salarias aequipinnis* Gthr. are in a very soft condition and any measurement of the eyes or interorbital region is therefore quite impossible. I am able to give the following information, however, about these two specimens of which I should be inclined to select the larger, slightly better preserved, one as the type. This is 70 mm. in total length and 56 mm. standard length, all the dorsal spines are more or less produced beyond the membrane of the fin, the second spine being definitely prolonged. There is no trace of a crest on the head ; the anal fin has a dark brown longitudinal band running along the whole of its length with a pale basal area below it and above it. Testing this specimen on your key there seems to be very little doubt that it runs down to a ♂ *Andamia expansa*. The second specimen has a total length of 64 mm. and a standard length of 53 mm. The dorsal fin membrane is very much damaged and broken but it is perhaps possible that the spines were more or less produced beyond the membrane, although it is quite impossible to be certain about this. There is no crest on the head and the anal fin is uniformly pale. Thus this specimen is most likely to be a ♀ *Andamia expansa* but might possibly be the ♀ of your other species.

In the light of this report it seems that the previous conclusion was correct and that *Salarias aequipinnis* Gthr. is a synonym of *Andamia expansa*."

During the period from 1930 to 1935, when the Zoological Survey of India was in charge of the *Trochus*-shell fishery investigations in the Andamans, large collections of marine animals were made by the successive parties of the Department, and at my request special attention was paid to the ecology and biology of *Andamia*. Consequently, a great deal of material was also collected, mainly from the Ross Island. Dr. H. S. Rao, who was in charge of the Fishery for a little over three years, and had thus opportunities to observe the Blenniid fishes in various environments in different parts of the Andaman Islands, found that he could group the *Andamia* of the Andaman waters into two species,

but for a considerable time it was found difficult to separate them by any well-marked morphological characters. A systematic detailed study of the material has, however, revealed that Dr. Rao's surmise was correct and that the two species may be differentiated by the following characters :—

I. Dorsal spine not forming filamentous prolongations beyond the membrane (Anal fin without extensive black spots or colour in its middle or basal half)	*A. heteroptera* ♀.
II. Dorsal spines, especially the second, forming filamentous prolongations beyond the membrane.	
A. Anal fin without extensive black spots or colour in its middle or basal half ..	*A. raoi*, sp. nov. ♀.
B. Anal fin with extensive black marks in its middle or basal half, or whole fin black with only tips of spines white.	
1. A prominent crest on head (dorsal spines greatly produced) ..	*A. raoi*, sp. nov. ♂.
2. No crest on head (dorsal spines moderately produced)	*A. heteroptera* ♂.

In the above key use is made of only the secondary sexual characters of the two species and in consequence these diagnostic features are not applicable to very young specimens. It has, however, been found that as a rule the interorbital space of *A. heteroptera* is about four-fifths of the diameter of the eye, while it is half or less than half of the diameter of the eye in *A. raoi*. Another character by which the two species may sometimes be separated is the presence of small rounded or oval white spots on the head and anterior part of the body in *A. raoi* ; sometimes two white broad streaks also radiate from the eye to the maxillary groove in *A. raoi*. Such colour markings are absent in *A. heteroptera*. In view of abundant fresh material, *A. heteroptera* is also described here along with the new species.

In the earlier accounts no mention is made of the precise habitat of *Andamia* and for this reason Annandale and Hora (1925, p. 41) could only surmise, after a study of the adhesive organs of the fish and the convergence they show to the similar structures found in fishes of torrential streams, that " It is probably a fish of rocks in the surf-line or of the shores of islands and is evidently modified for resistance to rapid-flowing water of marine waves."

In February 1930, Dr. Baini Prashad and myself went to the Andamans in connection with the *Trochus*-shell fishery, and observed for the first time the actual habitat and behaviour of *Andamia*. The results of these observations were communicated to the Ordinary Monthly Meeting of the Asiatic Society of Bengal in August 1932 (*vide* Hora 1932), and a somewhat more detailed account of its bionomics and habitat was published a year later (Hora 1933). Mukerji (1933, p. 123) also published a short note on the habits of the fish, and in 1935 I commented on the aerial respiration of the species. The observations so far recorded are of a sketchy nature, but in the preceding pages (pp. 377-393) Dr. H. S. Rao presents a detailed study of the bionomics of the two species of the Andaman Islands. Further work on the morphology of the respiratory and adhesive organs of this remarkable Blenniid is likely to throw considerable light on the probable mode of evolution of the various adaptations found in these fishes.

