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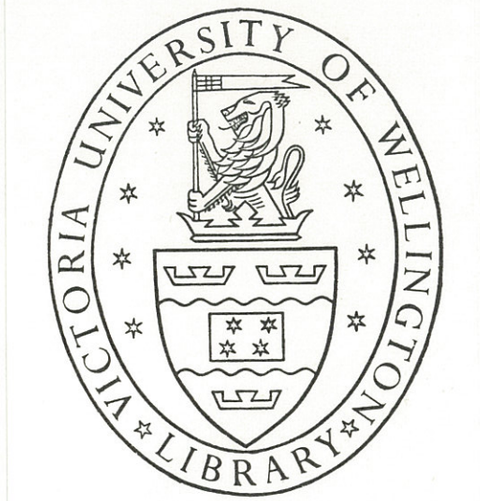

CONTENTS

DEVELOPMENT OF *TRIPTERYGION CAPITO* AND *T. ROBUSTUM* (PISCES: TRIPTERYGIIDAE)

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ABSTRACT

In the Wellington area *T. capito* Jenyns, 1841 and *T. robustum* Clarke, 1879 spawn from July to October, depositing their eggs in clusters on the undersurface of rubble throughout the littoral zone. These clusters are attended by the male parent until hatching which under laboratory conditions occurs after 17 and 22 days respectively, in temperatures ranging from 11° - 13.5°C. The egg development of both species is described.

The prolarvae of *T. capito* average 4.90mm standard length and possess yolk sacs of varying sizes each with 1-2 small oil droplets. Two large stellate melanophores lie above the gut. There are 16-26 stellate post-anal melanophores along the ventral mid-line, and 2-5 along the dorsal mid-line of the tail. The prolarvae of *T. robustum* average 5.95mm standard length and differ from *T. capito* in having only 5-15 mid-ventral melanophores.

INTRODUCTION

Tripterygion capito Jenyns, 1841 and *T. robustum* Clarke, 1879, are endemic tripterygiids abundant in areas of seaweed and rock throughout Wellington Harbour and along the shoreline of Cook Strait, New Zealand. Both species occur around all New Zealand and are found throughout the intertidal zone. There are several other tripterygiid species in New Zealand but the systematics of these are at present confused.

Tripterygion capito is relatively small (maximum size 70mm s.l.) and individuals are generally dark in colour although many specimens appear silvery - grey with dark dorso - lateral bands from head to tail. *Tripterygion robustum* is larger (maximum size 105mm s.l.) and characteristically has a blunt rounded forehead. The colour ranges from a uniform black to light green with irregular greenish-brown patches. The anal fin is often fringed with white.

This paper describes the egg and prolarval development of the two species. Graham (1939, 1953) has briefly outlined the egg and prolarval stages and spawning behaviour of *T. varium* (Bloch and Schneider, 1801) from New Zealand.

Publication of this paper is assisted by a grant from the Victoria University of Wellington Publications Fund.

MATERIALS AND METHODS

On 1.7.70 15 adult *T. robustum* were placed in an asbestos aquarium (2.5 x 0.38 x 0.23m) at the Island Bay Marine Laboratory. Several stones and *Haliotis* (paua) shells were placed in the aquarium to provide shelter and objects on which to spawn. The tank was supplied with fresh running seawater and the fish were fed chopped liver and fish. On 8.7.70 freshly laid eggs were found on the undersurface of one of the *Haliotis* shells. These were attended by a male *T. robustum* (78mm s.l.) which, along with the eggs, was removed from the asbestos tank and placed in a small plastic aquarium (30 x 28 x 13cm). The water was changed daily and kept constantly aerated.

On 25.7.70 a similar system was set up using 10 adult *T. capito,* but no spawning occurred. However on 28.8.70 an egg mass on a portion of clay pipe was collected from the Island Bay shore and kept in a plastic aquarium (30 x 28 x 13cm), along with the adult male *T. capito* found attending the eggs. The water was changed and aerated in the same manner as for *T. robustum.*

Eggs of both species required for observation were easily removed from the substrate by sliding a scalpel or mounted needle beneath the egg and then pipetting the dislodged egg into a petri dish.

Development of these eggs was studied and sketches of the eggs and larvae were made using a camera lucida. An ocular micrometer was used for measuring eggs and larvae. Measurements of the larvae were based on those recommended by Hubbs and Lagler (1958), with the exception of head length, taken here as the distance from the tip of the snout to the back of the otic capsule. This is more definite than the opercular flap which is often not readily visible. Egg and larval terminology is based on that used by Rugh (1948), Balinsky (1965) and New (1966).

SPAWNING AND DEVELOPMENT OF *T. CAPITO*

In the Lyall Bay and Island Bay area near Wellington *T. capito* spawns from mid-July to late October. Egg masses are found from mid-tide to low tide levels in areas of rubble. The egg clusters are comparatively small measuring about 7 x 4cm and containing 2-3 hundred eggs. The eggs are laid close together forming flat, irregular shaped masses.

The egg clusters may contain groups of eggs at different stages of development, suggesting differing spawning times on the one substrate. *In situ* the eggs are colourless, pale pink or pale orange, the latter being associated mainly with the later "eyed egg" stages of development where the yolk is compact and the blood flow is copious. Being small and essentially transparent the egg clusters may pass unnoticed by the casual observer. The pale pink eggs blend in with encrusting pink algae. Virtually all egg masses observed on the shore had an adult *T. capito* in attendance. On several occasions 2-3 adults were found close to the eggs. The male *T. capito* found with the eggs kept at the laboratory remained close to the eggs, moving from side to side and fanning the pectoral fins to create a current of water. This constant circulation apparently ensures a supply of oxygenated water to the eggs and helps in the removal of detritus that may otherwise attach to the egg surface.

DEVELOPMENT OF THE EGG AND PROLARVA

The egg is essentially spherical although slightly dorsoventrally depressed. The flattened base is covered with numerous fine, translucent, adhesive threads. The mean chorion diameter is 1.07mm (100 eggs measured) and ranges from 1.00mm - 1.10mm. Early in development the yolk is spherical and averages 0.90mm and contains 80 - 120 small oil globules closely associated with 20-25 pigment spheres. No cluster was found with eggs earlier than the blastula stage and these were estimated to be about thirty hours old. Development to hatching (Fig. 1, Nos. 1-9) took 17 days at a temperature ranging from 11°C-13.5°C.

Thirty hours (Fig. 1, No. 1). The blastula is well formed and consists of a rounded cap of cells (blastoderm) overlying a deep blastocoel. Pigment spheres and associated oil droplets are distributed evenly throughout the yolk.

Second day (Fig. 1, No. 2). The blastodisc has spread half way around the yolk. The embryonic shield is poorly defined, appearing only as a thickened portion of the blastodisc.

Third day (Fig. 1, No. 3). The blastopore has closed. The optic vesicles are present but rudimentary. The embryo is deeply notched into the yolk, particularly in the head region, and the tail bud is flat. Several of the yolk pigment spheres have coalesced, as have some of the oil globules, effectively reducing slightly the number of each.

Fifth day (Fig. 1, No. 4). The pericardial cavity is well defined and the heart beats faintly, but there is no visible blood circulation. The brain is lobed and the ventricles pronounced. A cluster of small stellate melanophores lies anterior and posterior to each eye; the greatest number lie posterior to the eyes. The chorioid fissure is not closed. The auditory placodes appear as two small rings lateral to the hind brain. Behind each placode there is a group of about 10 small melanophores. Two more pigment clusters lie half way along the embryo, and several scattered melanophores are present in the tail bud. Pigment spheres and oil globules continue to coalesce.

