Japanese Journal of Ichthyology
Vol. 15, No. 3, February 25, 1969

魚 類 学 雑 誌
15巻3号1969年2月25日

Systematics and Biology of the Two Species of Embiotocid Fishes Referred to the Genus *Ditrema* in Japan

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Abstract The species referred to the genus *Ditrema* has received a confusing treatment on their forms and nomenclature here and abroad. Recently Yamane (1964) recognized *D. temmincki* Bleeker and *D. viridis* Oshima, and further, divided the former into two forms by the differences of coloration. The present study, based on the specimens of *Ditrema* collected at Hashirimizu, Miura Peninsula, Kanagawa Pref., has been started in 1963 and continued to the present in a hope to clarify the status of its taxonomy and features of life history, and recognized two species, *D. temmincki* and *D. viridis*. However, the former was found not to be divided into different races, forms, or any other systematic groups within the species *D. temmincki*. The most significant differences found on the life history between the two species were those of number of embryos and its size at birth. The average number of embryos carried by a female was 13.02 for *D. temmincki* and 29.65 for *D. viridis*, the differences being nearly twice in every ages of females between the two species. The averaged size of embryos at birth was 57.4 mm long in total length for *D. temmincki* and 49.6 mm long for *D. viridis*, and the size gap, regardless size or age of mother fishes considered to be 7–8 mm at least. Such size differences at birth was also evidenced by the number of ridges formed on the scales during prenatal growth. The distribution of both species, investigated by means of nation wide census, is almost overlapped throughout Japan from southern Hokkaido to Kyushu. The preferred habitat taken by the two species was found to be different between them at Hashirimizu; *D. viridis* lives in shore waters characterized by *Zostera* vegetation in the bay or inlet, while, usual habitat of *D. temmincki* was found in rocky region of outer sea. Similar difference of habitat by species was also well confirmed by the result of the census in the country.

Contents

Introduction

With Amphi-Pacific or Japan-Californian distribution the viviparous perches in the waters of Japanese Islands are represented by two genera *Neoditrema* and *Ditrema*. These fishes known as "UMI-TANAGO" locally are common game fishes in the coastal waters of the country, and also are commercially important. The genus *Neoditrema* with a single species, *N. ransonneti* Steindachner is clearly distinguishablefrom *Ditrema* by having gill rakers numbering some 25 instead of 15 and other characters. The species referred to the genus *Ditrema*, however, have not been well-defined, and received a confusing treatment on their characters and nomenclature.

The genus *Ditrema* was established by Temminck and Schlegel in 1844, but the species *D. temmincki* was named later by Bleeker (1853) based on specimens from Nagasaki. Jordan and Sindo (1902), collecting specimens from a deep water off Misaki, Kanagawa Pref., identified them *temmincki* and described its life color—coppery red with redder lines on the scale rows. However, Franz (1910), referring to the life color as described by Jordan and sindo (l.c.), proposed *temmincki* var. *jordani* on his specimens taken from Yokohama and Misaki. Later, Jordan, Snyder and Tanaka (1913) elevated var. *jordani* to a specific rank, *jordani* Franz with Japanese name, "Misaki-umitanago".

Hubbs (1918) believed that *D. smithi* Nystrom and *D. jordani* Franz appear to be synonyms of *D. temmincki* Bleeker, and Tarp (1952) held similar opinion as Hubbs (l.c.) by recognizing the one species.

On the other hand, Kamohara (1940) recognized three forms in his specimens of *Ditrema* collected from Misaki, i.e., *D. temmincki* Bleeker (Ma-tanago in Japanese), *D. jordani* (Aka-tanago) and Ao-tanago, of which specific name was withheld though. He commented that Ma-tanago characterized by steel blue color on back is abundant in shallower waters, and Aka-tanago having coppery reddish color and red lateral stripes is common in deeper rocky regions, while Ao-tanago is yellow-green on back and lives mostly near bottom with vegetation. In his review on Japanese surf-fishes Oshima (1955) recognized three species of *Ditrema*, including a new species, *D. viridis*, which is characterized by having yellow-green color and living usually in weedy waters as usual habitat.

In his work on the genus *Ditrema*, which is the most recent study on this group of fish, Yamane (1964) recognized two species, *temmincki* Bleeker and *viridis* Oshima, on the basis of coloration and morphometric characters especially of interorbital width, and further, he described form A (Ma-tanago) and form B (Aka-tanago) as color varieties within the species *D. temmincki*.

The present study, under the realization of unsettled state of affairs involved in the taxonomy of the species in *Ditrema*, has been started in 1963 and continued to the present in a hope to clarify the taxonomic status and features on the life history of the two species. The studies were also made on the observations of the gonad development, and the embryology demonstrated by the species, and habitat preferred by the species. That inclusion of study on fecundity, embryological features and habitat was emphasized and hinted by Hubbs (1921 and 1954) and Tarp (1952) on Californian species, and by Uchida (1938), Ishii (1957) and Mizue (1961 and 1962) on Japanese species (*D. temmincki*). The type of viviparity of *D. viridis*, which was studied here for the first time, was found to be well differentiated from that held by *D. temmincki*.

Acknowledgment

The author is deeply indebted to Dr. Katsuzo Kuronuma, formerly President of the Tokyo University of Fisheries, who rendered encouragement and advices throughout the study and the free use of his library. Mr. S. Miura, a veteran fisherman at Hashirimizu presented the specimens for the free use of the author. Prof. Tomokichi Yoshiwara of the same university gave valuable suggestions on the interpretation of the data. Many aquaria and other fisheries institutions also gave the author valuable informations. To them, the author wishes to record herewith the highest gratitude and thanks. Drs. Reizo Ishiyama and Teruya Uyeno, reading the manuscript, afforded valuable suggestions and comments, and their generous advices are acknowledged.

Materials and methods of study

The majority of specimens studied in the present investigation was collected by a set-net (Masu-ami in Japanese) operated in shallow waters at Hashirimizu, Kanagawa Pref. (Fig. 1), during the years 1963–1967, and on the dates as tabulated in Table 1. Hashirimizu is a small town and located near southeastern tip of Miura Peninsula facing the entrance of the Tokyo Bay from the Pacific Ocean. The sea-bed off Hashirimizu shore water is either sandy with or without *Zostera* or rocky with or without sea-weeds (*Gelidium amansii, Ecklonia cava, Sargassum fulvellum, Undaria pinnatifida, Hijikia fusiforme*, etc.), thus, presenting roughly three types of habitat for fishes and other organisms. The shore is accordingly formed irregularly with alternated development of sandy and rocky beach extending some distance, and formation of a small inlet surrounded by rocky shore.

