1965

Percina notogramma montuosa Hogarth, a new subspecies of a percid fish from the upper James River

William Thomas Hogarth

PERCINA NOTOGRAMMA MONTUOSA HOGARTH, A NEW SUBSPECIES OF A PERCID FISH FROM THE UPPER JAMES RIVER

A Thesis

Presented to the Faculty of the Graduate School

of the University of Richmond

in Partial Fullfillment of the Requirements of the

Degree of Master of Science

Approved
W. R. West Jr.
W S Woolcott
[illegible]
F. B. Leftwich
N. E. Rice
Wilton R. Tenney
J. C. Strickland
[illegible]
Jackson J Taylor
E. Sherman Grable

by

William Thomas Hogarth

June 1965

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Sincere thanks are expressed to the following persons who have offered much help in the preparation of this thesis: Dr. William S. Woolcott, Jr., chairman of my graduate committee, for his help in securing specimens and for many hours of advice, encouragement and critical reading of the manuscript; Dr. Warwick R. West and Dr. Frank B. Leftwich, the other members of my committee, for their helpful criticisms. Specimens and x-rays were provided by Drs. Leonard P. Schultz and Ernest A. Lachner, curators at the U.S. National Museum. Specimens were made available also by Dr. Edward C. Raney, Cornell University, Dr. Robert D. Ross, Virginia Polytechnic Institute, and Dr. Reeve M. Bailey, University of Michigan Museum of Zoology. Much of the equipment used in the study was provided by Dr. Willie M. Reams, University of Richmond. Dr. William H. Leftwich of the Department of Psychology helped with the statistical analyses. Dr. Wilton R. Tenney helped with the photography. Dr. Bruce B. Collette, U.S. National Museum, Dr. Bruce Hobbs, State Division of Mineral Resources, Charlottesville, Virginia, and the University of Virginia Department of Geology aided by clarifying certain aspects of this problem. Miss Anne Caperton Beirne assisted in the preparation of maps, graphs and typing. Field collecting was greatly facilitated by Dr. William S. Woolcott, Anne Caperton Beirne, Dennis M. McKee,

Lawrence W. Kiss, Ronald W. Burset and Eric J. Collins, all of the University of Richmond, and Kenneth L. Poff, West Virginia University. The work was supported partly by a University of Richmond Williams Fellowship. Without the encouragement and aid from my mother, Mrs. Margaret S. Hogarth, the study would have been impossible.

ABSTRACT

Percina notogramma montuosa is described from 50 specimens taken in the tributaries of the upper James River. It is best separated from Percina notogramma notogramma, which inhabits the lower James, Rappahannock, York, Potomac and Patuxent rivers, on the basis of lateral-line scales (average difference 89%) and scales around the caudal peduncle (average difference 79%). A comparison of the meristic indices resulted in an average difference of 89%. A total of 18 out of 31 meristic and proportional characters were found to give significant differences.

The relatively few specimens from the Rappahannock, Potomac and Patuxent rivers precluded an intensive investigation of intrasubspecific variation but the data indicate that each river system represents a genetically isolated population cut off from its neighboring population by Chesapeake Bay.

INTRODUCTION

In 1948 Raney and Hubbs described the stripeback darter, Percina notogramma (Raney and Hubbs), which formerly had been confused with the shielded darter, Percina peltata (Stauffer). Percina notogramma occurs in the tributaries of Chesapeake Bay (except base-level parts) from the James River system in Virginia and West Virginia, north to the Patuxent River system in Maryland. On the basis of differences in certain meristic characters, they suggested the possibility of the existence of two subspecies; one with higher counts in the upper James River, and a second subspecies within the lower James, York, Rappahannock, Potomac and Patuxent rivers. However, because of a sparsity of specimens they did not consider it feasible to pursue this phase of the investigation.

Subsequent collections have added to the available specimens and in this study a new subspecies of Percina notogramma has been designated from the upper James River.

CHANGE OF SPECIES HOLOTYPE

In their paper Raney and Hubbs (1948) designated UMMZ 144696 (♂, 67), Va. Rockbridge Co., South R., 5 mi E Lexington, L.C. Pettit; May 17, 1941; orig. CU 9719 as holotype; and USNM 40242; CU 8324, 9708, 10138, 4909; UMMZ 144697 and 95194 as paratypes for Hadropterus notogrammus

Raney and Hubbs = Percina notogramma (Raney and Hubbs). Collette and Knapp (unpublished manuscript) do not consider these as valid types because the type specimens for a nomen novum must be the same as for the original name (Art. 72 d, Int. Code Zool. Nomencl.). Their correction of the holotype of Percina notogramma is reproduced in toto herein with the following data after each name: Citation of original description; catalogue number; in parentheses sex, number of specimens and standard length in mm; locality; collector; date of collection; determination of current status with reference to pertinent literature.