The systematic position of *Andamia* was discussed by Annandale and Hora (1925, p. 39), who disagreed with Jordan (1923, p. 233) and retained the genus in the family Blenniidae. Observations on the living fish have clearly indicated that the immediate ancestors of *Andamia* were probably *Salarias*-like forms. In fact, the inclusion of the specimens of *Andamia* by Bleeker (*Salarias heteropterous*) and Günther (*Salarias aequipinnis*) in the genus *Salarias* shows its great similarity to the members of the latter genus. The limits of the two genera, as already noted by Day (1876), can be demarcated by the presence or absence of the labial disc.

The two species of *Andamia* are described below from the extensive fresh material now available.

Andamia heteroptera (Bleeker).

(Plate IX, figs. 1-6.)

1857. *Salarias heteropterous*, Bleeker, *Act. Soc. Sci. Indo-Neerl.* II, pp. 65, 66.
1857. *Salarias heteropterous*, Bleeker, *Nat. Tijdschr. Ned. Ind.* XIII, p. 372.
1858. *Andamia expansa*, Blyth, *Journ. As. Soc. Bengal* XXVII, p. 271.
1861. *Salarias aequipinnis*, Günther, *Cat. Fish. Brit. Mus.* III, p. 253.
1861. *Andamia expansa*, Günther, *Cat. Fish. Brit. Mus.* III, p. 294.
1869. *Andamia expansa*, Day, *Proc. Zool. Soc. London*, p. 518.
1870. *Andamia expansa*, Day, *Proc. Zool. Soc. London*, p. 695.
1873. *Andamia expansa*, Day, *Rep. Sea Fish & Fisheries India and Burma*, p. ccli.
1876. *Andamia expansa*, Day, *Fish. India*, p. 336, pl. lxxi, fig. 2.
1889. *Andamia heteroptera*, Day, *Faun. Brit. India*, Fish. II, p. 323, fig. 104.
1909. *Andamia cyclocheilus*, Weber, *Notes Leyden Mus.* XXXI, p. 143.
1913. *Andamia cyclocheilus*, Weber, *Siboga-Expeditie Monograph.* LVII, p. 538, pl. iii, fig. 3.
1925. *Andamia heteroptera*, Annandale & Hora, *Rec. Ind. Mus.* XXVII, p. 39.
1933. *Andamia heteroptera*, Mukerji, *Rec. Ind. Mus.* XXXV, p. 121.

D. 35 ; A. 26-27 ; P. 14-15 ; V 3 ; C. 14-15.

The body is elongated and narrow ; the head and the anterior part of the body are somewhat depressed while the tail region is compressed. Both the profiles are almost straight ; the body only tapering slightly towards the posterior end. The head is relatively short and broad ; the snout is rounded and overhangs the mouth. The length of the head is contained from 5·2 to 5·8 times in the length of the body without the caudal ; the width of the head is only slightly less than its length. The eyes are dorsolateral in position and are not visible from the ventral surface. The supraorbital rim is provided with a small, palmate appendage. The eyes are somewhat smaller in the males and larger in the females ; the diameter of the eye is contained from 3·0 to 3·3 times in the length of the head in the females and from 4·0 to 4·3 times in the males. The interorbital space is usually equal to four-fifths of the diameter of the eye, but in some cases it may be equal to it. There are some open pores round the eyes and in the interorbital space. The nostrils are small, separate and situated in front of the inner border of the eyes ; the anterior nostril is the larger of the two and is provided with a small, almost indistinguishable, unbranched appendage ; the posterior nostril is much smaller and is represented by a shallow circular pit. There is no appendage at the nape and the males are not

provided with a crest. The mouth is large, extending across the entire width of the snout ; it is almost straight and horizontal. The anterior lip and jaw are overhung by the rostral flap which is distinctly fringed. The lower lip is fleshy and coarsely fringed. The lips are continuous and folded at the angles of the mouth forming a sort of a frenulum to permit the distension of the mouth. Behind the posterior lip the skin is hardened to form a labial disc which is oval in outline and free at the posterior end. At the angles of the mouth there is a deep V-shaped groove. The jaws are provided with a series of closely-set, small, golden coloured, elongated teeth. As a rule, the gill-chambers form conspicuous bulgings outwards. The gill-openings are extensive and the gill-membranes are united across the isthmus. The membranous flaps of the gill-covers are short, but well-marked.

The body is apparently smooth, but under a magnifying glass it appears to be finely grained. The depth of the body, which is a very variable character and suffers greatly through preservation, is contained from 8·5 to 10·8 times in the standard length. The lateral line is absent, but anteriorly it may be represented by a few small open pores on the head above the gill-openings.

