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The Sympatric Occurrence of the Carapid Fishes *Pyramodon ventralis* and *P. lindas* in Japanese Waters

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Abstract Twenty-five specimens of *Pyramodon ventralis* from Japanese waters and seven specimens of *P. lindas* recorded for the first time from Japanese waters were examined and compared with the holotypes of both species. The two species are distinguished by differences in coloration of the dorsal and anal fins, number of dorsal-fin rays to the anal-fin origin as previously indicated. We present two additional characters differentiating the species: morphology of the dorsal surface of the cranium, and relative length from the pelvic-fin base to the middle of the vent. Counts of pectoral-fin rays and precaudal vertebrae in both species exhibit wider intraspecific variation than previously reported. Some morphometric characters are discussed in relation to head length.

According to the recent revision of the Carapidae by Markle and Olney (1990), the genus *Pyramodon* contains four nominal species, *P. ventralis* Smith et Radcliffe, 1913, *P. punctatus* (Regan, 1914), *P. lindas* Markle et Olney, 1990, and *P. parini* Markle et Olney, 1990. Only one species, *P. ventralis*, originally described from a single specimen from near Doworra Island, Indonesia (Radcliffe, 1913), has been known from Japanese waters (Markle and Olney, 1990).

Although *P. ventralis* is widely distributed in the Indo-Pacific from the equator to about 35°N (Markle and Olney, 1990), relatively few specimens are known. In an earlier revision of the genus, Smith (1955) listed only eight specimens, and Gordon et al. (1984) presented meristic details from ten specimens. Markle and Olney (1990) examined 12 juvenile and adult *P. ventralis*, comparing their meristic and proportional characteristics with those of other nominal *Pyramodon* species. They reported that the precaudal vetebrae of *P. ventralis* varied in numbers from 14 to 15, whereas Gordon et al. (1984) noted a range of 15 to 18. Gordon et al. followed Williams (1983) and included *P. punctatus*, which has 16 or more precaudal vertebrae, in the precaudal vertebral count for *P. ventralis*.

Pyramodon lindas was previously known from six adults and one vexillifer larva, all from the northern coast of Australia from depths of 300–385 m (Markle and Olney, 1990). It differs from its congeners in having dorsal and anal fins edged in black over entire length, lower pectoral-fin ray counts (22–23), and 11–18 dorsal-fin rays to the anal-fin origin (Markle and Olney, 1990: 322).

In this study, we examined seven large specimens of *Pyramodon* collected from the Pacific off Tosa Bay, Kochi Prefecture, southern Japan. The comparison of these specimens with 26 specimens, including the holotype, of *P. ventralis* and the holotype of *P. lindas* revealed that our material is *P. lindas*. In this paper, we present detailed meristic and morphometric data on the two sympatric species, *P. ventralis* and *P. lindas*, from the Pacific Ocean off the central to southern coasts of Japan, and discuss diagnostic characteristics and allometric growth of the two species. A new Japanese name, Bake-onikakureuo, is given for *P. lindas*.

Materials and Methods

Specimens examined are listed below. Institutional symbolic codes follow Leviton et al. (1985).

Pyramodon ventralis (26 specimens). USNM 74155, holotype, 185+ mm standard length (SL), 32.0 mm head length (HL), sex unknown, 128°12′00″E, 00°50′00″S, Albatross sta. 5629, Doworra Island, Indonesia, 369 m. Eleven BSKU specimens caught by commercial bottom trawlers from Tosa Bay, southern Japan, at depths ranging from about 250 to 350 m, and 1 BSKU specimen (BSKU 46725) from Suruga Bay, central Japan: BSKU 145, 136 mm SL, 25.7 mm HL, sex unknown, 7 Feb. 1951; BSKU 3405, ♂, 140 mm SL, 26.0 mm HL, 27 Nov. 1953; BSKU