The Masu-ami set-net is placed in the

Table 1. Date of collection and the number of specimens by sexes of *D. temmincki* and *D. viridis* at Hashirimizu, Kanagawa Prefecture.

Date		*D. temmincki*			*D. viridis*	
	Male	Female	Total	Male	Female	Total
Apr. 20, '63	23	48	71	3	9	12
Apr. 27, '63	11	8	19	1	2	3
May 3, '63	8	3	11	2	4	6
May 28, '63	8	11	19	4	3	7
June 5, '63	7	8	15	0	0	0
July 23, '63	5	5	10	15	18	33
Sept. 15, '63	1	1	2	0	0	0
Oct. 16, '63	7	12	19	2	1	3
Oct. 24, '63	12	5	17	2	0	2
Oct. 28, '63	17	10	27	0	0	0
Nov. 5, '63	0	2	2	4	1	5
Dec. 4, '63	7	5	12	0	2	2
Feb. 1, '64	5	8	13	1	0	1
May 5, '64	0	4	4	0	3	3
May 10, '67	—	—	—	2	0	2
May 17, '67	—	—	—	1	0	1
May 24, '67	—	—	—	0	1	1
June 7, '67	0	4	4	7	10	17
Total.	111	134	245	44	54	98

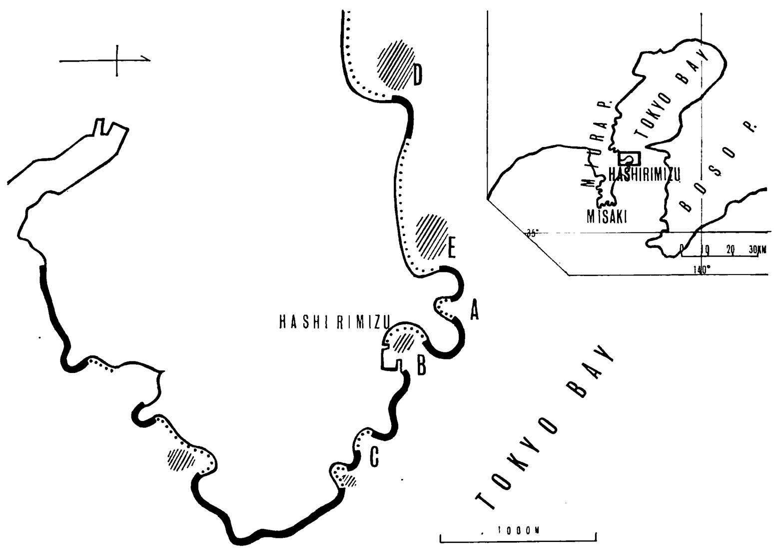

Fig. 1. Ecological feature of the shore at Hashirimizu and adjacent waters, showing rocky (heavy solid lines) and sandy beach (dotted lines), and *Zostrea* vegatation (diagonal hatching). A to E show the stations where the specimens of *Ditrema* used in the present study were collected. Inserted map showsthe location of Hashirimizu on eastern side of Miura Peninsula facing the entrance to Tokyo Bay.

waters about 5 m deep with sandy bottom, operating nearly throughout a year with exception of July and August. Various fishes, such as *Plotosus anguillaris, Trachurus japonicus, Lateolabrax japonicus, Mylio macrocephalus, Girella punctata, Oplegnathus fasciatus, Neoditrema ransonneti, Sebastes inermis, Sphoeroides niphobles* and others, are usually found in the net.

The collection by the set-net was made at stations A, B and C (Fig. 1), and the study materials of *D. temmincki* were picked up from a haul, approximately proportional to the total catch of the species, but taking the total catch for *D. viridis*. An effort was made in the collection of specimens of *D. temmincki* from the catch so as to make the size of fish unbiased. Those specimens on July 23, 1963 were obtained by a small drag-net operated at station D, where bottom is sandy with moderately broad *Zostera* vegetation (2–3 m deep), and those on June 7, 1967 by a gill-net operated at station E, where bottom is rocky or sandy with narrow *Zostera* vegetation.

The methods of morphometric measurements and meristic counts were made following Hubbs and Lagler (1947) except the depth of body which was measured from the insertion of spiny dorsal to that of pelvic fin. The scales on the lateral line were counted from the first to the last regardless of their location. The scales, used for the reading of ages and other purposes, were taken on the mid-part of body side immediately below the lateral line. The pattern of sensory canals on the head and the number and distribution of external pores associated to the canals, were carefully traced by sending air-blow after staining by Iljin's solution and bleached by oxalic acid and satulated glycerine (Takagi, 1961).

Particular attention was called to the coloration of the specimens in observation and recording. The color notes were made on the field on many living specimens and on those just died; color photographs taken on the specimens proved to be extremely helpful in later studies at the laboratory. Some specimens were taken back to the laboratory and reared in aquaria so as to observe the change of color phases during the period which extended nearly two months. The embryos were dissected out from the preserved fishes for detailed studies, while the life color of the embryos was observed at the field on some specimens.

The scales for reading the age and numbering the scale ridges formed before birth were examined with the shadow projector with magnification of 50 times. The seasonal marks were observed on anterior part of embedded portion of the scales. The number of the scale ridges from the focus to the outermost ridge formed during the embryonic growth was carefully counted on the same part of the scale of each 50 adult specimens of both species, and those of embryos were also counted in the same manner.

The distribution of the two species in the country and neighbouring areas was investigated by means of census. This census was made by return-postcards with colored figures giving the morphological characteristics of two species of *Ditrema*, asking information about the distribution. To avoid the erroneous conclusion the author sent out the postcards to 109 places, including 42 aquaria, 37 fisheries experiment stations, and 30 fisheries high schools, which are located on both sides of Japan, the Sea of Japan and Pacific Ocean, and 81 answers were returned. Uncertain replies were verified again by letters, and those believed unreliable were discarded.

Description and comparison of *D. temmincki* and *D. viridis*

1) External characters

a) Coloration

The coloration of the two species in life, as tabulated below, is the most significant feature in discrimination, and the species were distinguished without much difficulties or confusion, but the life color of the species changes so rapidly after fixation that the identification of the species on the preserved specimens was proved to be extremely difficult.