The dorsal fin commences above the base of the pectoral and extends almost to the base of the caudal from which it is, however, distinctly separated. There are no branched rays in the fin and in most cases it is difficult to separate the two portions of the dorsal fin. The tips of the spines are usually produced beyond the membrane to a very slight extent, but in the males these spines are produced into filamentous prolongations some of which may even exceed the length of the head. The second spine is usually the longest. Leaving the prolongations aside, the anterior portion of the fin is lower than the posterior part. The anal fin is also extensive ; it is much lower than the dorsal and extends to the base of the caudal from which it is distinctly separated ; its rays, in which the tips are free, increase in length posteriorly. The pectoral fin is broad and fan-shaped ; it is considerably longer than the head and can be divided into a horizontal and a vertical portion. The rays of the horizontal portion are thickened and flattened and are no doubt used for adhesion. The fin possesses a well developed muscular base. The ventrals, though small, are somewhat fleshy and thickly padded for adhesive purposes ; they are composed of two broad and flexible spines and a ray which is divided to the base. The bases of these fins are only slightly behind the commencement of the pectoral. The caudal fin is provided with unbranched rays which project beyond the membrane ; it is almost rounded, but the central rays are sometimes considerably longer than the outer rays.

Colouration.—In young specimens the colour is plumbeous above and the body is marked with somewhat pale mottled vertical bands on the sides. The sides of the head and the anterior part of the body are studded with minute dusky specks. The dorsal fin is dusky with the anterior 2 or 3 rays dark ; the anal fin is whitish with a dark spot on each ray. The rays of the caudal fin are much darker than the interspaces between them. In very small specimens the colours are considerably lighter, but in adult specimens there is well marked

sexual dimorphism as regards colouration. In a male specimen, about 87 mm. in length, the body is still distinctly banded but the markings are very irregular and diffuse. The anal fin, with the exception of the tips of spines, is deeply stained with black. The dark colour of the anal fin is continued on to the lower portion of the tail fin. The dorsal fin is also dusky but its anterior half is much darker than the posterior half. In the females the colour is more uniformly grayish and the vertical bands are not so clearly marked. The anal fin continues to exhibit the juvenile colouration. The lower portion of the caudal, and the edges of the pectoral and dorsal fins are whitish.

Sexual Dimorphism.—In the case of the males attention has been directed to the prolongation of the rays by all the earlier authors, but the dark colour of the basal portion of the anal fin is also an important character of ripe males. In fact, the development of these two characters is very closely correlated. Besides these two principal characters, the males possess relatively smaller eyes and longer snout.

Distribution.—Andamans, Nicobars, Amboina and New Guinea. In the preceding section Dr. Rao has indicated the types of habitat in which the fish lives (*see* pls. IX, fig. 5, and pl. X, figs. 5 and 7). As surmised by Annandale and Hora (1925) it lives on rocks in the surf-line where it is constantly washed by spray or by breakers.

Measurements in millimetres.

	♂	♂	♂	♂	♀	♀	♀	♀
Total length without caudal	76·0	68·0	67·0	64·0	56·0	55·0	52·0	50·0
Length of head	13·0	12·0	12·0	12·0	10·0	10·0	10·0	9·0
Width of head	12·5	11·0	11·0	10·8	9·0	9·0	8·5	8·5
Depth of body	7·0	6·5	6·5	7·5	6·0	6·0	5·0	5·0
Diameter of eye ..	3·0	3·0	3·0	3·0	3·0	3·0	3·0	3·0
Length of snout ..	4·0	3·5	4·0	3·0	3·0	3·0	3·5	3·0
Interorbital width ..	3·0	2·5	2·5	2·5	2·5	2·2	2·5	2·0
Length of pectoral	16·0	15·5	15·5	14·5	14·0	13·0	11·0	10·5
Length of ventral ..	6·0	5·0	5·0	5·0	4·5	4·5	4·0	4·0

Andamia raoi, sp. nov.

(Plate X, figs. 1-4, and 6.)

D. 34 ; A. 25-26 ; P. 15 ; V 3 ; C. 13.

In its general facies and proportions the new species of *Andamia* is very similar to *A. heteroptera*. The length of the head is contained from 5·3 to 5·7 times in the standard length ; the width of the head is almost equal to its length. The eyes are much more approximated dorsally and project in sockets more prominently. The supraorbital rim is provided with a small, fleshy, palmate appendage. In the males there is a thick, triangular, fleshy crest which commences behind the eyes and extends to the termination of the head. The eyes are somewhat smaller in the males than in the females ; the diameter of the eye is contained from 3·6 to 3·7 times in the length of the head in the males and from 3·0 to 3·2 times in the females. The interorbital space is about half the diameter of the eye. The open pores on the head and

nostrils are similar to those of *A. heteroptera*. The form and structure of the mouth, lips, teeth and gill-openings are similar to those found in *A. heteroptera*; the lips, however, are not so distinctly fimbriated. The body is somewhat more robust ; its depth being contained from 8 to 9 times in the standard length.

