

## A Larval *Ipnops* and Its Possible Metamorphosing Process

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**Abstract** A remarkable postlarva of 13.9 mm in standard length collected by surface tows of a larva net from the tropical western Pacific is described in detail, with special reference to its elaborated head and pectoral fin features. On the basis of morphological close fit, this specimen is identified with the genus *Ipnops*, family Chlorophthalmidae. Its specific name was tentatively referred to *I. agassizi*. This epipelagic larva is compared with recently transformed specimens, and possible metamorphosing process is discussed in relation to their drastic habitat change. It is clear that the flattened, dorsally-directed plaques unique to *Ipnops* are derived from the typical laterally situated eyes in pelagic larvae.

Marshall and Staiger (1975) stated: "Perhaps the most curious products of inionous benthic radiations are the species of *Ipnops*. Their strange eyes are evidently functional, but how are they used?" These peculiar eye plaques unique to this deep sea genus have attracted special interest (cf. Marshall, 1979). Munk (1959) supposed the typical eyes in early-stage larvae as a preceding state of this unusual structure, but his speculation was based on a morphological study of adult materials. Recently, larval taxonomy of the myctophoid fishes has made a remarkable advance (cf. Okiyama, 1979), but larvae of *Ipnops* remain unknown. Accordingly, the discovery of a single postlarva referable to this genus deserves particular attention. The purpose of the present study is to describe fully the morphology of this specimen and compare it with advanced material to clarify the metamorphosing process with emphasis on some remarkable characteristics such as the eye plaques.

### Material and methods

A single postlarval specimen (ZUMT 54273) was collected by surface tow with a conventional larva net (140 cm mouth diameter; 0.33 mm mesh opening) from T/V Choho-Maru Cruise 1967, Station No. 5 (10°-09'S., 153°-09'E) in the tropical western Pacific; surface water temperature 27.2°C; 19 August 1967; zone time 0850-0905. Four benthic specimens (uncatalogued) of *Ipnops agassizi*, 49~93 mm SL, from ORI (Ocean Research Institute) collection were used for comparative study. Their collection data

are as follows: 1 January 1968; KH 67-5, St. 19 (01°-59.6'S., 157°-12.3'E); beam-trawl at a depth of 1610 m.

The larva and the smallest benthic specimen (49 mm SL) were prepared for osteological examination after trypsin cleaning and alizarin staining. Terminology for bones follows Theissen (1965), Okiyama (1972) and Sulak (1977).

### Results

**Measurements and counts.** Meristic characters are given in Table 1. Proportional measurements as percentages of the standard length (13.9 mm) are given below. Values in parentheses are those from the smallest and fully transformed benthic specimen (49 mm) from ORI collections.

Head 18.0 (21.4). Snout 3.0 (-). Interorbital 9.0 (-). Eye along longest axis 5.8 (-). Upper jaw 7.2 (12.4). Depth of body at pectoral insertion 15.8 (7.3). Distance from tip of snout to: anus 32.4 (34.1); dorsal fin origin ca 40.3 (38.8); anal fin origin 66.9 (64.3). Length of dorsal fin base ca 9.0 (7.6). Length of anal fin base 19.2 (22.0). Longest pectoral fin ray 45.3 (damaged). (-) means that relevant figure is unavailable.

### General morphology of postlarval specimen.

The body is slender and laterally compressed, particularly in the tail (Fig. 1). The head is massive, wide and slung down in the pectoral region at an angle of about 60° from the body axis, thus typically being humpbacked. Anterior half of the abdomen is well produced ventrally and laterally, where the maximum body depth is seen. The anus opens at about one-third of the body

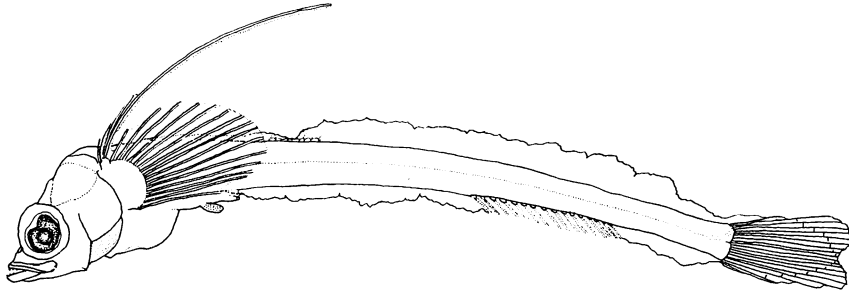


Fig. 1. A larva of *Ipnops agassizi*, 13.9 mm SL, from the western tropical Pacific.