Sixth day (Fig. 1, No. 5). The heart beats strongly and rapid circulation is visible in the dorsal and ventral blood vessels and the vitelline tributaries. Brain lobes have expanded laterally, especially the mesencephalon, and two otoliths are present within the otic vesicles. The tail extends well clear of the yolk and the gut is long and tubular. Several stellate melanophores surround the gut and extend in two rows along the ventral aspect of the tail. These melanophores are obscure and cannot be accurately counted. Ten to 15 stellate melanophores lie scattered over the yolk surface. Twenty to 30 oil droplets and 3-4 pigment spheres remain within the yolk. The relative position of the oil globules in the yolk varies according to the attitude of the egg because the oil floats to the uppermost portion of the yolk.

Eighth day (Fig. 1, No. 6). The heart now lies slightly forward of the head. The chorioid fissure has closed and eye pigmentation is just visible. The general arrangement of the body pigment has altered very little. A large pigment patch is present at the posterior end of the gut, and a single row of 5 stellate melanophores runs along the ventral mid-line of the tail. Beginning directly above the anus 6 stellate melanophores run along the dorsal mid-line of the tail. Several melanophores are visible above the hind portion of the mesencephalon. All pigment spheres have disappeared from within the yolk. The tubular gut is longer.

Tenth day (Fig. 1, No. 7). The mesencephalon has expanded dorsally. The chorioid pigmentation is extensive although the lenses are still visible through it. The number of scattered melanophores present anterior and posterior to the eyes, above the gut and laterally within the tail is reduced. Two are present above the brain and 4 behind each otic vesicle. The melanophores along the dorsal mid-line are reduced to 3 or 4 while those on the ventral mid-line have increased to 11 or 12. Rudimentary pectoral buds and fin folds are visible.

Twelfth day (Fig. 1, No. 8). A further reduction in the number of melanophores above the gut, over the yolk surface, and anterior and posterior to the eyes has taken place. Those melanophores situated around the eyes adhere closely to the back of the eye and are somewhat obscured by the chorioid pigment. One or two melanophores lie along the lateral aspect of the body directly behind each pectoral bud.

Fourteenth day (Fig. 1, No. 9). The yolk is considerably reduced, more dense and contains a single large oil globule and 13-15 smaller ones. The head is raised from the yolk revealing the chambers of the heart and the lower jaw. Pigmentation of the chorioid appears complete with many iridiophores present. The amount of body pigmentation varies. Many individuals have only those melanophores found above the gut and along the mid-ventral and mid-dorsal lines. Other specimens still possess the clusters behind each otic capsule and the 8 melanophores around the base of the brain and between the eyes. The mouth, external nares, pectoral fins and fin folds are well formed. By the 16th day (hatching) there is no pigment beneath the brain or behind the otic capsules. Just before hatching the embryo turns violently within the egg at frequent intervals. Eventually the tail penetrates the chorion, freeing the new prolarva.

Prolarva (Fig. 1, Nos. 10 and 11). Prolarval length on hatching ranges from 4.50mm - 5.25mm s.l. The amount of yolk present varies, being influenced by the degree of premature hatching caused by disturbance of the egg, such as by changing the water. The gut is long and convoluted. Above the gut, within the peritoneal layer, are two large melanophores, one directly anterior to the vent and the other above the hind portion of the liver. Some specimens also possess a melanophore beneath the gut and slightly anterior to the vent. The reduced yolk is bordered anteriorly by the heart and posteriorly by the liver and prominent green gallbladder. Sixteen to 26 (most commonly 21) stellate melanophores are present along the ventral mid-line behind the anus. Two to 5 dorsal melanophores are present in the tail. Two stellate pigment spots are situated either side of the anterior part of the yolk. An occasional specimen was found in which the melanophores around the brain and eyes and behind the otic capsules were still present, but these melanophores rapidly faded.

SPAWNING AND DEVELOPMENT OF *T. ROBUSTUM*

In the Lyall Bay and Island Bay areas *T. robustum* spawns from early July to late October. Egg masses are found throughout the tidal zone beneath stones, broken clay pipes, sheets of asbestos and *Haliotis* shells. Egg clusters appear most abundant about the upper mid-tide level although many are found further up the tide, sometimes completely out of the water for several hours during low tides. Several egg clusters were found in oyster shells located in spat collecting trays that were suspended from rafts 20 feet above the nearest portion of rocky seabed.

The size of the masses range from 5cm in diameter, with 1-2 hundred eggs, to about 12cm in diameter with several thousand eggs. The eggs are laid close together forming flat irregularly arranged clusters.

The large egg masses contain groups of eggs at different stages of development, suggesting that like *T. capito,* these clusters are the result of several different spawnings. The eggs are essentially colourless although collectively they appear pale green. The colour of the yolk (pale yellow) changes very little as development proceeds. Five separate egg masses were laid in the asbestos aquarium and in each case the male parent attended the eggs. The male *T. robustum,* like the parent *T. capito,* lay close to the eggs and created a current of water by movement of its anal and pectoral fins. Again this ensured a supply of oxygenated water and the removal of detritus. Egg masses kept without a male parent or adequate aeration suffered up to 90% mortality. These eggs also accumulated masses of minute debris which covered the entire chorion and obscured the embryo.

DEVELOPMENT OF THE EGG AND PROLARVA

The egg and yolk are completely spherical, and the mean chorion diameter of 80 eggs was 1.16mm (range 1.12-1.23mm). The yolk early in development is slightly granular, and contains 25-35 medium sized oil droplets closely associated with 15-25 pigment spheres. The eggs attach to the substrate by a mass of tendrils arising from one side of each egg. Each tendril consists of a matted series of fine filaments that arise from a single point on the chorion. These tendrils are larger than those of *T. capito.*

Development to hatching (Fig. 2. Nos. 1-12) took 22 days at a water temperature ranging from 11°C-13.5°C.

Two hours (Fig. 2. No. 1). A single large mass of protoplasm appears at one end of the yolk.

Fifteen hours (Fig. 2, No. 2). One hundred and twenty-eight angular cells form a low cap on one side of the yolk.

Thirty hours (Fig. 2, No. 3). The blastula is well formed and consists of a semi-circular mass of cells (blastoderm) overlying a wide blastocoel.

Fifty hours (Fig. 2, No. 4). The blastodisc covers two-thirds of the yolk. The embryonic shield is clearly defined and lies slightly embedded in the yolk, particularly in the anterior region.

Third day (Fig. 2, No. 5). The embryonic axis (neural keel and somite precursors) is obvious although still flattened against the yolk. Poorly defined optic vesicles are visible. Twelve to 20 large oil globules are present and the pigment spots have decreased in number (to 5-10). The blastopore is closed.

Fourth day (Fig. 2, No. 6). The embryo is prominent above the yolk surface and encircles more than half of the yolk sac. The lenses are formed and have partially separated from the ectoderm. Eight myomeres lie well forward either side and Kupffer's vesicle has appeared directly beneath the tail bud. A group of tiny melanophores lies anterior and posterior to each eye. A further two clusters are laterally positioned within the myomeres half-way along the embryo.

Fifth day (Fig. 2, No. 7). The brain is lobed and the ventricles are visible. The auditory placodes appear as faint depressions behind the eyes. Approximately 15 stellate melanophores lie scattered over the

surface of the yolk sac. The relative position of the melanophores is unchanged although there is an increase in the chromatophore number. A further group of melanophores has developed behind each otic vesicle.