The general form and disposition of the fins are more or less similar to those of *A. heteroptera*. In *A. raoi*, however, the second dorsal spine is elongated in both the sexes, and, as a rule, the dorsal spines are greatly produced in the males but less so in the females.

Colouration.—In very young specimens the body is very distinctly banded, but in the grown-up specimens the body is indistinctly marked or is uniformly grey. The anterior half of the dorsal is darker ; base of anal fin and the lower edge of the caudal fin are intensely black in the males. In the interspaces between the rays of the dorsal fin, on the head and the anterior part of the body there are usually a number of white spots. In some specimens these markings are wanting. Two white, broad streaks, usually radiate from the eye and extend obliquely to the side of the head. In the female examples, which are generally smaller, the vertical bands on the body are somewhat more distinct.

Dr. Rao made the following observation on the colouration of the living specimens :—

" The female of *Andamia raoi* is generally smaller than the male[1]. The dorsal surface is of a dark-gray colour, while the ventral is of a much lighter shade, and the sides are a pale steel-blue in colour. Seven to nine indistinct broad vertical bands of a deeper shade than the ground colour of the body are present on the sides. A row of white spots commencing from each external nares and round the front part of the eye is continued between the eyes up to the base of the anterior part of the dorsal fin. This, however, does not appear to be a constant feature in all the specimens examined.

" A similar row on each side commencing from the side of the operculum is continued up to a point some distance below the 9th or 10th dorsal ray. A semi-circular orange-coloured band commencing from the base of the cockscomb-like ocular process surrounds the outer margin of the eye. A series of small sensory pits is present round the eye, and also on each side commencing opposite the corner of the mouth and the sucker, and running along the middle of the operculum to the upper part of the base of the pectoral fin. The ventral fin has 3 rays, the innermost bifid near the tip. The second dorsal ray is elongated and reddish in colour. The male of *Andamia raoi* is relatively large and stout, and the ground colour of the body of a slightly deeper shade than that of the female. The dorsal, anal and caudal fins are of a darker shade, the membrane between the rays being pale yellow or white. The reddish rays of these fins are all prolonged beyond the membrane, the second dorsal being the longest of the series. The white spots on the head are confined to the front portion of the eye and the middle of the operculum. A white band runs obliquely from behind each eye skirting the orange band and ends behind the fold of the skin of the upper jaw at the corner of the mouth. A stout and prominent crest with its extremity of a steel-blue colour extends from behind the eyes to the posterior margin of the head. The crest is proportionately small in the younger males. The sensory pits on the head and the operculum are smaller. The male is more active than the female, and often erects the front half of the dorsal fin while perched on a rock which is not within reach of the surf."

Sexual Dimorphism.—Besides the characters showing sexual dimorphism as in the case of *A. heteroptera*, attention must here be directed to the possession of a well-developed crest by the males. The development of the crest, the prolongation of the dorsal rays and the intensity of the black colour at the base of the anal fin are closely correlated features. The males possess relatively small eyes and a long snout as compared with the females.

[1] Mukerji (*loc. cit.*) observed that the females of *A. heteroptera* were also smaller than the males.

Distribution.—The majority of the specimens in the collection are from the east side of the Ross Island in the Andamans. There are also a few specimens from North Bay and S. Corbyn's Cove in the Andamans.

As explained above by Dr. Rao (*vide supra*, pp. 378,379) this species lives on rocks which are either actually beaten by the waves or washed by the swell of the sea, and are in consequence more difficult to collect. *A. heteroptera* is thus more terrestrial in its habits than *A. raoi*.

Type-specimen.—Holotype No. F 12933 /1, *Zoological Survey of India, Indian Museum, Calcutta.*

Measurements in millimetres.

	♂	♂	♂	♂	♀	♀	♀	♀
Total length excluding caudal ..	73·0	69·0	67·0	65·0	60·0	55·0	54·0	48·0
Length of head	13·0	12·0	12·0	12·0	10·5	10·0	10·0	9·0
Width of head ..	13·0	12·0	12·0	11·0	10·0	9·5	9·0	8·5
Depth of body ..	8·5	8·5	7·0	7·5	7·0	6·0	6·0	6·0
Diameter of eye	3·5	3·3	3·3	3·3	3·3	3·3	3·3	3·0
Length of snout	5·0	4·0	4·0	4·0	3·5	3·5	3·5	3·0
Interorbital width	2·0	1·5	1·5	1·6	1·5	1·5	1·5	1·4
Length of petoral	16·0	15·5	15·0	15·0	11·5	13·0	12·5	11·0
Length of ventral	7·0	6·0	6·0	5·3	6·0	5·0	5·0	4·0

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