length posteriorly, around myomere 16. The dorsal fin originates on myomere 18, and the anal on myomere 37. The anal base is about twice as long as the dorsal. The pelvic is small, located slightly in advance of the anus. The larval finfold is distinct throughout the long tail with interruptions by vertical fins. Presence of the adipose fin is thus unable to be distinguished. The tip of the notochord is fully flexed. Full ray counts are seen for the anal, principal caudal and pectoral, whereas the dorsal and pelvic are poorly differentiated. Of these, the pectoral configuration is conspicuous in that it is completely bifid to the base between the fourth and fifth rays from above and is oriented slightly dorso-laterally. This divided appearance is marked, because the fourth ray, the lowermost element of the upper lobe, is extremely elongated reaching the level of the midpoint of the body when depressed. Lower lobe is fan-like with a greater extension in the lower part. Its posterior tip extends beyond the level of the dorsal fin origin. The caudal fin is slightly forked. All anal rays

are uniformly low.

The top of the head is nearly flat and wide, but the supraorbital part protrudes greatly to the dorsal profile of the head. The diameter of the bony orbit occupies a little less than half of the head length. The eye is normal, nearly spherical and large. There is an equally wide interspace between the eyeball and bony orbital. The nostril is a simple shallow hole located just in front of the orbit.

The mouth is terminal, rather large, extending posteriorly to the level below the center of the eye. The lower jaw slightly projects beyond the snout tip.

The specimen is scantily pigmented. Except for the eye, no melanophores are found. Peritoneal pigment section is absent.

**Visceral anatomy.** The oesophagus and cardiac portion of the stomach is a simple broad tube terminating in a small blind sac (Fig. 2). The pyloric part is short and narrow, but abruptly broadens at the anterior part of the intestine where it twists obliquely upwards on the right

Table 1. Comparisons of meristic counts between the present larva and the known *Ipnops* species. ( ) indicates that numbers do not reach the constant value.

Character	Present larva	<i>Ipnops agassizi</i>	<i>Ipnops murrayi</i>	<i>Ipnops meadi</i>
No. sp.; SL, mm	1; 13.9	15; 81~137*	4; 49~93**,**	71; 60~122*** 21; 50~121*
Dorsal	( 9)	9~11	9~11	8~10 8~9
Anal	16	15~19	14~17	13~16 11~13
Pelvic (L/R)	( 5)	8 / 8	8 / 8	8 / 8 8 / 8
Pectoral (L/R)	19 / 19	13~16	14~16	12~15 14~16
Caudal (Principal)	19	19~20	19	17~19 17~19
Branchiostegals (L/R)	11 / 10	9~11	10~11	10~12 10~11
Gill rakers (1st arch)	21 / 22	20~24	23~24	20~23 17~20
Vertebrae (Myomeres)	(62)	57~61	55~57	54~58 57~61

\* Nielsen (1966). \*\* Marshall and Staiger (1975). \*\*\* ORI specimens.

side of the stomach. Viewed from the lateral side, a ventral projection in this portion is remarkable, although two separate lobes of the liver cover its anterior and posterior ends. The posterior section of the gut tapers evenly toward the anus except for a small indication of a rectal branch. The gas bladder is absent. The gall bladder of a spherical shape is distinct at the right corner of the anterior lobe of the liver. Stomach contents consisted of a half digested specimen of arrow-worm and a small amount of unidentifiable digested substances.

**Osteology.** Ossified elements are extremely limited except for the head (Fig. 3A, B).

The upper and lower jaw bones are well ossified including a small supramaxillary. The premaxillary develops conspicuously and has a single row of six (left side) and four (right side) evenly spaced teeth. Likewise, there are five (left) and four (right) teeth on the dentary. All these teeth are small and conical in shape. The maxillary is moderately dilated posteriorly and lacks teeth. Bones of the suspensorium including the opercular cover are similarly stained. The metapterygoid and symplectic are not dis-

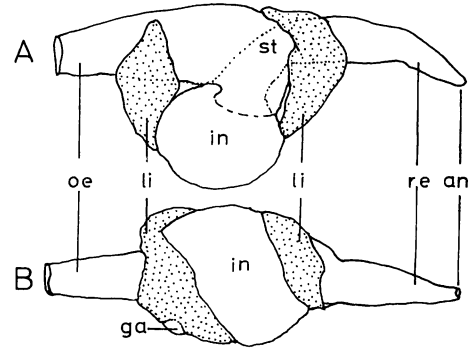


Fig. 2. Digestive canal of postlarval *Ipnops agassizi*, 13.9 mm, SL. A: Lateral view. B: Ventral view. an, anus; ga, gall bladder; in, intestine; li, liver; oe, oesophagus; re, rectum; st, stomach.