"Hadropterus maculatus Girard, 1859, Proc. Acad. Nat. Sci. Phila. 11: 100.

Lectotype: USNM 1157 (♂, 69), Md., Anne Arundel Co., eastern trib. of Potomac R.; J.H. Clark;selected herein by Dr. Edward C. Raney. D XIV-12; A II, 9; pectoral rays 14-13; LL 55; scales above and below lateral line 7-10; caudal peduncle scales 21; cheeks sparsely scaled; opercles scaled; preopercles and nape naked; 11 enlarged scales on midline of belly. This specimen is also the type of Hadropterus notogrammus Raney and Hubbs.

Paralectotype; USNM 197773 (♂, 56) removed from USNM 1157. MCZ 24525 (2♂, 60-64), originally USNM 1303,

then MCZ 129, and MCZ 242546 (2♂, 54-55), originally USNM, then 130, have the same data and were probably part of the original series but they were received from the USNM in 1853 and the description was not published until 1859 so it is doubtful if Girard had the specimens before him at the time of the original description. Therefore the four specimens had best be considered only as topotypes, both of H. maculatus Girard and H. notogrammus (Raney and Hubbs) because maculatus is preoccupied by Alvordius maculatus Girard.

Hadropterus notogrammus Raney and Hubbs, 1948, Occ. Pap. Mus. Zool. Univ. Mich. no. 512; pl. 1, figs. 1-2; pl. 2, figs. 1-2; a replacement name for Hadropterus maculatus Girard which was preoccupied.

Types: Raney and Hubbs designated UMMZ 144696 [(♂, 67), Va. Rockbridge Co., South R., 5 mi.E. Lexington, L.C. Pettit; May 17, 1941; orig. CU 9719.] As holotype; and USNM 40242; CU 8324, 9708, 10138, 4909; UMMZ 144697 and 95194 as paratypes. However, these designations are not valid because the type specimens for a nomen novum must be the same as for the original name (Art. 72 d, Int. Code Zool. Nomencl.) in this case USNM 1157, lectotype and USNM 197773,

paralectotype of Hadropterus maculatus Girard. = Percina (Alvordius) notogramma (Raney and Hubbs)."

Therefore the nominal subspecies P. n.notogramma occurs in the lower James and other rivers within the range of the species and the new subspecies in the upper James. It should also be noted that Raney and Hubbs (1948) considered the USNM 1157 collection (new type specimen) to be from a tributary of the Patuxent River rather than from the Potomac as listed in the data.

Percina notogramma montuosa

n. subsp. - Mountain Stripeback Darter

Hadropterus notogrammus Raney and Hubbs 1948. Percina notogramma Bailey and Gosline 1955.

Diagnosis: Percina notogramma montuosa may be differentiated from Percina notogramma notogramma on the basis of the following meristic characters. The ranges, (means in parentheses), are given first for P. n. montuosa and then for P. n. notogramma. Lateral-line scales, 56-67 (62.1); 49-64 (55.9): Scales above lateral-line, 6-8 (7); 5-8 (6): Scales around caudal peduncle, 20-23 (22); 18-34 (21): Total dorsal elements, 25-29 (28); 24-30 (27): Vertebrae, 42-45 (43); 40-45 (41.6): Meristic index, 101-111 (104.9); 87-107 (96.7). Differences in characters

having less diagnostic significance are given in the Results section.

Etymology of montuosa is from the Latin meaning "of the mountains."

Range and Habitat: Percina notogramma notogramma inhabits the Piedmont tributaries of the James River west to the Albermarle County line and rivers north of the James to the Patuxent River system in Maryland (Fig. 3). The Rappahannock and Potomac rivers like the James have headwaters in the mountains; the headwaters of the York (Mattaponi and Pamunkey) and Patuxent rivers are entirely within the Piedmont Province. Except for the samples from the upper Rappahannock River, all specimens were taken in the Piedmont and upper coastal plain regions, even though several tributaries of the Potomac River west of the falls were sampled. This finding was in agreement with the work of Raney and Hubbs (1948) who also found that the northern river populations were in the lower region.

In general, P. n. notogramma was found in lower riffle or pool area of streams characterized by short, gravel-bottom riffles and long, deep, silted-in pools.

Percina notogramma montuosa occurs in the James River from Scottosville in Albermarle County west to the head-

waters in Monroe County, West Virginia (Fig. 3).