3474, 163 mm SL, 28.3 mm HL, ♂, 21 Dec. 1953; BSKU 4487, 171 mm SL, 30.3 mm HL, ♂, 25 Jan. 1955; BSKU 5810, 152 mm SL, 27.1 mm HL, ♀, date unknown; BSKU 7195, 153 mm SL, 29.3 mm HL, ♂, 10 Apr. 1957; BSKU 7844, 164 mm SL, 27.3 mm HL, ♀, cleared and stained, 20 May, 1958; BSKU 9897, 134 mm SL, 31.3 mm HL, ♀, date and month unknown, 1955; BSKU 9898, 158 mm SL, 26.1 mm HL, ♂, date and month unknown, 1955; BSKU 10002, 178 mm SL, 33.6 mm HL, ♀, 10 Feb. 1958; BSKU 13813, 157 mm SL, 28.0 mm HL, ♀, Jan.–Mar. 1968; BSKU 46725, 157 mm SL, 27.2 mm HL, ♀, 23 Sep. 1980. Thirteen FAKU specimens from the Kumano-nada Sea, southern Japan: FAKU 21148, 196–239 mm SL, 30.1–41.1 mm HL, each 1♂, 1♀, and 1 sex unknown, 5 Nov. 1953; FAKU 24334–24341, 119–248 mm SL, 23.0–41.7 mm HL, 1♂, 3♀, and 4 sex unknown, 25 Oct.–10 Nov. 1954; FAKU 24497-24498, 114+ –171 mm SL, 24.5–28.7 mm HL, 2 sex unknown, 25 Oct.–10 Nov. 1954.

Pyramodon lindas (8 specimens). AMS I. 22825011, holotype, 273 mm SL, 51.7 mm HL, 18°59′S, 117°10′E, Northwest Shelf, Indian Ocean, coll. by J. Paxton, 300–326 m, 13 Apr. 1982. Seven BSKU specimens caught by commercial bottom trawlers from Tosa Bay, at depths ranging from about 250 to 350 m: BSKU 3404, 276 mm SL, 42.1 mm HL, ♀, 27 Nov. 1953; BSKU 4408, 315 mm SL, 51.8 mm HL, ♀, cleared and stained, 26 Dec. 1954; BSKU 13625, 348 mm SL, 61.2 mm HL, ♀, Jan.–Mar. 1968; BSKU 29145, 336 mm SL, 60.2 mm HL, ♀, 27 Oct. 1976; BSKU 37165, 332 mm SL, 54.7 mm HL, ♀, 21 Apr. 1982; BSKU 39669, 328 mm SL, 59.4 mm HL, ♀, 8 Nov. 1983; BSKU 40022, 247 mm SL, 41.9 mm HL, ♀, 10 Feb. 1974.

Table 1. Counts and measurements of *Pyramodon ventralis* and *P. lindas*

Character*	*P. ventralis* (26 specimens)	*P. lindas* (8 specimens)
SL (mm)	114+ –248	247–348
HL (mm)	24.5–41.7	41.9–61.2
Counts		
D_{30}	48–52	48–53
A_{30}	48–52	44–50
PCV	14–15	15–16
DRAO	1–3	10–13
VDO	6–7	6–7
VAO	6–8	10–12
ARDO	—	—
Pectoral-fin rays	25–28	21–25
Pelvic-fin ray	1	1
Branchiostegal rays	7	7
Developed gill rakers on 1st arch	3	3
Pseudobranchial filaments	2	2
Pyloric caeca	2	2
In % of HL		
Body depth	70.8–117.1	79.4–96.5
Predorsal length	113.4–125.7	119.2–127.0
Preanal length	118.3–140.6	156.5–177.6
Gnathoproctal length	114.5–137.0	149.6–177.6
Lower jaw tip to pelvic-fin base	64.8–84.2	67.3–76.9
Pelvic-fin base to vent	42.3–64.5	87.2–106.8
Snout length	17.9–22.7	19.3–21.9
Eye diameter	18.1–23.6	17.9–20.0
Interorbital width	12.1–18.5	16.8–19.1
Upper jaw length	46.9–52.8	49.9–53.2
Lower jaw length	51.5–56.8	55.1–59.1
Pectoral-fin length	86.8–110.3	71.2–83.4
Pelvic-fin length	21.0–33.9	12.0–29.2

* See text for abbreviations.