Coloration of adult:

	D. temmincki	*D. viridis*
Ground color:	Coppery brown or dusky steel blue on back and silver ventrally; coppery red or golden lines on each scale row below lateral line	Dusky olive on back and silver ventrally; dusky olive lines in each scale row below lateral line
Soft dorsal:	Dusky brown or colorless	Dusky olive or colorless
Pectoral:	Pale orange; no black spot on upper edge of the base	Pale yellow or cloroless; a black spot on upper edge of the base
Pelvic:	Black; a black spot on the base of the spine, the spot often obsolete or missing	Black and yellowish at the base; no black spot on the base of the spine
Anal:	Dusky brown or colorless; no black line along the base	Dusky olive or colorless; a black line along the base always present
Preopercle:	A black spot on posterior angle, and with or without a small spot in front	A black spot on posterior angle, and a distinct black spot in front always present
Snout:	Two black bands; the bands rarely obsolete or missing	Dusky; no distinct marking
Lips and throat:	Orange red or uncolored	Uncolored

The colorations listed above were noted to show some range of variation in *D. temmincki*, but not so significantly in *D. viridis*. The coloration, nonetheless, is effective in separating the two species. As aftermentioned, Yamane (1964) stated that there are two forms of *D. temmincki* because of the difference in color, which was emphasized especially in the color of embryo. His form A, identified as Ma-tanago (*D. temmincki*) has violet-red embryo, and embryo of his form B or Aka-tanago (formerly described as *D. jordani*) is orange-red. The same author noted the color of adult of the two forms (p. 5) and concluded stating, "The adult fish of the two forms are not so different in the body color as to separate them in the two significant taxonomic groups.", however, his statement as such is weakened by his another sentence, "... But as already described above, the embryos of the two forms A and B are reddish in the body" (p. 5–6), apparently reducing the significance of marked difference in their embryonic color phases. The morphometric and meristic characters shared by the two forms either for adult fish or embryo (Figs. 1, 4 and 5: Tables 1 and 2) do by no means warrant the clear-cut separation of two forms, as pointed out by the author himself.

Oshima's statement that color difference between Ma-tanago (*temmincki*) and Aka-tanago (*D. jordani*) is "inheritable" is not convincing because of the lack of experiment or any other evidence to endorse the fact.

The present study, with the examination of 245 adult (0 to 4 years) individuals ***indentified*** as *D. temmincki*, showed that some individuals had coppery brown ground color with red stripes and some had dusky steel blue with golden stripes, while others did not fall on either categories of coloration. Furthermore, the ground color of the fish reared in aquaria

Table 2. Measurments in 4 body parts expressed in thousands of standard length, and eye diameter in thousands of head length for *D. temmincki* and *D. viridis*. Figures on top show mathematical mean for given part, middle number of specimens tested and bottom in parenthesis range.

Standard length in mm arranged in 20 mm size group	Pectoral length		Depth of body		Depth of caudal peduncle		Diameter of eye		Caudal length	
	temmincki	*viridis*	*temmincki*	*viridis*	*temmincki*	*viridis*	*temmincki*	*viridis*	*temmincki*	*viridis*
45—64.9	—	213	—	405	—	122	—	334	—	284
	—	29	—	29	—	29	—	29	—	29
	—	(198–229)	—	(396–422)	—	(107–132)	—	(310–368)	—	(261–310)
65—84.9	223	202	431	412	129	124	323	318	273	284
	7	3	7	3	7	3	7	3	7	3
	(218–230)	(191–205)	(419–452)	(400–432)	(124–145)	(123–125)	(313–335)	(309–326)	(257–289)	(271–293)
85—104.9	244	212	411	395	128	125	301	289	297	282
	52	5	52	5	52	5	52	5	52	5
	(225–263)	(183–228)	(389–445)	(384–405)	(116–142)	(114–129)	(273–333)	(273–302)	(268–337)	(252–300)
105—124.9	227	197	407	388	126	119	287	276	276	255
	84	9	84	9	84	9	84	9	84	9
	(203–252)	(177–217)	(378–435)	(355–451)	(115–140)	(106–123)	(247–305)	(225–300)	(235–313)	(228–274)
125—144.9	221	191	407	379	126	118	276	255	269	245
	60	18	60	18	60	18	60	18	60	18
	(196–263)	(179–201)	(374–437)	(352–412)	(116–140)	(90–133)	(247–300)	(231–271)	(227–280)	(220–263)
145—164.9	216	195	412	388	126	120	261	243	266	250
	14	7	14	7	14	7	14	7	14	7
	(200–240)	(183–215)	(387–465)	(360–414)	(114–139)	(109–132)	(242–273)	(229–257)	(217–300)	(231–280)
165—184.9	214	191	408	399	124	119	246	232	253	235
	13	3	13	3	13	3	13	3	13	3
	(197–236)	(175–201)	(385–478)	(374–483)	(116–134)	(114–123)	(230–263)	(222–240)	(231–276)	(224–254)

faded out in a short period of time. It also should be recorded that, as mentioned already, the color rapidly changes after the death of fish.

In the examination of the coloration of embryo, the author did not recognize any particular color phase associated with the color of the adult fish. All these facts seem to point out that the ground color of *D. temmincki* is highly variable and does not warrant the recognition of any races or forms within the species.

b) Morphometric and meristic characters

The morphometric measurements, made on 230 specimens of *D. temmincki* ranging 71 to 194 mm in standard length and on 74 specimens of *D. viridis*, ranging 48 to 182 mm long, all collected at a same locality of Hashirimizu,

Table 3. Variation of meristic counts by sexes in 4 characters in two species of *Ditrema*; figures are shown in the number of specimens counted in parentheses, the number of individuals for respective count, mathematical mean and percentage.