Scottsville is at the point where the course of the James River abruptly changes from a northeasterly direction toward the southeast. In this area and for several miles downstream the James is wide and shallow with a shifting sand bottom. Tributaries on the east side, which yielded no specimens, have essentially the same characteristics as the major stream. The species P. notogramma normally is not found in habitats with shifting sand bottoms. Therefore it is suggested that this region of the river acts as a partial barrier between the subspecies P. n. notogramma and P. n. montuosa. On the west side, however, where several successful collections were made, the secondary streams have a steeper gradient, gravel and rubble bottoms and are characteristic of the lower montane or upper Piedmont regions. The habitat of P. n. montuosa, in contrast to that of P. n. notogramma,was usually the faster parts of riffles.

MATERIALS EXAMINED

The materials are listed by species, subspecies, and drainages. The abbreviations which precede the collection numbers are CU (Cornell University), UMMZ (University of Michigan Museum of Zoology), UR (University of Richmond),

USNM (United States National Museum) and VPI (Virginia Polytechnic Institute). The number of specimens in the sample, (in parentheses), follows the museum designation.

Standard abbreviations are used in recording locality data.

Percina notogramma montuosa Hogarth

Upper James River

Holotype: UR 2099 to be sent to USNM (♂,51), Beaver Cr. 4 mi E of Lynchburg at bridge on U.S. Rt. 460, Campbell Co., Va., October 20, 1964. WTH-Va-8, W.T. Hogarth and Eric Collins. (Fig. 1 A&B) Star on the map represnets type locality (Fig. 3).

Paratypes: 49 specimens. UR 2237 (3), Hog Cr. at junc. with Rockfish R., Albermarle Co., Va., April 15, 1965. UMMZ 144697 (3), North R., Rockbridge Co., Va. UMMZ 175103 (5), Potts Cr. above junc. with Jackson R., Alleghany Co., Va. UR 2294 (6), junc. Rock Castle Cr. and Totier Cr., Albermarle Co., Va., April 1, 1965. VPI 1006 (2), Craig Cr., Craig Co., Va., August 19, 1958. CU 47322 (1), Craig Cr., Craig Co., Va., June 6, 1963. VPI 1014 (1), South R., Rockbridge Co., Va., August 21, 1958. VPI 981 (1), Jackson R., Bath Co., Va., July 15, 1958. CU 47321 (2), Jackson R.,

Bath Co., Va., July 20, 1963. VPI 954 (2), Cow Pasture R., Bath Co., Va., July 3, 1958. UR 2350 (1), Owens Cr., Nelson Co., Va., April 15, 1965. UR 1797 (3), John's Cr., Craig Co., Va., June 27, 1963. UR 2321 (12), Partridge Cr., Amherst Co., Va., April 15, 1965. VPI 963 (1), Jackson R., Bath Co., Va., July 2, 1958. VPI 1005 (1), Craig Cr., Craig Co., Va., August 19, 1958. UR 2099 (3), Beaver Cr., Campbell Co., Va., October 20, 1964. UMMZ 175121 (1), Potts Cr., Alleghany Co., Va. UMMZ 95941 (1), Dunlap Cr., Alleghany Co., Va.

Percina notogramma notogramma (Raney and Hubbs)

Lower James and Appomattox Rivers

UR 1847 (3), Willis R., Buckingham Co., Va., June 25, 1964. UMMZ 174699 (6), Swanee Cr., Appomattox Co., Va. UMMZ 174686 (2), Rough Cr., Appomattox Co., Va. USNM 100190 (2), Appomattox R., Appomattox Co., Va. UR 96 (2), James R., Powhatan Co., Va., October 11, 1956. CU 18297 (1), Appomattox R. UMMZ 168943 (6), N. Anna R., Louisa Co., Va. UR 1833 (1), Willis R., Cumberland Co., Va., June 25, 1964. UR 2007 (6), Rivanna R., Fluvanna Co., Va., October 16, 1964. UR 1808 (3), Whispering Cr., Buckingham Co., Va., June 25, 1964. UR 870 (4), Tuckahoe Cr., Henrico Co., Va., June- December, 1958.

CU 25395 (4), Cary Cr., Fluvanna Co., Va., April 2, 1949. UR 771 (1), Norwood Cr., Powhatan Co., Va., April 22, 1960. UR 711 (3), Tuckahoe Cr., Henrico Co., Va., May 26, 1959. UR 142 (3), Tuckahoe Cr., Goochland Co., Va., November 14, 1956. UR 1667 (4), Tuckahoe Cr., Henrico-Goochland Co. line, Va., May 12, 1964. UR 257 (1), Tuckahoe Cr., Goochland Co., Va., September 12, 1957. UR 1854 (2), Willis R., Cumberland Co., Va., June 25, 1964. UR 686 (4), Bernard Cr., Powhatan Co., Va., July 4, 1959. UR 868 (1), Pine Cr., Powhatan Co., Va., July 11, 1961. UR 109 (1), Willis R., Cumberland Co., Va., October 10, 1956. UR 1827 (4), Willis R., Cumberland Co., Va., June 25, 1964. UMMZ 102326 (12), NiR., Spotsylvania Co., Va.