Sixth day (Fig. 2, No. 8). The heart beats slowly and faintly but no blood flow is visible except very close to the heart. The pericardial cavity has not yet expanded and the heart is embedded in the yolk directly beneath the head. The chorioid fissure has not closed. Each auditory placode appears as a double ringed structure. Four pairs of chromatophore groups are present, with one group anterior and another posterior to each eye, one behind each auditory placode and one two-thirds back along the body of the embryo. The melanophores in these groups form a diffuse network making accurate counting impossible. The tail bud is still attached firmly to the yolk surface.

Seventh day. The heart beats regularly and strongly, and blood flows through the main vessels and across the yolk tributaries. The heart lies deep within the pericardial cavity slightly forward of the head. The sinus venosus is the only clearly visible chamber. The oil globules are reduced further (to 5-10), and all pigment spheres deep in the yolk have dispersed. The anterior myomeres are chevron shaped.

Eighth day. The yolk is dense and granular. The embryo alters position about once every minute.

Eleventh day (Fig. 2, No. 9). Pigmentation has appeared in the chorioid of the eye and the chorioid fissure has closed. The eyes have shifted laterally broadening the head and bringing the otic vesicles closer to the eyes. Several stellate melanophores are scattered above the brain and along the mid-ventral and mid-lateral aspects of the body and tail. The tail overlaps the head and the rudimentary pectoral buds are present.

Thirteenth day (Fig. 2, No. 10). Three otoliths lie within each otic vesicle. The chorioid pigment is darker although with transmitted light the lenses are still visible. Individual melanophores throughout the embryo are generally larger, although the size varies according to changes in light intensity. The melanophore clusters that were located two thirds back along the body have dispersed. Fewer pigment spots are present on the yolk surface. There is a large melanophore in the upper peritoneum slightly forward of the anus and 8 smaller ones above the gut in the region of the pectoral fins. The tail is long and passes over the head and returns to lie parallel with the body. Narrow fin folds are visible.

Sevententh day (Fig. 2, No. 11). The head is lifted slightly from the yolk, exposing the chambers of the heart and the poorly developed lower jaw. The lenses are no longer visible through the eye pigmentation. The gallbladder is visible in the mid-gut region. Two to 8 oil globules are present within the yolk.

Twentieth day. The external nares appear as two shallow depressions anterior to the telencephalon. A row of 9-10 stellate melanophores runs along the mid-ventral line past the vent. Fin folds and pectoral fin buds are well developed.

Twenty-second day (Fig. 2, No. 12). The yolk is reduced considerably and the ventral side of the embryo faces upwards. Numerous iridiophores are present in the chorioid of the eye. A considerable reduction in the amount of pigment present around the brain, above

the gut and in the lateral mid-line of the tail has taken place. Two to 3 chromatophores lie on the yolk surface. The mouth, external nares and pectoral fins are well defined. The embryo twists violently before hatching. The tail is flexed rapidly, as a result of which the chorion is ruptured and the prolarva is released. Immediately following this release the prolarva swims to the surface.

Prolarva (Fig. 3, Nos. 1 and 2). Prolarval length on hatching ranges from 5.70mm-6.10mm s.l. All melanophores about the brain have faded. As with *T. capito* the size of the yolk sac varies according to the degree of premature hatching. Three to 4 oil globules are present in the yolk. The upper gut peritoneum has two large melanophores, one slightly behind the yolk and the other slightly anterior to the anus. The yolk is bordered anteriorly by the heart and posteriorly by the liver and the prominent gallbladder. From 5-15 stellate melanophores are present along the ventral mid-line behind the anus and from 2-4 are situated along the dorsal mid-line of the tail. One or two melanophores lie beneath the pectoral fins on either side of the yolk. The prolarvae are positively phototropic.

The average measurements of 25 prolarvae of each species are as follows:

	T capito	*T. robustum*
Standard length (mm)	4.90	5.95
Total length (mm)	5.17	6.20
Head length (mm)	0.76	0.84
Eye length (mm)	0.33	0.37
Snout to anus (mm)	1.90	2.50
Mid-ventral melanophores	21 (16-26)	7 (5-15)
Mid-dorsal melanophores	2 (2-5)	2 (2-4)
Lateral yolk melanophores	2	1 (1-2)

ACKNOWLEDGEMENT

I should like to thank Dr P. H. J. Castle, Department of Zoology, Victoria University of Wellington, for his constructive criticism of this paper.

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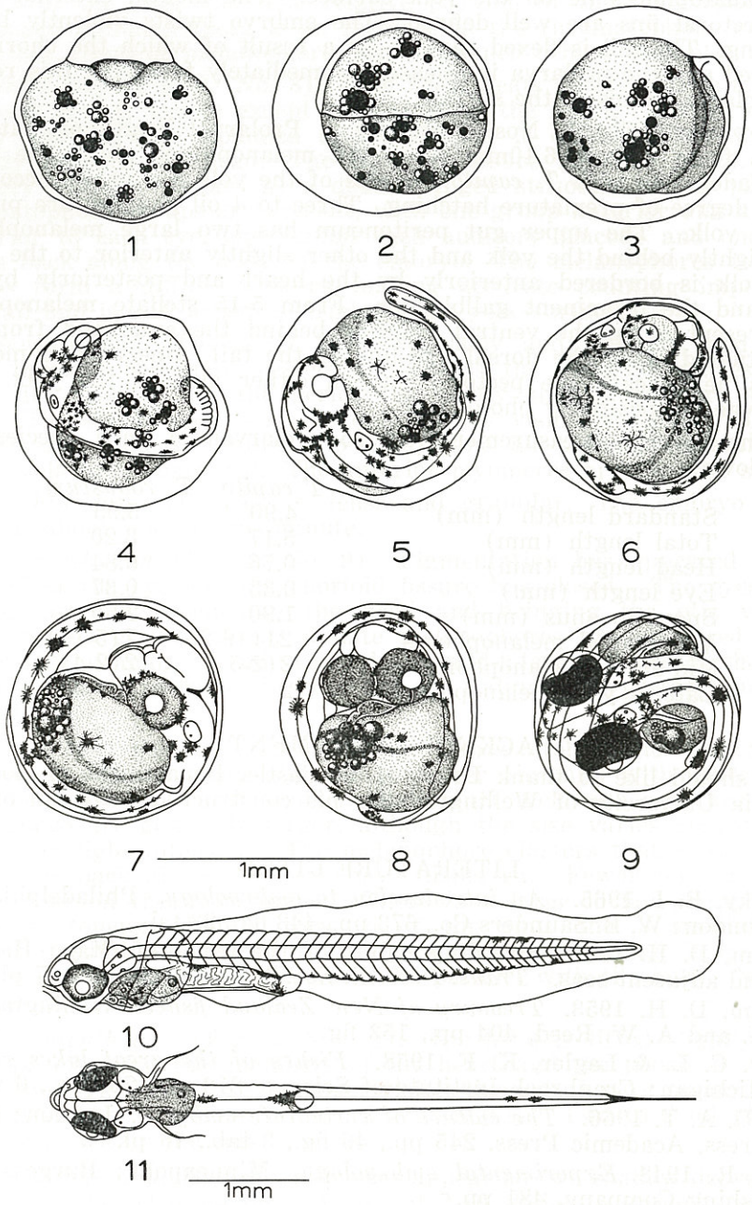

Fig. 1. *Tripterygion capito*. No. 1:30 hours; 2:2nd day; 3:3rd day; 4:5th day; 5:6th day; 6:8th day; 7:10th day; 8:12th day; 9:14th day; 10 and 11:prolarva, 4.51mm s.l.