Dorasal spines:		VIII	IX	X	XI	XII	Mean
D. temmincki	Female (119)	0	44	68	7	0	9.689
	Male (111)	1	41	67	1	1	9.640
	Total (230)	1	85	135	8	1	9.665
	%	0.4	37.0	59.1	3.5	0.4	
D. viridis	Female (40)	0	2	30	8	0	10.150
	Male (34)	0	1	23	10	0	10.265
	Total (74)	0	3	53	18	0	10.203
	%	0	4.1	71.6	24.3	0	

Dorsal rays:		19	20	21	22	23	Mean
D. temmincki	Female (119)	1	25	72	19	2	20.966
	Male (111)	1	25	54	26	3	20.666
	Total (230)	2	50	135	45	5	20.817
	%	0.9	21.7	54.8	19.6	2.2	
D. viridis	Female (40)	0	13	23	4	0	20.775
	Male (34)	2	11	18	3	0	20.647
	Total (74)	2	24	41	7	0	20.716
	%	2.7	32.4	55.4	9.4	0	

Anal rays:		24	25	26	27	28	Mean
D. temmincki	Female (119)	3	22	64	30	0	26.017
	Male (111)	3	18	60	27	3	26.081
	Total (230)	6	40	124	57	3	26.048
	%	2.6	17.4	53.9	24.8	1.3	
D. viridis	Female (40)	0	3	9	25	3	26.700
	Male (34)	0	3	13	18	0	26.441
	Total (74)	0	6	22	43	3	26.581
	%	0	8.1	29.7	58.1	4.2	

Lateral line scales:		70	71	72	73	74	75	76	77	78	Mean
D. temmincki	Female (94)	1	5	9	22	26	17	10	3	1	73.904
	Male (83)	2	1	5	20	23	15	12	4	1	74.168
	Total (177)	3	6	14	42	49	32	22	7	2	74.036
	%	1.7	3.4	8.0	23.8	27.7	18.1	12.4	4.0	1.2	
D. viridis	Female (32)	2	3	4	11	6	3	2	0	1	73.219
	Male (25)	2	2	4	7	5	3	1	1	0	73.160
	Total (57)	4	5	8	18	11	6	3	1	1	73.189
	%	7.0	9.3	14.0	31.6	19.3	10.5	5.3	0.2	0.2	

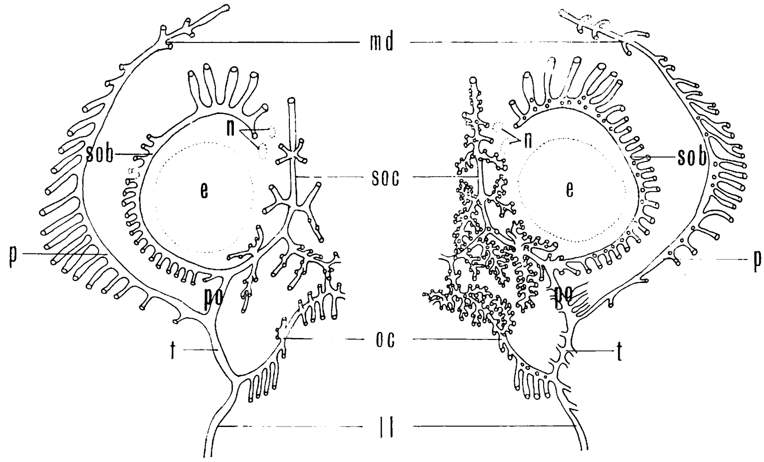

Fig. 2. Diagramatic drawings of sensory pore systəm of *Ditrema viridis* (left) and *D. temmincki*: ll, lateral-line of trunk; md, mandibular canal; p, preopercular canal; oc, occipital canal; po, postorbital canal; sob, suborbital canal; soc, supraorbital canal; t, temporal canal; n, nasal pores; and e, eye. (see text).

are shown in Table 2. Characters in this Table are restricted to those which indicate clearer difference between the two species treated, and results of other measurements which are insignificant in distinguishing species are not included here. The proportional length of each given body part shows quite clearly the changes due to size of fish, which are natural and expected phenomena. These figures, however, show the measurments of these body parts well distinguishable between the two species. In addition to these measurements the clear specific differrence was noted by Yamane (1964) on their interorbital width. Though excluded from Table 2, this difference was also confirmed by the measurements on the skull of both species in the present study.

The numbers of dorsal spines and rays, and anal rays and of scales on lateral line are given in Table 3. Except the number of dorsal spines, these counts do not show any specific difference. The number of dorsal spines appears to show a specific difference in the mean value, i.e., 9.66 for *D. temmincki* vs. 10.20 for *D. viridis*. These characters in the table are not different between the sexes in either species.

The sensory canal system on head was examined for both sexes on 10 preserved specimens ranging 95–147 mm in standard length in *D. temmincki*, and on same number of specimens ranging 125–153 mm in *D. viridis*. The arrangement of the main sensory canals on head is similar in the two species, but the number of external pores opening on the small branched canal was found to show clear-cut difference, especially in those of supraorbital canal, regardless of the size and sexes between the two species (Fig. 2). The other salient distinguishable features are also found, for example, in occipital canal.

The present study as explained above will conclude that the identification of *D. temmincki* and *D. viridis* is made most clearly by the coloration of living specimens observed on the field. Other characters, used conventionally, morphometric and meristic, will be interpreted to account for lesser significance than life color. The author experienced that some records of other workers on the Umi-tanago, lacking full description on color, could not be cited under a definite species. This fact led the omission of the "list of synonymy" in the present paper.

2) Reproduction and associated activities

a) Sex

As noted by Hubbs (1918) the genus *Ditrema* is referred to Embiotocinae, which is characterized by having a lunar depression on the anal base, and prominent, gland-like structure with tubercular intromittent organ which opens anteriorly in front portion of anal fin in the male.

The two sexes in the two species of *Ditrema* as in many other forms in the Family Embiotocidae of Japan and California (Hubbs, 1918; Kamohara, 1940; Tarp, 1952; Breder and Rosen, 1966; and others), are distinguished by having the intromittent organ and associated structure developed on the anal fin of males. Elongated posterior rays of the anal fin characterizes males as noted by Jordan and Sindo (1902) for *Ditrema temmincki* and confirmed by the present author for the same species as well as in *D. viridis*. The structural modification associated with intromittent organ of the male begins to develop in the fish about 70 mm long or longer in standard length for both species. The development of these secondary sexual structures was found to proceed along with the maturation of testis during mating season. Sexually matured males are always fully elaborated on the sexual organ on the anal fin as shown in Fig. 3, but these structures are subject to considerable retrogression into small fleshy portion in other seasons. No morphological differences in the external sexual organ between the species were found in the present observation.

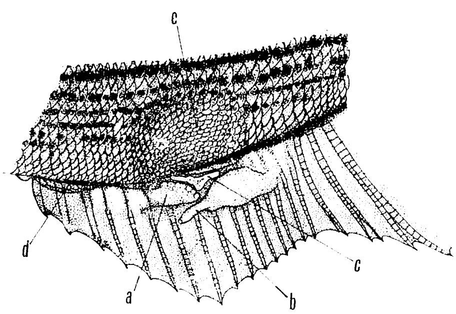

Fig. 3. Sexual structure on anal fin of *D. viridis* 155.5 mm in standard length, collected on November 5, 1967: a, excrecence with wart-like structure at its tip; b, tuber-cular intromittent organ; c, fold; d, grooye from genital opening; and e, lunar depression on anal base.

