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Comparative age and growth of two darters, Percina peltata (Stauffer) and Percina notogramma (Raney and Hubbs), in Virginia

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Comparative Age and Growth of two darters, *Percina peltata* (Stauffer) and *Percina notogramma* (Raney and Hubbs), in Virginia

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by

Garnett William Link, Jr.

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Abstract

Two closely related species of darters, Percina peltata and Percina notogramma, occur sympatrically in Virginia. An analysis of the number of scale annuli and standard length measurements on 447 peltata and 195 notogramma revealed four year classes in both species, with very few individuals surviving to III-year class. Both species had approximately 1:1 sex ratios after the first year, in which males were predominant. The growth of both species was approximately the same after the first year; however peltata, the larger species, apparently gains an advantage during the first year which it never loses. The sexes did not differ significantly in either age or growth.

Introduction

With the exception of Percina crassa, a form recently introduced in the upper James River, the closely related darters, Percina p. peltata and Percina n. notogramma, are the only species of the genus to occur in Virginia rivers tributary to Chesapeake Bay. Studies on the two species include the systematic ones by Raney and Hubbs (1948) who described notogramma and defined its range, and the description of a subspecies of notogramma from the upper James by Hogarth and Woolcott (1966). Loos and Woolcott (1969) discussed hybridization between the two species where they were found together in disturbed habitats. In 1966 New reported on field and laboratory studies made in New York on the reproductive behavior of peltata. In the present study the comparative age and growth of peltata and notogramma were investigated. This kind of study provides information on the structural composition of their populations and is essential to the understanding and intelligent management of them and their environment.

Materials Examined

In this study 447 specimens (39 collections) of P. p. peltata (Fig. 1A) were examined and 195 specimens (44 collections) of P. n. notogramma (Fig. 1B) were examined. The following collections were used (the earliest taken in 1956, the last in 1970). The catalog number of the University of Richmond and the number of specimens (in parantheses) are followed by the locality and date.

Percina peltata peltata.--- Rappahannock River, Virginia: 2036 (12), Madison Co., Robinson R., 6 Nov. 1964; 2259 (5), Madison Co., Robinson R., 4 Dec. 1964; 2270 (5), Madison Co., Robinson R., 4 Dec. 1964; 2302 (2), Fauquier Co., Cedar Run, 29 Dec. 1964; 2430 (2), Fauquier Co., Thumb Run, 29 Dec. 1964; 3026 (16), Orange-Madison Co., Rapidan R., 13 May 1970; 2719 (7), Orange-Madison Co., Rapidan R., 31 July 1969; 2657 (9), Orange-Madison Co., Rapidan R., 30 Sept. 1968; 2665 (12), Orange-Madison Co., Rapidan R., 30 Sept. 1968; 2656 (67), Orange-Madison Co., Rapidan R., 30 Sept. 1968; 1610 (1), Madison Co., Rapidan R., 14 Sept. 1963; 2526 (32), Orange-Madison Co., Rapidan R., 6 Oct. 1967; 2888 (28), Orange-Madison Co., Rapidan R., 24 Oct. 1969; 2229 (14), Orange-Madison Co., Rapidan R., 6 Nov. 1964. James River, Virginia: 366 (1), Hanover Co., Beaver Dam Cr., 8 April 1958; 1826 (3), Cumberland Co., Willis R., 25 June 1964; 1834 (1), Cumberland Co., Willis R., 25 June 1964; 2450 (16), Chesterfield Co., James R., 13 July 1966; 2572 (14), Powhatan Co., James R., 8 July 1968; 2574 (12), Powhatan Co., James R., 8 July 1968; 2571 (10), Powhatan Co., James R., 14 Sept. 1968; 2137 (1), Prince Edward Co., Buffalo Cr., 1 Nov. 1964; 2465 (14), Fluvanna Co., Rivanna R., 13 July 1967; 2662 (12), Fluvanna Co., Rivanna R., 30 Sept. 1968; 2655 (4), Fluvanna Co., Rivanna R., 30 Sept. 1968;

2008 (7), Fluvanna Co., Rivanna R., 16 Oct. 1964. York River, Virginia: 542 (8), Hanover Co., Little R., 11 Sept. 1958; 1066 (10), Spotsylvania Co., Matta R., 10 July 1961; 557 (3), Caroline Co., Matta R., 11 Sept. 1958; 576 (19), Caroline Co., Matta R., 11 Sept. 1958; 2784 (4), Spotsylvania Co., Matta R., 29 Oct. 1969; 1319 (2), Hanover Co., South Anna R., 10 May 1963; 522 (22), Hanover Co., South Anna R., 11 Sept. 1958; 2240 (12), Hanover Co., South Anna R., 23 Oct. 1964; 2585 (3), Hanover Co., South Anna R., 2 May 1968; 2575 (7), Hanover Co., South Anna R., 24 May 1968; 3337 (12), Hanover Co., South Anna R., 22 Sept. 1967; 2664 (16), Hanover Co., South Anna R., 24 Sept. 1968; 2085 (22), Hanover Co., South Anna R., 23 Oct. 1964.