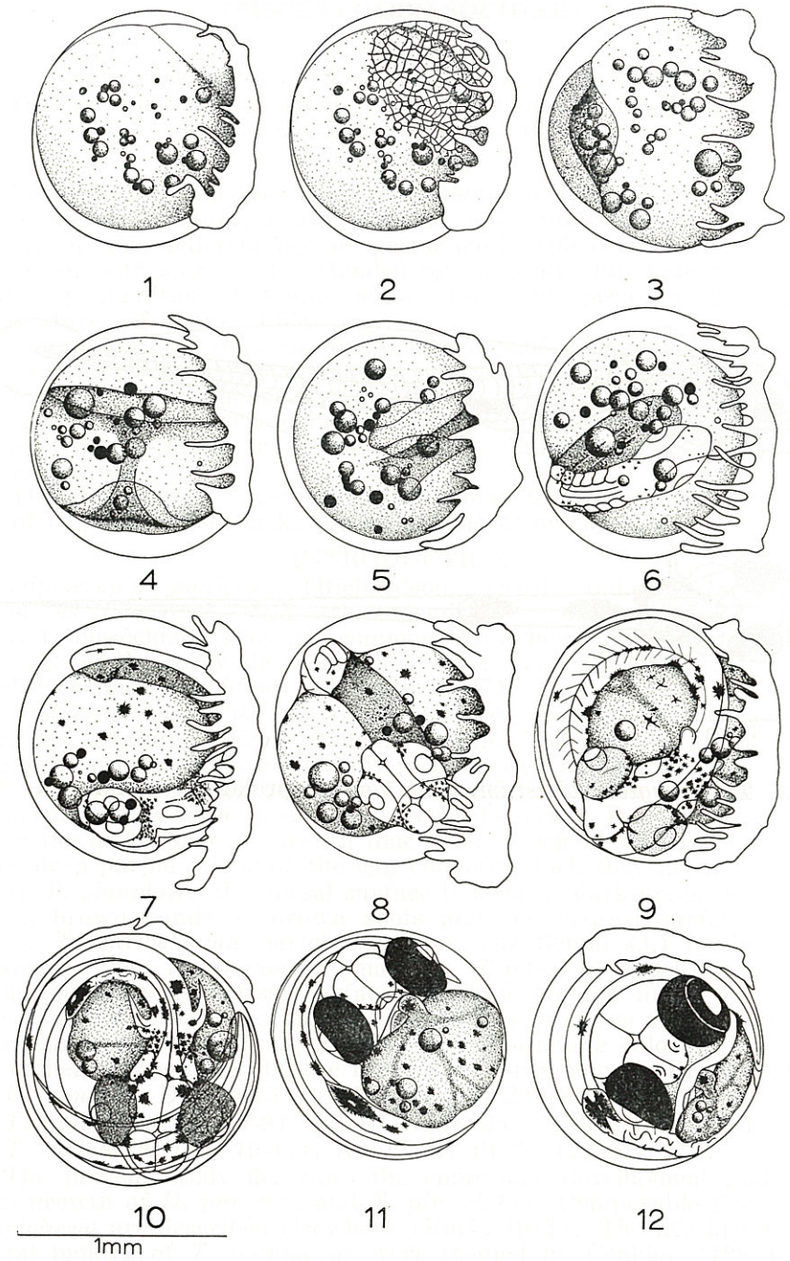

Fig. 2. *Tripterygion robustum*. *No.* 1:2 hours; 2:15 hours; 3:30 hours; 4:50 hours; 5:68 hours; 6:4th day; 7:5th day; 8:6th day; 9:11th day; 10:13th day; 11:17th day; 12:22nd day.

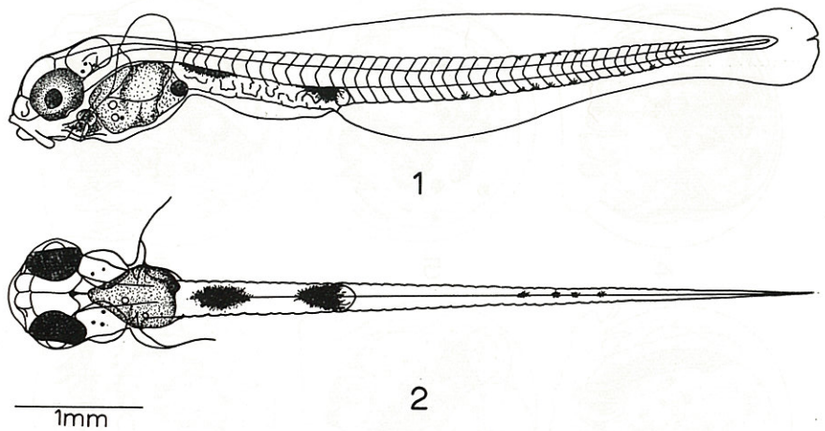

Fig. 3. *Tripterygion robustum*. No. 1 and 2:prolarva, 6.00mm s.l.

DEVELOPMENT OF THE CLINGFISHES, *DIPLOCREPIS PUNICEUS* AND *TRACHELOCHISMUS PINNULATUS* (PISCES : GOBIESOCIDAE)

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No. 64, issued August, 1973.

ABSTRACT

In the Wellington area eggs of *D. puniceus* (Richardson, 1846) and *T. pinnulatus* (Forster, 1801) are laid from mid-winter to spring, in clusters on the undersurface of permanently tide-covered stones. Egg clusters of both species are attended by an adult until hatching. Under laboratory conditions hatching occurs for each species at 24 days in temperatures of about 11.5°C.

The prolarva of *D. puniceus* is 5.00mm - 6.05mm standard length and has a prominent pale mauve yolk sac with a single large oil globule. The upper parietal peritoneum and the lower hind-brain are covered with conspicuous, stellate melanophores. Numerous melanophores are present on the myomeres of the trunk and peduncle. Caudal rays begin to develop by the 15th day.

The prolarva of *T. pinnulatus* (5.35mm - 6.10mm s.l.) is similar to that of *D. puniceus* but lacks the melanophores on the myomeres.

INTRODUCTION

Diplocrepis puniceus (Richardson, 1846) and *Trachelochismus pinnulatus* (Forster, 1801) are endemic New Zealand species of the family Gobiesocidae. They are common throughout the mid-tide and low tide levels of the rocky shore around New Zealand as is also the clingfish *Trachelochismus melobesia* (Phillipps, 1927).

Diplocrepis puniceus is a relatively large clingfish with conspicuous coloration, attaining 100mm standard length. The patterns and intensity of its body colour vary considerably in both male and female. In general, however, the dorsal surface is mottled with light and dark shades of green, contrasting with a pale yellow ventral surface. During the breeding season the males have an overall lilac tinge which is possibly a response to the deep purple colour of the egg clusters which they attend.

In *T. pinnulatus* the dorsal surface is light or dark green with longitudinal brown bands or brown spots and the ventral surface is pale yellow. *Trachelochismus melobesia* (max. size 30mm s.l.) is similar to, but smaller than *T. pinnulatus* (max. size 72mm s.l.) and has a reddish-purple patch on the dorsal surface, which is lacking in *T. pinnulatus*. *Diplocrepis puniceus* is distinguished from *T. pinnulatus* and *T. melobesia* by its large horse-shoe shaped head and distinctive colour. The three are further distinguished by the following fin-ray counts (Briggs, 1955) :

D. puniceus D11 (10-11), A5 (4-5), PI 23 (23-24), C10.
T. pinnulatus D8 (7-9), A6 (5-7), PI 25 (24-26), C12 (11-12).
T. melobesia D10 (9-11), A8 (7-8), PI 23 (22-24), C12.