Although the number as well as the collection dates of the specimens handled in the present study may not be substantial enough to derive confirmative information of the sex ratio in nature in either species, it can be presumed that for both species the females rather dominate over the males, as ounting 134 females vs. 111 males in *D. temmincki*, and 54 vs. 44 in *D. viridis*.

b) Mating season

The extended time of breeding, which characterizes the viviparous surfperches, starts with the copulation and ends in the birth of young. This fact was confirmed on several Californian species by American authors including Eigenman (1894), Hubbs (1921 and 1954) and Tarp (1952), and others.

Japanese species, *D. temmincki*, according to Uchida (1938), Ishii (1957), Mizue (1961 and 1962) and Matsukiyo (1963), begins to copulate in late summer and ends in fall, and birth of the young takes place in the spring of the following year. The fertilization of eggs was seen during winter, thus 6 months elapse from the copulation to the birth of the young.

Although the fate of sperm in the body of females was not traced in the present study, indirect evidence was accumulated to verify the extended period of breeding held by both *D. temmincki* and *D. viridis*. Holding that the activity of copulation guessed by the development of testis which would take acting size, the materials at hand will indicate (App. II) that the copulation would have started already in mid-September and lasted at least to the end of October. Having collected males all in spent in early December and hence, added by the fact noted above, it may reasonably be deduced that *D. temmincki* enters copulatory activity in September lasting perhaps to mid-November, with the peak falling on October. The season of the high activity also coincides with the good catch of the species in the year, which as noted later (p. 117) is claimed also by local fishermen at Hashirimizu. It appears evident that in February to July (and perhaps to August), no male fish, regardless of their age, had functional testis. The age of male fish attaining sexual matulation was found to be O-year to III-year in materials at hand. The materials of *D. viridis* are admittedly insufficient (App. IV), but suggest that the copulatory activity takes place in the months which do not lag that for *D. temmincki*.

c) Birth of the young

For *D. temmincki*, the season of giving birth to the young was noted as May or June by Uchida (1938) at Pusan in Korea, by Ishii (1957) at Misaki in Kanagawa Pref., and by Matsukiyo (1963) at Aio Bay, Yamaguchi Pref., and as April or early May by Mizue, (1961) at Sasebo Bay, Nagasaki Pref.

The specimens collected at Hashirimizu (App. I) show the birth of the young in *D. temmincki* from April to early June. The ages of the mother fishes range from I to IV. There may be a clear indication that the old fish participates the activity earlier than the younger in the season.

In *D. viridis* (App. III) there is an indication that the giving birth to their young lasts from April to July by mother fish, aged I to IV. For the same species it was observed that the season did not find the discriminating age composition of the mother fishes participated.

d) Characters of the young

The number and the size of embryo at birth distinctly differ by the species. Their rate of growth measured on the formation of scale ridge is also different between the two species. It is probable as seen on Appendixes I and III that in *D. temmincki* the females giving birth to their young are represented by the fishes of I-, II, and III-years, and few IV-years old, whereas, in *D. viridis* majority of the females is II- and III-years, but I- and IV-years are numbered very few.

Taking 74 females of *D. temmincki* and 22 of *D. viridis* the number of embryos carried by a female is averaged 13.02 for the former species and 29.65 for the latter, the difference being more than twice. The numerical difference of embryos carried by a individual female varies, as shown below, by the ages of the fish in the two species.

D. temmincki

age	I	II	III	IV
Average no. of embryos	9.2	12.0	18.9	22.8
Range	1–13	7–20	9–27	16–27
No. of females examined	32	25	11	6

D. viridis

Age	I	II	III	VI
Average no. of embryos	17.0	22.8	40.2	60.5
Range	14–20	15–37	26–51	57–64
No. of females examined	2	13	5	2

The figures above, claculated from Appendixes I and III, clearly show for both species the number increases with the age of mother fishes. Within the females of same age (I-year) that collected in the same date (April 20, 1963), were observed larger females with higher number of embryos than smaller ones. As to the size of embryo prior to birth, the Table 4 prepared from appendix I and III, will show clearly for *D. temmincki*, the large or old females carry larger embryo than smaller or younger ones. The fact also will be roughly held for *D. viridis* within the present collection, as shown in the same table (Table 4).

The size of embryo at birth was estimated for *D. temmincki* 50–70 mm long in total length by Uchida (1938), 50–60 mm long by Matsukiyo (1963), and 55–60 mm long by Mizue (1961). In the present study, the size of embryo at birth was found to be clearly different between *D. temmincki* and *D. viridis*. The embryos, dissected out from females which were apparently at birth or quite ready to birth as noted on reference column of Appendixes I and III, are always smaller in *D. viridis*. In *D. temmincki* the embryo of averaged size of 57.4 mm (ranging 52.0–59.5 mm examined on 6 females) was fully grown and ready to birth,

Table 4. Size of embryo carried by female of different ages in two species collected in different dates. Figures on top show average total length of embryo (mm) in a single brood; middle the range of the same; bottom the number of mothers examined.

D. temmincki	Age	Apr. 20, '63	Apr. 27, '63	May 3, '63	May 28, '63	June 5, '63	Feb. 1, '64	May 5, '64	June 7, '67
	I	19.7	23.7	29.1	40.2	52.7	—	—	53.0
		13.5–26.1	22.0–24.8	29.1	39.8–42.0	52.4–52.9	—	—	53.0
		22	4	1	2	2	—	—	1
	II	22.7	30.0	30.5	46.0	54.0	5.8	49.0	56.2
		19.5–32.0	25.0–35.0	30.5	44.7–47.3	48.2–59.5	4.0– 6.0	48.0–50.0	52.0–59.0
		12	2	1	2	3	3	2	3
	III	31.5	28.9	—	—	59.4	6.3	44.0	—
		20.0–52.2	28.9	—	—	59.4	5.5– 7.0	44.0	—
		6	1	—	—	1	2	1	—
	IV	35.1	30.0	—	—	—	—	57.0	—
		33.0–37.0	30.0	—	—	—	—	57.0	—
		4	1	—	—	—	—	1	—

D. viridis	Age	Apr. 20, '63	Apr. 27, '63	May 3, '63	May 28, '63	July 23, '63	May 5, '64	May 24, '67	June 7, '67
	I	15.5	—	21.5	—	—	—	—	49.0
		15.5	—	21.5	—	—	—	—	49.0
		1	—	1	—	—	—	—	1
	II	22.1	23.0	24.8	39.8	47.0	—	43.0	50.7
		14.0–37.0	23.0	24.0–26.0	38.9–40.6	47.0	—	43.0	49.0–52.0
		1	1	3	2	1	—	1	3
	III	14.3	19.5	—	45.0	—	42.0	—	—
		12.0–16.5	19.5	—	45.0	—	42.0	—	—
		2	1	—	1	—	1	—	—
	IV	—	—	—	—	—	40.5	—	—
		—	—	—	—	—	38.0–43.0	—	—
		—	—	—	—	—	2	—	—

while, in *D. viridis* the full grown embryo was observed as 49.6 mm on average (47.0 mm–52.0 mm on 5 females). Such size difference of embryo between the two species at birth is also evidenced by the growth of ridges on the scales of the embryos and adults, as explained below.