criminated. A single large canine develops at the tip of the palatine which is stained only in this tooth-bearing part along with a slightly posterior portion lateral to the broader endopterygoid (Fig. 3C). Six vomerine and two palatine teeth are arranged regularly to form a uniserial arch with somewhat wider space at the center of the

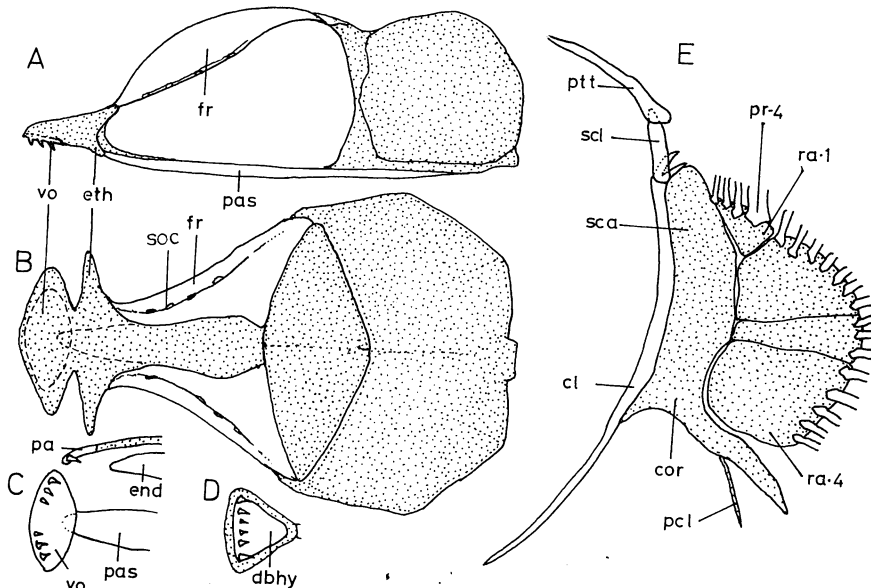


Fig. 3. Skeletons of larval *Ipnops agassizi*, 13.9 mm, SL. A, B: Lateral and dorsal view of neurocranium. C: Dentition in vomer and palatine. D: The same in dermal basihyal. E: Pectoral girdle. cl, cleithrum; cor, coracoid; dbhy, dermal basihyal; end, endopterygoid; eth, ethmoid; fr, frontal; pa, palatine; pas, parasphenoid; pcl, postcleithrum; pr, pectoral ray; ptt, posttemporal; ra, radial; sca, scapular; scl, supraclavicular; soc, supraorbital canal; vo, vomer. Cartilaginous parts are stippled.

vomer. A similar pattern is duplicated in the basibranchial dentition, where six teeth are evenly spaced along the straight tip of the dermal basihyal (Fig. 3D). These teeth are sharply pointed, recurved inward and gradually decreasing in size medially.

The hyoid and branchial arches, basibranchial toothplate, dermal basibranchial, ceratohyal and ten (six ceratohyal and four epihyal) branchiostegal rays are variously ossified. The toothpatch and/or associated bones of the (third and fourth) pharyngobranchials, third and fourth epibranchials and fourth ceratohyal are also stained. Gill rakers on the first pair of branchial arches are unossified, but their finger-like structures are fully visible as cartilaginous structures. Similarly, fundamental organization with necessary articulation among respective elements is achieved in other parts of the branchial apparatus.

The parasphenoid, vomer and frontals are the only bones stained in the neurocranium (Fig. 3A~C). The parasphenoid is closely articulated with the vomer anteriorly, but its posterior extremity is indistinct. The frontals are separated into two plates along the dorsal midline. Viewed in dorsal aspect, each half is an elongate triangle in outline. The anterior corner attaches to the posterior side of a cartilaginous ethmoid projection. Along the posterior border it contacts a cartilaginous plate, probably attributable to the parietal. In the remaining free lateral margin arises the supraorbital wing of crescent shape which grows obliquely upward along a weak traverse of the supraorbital canal. When viewed (under microscope) by transmitted light this transparent, thin wing reveals a regular structure arranged almost in parallel to the dorsal margin. Other parts of the neurocranium are still cartilaginous or undeveloped.