York River

UR 2239 (11), S. Anna R., Hanover Co., Va., October 23, 1964. UR 1920 (7), Deep Cr., Louisa Co., Va., September 30, 1964. UR 1292 (8), Deep Cr., Louisa Co., April 23, 1963. UR 1076 (2), Deep Cr., Louisa Co., Va., May 22, 1962. UR 1210 (1), Shop Cr., Hanover Co., Va., July 30, 1959. UR 2149 (1), N. Anna R., Spotsylvania-Louisa Co. line, Va., October 30, 1964. CU 21939 (3), S. Anna R., Louisa Co., Va., July 10, 1952. CU 21940 (2), S. Anna R. Louisa Co., Va., July 10, 1952. CU 10528 (3), S. Anna R., Louisa Co.,

Va., June 19, 1946. UR 523 (3), S. Anna R., Hanover Co., Va., September 11, 1958. USNM 100227 (1), S. Anna R., Orange Co., Va. USNM 107705 (1), N. Anna R., Louisa Co., Va. UR 2086 (9), S. Anna R., Hanover Co., Va., October 23, 1964. UR 2038 (6), S. Anna R., Louisa Co., Va., November 6, 1964. UR 2039 (9), Madison Run, Orange Co., Va., November 6, 1964. CU 29902 (13), Po R., Spotsylvania Co., Va., March 23, 1956. UR 575 (8), Matta R., Caroline Co., Va., September 11, 1958. UR 556 (2), Matta R., Caroline Co., Va., September 11, 1958. UR 866 (3), Matta R., Caroline Co., Va., July 10, 1961. UR 2216 (2), S. Anna R., Hanover Co., Va., September 13, 1957.

Patuxent River

UMMZ 144698 (2), Patuxent R., Anne Arundel Co., Md. UMMZ 138225 (1), Patuxent R., Prince George Co., Md. UMMZ 105519 (2), Trib. of Patuxent near laurel, Md. USNM 106584 (2), Patuxent R., Prince George Co., Md.

Potomac River

USNM 131798 (1), Little Paint Branch, trib. of Annacostia R., Prince George Co., Md. USNM 100709 (1), Cameron Run, Fairfax Co., Va. USNM 100643 (2), Middle Run, Fairfax Co., Va.

Rappahannock River

CU 25092 (3), Deep Run, Fauquier-Stafford Co. line, Va., March 26, 1949. USNM 88651 (1), Wilderness Run, Orange Co., Va. CU 10193 (4), Rappahannock R., Stafford Co., Va., March 28, 1941. UR 2037 (2), Robinson R., Madison Co., Va., November 6, 1964. CU 10999 (3), Fauquier Co., Va., April 13, 1947. UR 2228 (1), Rapidan R., Orange-Madison Co. line, Va., November 6, 1964.

Percina peltata peltata (Stauffer)

Upper James River

VPI 1575 (1), Jackson R., Bath Co., Va., July 20, 1963. VPI 1423 (2), Craig Cr., Craig Co., Va., October 12, 1960. VPI 194 (1), Craig Cr., Craig Co., Va., June 6, 1963. VPI 869 (1), Craig Cr., Craig Co., Va., August 16, 1957. VPI 549 (7), Rockfish R., Nelson C., Va.,

October 22, 1953.

Lower James River

UR 2008 (7), Rivanna R., Fluvanna Co., Va., October 16, 1964. UR 2137 (1), Buffalo Cr., Prince Edward Co., Va., November 1, 1964. UR 1834 (1), Willis R., Cumberland Co., Va., June 25, 1964. UR 1826 (3), Willis R., Cumberland Co.,

Va., June 25, 1964. UR 366 (1), Beaver Dam, Hanover Co., Va., April 8, 1958.

York River

UR 557 (3), Matta R., Caroline Co., Va., September 11, 1958. UR 303 (1), S. Anna R., Hanover Co., Va., September 13, 1957. UR 1319 (2), S. Anna R., Hanover Co., Va., May 10, 1963. UR 542 (10), Little R., Hanover Co., Va., September 11, 1958.

Rappahannock River

UR 1610 (1), Rapidan R., Madison Co., Va., September 14, 1963. UR 2229 (15), Rapidan R., Orange-Madison Co. line, Va., November 6, 1964. UR 2270 (5), Robinson R., (Hume Ford), Madison Co., Va., November 13, 1964.