Percina notogramma notogramma.---Rappahannock River, Virginia: 3027 (3), Orange-Madison Co., Rapidan R., 13 May 1970; 2660 (2), Orange-Madison Co., Rapidan R., 30 Sept. 1968; 2523 (10), Orange-Madison Co., Rapidan R., 6 Oct. 1967; 2228 (1), Orange-Madison Co., Rapidan R., 6 Nov. 1964; 2037 (2), Madison Co., Robinson R., 6 Nov. 1964; 2269 (2), Madison Co., Robinson R., 4 Dec. 1964. James River, Virginia: 711 (3), Henrico Co., Tuckahoe Cr., 26 May 1959; 1667 (4), Henrico-Goochland Co., Tuckahoe Cr., 12 May 1964; 257 (1), Henrico-Goochland Co., Tuckahoe Cr., 12 Sept. 1957; 142 (3), Henrico-Goochland Co., Tuckahoe Cr., 14 Nov. 1956; 1808 (3), Buckingham Co., Whispering Cr., 25 June 1964; 1847 (3), Buckingham Co., Willis R., 25 June 1964; 1833 (1), Cumberland Co., Willis R., 25 June 1964; 1827 (4), Cumberland Co., Willis R., 25 June 1964; 1854 (2), Cumberland Co., Willis R., 25 June 1964; 771 (1), Powhatan Co., Norwood Cr., 22 April 1960; 868 (1), Powhatan Co., Fine Cr., 11 July 1961; 2449 (1), Chesterfield Co., James R., 13 July 1966; 686 (3), Powhatan Co., Bernard Cr., 21 July 1959; 96 (2), Powhatan Co., James R., 11 Oct. 1956;

2464 (1), Fluvanna Co., Rivanna R., 13 July 1967; 2661 (5), Fluvanna Co., Rivanna R., 30 Sept. 1968; 2007 (6), Fluvanna Co., Rivanna R., 16 Oct. 1964. York River, Virginia: 2466 (14), Spotsylvania Co., Po R., 18 Aug. 1967; 866 (2), Caroline Co., Matta R., 10 July 1961; 2659 (4), Spotsylvania Co., Matta R., 20 July 1968; 556 (2), Caroline Co., Matta R., 11 Sept. 1958; 575 (8), Caroline Co., Matta R., 11 Sept. 1958; 2783 (15), Spotsylvania Co., Matta R., 29 Oct. 1969; 2149 (1), Spotsylvania-Louisa Co., North Anna R., 30 Oct. 1964; 2039 (9), Orange Co., Madison Run, 6 Nov. 1964; 1210 (1), Hanover Co., Shop Cr., 30 July 1959; 1292 (7), Louisa Co., Deep Cr., 23 April 1963; 1076 (2), Louisa Co., Deep Cr., 22 May 1962; 2721 (5), Louisa Co., Deep Cr., 31 July 1969; 1920 (7), Louisa Co., Deep Cr., 30 Sept. 1964; 523 (3), Hanover Co., South Anna R., 11 Sept. 1958; 2239 (11), Hanover Co., South Anna R., 23 Oct. 1964; 2038 (6), Louisa Co., South Anna R., 6 Nov. 1964; 2586 (4), Hanover Co., South Anna R., 2 May 1968; 2576 (9), Hanover Co., South Anna R., 24 May 1968; 2216 (2), Hanover Co., South Anna R., 13 Sept. 1957; 2663 (10), Hanover Co., South Anna R., 24 Sept. 1968; 2086 (9), Hanover Co., South Anna R., 23 Oct. 1964.

Methods

All data were taken from preserved specimens collected with a 10 ft seine of 0.25 in mesh. Standard length measurements were taken with dial calipers to the nearest .1mm and rounded to the nearest mm.

All specimens except for 10 young notogramma were sexed by either examination of external characters or gross examination of the gonads. Following the studies of Raney and Hubbs (1948), Collette (1965) and New (1966) the sexes were distinguished externally by the larger, highly

modified ventral and shield scales of the males, and the larger, more elaborate genital papillae of the females (Figs. 2, 3). All female notogramma had small nonspecialized ventral scales whereas about 92% of the female peltata were scaleless in this area.

For age determination at least five scales were removed from the right side of each specimen above the lateral line and at the distal end of the depressed pectoral fin. Occasionally, particularly on older specimens, this location contained regenerated scales. To get readable scales of comparable size, samples were taken from the corresponding area on the left side. All scales were immersed in 5% KOH and then scrubbed to remove adherent skin with a soft bristle under a dissecting microscope. Following a standard procedure, the scales were mounted in glycerine jelly on microscope slides for projection on a screen. As the scales had approximately the same refractive index as the temporary mounting medium it was necessary to provide contrast. The cleaned scales were stained with Alizarine Red S, destained in 5% KOH, washed in water and mounted in glycerine jelly. This time-consuming procedure was replaced by a simpler and more efficient one whereby cleaned scales were directly mounted in a deep purple mixture of Alizarine Red S and glycerine jelly.

Scales were read by viewing an enlarged image on a screen. A projector with a microprojection apparatus (10X objective) provided a magnification of 338X. A minimum of four scales from each specimen were read. Where annuli were difficult to interpret, verification of age was made by others with experience in scale reading.

Average length per year class is presented graphically following Hubbs and Hubbs (1953) in Fig. 5. A comparison of the growth by year in the two species is shown by plotting standard length means by year class

(Fig. 6). The sex and age structure data were analysed using Chi-square tests following the method of Downie and Heath (1959) and Siegel (1956).

An analysis of variance was made on the standard length measurements using a three-factor factorial design. An unweighted means analysis was performed because of unequal cell frequencies (Winer, 1962). The factors investigated were sex, species and year classes 0-II. Year class III was not included in the analysis because of insufficient data. Where differences were found among three or more means in a set, Duncan tests (Duncan, 1955) were performed. The .05 level of significance was chosen for all statistical tests.

Results

Two methods often used in aging fishes are length-frequency analysis and scale reading. A length-frequency analysis according to Lagler (1956) requires that a large sample or samples be collected in a restricted period of time and that a good representation of all sizes and age groups be present. These conditions could not be met in this study because the specimens available were from small samples irregularly collected over a long period of time (1956 - 1970). Therefore, the length-frequency procedure was abandoned and only the scale reading technique was employed.