The present study describes the embryonic development and early larval growth of *D. puniceus* and *T. pinnulatus*. Comparable features of *T. melobesia* are described elsewhere (Ruck, 1971). The life history and general biology of *T. pinnulatus* were studied by Coakley (1964), and Graham (1939, 1953) has briefly described the egg and prolarval stages of *D. puniceus*.

Publication of this paper is assisted by a grant from the Victoria University of Wellington Publications Fund.

MATERIALS AND METHODS

On 21.7.70 an egg mass of *D. puniceus* (identification from description by Graham, 1939) was collected from the western shore of Lyall Bay on the north coast of Cook Strait. This was kept in a rectangular plastic container (30 x 28 x 13cm) at the Island Bay Marine Laboratory. The water was changed daily and kept constantly aerated.

On hatching, prolarvae of *D. puniceus* were transferred to plastic containers (12 x 15cm) which had been sterilized by exposure to ultraviolet light. The water in each container was replaced daily with filtered and sterilized seawater. No artificial aeration was provided. *Artemia* ("brine shrimp") nauplii were fed to the larvae as soon as most of the yolk sac had been absorbed. The last larva died on the 15th day after hatching. During the 15 days several larvae were anaesthetised with Sandoz MS 222 and sketches were made.

Larvae of *D. puniceus* larger than 5.5mm were also obtained from the plankton approximately 100m off-shore at Island Bay and Lyall Bay, using a plankton net of standard conical design with a 57cm diameter opening and a mesh size of 500 microns.

Early in July, 1970, 10 adult *T. pinnulatus* were collected from the western shore of Lyall Bay, and kept in a glass aquarium (60 x 40 x 25 cm). Stones, broken clay piping and empty *Haliotis* (paua) shells were placed in the aquarium to provide shelter and areas on which to spawn. The tank was supplied with fresh running seawater and fish were fed chopped fish and beef liver. On 28.7.70 freshly deposited eggs were found on the undersurface of a portion of the clay pipe. These eggs were attended by a male *T. pinnulatus* (61mm s.l.) which, along with the egg mass, was transferred to a plastic container (30 x 28 x 13cm). The water was changed daily and supplied continuously with air.

The egg masses of both species adhered closely to the substrate and hence eggs required for observation were very difficult to remove without damage to the egg membrane. Limited success was obtained by sliding a sharp scalpel between the egg and the substrate and then pipetting the dislodged egg into a petri dish. Development of the eggs of *D. puniceus* and *T. pinnulatus* were studied and sketches of the eggs and larvae were made with a camera lucida. An ocular micrometer was used for measuring eggs and larvae. Measurements of the larvae are those recommended by Hubbs and Lagler (1958:24-26), with the exception of head length, taken here as the distance from the snout to the posterior margin of the otic capsule. In the prolarva the otic capsule provides a more positive point of reference than the operculum. Descriptive terminology of eggs and prolarvae follows that used by Rugh (1948), Balinsky (1965) and New (1966).

SPAWNING AND DEVELOPMENT OF *D. PUNICEUS*

In the Lyall Bay area *D. puniceus* spawns from early July to late September. The eggs are deposited on the undersurfaces of large stones and are in close contact, forming flat irregularly shaped egg masses which remain covered with water at low tide. Typically the egg masses are relatively large; one kept in the laboratory measured 13 x 5cm and contained approximately 2,400 eggs. Each egg mass contains sub-groups, each with up to 300 eggs, which differ slightly in colour, ranging from deep purple to pale mauve. The deep purple eggs appear crimson when viewed under the binocular microscope. The variation in colour between sub-groups is mainly a result of the progressive depletion of the yolk

supply in the eggs of each sub-group as development advances. This suggests that the eggs of adjacent sub-groups within the same mass are deposited at different times. The pale and small-yolked eggs, which show well-developed eyes, are the most advanced in development and are found mainly in the centre of the egg mass. In some sub-groups, however, the well-developed eggs retain deep purple yolks.

The male collected with the egg mass from Lyall Bay remained with the eggs constantly. It did not eat food offered. It swam backwards and forwards across the eggs, maintaining a constant flow of water over the egg mass. This helped to remove detritus from the egg membranes, and made observation of the embryo through the chorion relatively easy. By comparison the chorion of eggs kept separate from the male soon became covered in foreign particles to such a degree that the embryo and yolk within were very difficult to see.

DEVELOPMENT OF THE EGG AND LARVAE

Most of the eggs within the clusters are laid so close together that they impinge on each other and so deform the chorion (Fig. 1, No. 1). The consequent irregularities in the shape of most eggs make accurate measurement of the egg diameter difficult.

Eggs that make no contact with their neighbours, however, are spherical when viewed dorsally, and have a mean diameter of 1.80mm. The yolk is sub-spherical and in a standard sample of 100 eggs has a mean diameter of 1.30mm. During early development the yolk is dark purple and contains a single large oil globule (mean diameter 0.45mm) and 20-30 smaller ones. The eggs are dorso-ventrally depressed and are attached to the substrate by a flattened adhesive base.

Development to hatching (Fig. 1, Nos. 1-12) takes 24 days at 11.5°C. No eggs were found earlier than the gastrulation stage, and these were estimated to be nearly two days old.

Second day (Fig. 1, No. 1). At this stage the blastodisc has spread halfway around the yolk. Epiboly is not obvious, except for a slight thickening of the germ ring.

Third day (Fig. 1, Nos. 2 & 3). The embryonic shield is well defined and lies deeply notched into the yolk. The blastodisc continues to expand over the yolk, covering about two-thirds of the yolk surface. Separated eggs retain the ring-like shallow depressions that were produced by contact with other eggs.

Fourth day (Fig. 1, No. 4). The blastodisc is reduced to a small opening through which the yolk bulges. The neural keel (future central nervous system) is well defined, encircling almost half of the yolk. The optic vesicles are present but rudimentary.

Fifth day. The three main divisions of the brain are distinguishable. The closing of the blastopore is complete. Three to four myomere blocks are present on either side of the neural keel.

Sixth day (Fig. 1, No. 5). The embryo has increased in length and is well defined. The optic cups can be seen surrounding the spherical lens tissue. Approximately 13 pairs of myomeres are present, arising posterior to the faint outlines of the auditory placodes. Kupffer's vesicle is present as two small sacs beneath the tail bud.

Seventh day (Fig. 1, No. 6). The lobes of the brain are well defined and from the dorsal aspect the ventricles of the prosencephalon, mesencephalon and the rhombencephalon are conspicuous. Each ventricle is covered by a thin roof. The optic cups enclose the lenses but as yet the chorioid fissure has not closed. The anterior myomeres are chevron-shaped, and the tail bud has begun to lift clear of the yolk.

Ninth day (Fig. 1, Nos. 7 & 8). There is a distinct pericardial cavity beneath, and extending forward of, the head. The heart beats faintly, but there is no visible circulation, and the crimson-purple of the yolk obscures any sign of blood-island formation. The head is expanded laterally, and the brain ventricles, especially that of the mesencephalon, are relatively large. Pigmentation of the chorioid of the eye has begun. The gut is tubular, and there are scattered, stellate melanophores in the trunk muscle directly above it.