Methods

Unless otherwise stated, characters were treated according to Hubbs and Lagler (1958). Fin-ray counts were made and included all elements of the following: dorsal spines, dorsal soft rays, anal spines, anal soft rays, and the rays of both pectoral fins. The following scale counts (left side) were made: lateral-line, rows below lateral-line rows around caudal peduncle, and ventral scales; the latter were inconsistent and of questionable taxonomic value.

Specimens were x-rayed and counts of the vertebrae (including the ultimate) were made from radiographs with the use of a stereoscopic dissection microscope. All proportional measurements were taken to the nearest 0.1 mm using dial calipers. Body depth and head length were determined and the measurements were divided into the standard length. The following measurements were made and expressed as a proportion of head length: depth caudal peduncle, highest dorsal spine, highest dorsal soft ray, highest anal ray, pectoral fin length, pelvic fin length, head depth, head width and eye length (also expressed as a proportion of snout length and upper jaw length). Measurements of the least bony interorbital width and least fleshy interorbital width were expressed as a proportion of eye length. The distance from insertion of pelvic fin to union of gill membranes was expressed as a proportion of distance from tip of mandible to union of gill membranes.

A meristic index was prepared by adding number of lateral-line scales, total dorsal elements and number of vertebrae, and subtracting the total number of pectoral rays. All meristic characters and proportional measurements were tabulated in the form of frequency distribution tables according to river system, except for the James River which was divided into lower James (east of Scottsville)

and upper James (Scottsville and west).

Variation was analyzed by a comparison of the standard deviations of the samples from the various drainages with a 1-tail t-test (Mather, 1951) and the method advocated by Ginsburg (1938). The upper James population was compared with all others, which were treated collectively as one sample. Certain characters are presented graphically following the basic design of Hubbs and Hubbs (1953) (Figs. 4,5,6, & 7).

The meristic characters of P. peltata from the upper James, lower James, York and Rappahannock were treated statistically to determine if the variation in this species were comparable to that in P. notogramma.

RESULTS

Characters were first analyzed within drainage systems but only in the James River were differences significant. (Tables 1-31). In the James, the population above Scottsville was found to differ at the subspecific level from that in the lower James on the basis of a greater number of scales in the lateral-line, scales around the caudal peduncle and the meristic index. (Tables 1, 5 and 13).

In Tables 1-31 is presented evidence which suggested that each river contained an isolated population. This

was substantiated by the vertebral counts where a comparison of the lower James River population with the combined counts of the other river systems gave an average difference of 77.6% when a line was drawn between 41 and 42 vertebrae (Table 2). When the upper and lower James populations were compared, a line drawn between 43 and 44 vertebrae produced an average difference of only 60.2% indicating the relationship of the two populations (Table 2). Also, the meristic index of the population from the York River separated from the Rappahannock, the next lowest, with an average difference of 82% when a line was drawn between 98 and 99 indices (Table 13). Subsequent investigations involving larger samples from the Rappahannock, Patuxent and Potomac rivers may show significantly differences to exist among the populations of the different river systems. However on the basis of the available data it was considered valid to combine the lower James and other rivers for a comparison with the upper James.

Percina n. montuosa had a narrower range for most of its characters than did P. n. notogramma. Also the dorsal pigment saddles were distinctly outlined in the new subspecies; whereas in the lowland form the pattern was highly variable, ranging from distinct to diffused, and of little taxonomic value (Figs. 1 & 2).

Table 32 (A-M) shows the frequency distributions of the meristic characters for the two subspecies. Eight of thirteen meristic characters were significantly different when tested with the 1-tail t-test. A t-value of 1.64 was considered significant at the 95% confidence level. The t-values for the following characters were Lateral-line scales 24.80 (Table 32 A), scales above lateral-line 10.90 (Table 32 B), scales below lateral-line 5.00 (Table 32 C), scales around caudal peduncle 6.47 (Table 32 D), dorsal spines 2.38 (Tables 32 E), dorsal rays 1.67, (Table 32 F), total dorsal elements 6.71 (Table 32 G), anal soft rays 3.07, (Table 32 H), total anal elements 2.84, (Table 32 J), vertebrae 5.18 (Table 32 L), and meristic index 12.81 (Table 32 M). Using the Ginsburg test (1938) where a 75% average difference between two populations is considered significant for subspecies designation, the following characters differed significantly. A line drawn between 58 and 59 lateral-line scales gave an average difference of 89.2% (Table 32 A). For the scales around the caudal peduncle a line between 21 and 22 scales resulted in an average difference of 78.9% (Table 32 D). Vertebrae separated between 42 and 43 with a 78.6% average difference (Table 32 L). When a line was drawn between 101 and 102 indices for the meristic index, the average difference was

89.0% (Table 32 M). Tables 1-13 give frequency distributions of meristic characters by river systems.