The scales of embiotocids fishes are marked from focus to the border by evenly spaced concentric ridges; those of young fish, on the other hand, are marked near the margin by a zone in which the ridges are closely approximated than on either side, resembling the seasonal marks. This mark is apparently formed by birth, for which the term "metamorphic annulus" was proposed by Hubbs (1921). The number of scale ridges from focus to the metamorphic annulus calculated on 50 adult specimens by species are tabulated as follows.

Number of scale ridges:	8	9	10	11	12	13	14	15	16
Number of specimens:									
D. temmincki	0	0	0	0	4	10	17	18	1
D. viridis	1	0	8	23	16	2	0	0	0

The number of scale ridges in embryo, at birth or quite ready to birth, calculated on both species, was consistent as shown above, thus, present author comes to a belief that *viridis* gives birth to their young in smaller size than *temmincki*, regardless of the age or size of mother, and the size gap for latter species considered 7–8 mm at least.

3) Geographical distribution and ecology

The geographical distribution of *D. temmincki* is restricted to the coastal waters of Japanese islands and neighbouring seas, ranging from sourthern Hokkaido (Jordan and Sindo, 1902; Hikita, 1950; Hikita and Hukazawa, 1952; Ueno, 1966) south to Okinawa on both coasts of the Pacific and the Sea of Japan. The northern limit is Lake Saroma in Hokkaido (Hikita and Sibata, 1964). The westward distribution reaches Pusan in Korea (Uchida, 1938) and Chefoo in China (Tarp, 1952). *D. viridis* was recorded from Misaki (Kamohara, 1940, Oshima, 1955 and Yamane, 1964), and Maizuru Bay (Yamane, 1964). In addition to these, the author received a specimen of *D. viridis* from Asamushi, Aomori Pref., which was collected from Mutsu Bay on October 10, 1966.

According to the result of census, both species were found to be unknown or extremely rare at Kushiro, Atsukeshi, and Wakkanai, (in Hokkaido), and in Hachijo Is., Shirahama (Wakayama Pref.), Kochi (Kochi Pref.) and Okinawa. With the exception of these localities, all other replies from southern Hokkaido to Kyusyu, confirmed distribution of *D. temmincki*. The occurrence of *D. viridis* was reported from 39 localities, among which the following 15 localities were reported to see the species dwelling different habitat from that of *D. temmincki*: Tomioka Bay (Amakusa Is.), Omura Bay (Nagasaki Pref.), Karatsu Bay (Saga Pref), Tsuyazaki and Hakata Bay (Hukuoka Pref.), Aio Bay (Yamaguchi Pref.), Miyajima (Hiroshima Pref.), Sido Bay (Kagawa Pref.), Oki Isl., Noto (Ishikawa Pref.), Nezugaseki (Yamagata Pref.), Ryotsu (Sado Isl.), Hirota Bay (Iwate Pref.), Toba and Ago Bay (Mie Pref.). The replies received from these localities pointed out that most of the fishes taken from sandy bottom characterized by *Zostera* or other sea-weed vegetation in the bay is referred to *D. viridis*, and *D. temmincki*, on the other hand, prefer to live in outer seas.

The result of this census and past records of collection confirmed that the distribution of two species is completely overlapped from Hokkaido to Kyusyu, but the preferred habitat is different specifically.

Closely related species of fishes which live in a same locality are often found in diffrent water, which is well exemplified in the case of *D. temmincki* and *D. viridis*. This fact is well reflected in the catch of these species made at the same locality of Hashirimizu, where sandy bottom with or without *Zostera* vegetation and rocky bottom are recognized. In the collection of specimens (see p. 107), the catch by the Masu-ami set-net is predominantly represented by *D. temmincki* which numbered 231 against *D. viridis* 49. While, the catch in the gill-net and dragnet operated at *Zostera* region is represented by 50 *D. viridis* and 14 *D. temmincki*. These figures alone will suggest the fact that they do discriminate their own habitat.

The collection of fishes made in the present study will also throw a light on the understanding of the two species as to their behavior in the water by season (migration in narrow sense). The local fishermen, from their long-term experience, tell that the Masu-ami set-net makes better catch of the fish during spring and fall months than in other two seasons in a year, and the fact was also confirmed by the record of the collection made by the present author. The spring-and-fall good catch, however, is shown by *D. temincki*, but not by *D. viridis* whose catch does not seasonally fluctuate as in the former. *D. temmincki* makes more active move during these two seasons; the species seems to move into bay or inlet from deeper water or from rocky shore facing to open sea. But this migration is not taken by *D. viridis*, which is also well reflected in the informations obtained by census.

The record of catch and information given by veteran local fishermen may lead to the belief that the population of *D. temmincki* is larger than that of *D. viridis* at least in the water of Hashirimizu. According to the result of the census such difference in population size appears to be held also throughout country.

Summary

1) The validity of the two species, *Ditrema temmincki* and *viridis*, is firmly established by their morphological characters. The ground color of *D. temmincki* is highly variable and will not warrant the recognition of different races, forms, or any other systematic groups within the species.

2) The validity of two species is further substantiated by their habitat, reproductive activities, and fecundity as well as embryo and its birth demonstrated by each species.

3) *D. temmincki* enters copulatory activity in September lasting to mid-November, with the peak falling on October. The materials of *viridis*, admittedly insufficient, will suggest that the copulatory activity takes place in the months which do not lag that for *temmincki*.

4) The birth of the young is seen in *temmincki* from April to early June. In *viridis* the giving birth to their young lasts from April to July.

5) The number and size of embryo at birth differ distinctly by the species, and their rate of growth measured on the formation of scale ridges is also well distinguished between the two species.