The scale annuli were defined as cross-overs of the circuli on the lateral fields and where an increase in spacing followed the conspicuous crowding of the circuli on the anterior field (Fig. 4). Even though the scales were readily identifiable for each species, the annuli had similar characteristics and could be interpreted in the same way. The scales from peltata were approximately equal in length and width, and had an extensive posterior field with short, stout cteni (Fig. 4A). The scales

of notogramma had a more delicate appearance and were longer than wide. Also, the posterior field of these scales was less extensive and had recognizably thinner cteni (Fig. 4B).

Both species are short-lived, only one male peltata and three males and one female notogramma survived to the fourth year. The year classes were more easily distinguishable in peltata although the differences between the mean lengths per year class were statistically significant in both species (Table 1, Fig. 5). In analysing the internal age structure of the species no significant difference was found between year classes 0 and I; however, between year classes I and II the difference in numbers was highly significant (Table 2). The much greater size of the II-year class precluded a statistical analysis of the difference between it and the III-year class.

A higher ratio of males to females occurred in 0-year classes of both species and this was the only age group to show significant sexual dominance (Table 3). The overall sex ratio in peltata did not depart significantly from a 1:1 ratio, whereas notogramma showed a significant predominance of males.

The growth in both species of darters was approximately the same after the first year. Percina peltata, the larger of the two species, appeared to gain an advantage in its first year (P. peltata $\bar{X}$ 42.7 mm, P. notogramma $\bar{X}$ 38.3 mm) and maintained it thereafter. Average increments of growth between successive year classes for peltata were approximately 11, 8 and 4 mm; for notogramma 9, 11 and 4 mm (Table 1, Fig. 6). A maximum size of 71 mm standard length was recorded for a female peltata and a female notogramma, both members of II-year class. An analysis of variance for species, sex and year class was done on the standard length

data for the first three year classes of each species (Table 4). A significant difference at the .01 confidence level existed between the two species and among the year classes of the species (.05 level acceptable). No significant difference occurred between the sexes nor were the interaction effects significant. Further statistical analysis employing the Duncan procedure for testing differences between ordered means of the year classes proved significant at the .01 level (Table 5).

Discussion

Annual marks on scales, which reflect the cessation of one year's growth and the resumption of the next in freshwater fishes in temperate zones, provide a record of their age and growth. The scale method of analysing age and growth has been applied to many groups of fishes and has proved a valid technique in the studies of percids (Raney and Lachner, 1943; Lachner et al., 1950; Parsons, 1950; and Fahy, 1954). Percina peltata and notogramma lend themselves to this type of study as they have easily recognizable annuli which are readily traceable from the anterior field onto the shoulders of the scales. In this respect they are like the darters, Etheostoma variatum, E. zonale and E. blennioides (Lachner et al., 1950) but unlike E. olmstedi and E. longimanum (Raney and Lachner, 1943) where annuli were not apparent on the lateral field. The annulus is formed on the scales of peltata and notogramma in the spring (March to late May) when growth begins after a winter's quiescence. False annuli (first year accessory marks) were present on the scales of a few specimens of each species. The occurrence of these supernumerary marks, which followed no discernible pattern and represent an interruption in growth, could have been caused by a variety of environmental conditions affecting their physiology.

The typical life-span for peltata and notogramma was three years, with a few individuals of each species surviving to the fourth year (Table 1). Longevity studies on other percids (Raney and Lachner, 1939, 1943; Parsons, 1950; Lachner et al., 1950; and Fahy, 1954) have indicated that they are relatively short-lived fishes, existing from three to six years. Significant losses occurred in both darters between I and II-year classes and again between II and III-year classes (Table 2). The causes of these fatalities are not known but may be the result of winter-kill. Fishes subjected to extreme temperature drop often die because they are unable to regulate vital metabolic processes (Lagler et al., 1962). In the shallow streams where the species are found temperature fluctuations are common. It is also possible that the stress of overwintering may leave the surviving darters in a weakened condition which could result in death during the energy-consuming spawning activities. While there is no direct evidence available of predation on these fishes it is reasonable to assume that there is some predation pressure since they occur in streams where predators of other fishes exist.

Males dominate the 0-year classes of both species but in all other year classes the sexes were approximately equal. The statistical male advantage in the 0-year class of notogramma was great enough to bias the over-all sex ratio. Possibly the preponderance of males in the 0-year class was due to sampling technique. Fahy (1954) in his study of blennioides found that males dominated the I-year class. Raney and Lachner (1943) noted that the sex ratio for olmstedi was inconsistent and varied with the population. Individual populations were not analysed in the present study and conclusions as to why the first year was dominated by males must await further investigation.

The growth curves of peltata and notogramma were similar, rising sharply during the first year and leveling off with age (Fig. 6). The amount of growth in peltata decreased in successive year classes; however, notogramma had a greater average increment of growth between I and II-year classes than between 0 and I-year classes (Table 1). The greater growth between 0 and I-year classes is probably due to sampling error in the first year which caused the mean to be displaced upward. The standard length means given for the 0-year classes of both species (Table 1, Figs. 5, 6) are probably high and may have resulted from the times of collection and the type of collecting equipment used. That this sampling error was more apparent in notogramma taken in their first year was to be expected as only four specimens in this age group were taken prior to August 1 and they did not appear in the samples until late July as they were too small to be caught by the mesh of the seine. Young peltata reached a collectable size in early July and therefore the smaller sized specimens of the 0-year class were better represented in the samples.