Frequency distributions of proportional measurements (Table 33 A-R), when tested with the 1-tail t-test at the 95% confidence level, showed that eight of eighteen characters differed significantly. The new subspecies had a thinner body (t-value 2.22). The dorsal elements were found to be shorter; for the highest dorsal spine t-value was 3.17, for the highest dorsal ray, the t-value was 2.00. The longest caudal ray was shorter in the upland form (t=5.00). In P. n. montuosa the depth of the head was less (t=1.85), but wider (t=3.16). The eye was shorter when compared with the length of the head (t=2.25) and to the length of snout (t=2.44).

At the 90% confidence level, fishes from the upper James were found to differ significantly from the other population with a shorter head length (t=1.40) and a longer jaw (t=1.59). As propotional measurements are subject to environmental influence and are therefore less reliable than the more stable meristic characters, the Ginsburg test was not applied to them.

Tables 14-31 show frequency distribution of proportional measurements by river systems.

Meristic characters were not affected by age or sex of

the specimen except for the ventral scales which were more prominent in males. Swollen gravid females were not used in the proportional measurements.

In Table 34 (A-L) the frequency distributions of the meristic characters are given for P. peltata from the upper James. lower James, York and Rappahannock rivers.

DISCUSSION

In an analysis of intraspecific variation, Raney and Hubbs (1948) theorized that following the retreat of the Wisconsin glacier and the associated drowning of a connecting river by Chesapeake Bay, a population of P. notogramma was isolated in each tributary. In their opinion the upper James population, the only truly montane one, (now designated P. n. montuosa), antedated the Wisconsin glacial period and the variation exhibited had an ecological basis. Their data obtained from a total of 118 specimens, 24 from the James of which only four were from the lower James, indicated that for meristic characters the upper James population most closely resembled that of the Rappahannock River. In the present study this was found to be true for only three characters: scales above lateral-line (Table 3), anal soft rays (Table (7), and dorsal rays (Table 10). Lateral-line scale counts were also high for the Rappahannock

population ($\bar{x}$ 58.4, S.D. 3.2), however the small Patuxent River sample was also high ($\bar{x}$ 59.0, S.D. 2.0), and both differed significantly from P. n. montuosa ($\bar{x}$ 62.1, S.D. 0.4). For three characters, number of vertebrae, dorsal spines, and the meristic index, P. n. montuosa most closely agreed with the lower James form. According to Bailey and Gosline (1955), vertebral counts in darters are subject to geographical influence and should be used with great caution at the species level of differentiation. On the basis of vertebral counts of 13 specimens of P. notogramma from the York River ($\bar{x}$ 41.08, S.D. 0.28) and 10 from the mountain region of the upper James ($\bar{x}$ 43.40, S.D. 0.84) they postulated that the difference was an environmental one related to altitude. This was not substantiated by the present investigation. The population from the Rappahannock River (which has a mountain influence) gave vertebral counts ($\bar{x}$ 41.3, S.D. 0.8), which were essentially like those of the York ($\bar{x}$ 41.4, S.D. 1.5) (Table 2). As it was pointed out in the results, the lower James population of 53 specimens ($\bar{x}$ 42.7, S.D. 0.6) most closely agreed with P. n. montuosa (36 specimens; $\bar{x}$ 43.1, S.D. 1.8). Two tributaries of the lower James, Willis River (14 specimens, $\bar{x}$ 42.5, S.D. 0.6) at an elevation of 200-250 ft. and Tuckahoe Creek (12 specimens, $\bar{x}$ 43.1, S.D. 1.0), elevation 90-150 ft., contained populations that had vertebral counts in agreement with

those of the upper river population. A comparison of vertebral counts among fishes inhabiting different altitudes within the range of P. n. montuosa showed that 12 specimens ($\bar{x}$ 43.0, S.D. 0.71) from Partridge Creek, elevation 450 ft., had the same mean as 4 specimens from Graig County, elevation 1500-2000 ft.

From this evidence it appears that the high vertebral count of the mountain subspecies and lower James population is an expression of genetic relationship between the two populations and not due to an environmentally induced altitudinal effect as suggested by Bailey and Gosline (1955). The relationship between the dorsal spines of P. n. montuosa and P. n. notogramma of the lower James further substantiated the relation between upper and lower James populations (Table 32 E). It is proposed that the higher counts for these two characters in P. n. montuosa are associated with a tolerance for colder water. This may explain why northern populations which never developed the higher counts could not move northward following the retreat of the Pleistocene glaciers as did Percina peltata, a closely related form.