All measurements were taken point to point, as in Hubbs and Lagler (1958). Gnathoproctal length was measured from the tip of the lower jaw to the middle of the vent. Distances from the tip of lower jaw to the pelvic-fin base, and from the pelvic-fin base to the middle of the vent are abbreviated as LJ–P_2 and P_2–Vent in the text.

Counts of vertebrae, and dorsal- and anal-fin rays were taken from radiographs. Morphometric data were compared in relation to head length, because most specimens had a damaged and regenerated tail.

Precaudal vertebrae are abbreviated as PCV. Counts for D_{30}, A_{30}, DRAO, VDO, VAO, and ARDO follow Markle and Olney (1990) as follows: D_{30}—dorsal-fin rays anterior to 31st vertebra, A_{30}—anal-fin rays anterior to 31st vertebra, DRAO—dorsal-fin rays anterior to anal-fin origin, VDO—vertebrae anterior to dorsal-fin origin, VAO—vertebrae anterior to anal-fin origin, and ARDO—anal-fin rays anterior to dorsal-fin origin.

Results and Discussion

Meristic counts and proportional measurements for each species are given in Table 1.

Dorsal surface of the cranium in both species are shown in Figure 1. The top of the frontal and supraoccipital of *Pyramodon ventralis* are knobby and very rough (Fig. 1A), in contrast to the frontal of *P. lindas*, which is rather smooth, and bears very low, longitudinal ridges, and no distinct ridges on the supraoccipital (Fig. 1B). The condition of the dorsal surface of the cranium in both species can be seen through the translucent skin, or the ridges or bumps can be felt by touching the top of the head of large

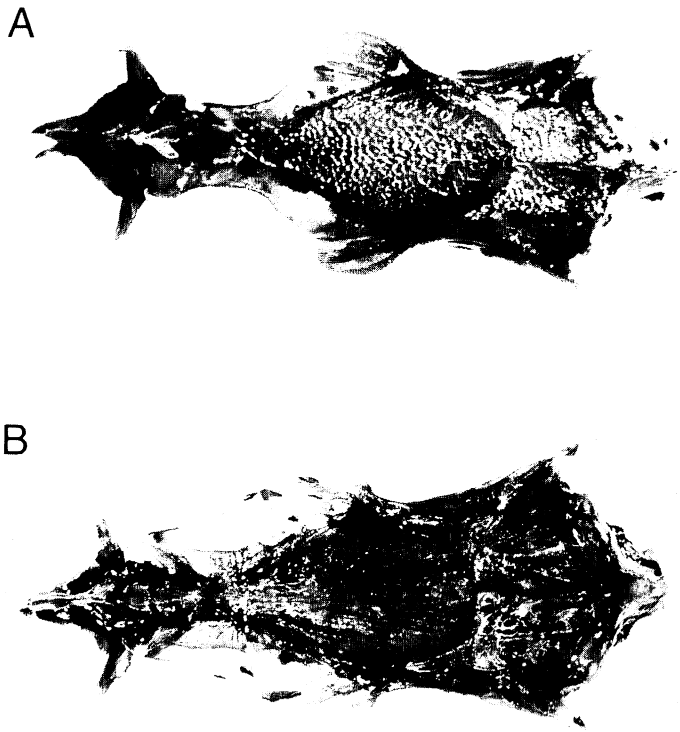

Fig. 1. Dorsal view of the cranium of *Pyramodon* species. A) *P. ventralis*. BSKU 7844; B) *P. lindas*. BSKU 4408.

specimens.

Specimens of *P. ventralis* preserved in alcohol had the head and body lightly pigmented, and fins without pigmentation. *P. lindas* specimens have the head rather darkly pigmented, body pale, and the dorsal and anal fins edged in black along their entire length.

The two species are easily distinguished from each other by morphology of the dorsal surface of the cranium, which has not been mentioned in previous studies. The coloration of dorsal and anal fins differs between the two species as previously mentioned by Markle and Olney (1990: 322).

Markle and Olney (1990: table 4, 322) noted that *P. lindas* differs from its congeners by the lower pectoral-fin ray counts (22–23): 24–26 in *P. ventralis*, 26–28 in *P. punctatus*, and 28–30 in *P. parini*. However, it was hardly possible to separate *P. lindas* from *P. ventralis* in this character in the present material (Tables 1 and 2), and intraspecific variation in this character in both species was greater than that reported by Markle and Olney (1990).