The mean size of peltata was significantly larger than that of notogramma (Table 4) and the almost parallel growth curves after the first year (Fig. 6) indicated that the larger size of peltata was primarily a result of greater growth during its first year of life. The males did not differ significantly in size from females in either species (Table 4). The equal size of the sexes in these two Percina is like that reported for P. maculata (Petravicz, 1938) and may be related to the absence of egg-guarding activities in the genus. Raney and Lachner (1943) proposed that the males of egg-guarding darters were larger than the females, whereas non-egg-guarding percids either had sexes of equal size or larger females. Studies on darters of the egg-guarding genus, Etheostoma, by

Raney and Lachner (1939, 1943), Lachner et al. (1950) and Fahy (1954) have shown that the males reach a larger size earlier in their lives than do the females. There is no data on the post-spawning behavior of notogramma, however New (1966) reports that peltata does not protect its eggs. Winn (1958) who studied eleven species of Etheostoma and three species of Percina, believes that the lack of a sexual dichotomy in size is characteristic of the more primitive groups of darters (Percina) and that the complex reproductive behavior of Etheostoma is indicative of their advanced condition.

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Table 1. The mean lengths per year class of *Percina peltata* and *Percina notogramma*[1].

	Year Class	N	Range mm	$\bar{X}$ mm	SD	2SE	Ave. growth increment mm
P. peltata							
	0	198	28-57	42.7	6.4	1.2	42.7
	I	194	43-65	54.0	3.0	0.6	11.3
	II	54	55-71	62.1	3.4	0.9	8.1
	III	1	66	66.0	-	-	3.9
P. notogramma							
	0	53	27-55	38.3	6.5	1.8	38.3
	I	77	32-61	47.0	6.4	1.4	8.7
	II	51	46-71	57.5	5.6	1.6	10.5
	III	4	58-66	61.8	3.3	3.3	4.3

[1] 10 unsexed 0-year class *notogramma* not included.

Table 2. Chi-square analyses of the age structures of Percina peltata and Percina notogramma.

	Year Class	N	Comparison of year classes	N	χ^2
P. peltata					
	0	198	0 x I	392	0.16
	I	194	I x II	248	79.03*
	II	54	0+I x II+III	447	258.25*
	III	1			
P. notogramma					
	0	63	0 x I	140	0.71
	I	77	I x II	128	5.28*
	II	51	0+I x II+III	195	370.51*
	III	4			

* significant at .05 level

Table 3. Chi-square analyses of the sex ratios of Percina peltata and Percina notogramma[1].

Year class	No. specimens Male	Female	χ^2
P. peltata			
0	114	84	4.54*
I	110	84	3.48
II	25	29	0.30
III	1	0	-
0 x I x II+III	250	197	2.17
P. notogramma			
0	37	16	8.32*
I	36	41	0.32
II	23	29	0.49
III	3	1	-
0 x I x II+III	99	86	7.94*

[1] 10 unsexed specimens of notogramma not included,

* significant at .05 level

Table 4. Analysis of variance summary table for the standard length data of Percina peltata and Percina notogramma.

Source	SS	df	MS	F
species	3,004.34	1	3,004.34	110.80*
sex	94.64	1	94.64	3.49
year class	27,216.20	2	13,608.10	501.89*
species X sex	72.63	1	72.63	2.68
species X year class	116.03	2	58.02	2.14
sex X year class	114.79	2	57.39	2.12
species X sex X year class	145.48	2	72.74	2.68
within cell	16,675.41	615	27.11	

* $F_{.01}$ (1, 615) = 6.68, $F_{.01}$ (2, 615) = 4.64; $F_{.05}$ (1, 615) = 3.86, $F_{.05}$ (2, 615) = 3.01

Table 5. Summary table of the Duncan procedure for testing differences between the ordered means of year classes 0-II of Percina peltata and Percina notogramma.

Ordered differences	0	I	II
0	-	41.45*	78.12*
I	-	-	36.67*
II	-	-	-

* significant at the .01 level

Fig. 1. A. Dorsal and lateral views of Percina peltata peltata. B. Dorsal and lateral views of Percina notogramma notogramma.