Percina notogramma probably occured extensively throughout the James River, and during the colder periods of the Pleistocene those fishes tolerant to colder conditions became established in the montane regions of the James. At the present time the unsuitable habitat in the upper part

of the lower James probably acts as a barrier to a free exchange of genetic material between the two populations.

A study of the meristic characters of P. peltata, where the species occurres within the range of P notogramma, did not show the variation that was found among populations of P. notogramma (Tables 34-44). This evidence supports the basic tenet of this paper that the variation in P. notogramma is genetically fixed and not due to phenotypic responses to environment.

LITERATURE CITED

Bailey, Reeve M. and William A. Gosline. 1955. Variation and the systematic significance of vertebral counts in the American fishes of the family Percidae. Misc. Publ. Mus. Zool. Univ. Mich. 93: 1-44, figs. 1-4.

Collette, Bruce B. and Leslie W. Knapp. A catalogue of the type specimens of the darters (Pisces, Percidae, Etheostomatini). (Unpublished Manuscript).

Ginsbury, Isaac. 1938. Arithmetic definition of the species, subspecies and race concept, with a proposal for a modified nomenclature. Zoologica 23: 253-286.

Girard, Charles. 1859a. Ichthyological notices. Proc. Acad. Nat. Sci. Phila. 11: 56-68. IN: Collette, Bruce B. and Leslie W. Knapp. A catalogue of the type specimens of the darters (Pisces, Percidae, Etheostomatini). (Unpublished Manuscript).

Hubbs, Carl. and Clark Hubbs. 1953. An improved graphical analysis and comparison of series samples. Syst. Zool. 2: 49-56.

____and Karl F. Lagler. 1958. Fishes of the Grest Lakes Region. Cranbrook Inst. Sci. Bull. 26: 1-27.

Mather, Kenneth. 1951. Statistical Analysis in Biology. Methuen & Co., Ltd., London.

Raney, Edward C. and Carl L. Hubbs. 1948. Hadropterus

notogrammus, a new percid fish from Maryland, Virginia and West Virginia. Occ. Pap. Mus. Zool. Univ. Mich. 512: 1-26.

Stoll, Norman R., Chair. Editoral Comm. 1961. International Code of Zoological Nomenclature. Richard Clay and Co, Ltd., Bungay, Suffolk; XVII-176.

Table 1. Frequency distribution of lateral-line scales by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Lateral-Line Scales																		$\bar{x}$	S.D.
		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	
P. n. notogramma																					
Patuxent R.	7								1		3	1		1		1					59.0	2.0
Potomac R.	4				1			1			1		1								56.2	3.8
Rappahannock R.	14							2	1	4	1	1	2	1	1		1				58.4	3.2
York R.	95	2	1	3	6	20	15	16	17	6	2	3	2	1	1						54.7	2.0
Lower James R.	74	1	2	2	4	2	3	8	11	13	11	4	4	2	5	2					56.7	3.2
P. n. montuosa																					
Upper James R.	50										2	6	6	4	10	10	6	3	1	2	62.1	0.4

Table 2. Frequency distribution of vertebrae by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Vertebrae							
		40	41	42	43	44	45	$\bar{x}$	S.D.
P. n. notogramma									
Patuxent R.	2	1	1					40.5	0.6
Potomac R.	4	1	2	1				41.0	0.7
Rappahannock R.	14	2	7	4	1			41.3	0.8
York R.	95	6	50	37	2			41.4	1.5
Lower James R.	53		3	12	37		1	42.7	1.8
P. n. montuosa									
Upper James R.	36			7	21	7	1	43.1	1.8

Table 3. Frequency distribution of scales above lateral-line by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Scales Above Lateral-Line					$\bar{x}$	S.D.
		5	6	7	8	9		
P. n. notogramma								
Patuxent R.	6		4	2			6.2	0.6
Potomac R.	4	1	2		1		6.2	1.3
Rappahannock R.	14		5	9			6.6	0.9
York R.	95	5	72	18			6.1	0.8
Lower James R.	75	5	39	26	4	1	6.4	1.0
P. n. montuosa								
Upper James R.	50		13	30	7		6.9	1.0

Table 4. Frequency distribution of scales below lateral-line by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Scales Below Lateral Line							
		7	8	9	10	11	12	$\bar{x}$	S.D.
P. n. notogramma									
Patuxent R.	7	1		1	2	3		9.8	0.6
Potomac R.	4			1	2	1		10.0	0.7
Rappahannock R.	14			4	4	4	2	10.3	0.8
York R.	95	1	7	44	36	7		9.4	1.1
Lower James R.	75		10	25	33	7		9.5	0.8
P. n. montuosa									
Upper James R.	50		6	10	28	6		9.7	0.6