Markle and Olney (1990: table 4) showed that intraspecific variation in PCV was small in all *Pyra-*

Table 2. Frequency distributions of pectoral-fin rays and PCV in *Pyramodon ventralis* and *P. lindas*

	Pectoral-fin rays							
	21	22	23	24	25	26	27	28
P. ventralis					4	12*	9	1
P. lindas	1	4*	1	1	1			

	PCV		
	14	15	16
P. ventralis	11*	15	
P. lindas		1	7*

* Counts from holotype.

modon species: 14–15 in *P. ventralis*, and 16 in *P. lindas*. We found a single specimen of *P. lindas* with 15 PCV (Table 2). Thus, *P. ventralis* and *P. lindas* were not completely separable by counts of pectoral-fin rays and PCV.

Counts for D_{30}, A_{30}, VDO, and VAO in this study (Table 1) agreed well with the following taken from Markle and Olney (1990: table 4): 48–51, 49–53, 6–7, and 5–8 for *P. ventralis*, and 50–53, 45–50, 6–7, and 10–13 for *P. lindas*. According to Markle and Olney (1990: table 4, 322), DRAO counts in *P. ventralis* are 0–4, and 11–18 in *P. lindas*. We recorded 1–3 and 10–13, respectively, slightly increasing the range of variation for *P. lindas*.

There are dramatic allometric changes in carapid development (Markle and Olney, 1990: 273). We examined 13 morphometric characters in relation to HL (Table 3). Predorsal length was fairly constant, 113–126% HL in *P. ventralis* and 119–127% in *P. lindas* (Tabel 1), in the study material, regardless of HL. In fact, predorsal length was found to be isometric in relation to HL (Table 3). Markle and Olney (1990: 322) noted that the distance between snout to anus, one of the diagnostic characters of *P. ventralis*, ranged from 0.99–1.33 times HL. They also showed that the preanal length of *P. lindas* was 1.6–1.7 times HL (Markle and Olney, 1990: table 10). Our data for preanal length, 1.18–1.41 times HL in *P. ventralis* and 1.57–1.78 times HL in *P. lindas* (Table 1), generally agree with their results, indicating the anal-fin origin of *P. lindas* being more posteriorly positioned than in *P. ventralis* (Fig. 2). The anal-fin origin changes position with increasing size, being relatively more distant from the snout tip in large specimens (Fig. 3).

Gnathoproctal length in relation to HL was found to show strongly positive allometry in both species (Fig. 4, Table 3). This length was divided into two

Table 3. Relationships between each morphometric character (y) in mm and head length (x) in mm in *Pyramodon ventralis* and *P. lindas*

Character	Regression equation	r*
P. ventralis (26 specimens)		
Body depth	$\log y = 1.3053 \log x - 0.5273$	0.8889
Predorsal length	$\log y = 1.0104 \log x + 0.0613$	0.9850
Preanal length	$\log y = 1.1950 \log x - 0.1801$	0.9703
Gnathoproctal length	$\log y = 1.2082 \log x - 0.2112$	0.9699
Lower jaw tip to pelvic-fin base	$\log y = 1.1725 \log x - 0.4134$	0.9630
Pelvic-fin base to vent	$\log y = 1.2462 \log x - 0.6302$	0.8793
Snout length	$\log y = 1.1098 \log x - 0.8621$	0.9331
Eye diameter	$\log y = 0.8757 \log x - 0.4788$	0.9315
Interorbital width	$\log y = 0.9400 \log x - 0.7323$	0.8120
Upper jaw length	$\log y = 1.0536 \log x - 0.3758$	0.9825
Lower jaw length	$\log y = 0.9806 \log x - 0.2311$	0.9883
Pectoral-fin length	$\log y = 0.8641 \log x + 0.1930$	0.9044
Pelvic-fin length	$\log y = 1.0412 \log x - 0.6172$	0.8171
P. lindas (8 specimens)		
Body depth	$\log y = 0.8512 \log x + 0.2109$	0.8751
Predorsal length	$\log y = 1.0567 \log x - 0.0106$	0.9713
Preanal length	$\log y = 1.1844 \log x - 0.0913$	0.9810
Gnathoproctal length	$\log y = 1.2074 \log x - 0.1415$	0.9693
Lower jaw tip to pelvic-fin base	$\log y = 1.1291 \log x - 0.3516$	0.9498
Pelvic-fin base to vent	$\log y = 1.3002 \log x - 0.5268$	0.9642
Snout length	$\log y = 1.0660 \log x - 0.7967$	0.9721
Eye diameter	$\log y = 0.6992 \log x - 0.2131$	0.9496
Interorbital width	$\log y = 0.9302 \log x - 0.6261$	0.9474
Upper jaw length	$\log y = 0.9894 \log x - 0.2672$	0.9896
Lower jaw length	$\log y = 1.0528 \log x - 0.3358$	0.9924
Pectoral-fin length	$\log y = 0.7829 \log x + 0.2622$	0.9497
Pelvic-fin length	$\log y = -0.1398 \log x + 1.3121$	−0.0762