Eleventh day (Fig. 1, No. 9). The heart beats regularly and strongly, and a flow of blood through the dorsal and ventral blood vessels is obvious. The sinus venosus is pronounced, lying within the pericardial cavity slightly forward of the head, and receiving blood from the large vitelline vessels. The chorioid fissure has closed completely and appears as a faint white line on the ventral aspect of the eye. Chorioid pigmentation has increased. The brain lobes are more rounded and two otoliths are present in each otic vesicle. The tail bud is less rounded and extends well clear of the yolk, and the upper parietal peritoneum is covered by scattered melanophores. A single large oil globule is present in the yolk.

Fourteenth day (Fig. 1, No. 10). The head is broad and has lifted from the yolk, exposing the chambers of the heart and the rudimentary lower jaw. The eyes are prominent and the lenses can still be seen through the chorioid pigment. Pectoral fin buds are present and the tail is turned to lie parallel with the body.

Sixteenth day (Fig. 1, No. 11). The external olfactory pits appear as shallow depressions anterior to the telencephalon. The tail overlaps the head and there is an increase in the peritoneal and segmental pigmentation. The peritoneal melanophores extend forward beneath the myelencephalon. The embryo changes position frequently.

Twenty-fourth day (Fig. 1, No. 12). The yolk is reduced considerably and the ventral aspect of the embryo faces upwards. Pigmentation of the eye appears complete with many small iridiophores present. The embryo is cramped within the chorion and the tail completely overlaps the head and turns on itself. The mouth, olfactory bulbs and pectoral fins are well formed. The gut is large and convoluted. The liver lies posterior to the yolk and contains a green spherical gallbladder. Just prior to hatching the embryo becomes agitated and the tail begins to flex. As a result, the chorion is ruptured and the prolarva is released.

Prolarva (Fig. 2, Nos. 1 & 2). Prolarval length on hatching ranges from 5.00mm - 6.05mm s.l. There is considerable variation in the amount of yolk present in each prolarva immediately after hatching. Large amounts of yolk in some prolarvae may be accounted for by premature hatching, induced by disturbance. The yolk contains a single reduced oil globule. The heart is prominent and lies on the anterior yolk margin. The gut is long and convoluted and extends beyond the mid-length of the body. Numerous melanophores (30-50) are present on the myomeres

of the body and tail, the first of which is placed behind the pectoral fin base; this series extends to the fifth myomere past the vent. Occasional specimens have as few as 6 melanophores on the myomeres. A yellow tinge is present deep in the muscle tissue directly beneath the melanophores of the body and tail. Numerous melanophores line the upper parietal peritoneum. The head is broad and blunt, and there are two clusters of stellate melanophores beneath the myelencephalon. The prolarvae are positively phototropic.

Eight day larva (Fig. 2, Nos. 3 & 4). 6.20mm s.l. The yolk is almost completely absorbed and the oil globule is very small. Pigmentation is unaltered except for the development of several melanophores at the base of each pectoral fin. A yellow tinge surrounds the base of the brain, particularly the myelencephalon, and extends posteriorly within the myomeres above the gut.

Fifteenth day larva (Fig. 2, Nos. 5 & 6). 7.70mm s.l. The overall shape of the larva has altered slightly. There is an increase in the depth of the tail and the relative size of the gut. The pigment pattern is unchanged. Sucker buds are visible at the base of the pectoral fin. Myomeres have the double chevron pattern and the notochord is slightly upturned in the tail. Six rudimentary caudal rays are present. Larval and prolarval measurements in millimetres are as follows:

	Prolarvae	10 days	15 days
Number of Fish	25	25	1
Total length (mm)	5.67 (5.40-6.60)	7.12 (6.95-7.30)	7.90
Standard length (mm)	5.28 (5.00-6.05)	6.70 (6.55-6.90)	7.70
Head length (mm)	1.10 (1.00-1.15)	1.30 (1.25-1.40)	1.70
Eye length (mm)	0.52 (0.50-0.54)	0.54 (0.51-0.56)	0.65
Snout to vent (mm)	3.32 (3.20-3.51)	4.41 (4.15-4.55)	5.00
Greatest depth (mm)	1.15 (1.00-1.21)	1.02 (0.90-1.10)	1.35

SPAWNING AND DEVELOPMENT OF *T. PINNULATUS*

In the Lyall Bay area *T. pinnulatus* begins spawning early in July and continues through to mid-October. South of Cook Strait spawning occurs later. Along the Canterbury coast north of Christchurch the "Earliest records of spawning in the field were made late in August in both 1962 and 1963" (Coakley 1964). Egg masses are found beneath large and small stones, *Haliotis* shells and other debris which offer secure shelter and remain covered with water at low tide. The egg mass from which this description is made was small (4 x 1.5cm) and contained 198 eggs. Typically, however, egg masses are large (up to 10 x 7cm) and contain as many as 1500 eggs. Coakley (1964) observed that the earliest spent females were the largest, indicating that the larger fish spawn early in the season.

The eggs are laid close together forming flat, irregular-shaped masses. The larger egg clusters always contain groups of eggs which differ appreciably in colour, that is white, orange, pale pink, crimson-red, or pale yellow. There is little intergrading of these colours. Egg sub-groups differing in colour in this way may be at similar stages of development. The variation in colour, unlike that of *D. puniceus*, does not represent the progressive depletion of the yolk supply in the eggs as development advances, although as time proceeds there is a paling of

the colour of each sub-group. It suggests, rather, that the different coloured sub-groups are laid on the same substrate by different females, and that the variation in yolk colour is due to some biochemical difference between each contributing female.

The male *T. pinnulatus* found with the eggs in the aquarium remained close to them even when alternative shelter was provided. It lay over the eggs, fanning the pectoral and caudal fins, thus maintaining a constant flow of water over the surface of the egg cluster. This current again helped to prevent the accumulation of detritus on the egg membrane. Well over 90% of the egg masses observed on the shore had an adult *T. pinnulatus* in attendance. Coakley (1964) showed, by dissection, that the majority of adults found close to the egg clusters were males, but only one attendant adult was sexed in the present study.

DEVELOPMENT OF THE EGG AND PROLARVA

The eggs are oval (mean dimensions of a standard sample of 100 are 1.81 x 1.48mm), dorsoventrally depressed and attached to the substrate by a flattened adhesive base. At an early stage of development the yolk is central and subspherical and has a mean diameter of 1.30mm. Development to hatching (Fig. 3, Nos. 1-11) takes 24 days at 11.5°C. No eggs were found earlier than the gastrulation stage, and these were estimated to be approximately two days old.

Second day (Fig. 3, No. 1). The blastodisc has spread half way around the yolk. Epiboly is not obvious. There are six main oil globules and about 150 smaller ones present in the yolk.

Third day (Fig. 3, No. 2). The blastodisc continues to expand over the yolk, covering about two-thirds of the yolk surface. The embryonic shield is present as a thickened strip of the blastodisc.

Fourth day. The blastopore is reduced to a small opening bordered by the thickened germ ring. The narrow embryonic shield lies notched into the yolk. Many of the small oil globules have coalesced to form large globules.

Fifth day (Fig. 3, No. 3). The closing of the blastopore is complete. The optic vesicles are present but rudimentary. The embryo is still deeply notched into the yolk, particularly in the head region, and the tail is flat.

Seventh day (Fig. 3, No. 4). The embryo has increased in length, encircling more than half of the yolk. There is a distinct pericardial cavity anterior to the head. The three main divisions of the brain are distinguishable. The lens tissue is separate from the ectoderm. Approximately 11 pairs of myomeres are present, arising posterior to the faint outlines of the auditory placodes. Kupffer's vesicle lies beneath the developing tail bud.