In the shoulder girdle (Fig. 3E), a series of slender bones composing the pectoral girdle such as the posttemporal, supracleithrum and cleithrum are already well ossified. An extremely narrow postcleithrum is also stained weakly. A large coraco-scapular cartilage with a long posterior process occurs between the dorsal half of the cleithrum and the four radials which vary in size and shape. Of these radials the second and fourth are much larger than the other two. The dorsal four rays forming the

upper lobe of the pectoral fin are all supported by the small first radial. The fourth ray is pronounced in size. Rays in the lower lobe are supported by three radials as follows: 5~11th by 2nd radial, 12~14th by 3rd and 15~19th by 4th, respectively. These rays are evenly spaced and similarly structured in both lobes.

Bones in other parts such as the axial skeleton and fin supports, are incompletely differentiated. The exception is the caudal skeleton, where all the hypurals, the parhypural and perhaps the first uroneural are more or less ossified. Although the notochord is not yet segmented, two cartilaginous epurals are distinct. No scales or scale-like structures are formed.

### Discussion

Current information on the myctophoid larval taxonomy as reviewed by Okiyama (1979) clearly indicates that the present specimen belongs to the suborder Myctophoidei. The following aspects may be particularly relevant to this assumption: (1) the slung-down head with a flat or concave top, (2) extremely scanty pigmentation, (3) unusually high numbers of myomeres and retarded ossification, (4) vent location well in advance of the anal origin, close to the pelvic fins and with a nearly thoracic insertion, (5) dentition with opposing uniserial tooth rows of the vomer and dermal basihyal, and (6) characteristic patterns of hyobranchial organization. Although the morphology of this last feature of the present specimen is neither illustrated nor described in full detail, diagnostic points hitherto suggested in this connection (Rosen, 1971; Okiyama, 1972; Johnson, 1974) are also confirmed in this larva. Furthermore, there is a close fit of meristic, as well as morphometric, characters between this larva and known *Ipnows* (Table 1), suggesting identity with this genus.

However, in order to verify this association, further investigation seems necessary to resolve whether or not some trenchant morphological differences between the present postlarva and adult *Ipnows* (especially with respect to the head and pectoral organization) have an ontogenetic basis.

The eye plaque is a curious organ not found in any other teleosts (Munk, 1959). Only a few bony elements, such as the frontal and parietal, are chiefly involved in its organization (Theisen,

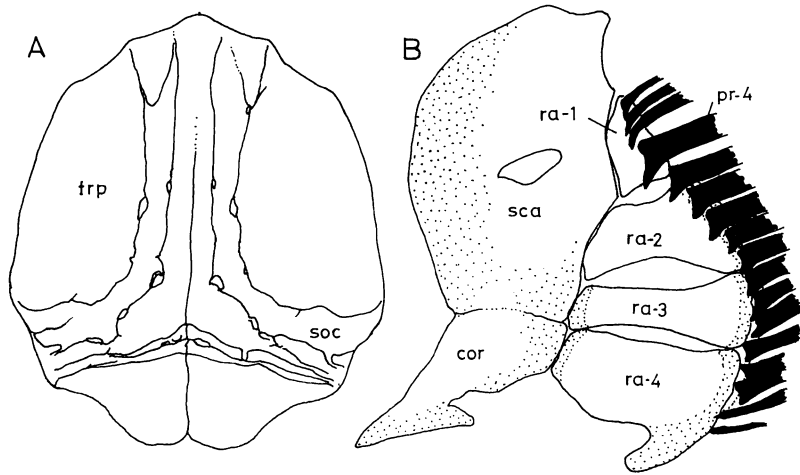


Fig. 4. Skeletons of transformed *Ipnops agassizi*, 49 mm, SL. A: Eye plaque. B: Pectoral girdle. frp, fronto-parietal plate; other abbreviations are the same as in Fig. 3. Cartilaginous parts are stippled.

(1965). I believe that the unusual lateral extension of the larval frontal, followed by fusion with the parietal, could lead to the similar condition found in transformed *Ipnops*. Otherwise, all that is required is the dorsal displacement of the plaques which involves about a 90° turn of the eye bulb (Munk, 1959). The large supra-orbital wing in the present larva may represent this feature in its early course of modification. The regular structure in the wing seems to substantiate the suggested growth.

On the other hand, some myctophoids pectoral structures are known to show remarkable ontogenetic changes, sometimes accompanying the loss of rays probably by resorption or shedding. For instance, about six more rays are observed in a larval myctophid (*Lowena rara*) than in adult (Moser and Ahlstrom, 1970). Comparison of the pectoral structure between this larva and transformed *Ipnops* (Figs. 3, 4) demonstrates that both retain the thick and stout fourth ray, but several rays near the ventral end are apparently degenerating in the transformed specimen. The occurrence of partially or completely imbedded pectoral rays usually located on both ends of the fin was reported in *I. murrayi* (Marshall and Staiger, 1975). It is therefore likely that the differences in pectoral counts shown in Table 1 are attributable to ontogenetic changes.