* Correlation coefficient.

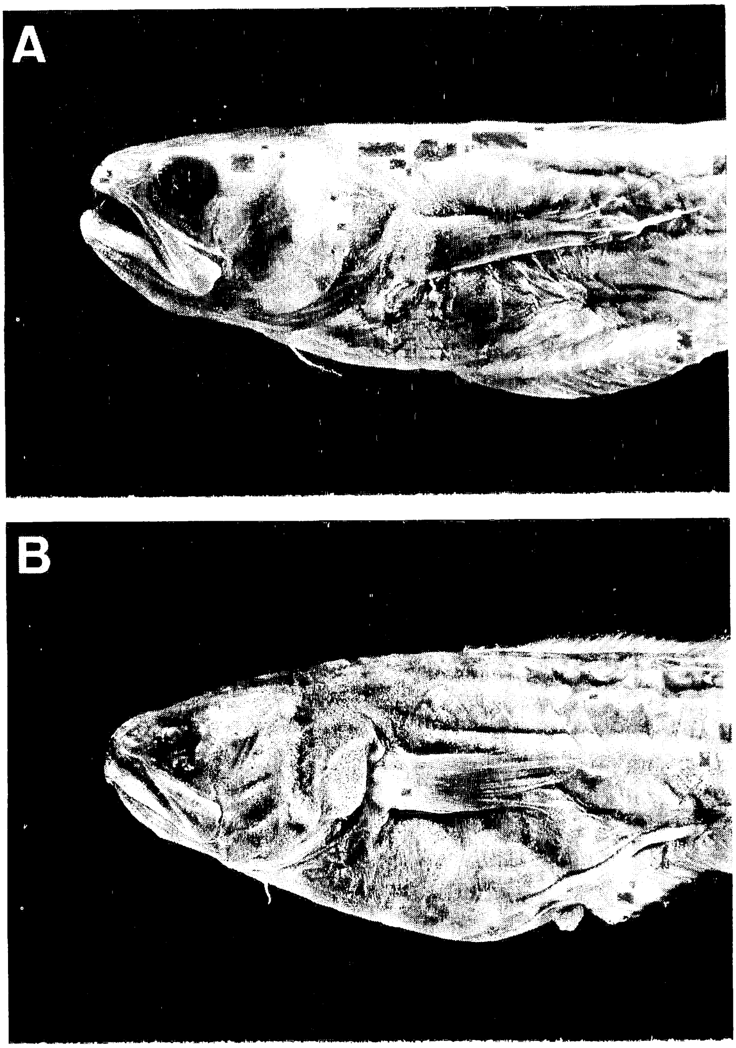

Fig. 2. Lateral view of the head of *Pyramodon* species from Tosa Bay, Pacific off southern Japan. A) *P. ventralis* BSKU 13813, 28.0 mm HL; B) *P. lindas* BSKU 39669, 59.4 mm HL.

dimensions: LJ–P_2 and P_2–Vent. The relationships between these two dimensions and HL are shown in Figures 5 and 6. All the slopes of regression equations in Figures 4–6 were greater than 1. In addition, the slope for LJ–P_2 vs. HL relationship was not as steep as that for P_2–Vent vs. HL relationship in both species, indicating a growth-related increase in the overall gnathoproctal length mostly due to a rapid increase in P_2–Vent length. P_2–Vent length is significantly different between the two species in our material (Fig. 6). Although we have not examined any *P. ventralis* specimens larger than 42 mm HL or *P. lindas* smaller than 41 mm HL, our study suggests that the two species may be separable by the P_2–Vent length character.