Eighth day (Fig. 3, Nos. 5 & 6). The brain, from the dorsal aspect, shows clearly defined ventricles, each covered by a thin roof. The optic cups surround the spherical lens tissue, and the chorioid fissure has not yet closed. The anterior myomeres are chevron-shaped, and the tail bud begins to lift clear of the yolk.

Tenth day (Fig. 3, No. 7). The heartbeat is regular, sending blood slowly through the major blood vessels. The head has expanded laterally, and the brain ventricles, especially that of mesencephalon, have increased in size. The chorioid is slightly pigmented and the fissure has closed. Two small otoliths are present in each round otic vesicle. The gut is thin and tubular.

Fourteenth day. The head is broad and has lifted from the yolk, exposing the chambers of the heart and the developing lower jaw. The sinus venosus is a thin expanded sac lying within the pericardial cavity forward of the head, and receiving blood from the large vitelline vessels. The brain lobes are rounded and larger. The chorioid fissure appears as a faint white line on the ventral aspect of the eye. The eyes are prominent and the lenses can still be seen through the chorioid pigment. The upper parietal peritoneum has scattered melanophores. Pectoral fin buds are present and the tail has turned to lie parallel with the head and trunk. A single large oil globule and ten smaller ones are present in the yolk.

Sixteenth day (Fig. 3, No. 8). Very little change has taken place, except that the jaws appear more definite and slightly fleshy.

Twentieth day (Fig. 3, Nos. 9 & 10). The olfactory pits appear as shallow depressions anterior to the telencephalon. The tail overlaps the head and there is an increase in the number of peritoneal melanophores. The embryo alters position frequently. A single large oil globule remains in the yolk.

Twenty-fourth day (Fig. 3, No. 11). The yolk is reduced considerably and the ventral aspect of the embryo faces upwards. Pigmentation of the chorioid appears complete, the silvery appearance of the eye being due to the presence of iridiophores. The embryo is cramped within the egg and the tail completely overlaps the head and turns on itself. The mouth, olfactory bulbs and pectoral fins are well formed. The gut is long and convoluted. The liver and the green spherical gallbladder lie behind the yolk. The upper peritoneal pigment is arranged approximately as two rows of 10 large stellate melanophores, extending from above the liver to the vent. In some individuals two rows of 3-4 stellate melanophores are present on the lower parietal peritoneum extending back from the yolk. Just prior to hatching the embryo becomes active and begins to flex its tail. As a result, the chorion is ruptured and the prolarva is released.

Prolarva (Fig. 4, Nos. 1 and 2). Prolarval length on hatching ranges from 5.35mm - 6.10mm. Like *D. puniceus* there was some variation in the amount of yolk present in each prolarva immediately after hatching. The yolk contains a single reduced oil globule, and the heart lies on the anterior margin of the yolk sac. The gut is long and convoluted and extends past the mid-length of the body. Upper peritoneal pigmentation is scattered and extends from above the liver to the vent. Some individuals retain the lower peritoneal pigmentation. A yellow tinge lies within the muscles directly above the peritoneal pigment, and extends beneath the otic capsules and the hind-brain. Two stellate melanophores are present beneath each pectoral fins, but no pigment is present on the head.

The measurements of prolarvae are as follows:

Number of fish	23
Standard length (mm)	5.70 (5.35-6.10)
Head length (mm)	1.04 (0.95-1.10)
Eye length (mm)	0.43 (0.40-0.45)
Snout to vent (mm)	3.43 (3.20-3.60)
Greatest depth (mm)	1.02 (0.80-1.20)

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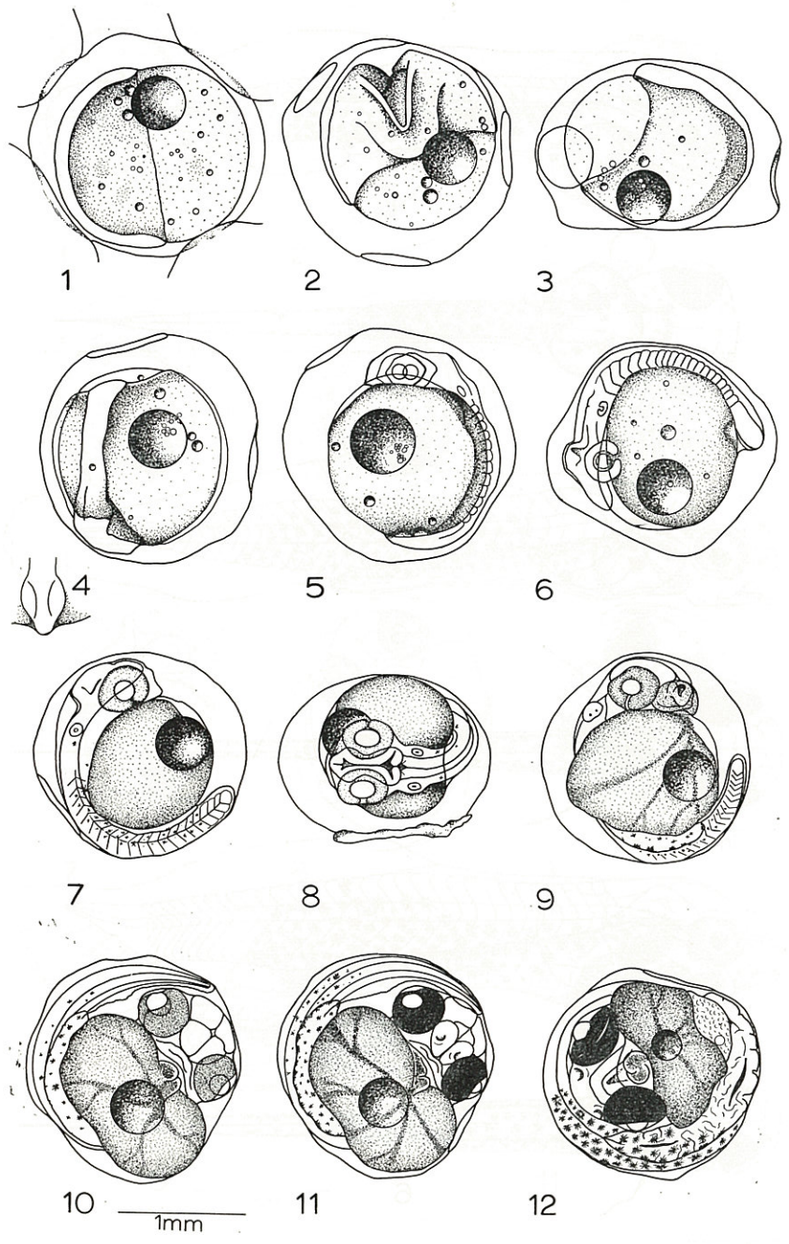

Fig. 1. *Diplocrepis puniceus.* No. 1:2nd day; 2 & 3:3rd day; 4:4th day; 5:6th day; 6:7th day; 7 & 8:9th day; 9:11th day; 10:14th day; 11:16th day; 12:24th day.