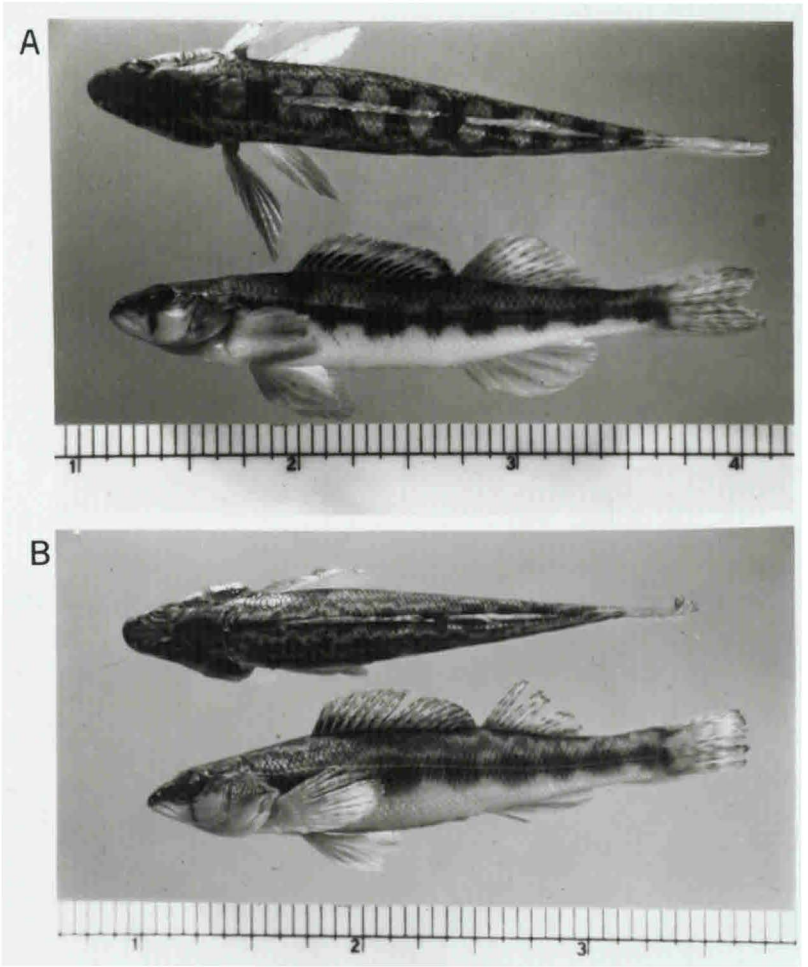
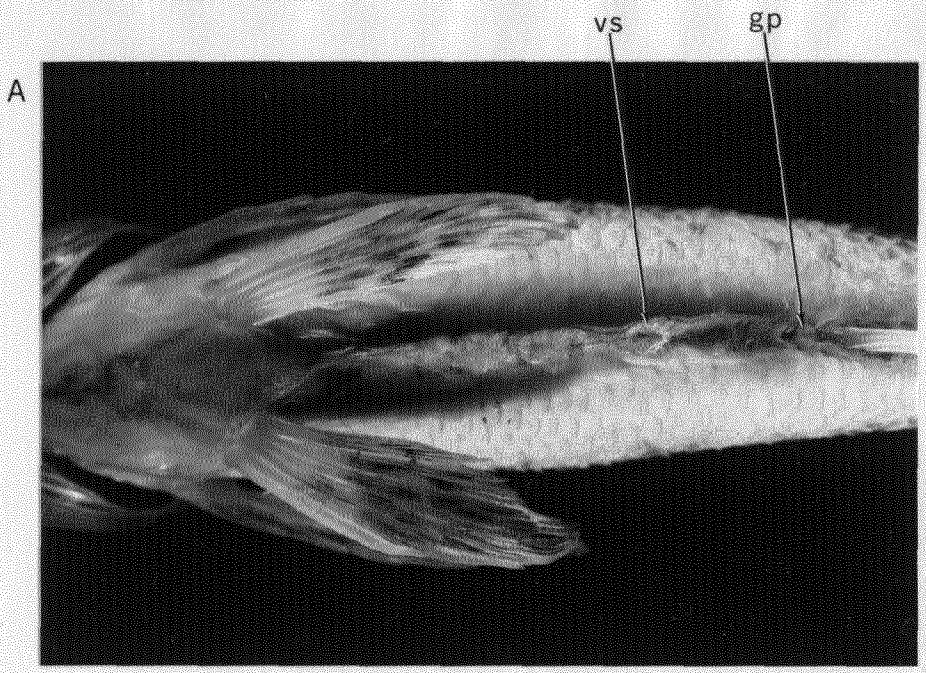

A
1
2
3
4
B
1
2
3

Fig. 2. Ventral view of Percina peltata. A. Male, S.L. 55.9 mm. B. Female, S.L. 59.0 mm. gp, genital papillae; vs. ventral scales.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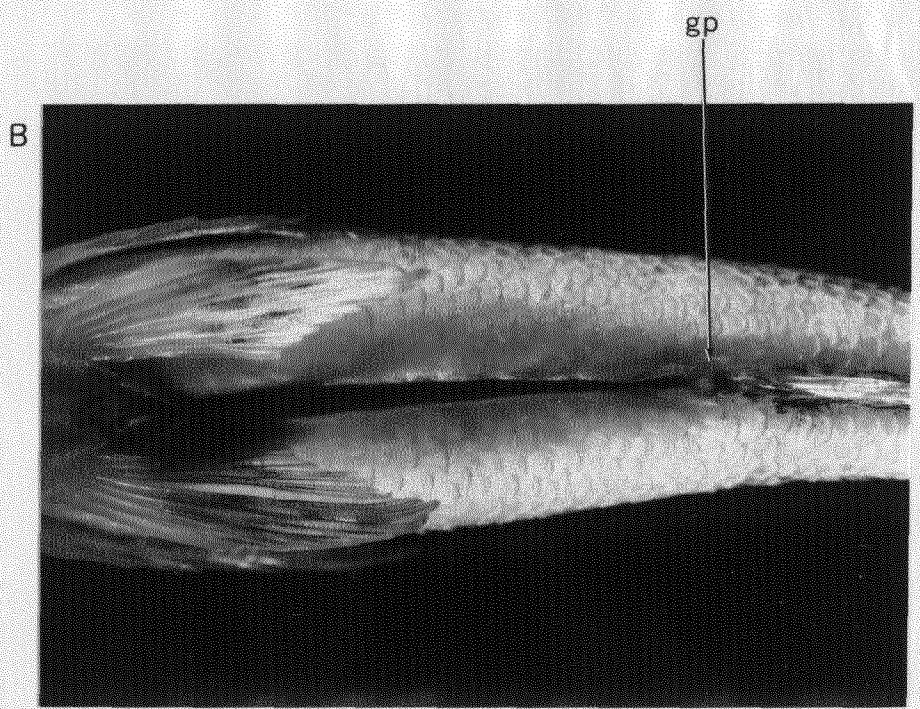
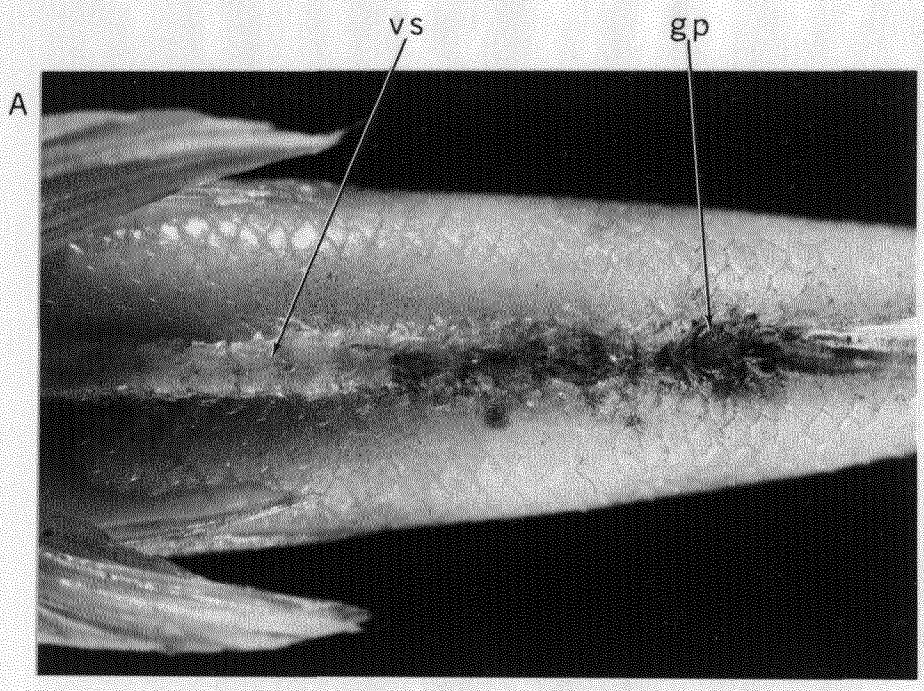