Markle and Olney (1990) noted in the description of *P. ventralis*: "Pectoral-fin length is also strongly allometric, being much shorter than the head length in juveniles and equal to or longer in adults." This statement conflicts with their figure 55, which illustrates the pectoral fin as being about 75% HL. The pectoral-fin length of our *P. ventralis* material ranged from 86.8 to 110.3% HL (Table 1). The relationship between the pectoral-fin length and HL in our material is shown in Figure 7. Our data indicate that the pectoral-fin length exhibits a growth-related decrease

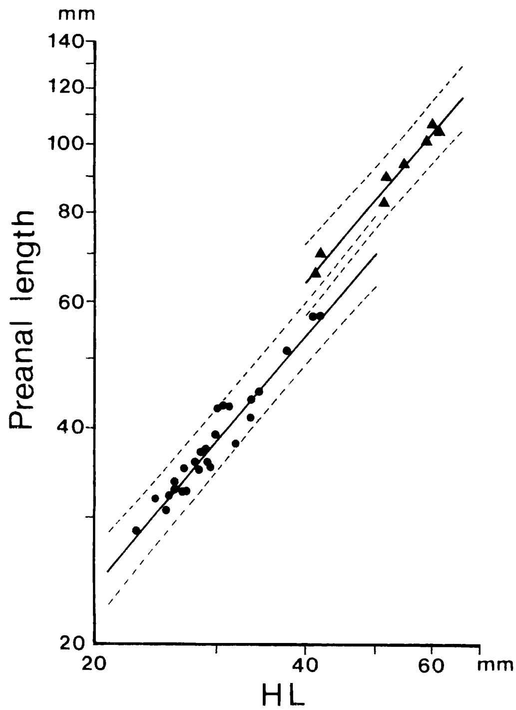

Fig. 3

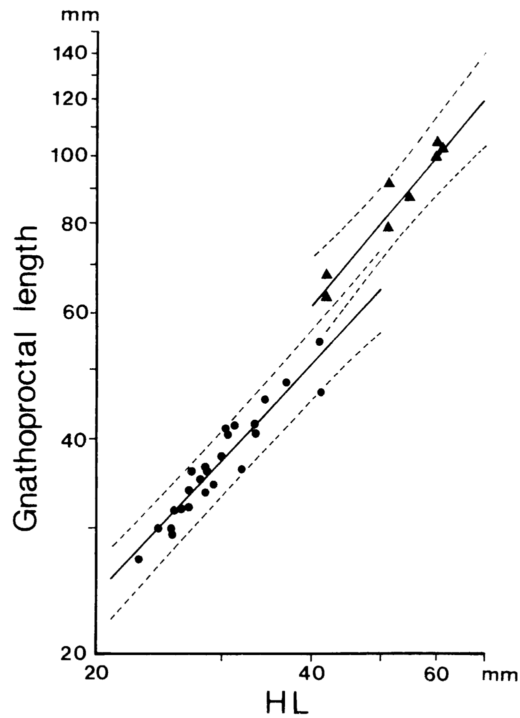

Fig. 4

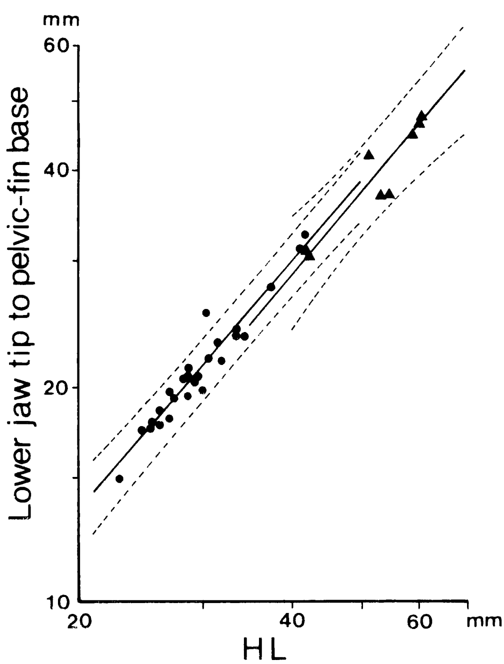

Fig. 5

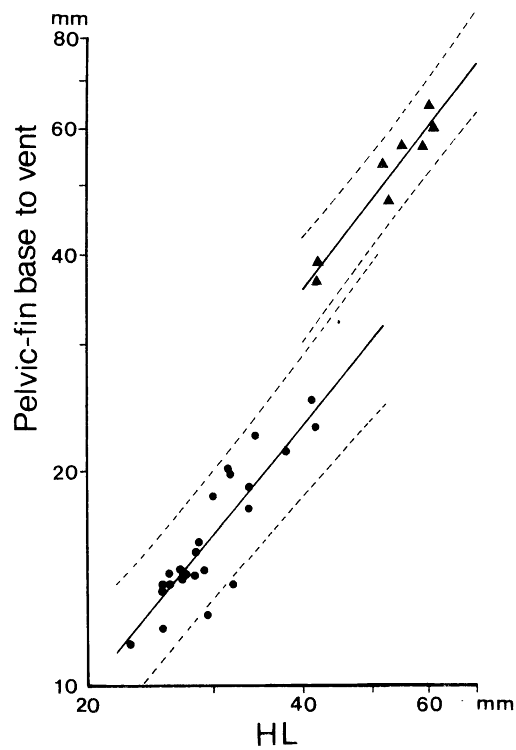

Fig. 6

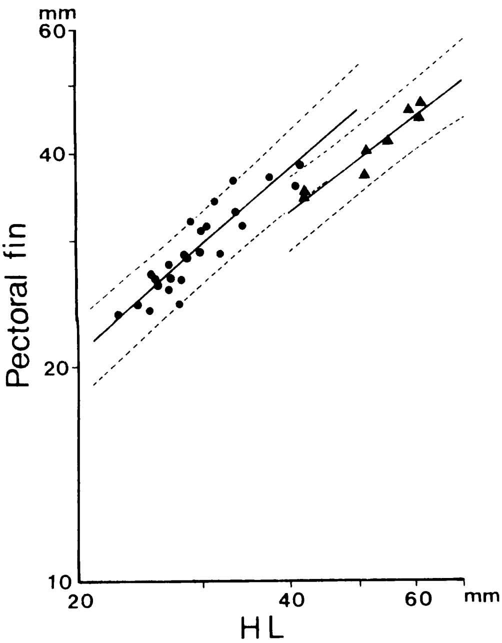