The specific identification of this larva is not an easy task, because three known species of

*Ipnops* closely resemble one another. However, the anal ray count of the present larva appears to distinguish it from *I. meadi* (Table 1). The geographical distributions of the remaining two species are clearly different in such ways as *I. agassizi* in the Indo-Pacific and the Atlantic, and *I. murrayi* in the Atlantic (Nielsen, 1966; Sulak, pers. comm.). The capture locality of the present specimen thus suggests that it is a larva of *I. agassizi*.

Now, a systematic problem that there are intermediate specimens between *I. agassizi* and *I. murrayi* once suggested by Nielsen (1966) arises again from new (ORI) material from the tropical western Pacific near the locality of the present larva. As is evident from Table 1, these additional specimens make the differences between these two species still more insignificant. Further studies covering wider geographical areas are badly needed to settle this confusion, including the problem of possible hybrids, also suggested by Nielsen (1966). The present larva is tentatively ascribed to the Indo-Pacific species, *I. agassizi* Garman.

Morphological changes unique to *Ipnops* are considered above, along with the identification problem. It is well known that other changes, such as the development of the dorso-ventrally depressed head with a huge mouth, straight head and flat abdomen, are not peculiar to this genus among myctophoids but commonly shared with

its close relatives including *Bathysaurus* and *Bathytyphlops* (Rosen, 1971; Okiyama, 1972). Despite limited materials, it may be concluded that the conspicuous transformation of *Ipnops* is attained in close association with the habitat transition from an epipelagic to demersal life in the lower bathyal zone (1392 to 2820 m in *I. agassizi*; Nielsen, 1966), and this genus is better adapted morphologically to this mode of life. The elongated pectoral may be advantageous to the floating pelagic life, and the extremely depressed head with the functional eye plaques (Marshall and Staiger, 1975) is surely adaptive to the bottom life.

The shared specialization of the slung-down head in larval *Ipnops* and *Benthalbella infans* is of particular interest, since the latter species is supposed to be adapted to a tilted swimming posture to keep the head upward in relation to its unusual visual field (Merrett et al., 1973). In *Ipnops* larvae, however, a similar "natural" posture may be inferred from the filamentous pectoral with a slightly dorso-lateral orientation. Such a fashion with the top of the head and the elongated pectoral parallel to the surface may favor the maintenance of the larvae in the epipelagic realm. Perhaps this conspicuous larval pectoral becomes reduced gradually toward the end of the pelagic life and eventually is lost soon after the fish settles at about 40 mm in standard length, since Sulak (1977) reported that the smallest benthic specimen of *Ipnops murrayi* available (42 mm SL) still demonstrated an unfinished condition with respect to the structure of the eye plaques. The smallest transformed specimen of *I. agassizi* (49 mm SL) found in our collection may also support the above assumption.

Despite differences in the details of classification, recent authors (Marshall and Staiger, 1975; Sulak, 1977) agree in that the four deep-sea genera, i. e., *Ipnops*, *Bathypterois*, *Bathytyphlops*, and *Bathymicrops*, compose a single unit of a family-group rank. Available larval evidence is yet too incomplete to substantiate this phylogenetic integrity. As is evident from the comparison of larval *Ipnops* and *Bathytyphlops* (Okiyama, 1972), they show considerable mosaics of characters. Their difference in the peritoneal pigment section is notable, since it appears to be interpreted as an indication of rather distant

relationships. A similar fashion in the pectoral fin between *Ipnops* larva and adult *Bathypterois* is also notable. Is this merely a parallel feature? Such a larval aspect deserves future studies.

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### チョウチンハダカ属 *Ipnops* の後期仔魚と変態過程

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西部熱帯太平洋の表層から採集された特異な形態をした後期仔魚(体長 13.9 mm)について、特に標徴的な頭部と胸鱗の性状に注目して形態の観察を行った。地理的分布および体節的特徴などから、この個体はアオメエソ科の深海底生性分類群チョウチンハダカ属に属することが判明した。種名を暫定的に *Ipnops agassizi* Garman と同定した。この真表属性の仔魚と底生移行した個体との比較を通じて、著しい生息域の変化に対応した変態の過程について検討を加えた。本属に特有の頭部背面に発達した平板状構造は、仔魚期には正常に側面に位置する眼球に由来することが明らかとなった。

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