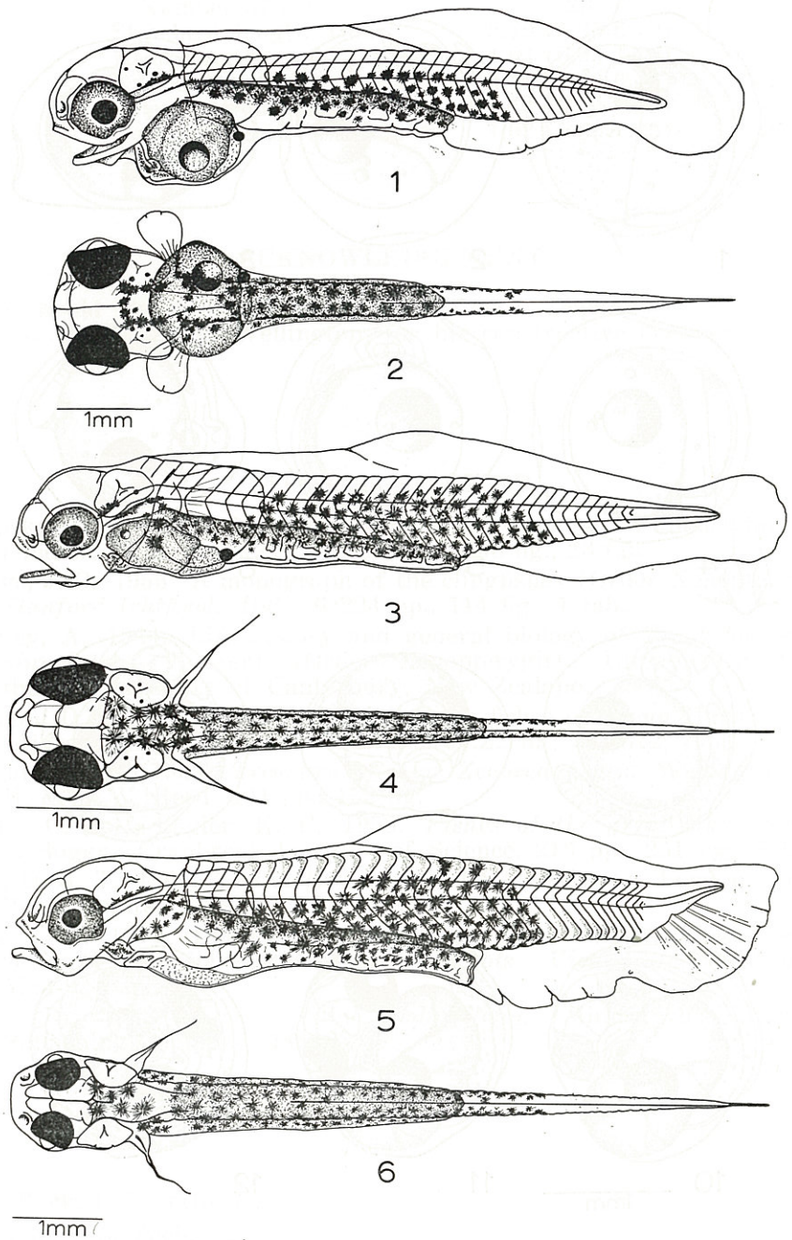

Fig. 2. *Diplocrepis puniceus*. Nos. 1 & 2: prolarva, 6.05mm s.l.; 3 & 4:8 day old larva, 6.20mm s.l.; 5 & 6: 15 day old larva, 7.70mm s.l.

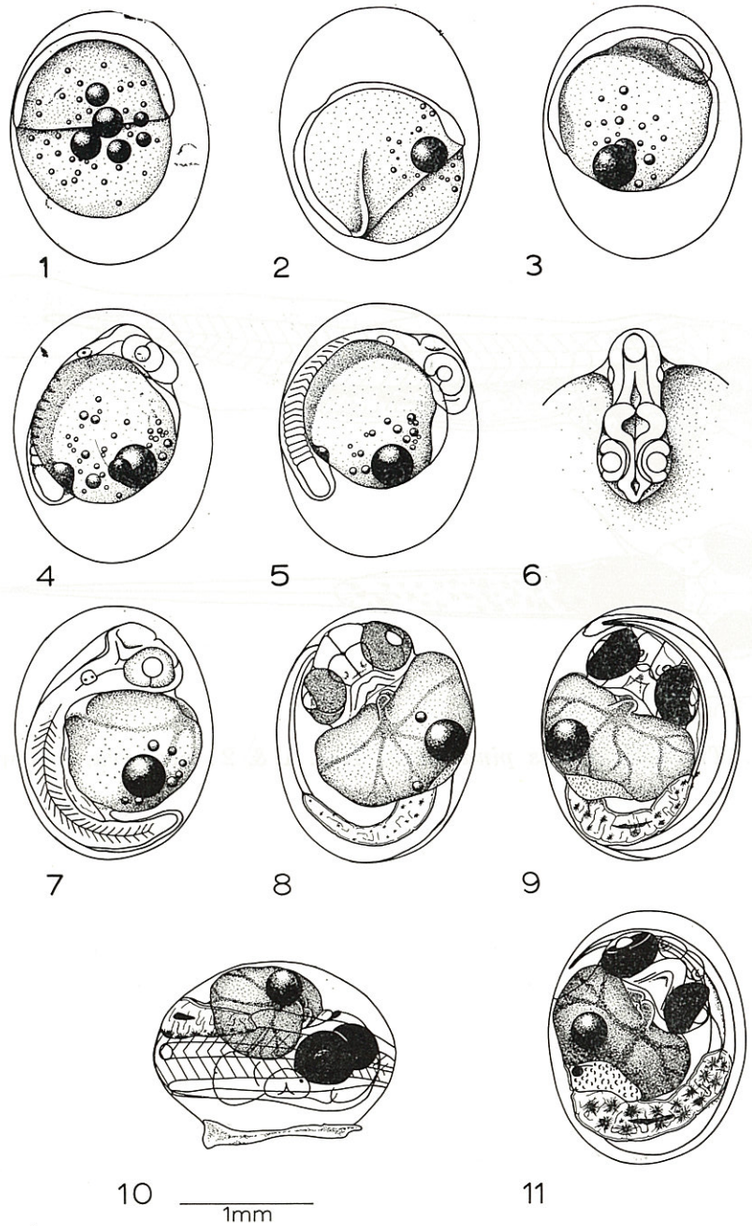

Fig. 3 *Trachelochismus pinnulatus*. No. 1:2nd day; 2:3rd day; 3:5th day; 4:7th day; 5 & 6:8th day; 7:10th day; 8:16th day; 9 & 10:20th day; 11:24th day.

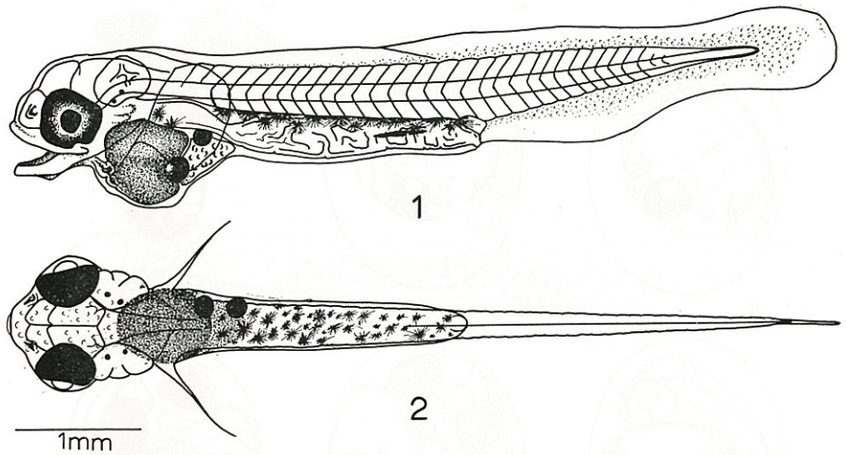

Fig. 4. *Trachelochismus pinnulatus*. Nos. 1 & 2: prolarva, 6.00mm s.l.