Fig. 7. Relationship between pectoral-fin length and head length in *Pyramodon* species. Symbols are as in Figure 3.

Fig. 3. Relationship between preanal length and head length in *Pyramodon ventralis* (●) and *P. lindas* (▲). Broken lines indicate 95% confidence interval of regression line.

Fig. 4. Relationship between gnathoproctal length and head length in *Pyramodon* species. Symbols are as in Figure 3.

Fig. 5. Relationship between the distance from the lower jaw tip to the pelvic-fin base and head length in *Pyramodon* species. Symbols are as in Figure 3.

Fig. 6. Relationship between the distance from the pelvic-fin base to the middle of the vent and head length in *Pyramodon* species. Symbols are as in Figure 3.

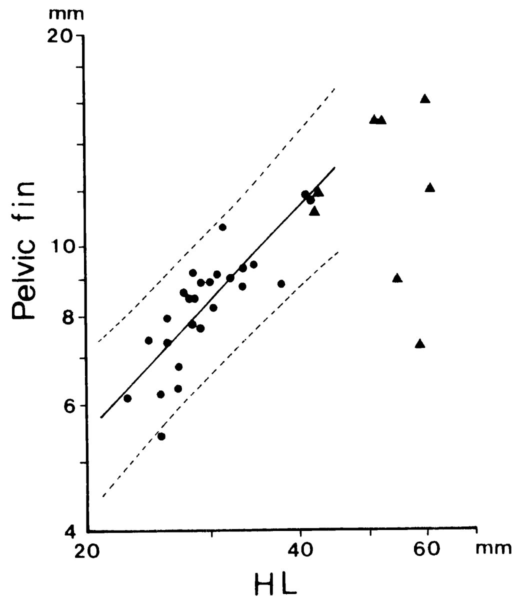

Fig. 8. Relationship between pelvic-fin length and head length in *Pyramodon* species. Symbols are as in Figure 3.