B
gp

Fig. 3. Ventral view of Percina notogramma. A. Male, S.L. 59.8 mm. B. Female, S.L. 53.5 mm.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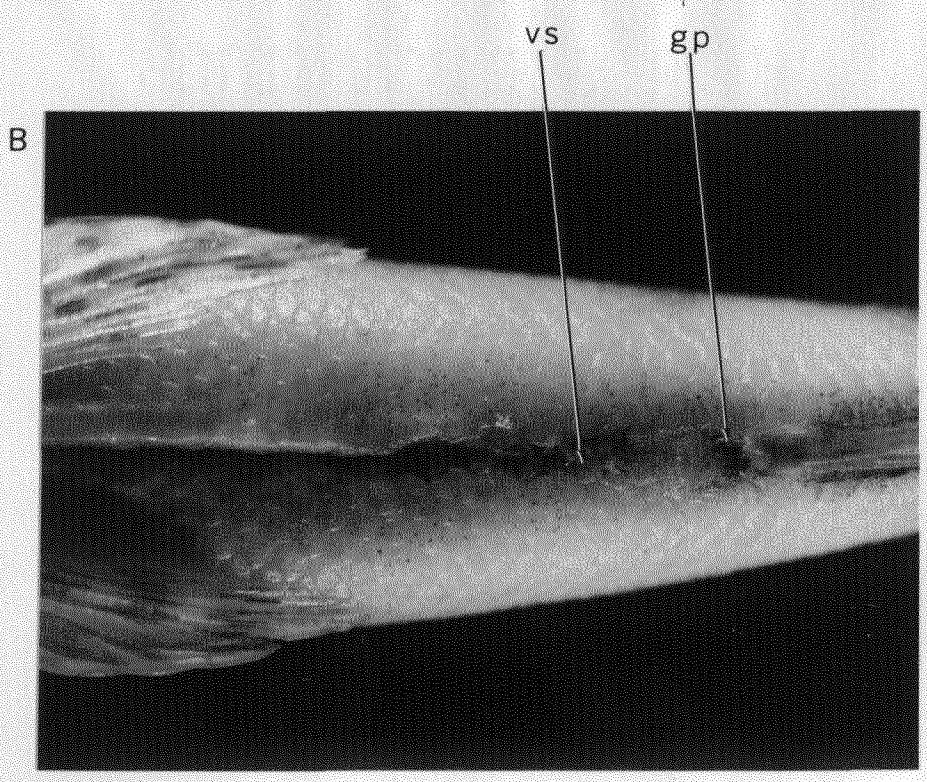

B
vs
gp

Fig. 4. A. Scale from Percina peltata in its third year of life, two annuli are present. Actual size of scale, 1.36 mm. B. Scale from Percina notogramma in its third year of life, two annuli are present. Actual size of scale, 1.23 mm.