6) The distribution of two species appears to be completely overlapped from Hokkaido to Kyusyu, but the preferred habitat taken by the species is different.

7) *D. viridis* undoubtedly prefers to live inshore water characterized by *Zostera* vegetation, and *D. temmincki* rocky shore with or without *Sargassum* vegetation as usual habitat. Both species appear to coexist in their early stage, but in meantime, *D. temmincki* leaves *Zostera* region and changes their habitat to rocky shore, while *D. viridis* does not leave there through out their life.

8) The population of *D. temmincki* is larger than that of *D. viridis* at least in the waters of Hashirimizu. Such difference in population size appears to be held not only in this particular water but also in other regions in the country.

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本邦産ウミタナゴ属2種の分類と生物学　安部義孝

ウミタナゴ属の種の命名については，従来，内外の研究者によって意見が相違しており，最近，Yamane (1964) は *Ditrema viridis* Oshima と *D. temmincki* Bleeker を認めて，後者には色彩に差異による2型のあることを論じた．筆者は 1963 年から今日まで，三浦半島走水附近で採集した本属の標本を材料にして，その形態と生活史の研究を行い，本属にはウミタナゴ *D. temmincki* Bleeker とアオタナゴ *D. viridis* oshima の2種を，特に，生態色彩によって，認めることができた．しかし，ウミタナゴを更に分類する根拠は得られなかった．両種の生活史の比較において，胎仔数は，ウミタナゴで1尾平均 13.02 尾，アオタナゴでは 29.65 尾であり，その2倍余の差異は各年級を通じてみられた．また，出産時の仔魚の平均全長はウミタナゴで 57.4 mm，アナタナゴで 49.6 mm であった．この 7 mm 余の差異は，胎内で成長する期間に形成される鱗の成長線の数にも現われ，また，その現象は成魚の体鱗にも継続して存在することを認めた．両種の地理的分布を既往の記録と全国から集めたアンケートの 81 件の回答より検討した結果，両種は北海道南部より九州に至る間に重複して分布することを知った．ただし，アナタナゴは内湾の藻場に生息し，ウミタナゴは，主として，湾外の岩礁間を常時の生息場所とすることが報ぜられ，この事実は走水においても，漁法の選択性から，確認された．

(上野動物図水族館，東京都台東区上野公図)

Appendix I. Size (St. l. in mm) and age of female *Ditrema temmicki*, and number and average size (T. l. in mm) of embryos carried by the female.

Date	Mother Size	Age	Embryo No.	Embryo Size	Date	Mother Size	Age	Embryo No.	Embryo Size	Reference
4/20 '63	112	I	2	13.5	5/28 '63	126.5	III	0		
” ”	112.5	I	0		” ”	136.5	II	12	44.7	
” ”	113	I	0		” ”	140.0	II	12	47.3	
” ”	114	I	7	19.0	6/5 '63	112.5	I	0		
” ”	117	I	11	16.5	” ”	120.5	II	0		
” ”	118	I	0		” ”	127	II	12	48.2	
” ”	118	I	10	18.2	” ”	133.5	I	9	52.9	
” ”	120	I	9	20.0	” ”	136	I	11	52.4	
” ”	120	II	7	19.5	” ”	153	II	11	54.2	
” ”	121.5	I	1	19.0	” ”	157	II	14	59.5	ready to birth
” ”	121.5	I	9	19.3	” ”	167	III	19	59.4	”
” ”	121.5	I	10	17.4	7/23 '63	71	0			
” ”	122	I	10	20.5	” ”	74	0			
” ”	122	I	0		” ”	76	0			
” ”	123	II	9	19.8	” ”	79	0			
” ”	124.5	I	7	23.7	” ”	79.5	0			
” ”	125	I	8	21.5	9/15 '63	123	III			
” ”	125	I	9	21.3	10/16 '63	87.5	0			egg immature
” ”	125	I	9	18.6	” ”	93.5	0			”
” ”	126.5	I	11	16.0	” ”	95	0			”
” ”	129	I	10	23.0	” ”	95	0			”
” ”	130	I	12	16.5	” ”	96.5	0			”
” ”	130	I	11	17.8	” ”	97	0			”
” ”	130	I	13	20.9	” ”	98	0			”
” ”	131	I	11	18.6	” ”	99.5	0			”
” ”	131	I	13	21.3	” ”	100.5	0			”
” ”	131.5	III	9	20.0	” ”	101	0			”
” ”	133	I	11	26.1	” ”	103	0			”
” ”	134	I	10	24.0	” ”	110	0			”
” ”	134	II	12	21.2	10/24 '63	94	0			”
” ”	134.5	II	8	24.0	” ”	98	0			”
” ”	135.5	II	8	24.4	” ”	106	0			”
” ”	137	II	12	20.0	” ”	108	0			”
” ”	142	II	11	27.0	” ”	122.5	I			”
” ”	142.5	II	10	29.5	10/28 '63	92.5	0			”
” ”	144.5	II	16	23.5	” ”	96	0			”
” ”	147.0	II	13	27.0	” ”	96.5	0			”
” ”	147.5	II	12	32.0	” ”	97	0			”
” ”	149	II	17	29.7	” ”	100	0			”
” ”	168	III	26	29.7	” ”	101.5	0			”
” ”	170	III	15	35.0	” ”	102.5	0			”
” ”	174	III	24	52.2	” ”	103	0			”
” ”	175	III	18	39.0	” ”	107	0			”
” ”	179.5	III	27	33.0	” ”	107	0			”
” ”	180	IV	22	33.0	11/5 '63	100	0			”
” ”	180	IV	16	36.0	” ”	176.5	III			egg segmenting
” ”	182	IV	23	34.3	12/4 '63	93.5	I			egg segmenting
” ”	182	IV	27	37.0	” ”	105	I			egg immature
4/27 '63	120	I	10	22.0	” ”	110	I			”
” ”	121.5	I	10	24.5	” ”	145.5	II			egg segmenting
” ”	123	I	.. 6	23.5	” ”	162	III			hatchout
” ”	124	I	11	24.8	2/1 '64	106	I			ripe egg
” ”	131.5	II	9	25.0	” ”	115	I			”
” ”	138	II	8	35.0	” ”	116	I			egg segmenting
” ”	173	III	17	28.9	” ”	143	II	16	6.5	
” ”	175	IV	24	30.0	” ”	143	II	17	4.0	
5/3 '63	113	II	0		” ”	144.5	II	16	6.5	
” ”	129.5	I	12	29.1	” ”	150	III	15	5.5	
” ”	135	II	10	30.5	” ”	152	III	16	7.0	
5/28 '63	112	II	0		5/5 '64	154	II	20	50.0	
” ”	115	I	0		” ”	160	II	18	48.0	
” ”	118	I	0		” ”	165	III	22	44.0	
” ”	118	I	0		” ”	194	IV	25	57.0	ready to birth
” ”	119	I	0		6/7 '67	122	I	8	53.0	”
” ”	119	I	4	42.0	” ”	144	II	2	57.5	at birth
” ”	123.0	I	0		” ”	151	II	8	59.0	”
” ”	123.5	I	8	39.8	” ”	154	II	5	52.0	”

Appendix II. Size (St. l. in mm) and age of male *Ditrema temminchi*, and weight (in g) of testis developed.