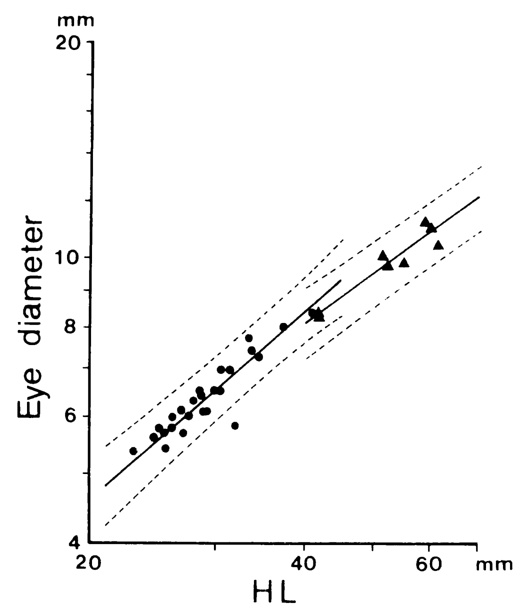

Fig. 9. Relationship between eye diameter and head length in *Pyramodon* species. Symbols are as in Figure 3.

in relation to HL in adults. The pectoral-fin length becomes shorter than HL in adults larger than 26.3 mm HL based on a regression equation (Table 3). The difference between our results and Markle and Olney's (1990) statement above cannot be explained. The pectoral-fin length of our *P. lindas* material also exhibited a growth-related decrease in relation to HL (Fig. 7, Table 3). The pelvic-fin length of *P. ventralis* in this study showed a growth-related decrease relative to HL, whereas in *P. lindas* there was no clear correlation between the two dimensions (Fig. 8, Table 3), indicating that this character is unstable in *P. lindas.* Length of the pectoral fin in both species and pelvic fin in *P. ventralis* in this study support Smith's (1955) comments on relative lengths of the pectoral and pelvic fins in *P. ventralis.* Eye diameter in both species exhibited a growth-related decrease relative to HL (Fig. 9, Table 3). Growth feature of the eye diameter in *Pyramodon* species is reported here for the first time. In the future, attention should be paid to the possibility of growth-related morphometric variation in adults of carapid species.

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同所性のオニカクレウオとバケオニカクレウオ（新称）

町田吉彦・岡村　収

本邦産の *Pyramodon ventralis*（オニカクレウオ）25 個体と *P. lindas*（バケオニカクレウオ）7 個体の形態の比較を，それぞれの完模式標本を含めて行った．本研究で，北部オーストラリアのみからしか知られていなかった *P. lindas* が土佐湾に生息することが明らかとなった．両種は腹椎骨数と胸鰭鰭条数に差異があるとされていたが，本邦産の標本では共に数値が重複しており，有効形質といえない．バケオニカクレウオは，背鰭と臀鰭の縁辺が黒色であること（オニカクレウオでは淡色）と，臀鰭始部より前方の背鰭鰭条数が 11–18 (0–4) であることでオニカクレウオと区別されていた．本研究で，新たに，前頭骨と上後頭骨の背面が前者では一様に小突起を生ずるのに対し，後者では前頭骨のみに後方に伸びる低い隆起線があることと，腹鰭起部から肛門中央部までの間隔が前者の方がはるかに長いことで識別可能であることが判明した．各計測形質を頭長と比較した結果，両種とも成長に伴い臀鰭始部が後方へ移動することが明らかとなり，これは主に腹鰭起部と肛門中央部までの間隔が成長に伴い著しく長くなることで説明された．同時に，成魚における成長に伴う若干の計測形質の変化についても論議した．

（〒780 高知市曙町 2–5–1　高知大学理学部生物学教室）