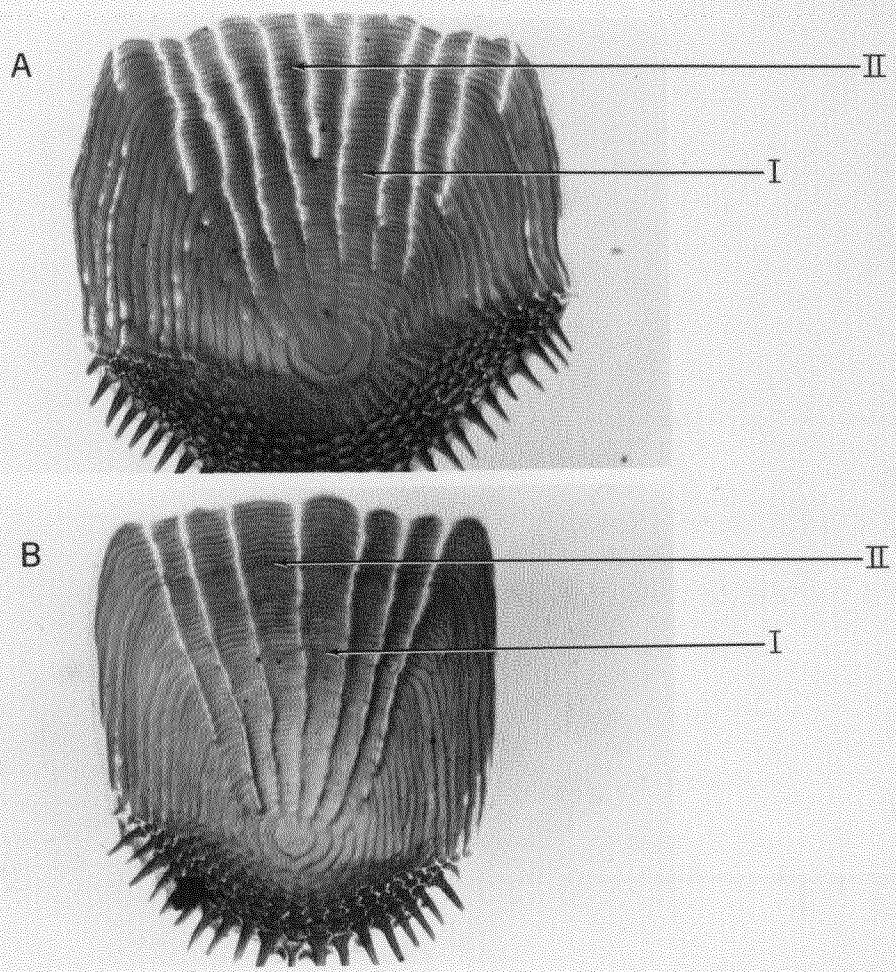

A
II
I
B
II
I

Fig. 5. Average length per year class of Percina peltata and Percina notogramma in Virginia. The range is indicated by the horizontal line; the mean, by the vertical line; twice the standard error on each side of the mean, by a black bar; and one standard deviation on each side of mean, by black bar plus white bar at end.