Date	Size	Age
4/20 '63	108.5	I
" "	110	I
" "	111	I
" "	113	I
" "	115	I
" "	117	I
" "	118	I
" "	118	I
" "	118	I
" "	118	I
" "	118.5	I
" "	120.5	I
" "	120.5	I
" "	121	I
" "	121	II
" "	122	I
" "	124.5	I
" "	125	I
" "	125.5	I
" "	135	II
" "	135	II
" "	143	II
" "	148	III
4/27 "	111	I
" "	114	I
" "	114	I
" "	114	I
" "	115	I
" "	116.5	I
" "	116.5	I
" "	120	I
" "	124	I
" "	132	I
" "	146	III
5/3 "	115	I
" "	120	I
" "	124	I
" "	124	I
" "	125	II
" "	128	I
" "	128	II
" "	129.5	I
5/28 "	117	I
" "	118	I
" "	118	I
" "	118	II
" "	119	I
" "	122	I
" "	122	I
" "	126.5	II
6/1 "	113	I
	117	I
	117.5	I
	121	I
	122	I

Date	Size	Age	Testis	Reference
7/23 '63	70	0		
" "	70	0		
" "	74	0		
" "	80	0		
" "	86.5	0		
9/15 "	120	I	0.5	
10/16 "	96	0		
" "	96	0		
" "	99	0		
" "	99.5	0		
" "	99.5	0	0.3	
" "	105	0	0.2	
" "	132	I	0.45	
10/24 "	91	0		
" "	91.5	0		
" "	93	0		
" "	96.5	0	0.2	
" "	96.5	0	0.1	
" "	98	0	0.15	
" "	99	0	0.2	
" "	100	0	0.2	
" "	100.5	0		
" "	108	0		
" "	135	I		spent
10/28 "	93	0		
" "	94	0	0.1	
" "	95	0		
" "	98	0	0.25	
" "	98.5	0	0.25	
" "	99	0		
" "	100	0		
" "	101	0	0.15	
" "	101.5	0		
" "	103	0	0.3	
" "	103.5	0	0.1	
" "	104	0		
" "	129	III	0.5	
" "	129	I	0.45	
" "	131	I	0.75	
" "	132	I	0.85	
" "	134	I	0.95	
12/4 "	99.5	I		spent
" "	103.5	I		"
" "	135.5	II		"
" "	137.5	II		"
" "	138	II		"
" "	138.5	II		"
" "	142.5	II		"
2/1 '64	102.5	I		"
" "	107	I		"
" "	130	II		"
" "	138	III		"
" "	146	III		"

Apendix III. Size (St.1. in mm) and age of female *Ditrema viridis*, and number and average size (T. 1. in mm) of embryos carried by the female.

Date	Mother		Embryo		Date	Mother		Embryo		Reference
	Size	Age	No.	Size		Size	Age	No.	Size	
4/20 '63	113	I	0		7/23 '63	59	0			
" "	130	I	20	15.5	" "	60	0			
" "	134	II	24	14.0	" "	60	0			
" "	137.5	II	21	21.5	" "	60.5	0			
" "	140.5	II	26	19.0	" "	61	0			
" "	142	II	21	18.9	" "	61	0			
" "	147	II	37	37.0	" "	63	0			
" "	154	III	26	12.0	" "	70	0			
" "	155.0	III	31	16.5	" "	123	II	17	47.0	ready to birth
4/27 "	140	II	20	23.0	10/16 "	157	III			egg immature
" "	171.5	III	45	29.5	11/5 "	107	0			egg immature
5/3 "	113	I	14	21.5	12/4 "	117	0			ripe egg
" "	132.5	II	25	24.5	" "	125	I			2–4 segmentation
" "	138.5	II	21	26.0	5/5 '64	180	III	48	42.0	
" "	147	II	19	24.0	" "	182	IV	64	43.0	
5/28 "	134	II	15	40.6	" "	182	IV	57	38.0	
" "	143	II	33	38.9	5/24 '67	137	II	18	43.0	
" "	171	III	51	29.5	6/7 "	134	I	4	49.0	at birth
7/23 "	48	0			" "	134	I	0		after birth
" "	53	0			" "	145	II	5	49.0	at birth
" "	54.5	0			" "	148	II	10	51.0	"
" "	55	0			" "	149	II	0		after birth
" "	55	0			" "	149	II	0		"
" "	56	0			" "	150	II	0		
" "	57	0			" "	151	II	0		
" "	57.5	0			" "	152	II	18	52.0	at birth
" "	58	0			" "	160	III	0		after birth

Appendix IV. Size (St. 1. in mm) and age of male *Ditrema viridis*, and weight (in g) of testis developed.

Date	Size	Age	Date	Size	Age	Testis	Reference
4/20 '63	133	I	7/23 '63	62.5	0		
" "	135	I	" "	62.5	0		
" "	179	III	" "	66	0		
4/27 "	133	I	10/16 "	101	0	0.2	
5/3 "	101	I	" "	113.5	0	0.3	
" "	128.5	I	10/24 "	106	0	0.25	
5/28 "	122	I	" "	104.5	0	0.2	
" "	128	I	11/5 "	99	0	0.15	
" "	132	II	" "	97.5	0	0.1	
" "	145	III	" "	135	II		spent
7/23 "	53	0	" "	153.5	II	0.5	
" "	54	0	2/11 '64	106	I		spent
" "	54.5	0	5/10 '67	125	I		
" "	57	0	" "	125	I		
" "	57	0	5/17 "	116	I		
" "	58	0	6/7 "	129	I		
" "	59	0	" "	132	I		
" "	59.5	0	" "	135	I		
" "	60	0	" "	139	II		
" "	60	0	" "	143	II		
" "	61.5	0	" "	144	II		
" "	62.5	0	" "	144	II		