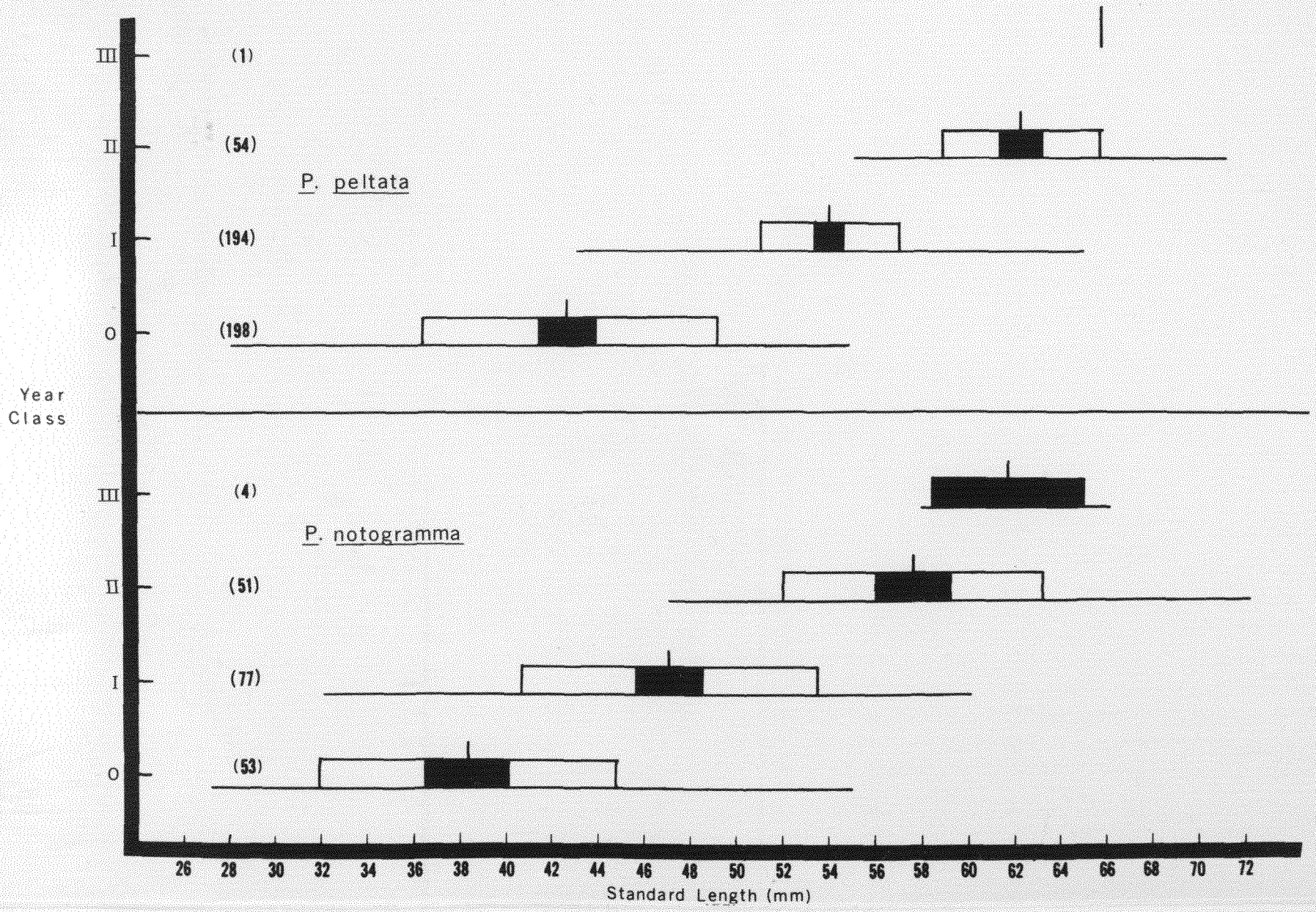
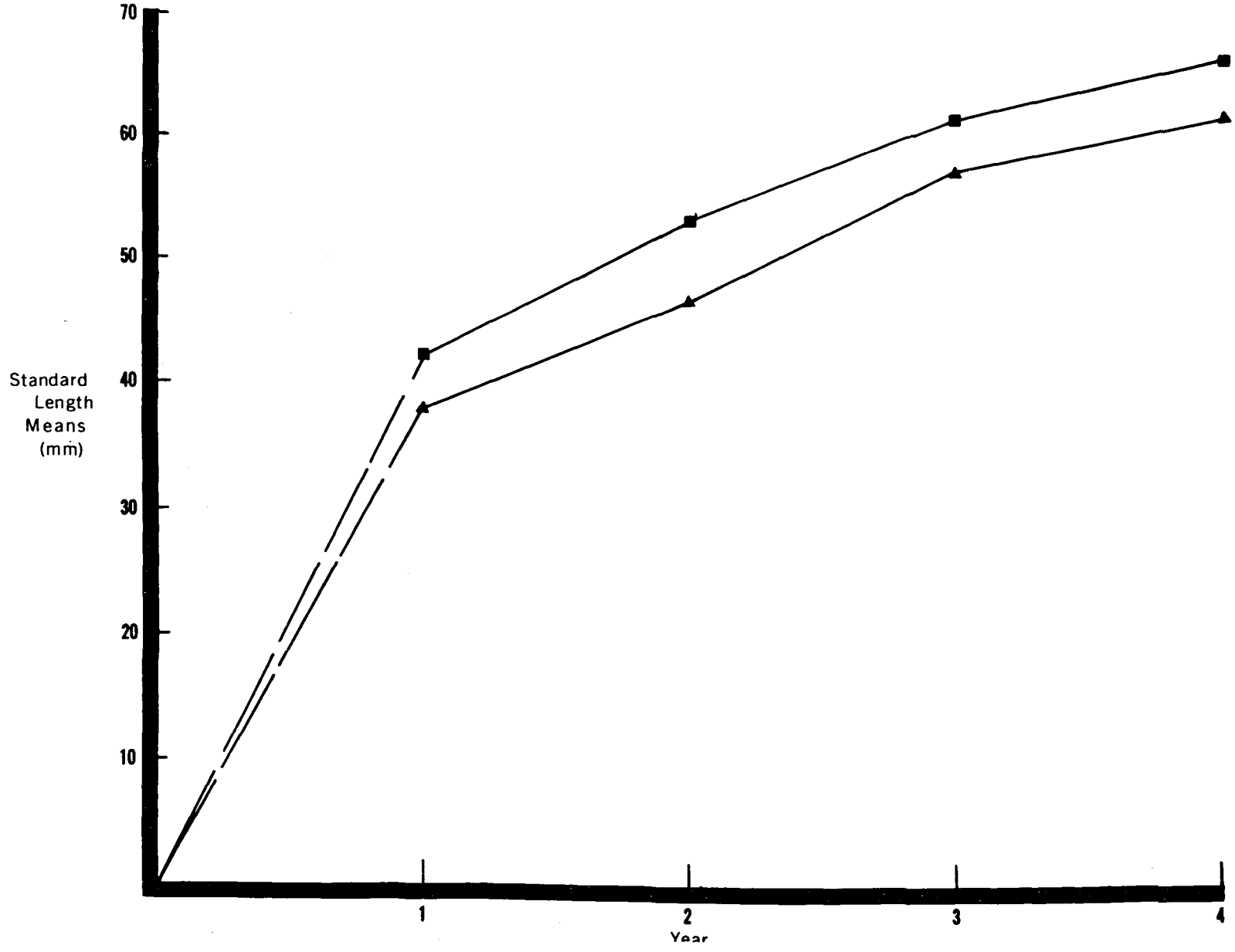

III
II
I
0
Year Class
(1)
(54)
P. peltata
(194)
(198)
(4)
P. notogramma
(51)
(77)
(53)
26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72
Standard Length (mm)

Fig. 6. A comparison of the growth by year of Percina peltata and Percina notogramma. Upper curve with squares is P. peltata; lower, with triangles is P. notogramma.


70
60
50
40
30
20
10
Standard Length Means (mm)
1
2
3
4
Year

Vita

Garnett William Link, Jr. was born May 7, 1945, in Charlottesville, Virginia. He attended public schools in Petersburg, Virginia and was graduated from Petersburg High School in June, 1963. He received a Bachelor of Arts degree from the University of Virginia in June, 1967 with a major in Biology. After graduation he began graduate study at the University of Richmond and while attending there became a member of the Beta Beta Beta Honorary Biological Society, the Atlantic Estuarine Research Society, the Association of Southeastern Biologists and the American Society of Ichthyologists and Herpetologists. He entered the Zoology Department of the University of North Carolina at Chapel Hill in September, 1970 to begin work toward the degree of Doctor of Philosophy with special interest in marine ichthyology. He completed the requirements for the Master of Arts degree from the University of Richmond in August, 1971.