Table 5. Frequency distribution of scales around caudal peduncle by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Scales Around Caudal Peduncle							$\bar{x}$	S.D.
		18	19	20	21	22	23	24		
P. n. notogramma										
Patuxent R.	7			3	1	2	1		21.1	1.7
Potomac R.	4					3	1		22.2	1.5
Rappahannock R.	14			3	7	4			21.1	0.8
York R.	95	3		53	22	17			20.5	1.4
Lower James R.	74	1	2	27	21	18	3	2	20.9	1.6
P. n. montuosa										
Upper James R.	50			2	8	32	8		21.8	0.8

Table 6. Frequency distribution of total pectoral rays by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Total Pectoral Rays								
		25	26	27	28	29	30	31	$\bar{x}$	S.D.
P. n. notogramma										
Patuxent R.	7			2	5				27.7	1.0
Potomac R.	4		3		1				26.5	0.9
Rappahannock R.	14		2	2	7	1	2		27.9	1.7
York R.	95		4	8	71	6	6		28.0	1.3
Lower James R.	75	1	9	9	50	5		1	27.7	1.1
P. n. montuosa										
Upper James	50		2	2	42	2	2		28.0	0.6

Table 7. Frequency distribution of anal soft rays by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Anal Soft Rays 9	10	11	$\bar{x}$	S.D.
P. n. notogramma						
Patuxent R.	7		6	1	10.1	1.0
Potomac R.	4		4		10.0	
Rappahannock R.	14	1	10	3	10.1	1.0
York R.	95	33	57	5	9.7	0.6
Lower James R.	75	13	55	7	9.9	0.8
P. n. montuosa						
Upper James R.	50	2	28	10	10.2	0.8

Table 8. Frequency distribution of anal spines by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Anal Spines 1	2	$\bar{x}$	S.D.
P. n. notogramma					
Patuxent R.	7		7	2.0	-
Potomac R.	4		4	2.0	-
Rappahannock R.	14		14	2.0	-
York R.	95	1	94	2.0	-
Lower James R.	75	2	73	2.0	-
P. n. montuosa					
Upper James R.	50		50	2.0	-

Table 9. Frequency distribution of total anal rays by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Total Anal Rays			$\bar{x}$	S.D.
		11	12	13		
P. n. notogramma						
Patuxent R.	7		6	1	12.1	1.0
Potomac R.	4		4		12.0	-
Rappahannock R.	14	1	10	3	12.1	1.1
York R.	95	33	58	4	11.7	0.4
Lower James R.	75	14	55	6	11.9	0.3
P. n. montuosa						
Upper James	50	2	38	10	12.2	0.8

Table 10. Frequency distribution of dorsal soft rays by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Dorsal Soft Rays					
		11	12	13	14	$\bar{x}$	S.D.
P. n. notogramma							
Patuxent R.	7			5	2	13.3	0.4
Potomac R.	4			3	1	13.2	1.3
Rappahannock R.	14		3	7	4	13.1	0.4
York R.	95	2	28	61	4	12.7	0.7
Lower James R.	75	1	18	39	17	13.0	0.7
P. n. montuoas							
Upper James R.	50		4	30	16	13.2	1.2

Table 11. Frequency distribution of dorsal spines by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Dorsal Spines								
		11	12	13	14	15	16	17	$\bar{x}$	S.D.
P. n. notogramma										
Patuxent R.	7		1	3	3				13.3	0.3
Potomac R.	4		1	2	1				13.0	0.7
Rappahannock R.	14		1	3	8	2			13.8	0.4
York R.	95			45	40	10			13.6	1.1
Lower James R.	75	1	4	14	26	23	6	1	14.2	0.7
P. n. montuosa										
Upper James R.	50			7	21	20	2		14.3	1.3

Table 12. Frequency distribution of total dorsal elements by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Total Dorsal Elements							$\bar{x}$	S.D.
		24	25	26	27	28	29	30		
P. n. notogramma										
Patuxent R.	7		1	2	3	1			26.5	2.2
Potomac R.	4		1	1	2				26.2	1.8
Rappahannock R.	14	1	1	3	4	4	1		26.8	2.2
York R.	95	1	13	45	26	9	1		26.3	1.6
Lower James R.	75	4	4	15	20	21	1	2	27.1	1.8
P. n. montuosa										
Upper James R.	50		1	4	16	22	7		27.6	0.9

Table 13. Frequency distribution of meristic index by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Meristic Index								
		87-90	91-94	95-98	99-102	103-106	107-110	111	$\bar{x}$	S.D.
P. n. notogramma										
Patuxent R.	2				2				99.5	0.6
Potomac R.	4		1	1	2				97.0	2.4
Rappahannock R.	14		3	1	8	1	1		98.6	3.2
York R.	95	5	45	37	7	1			94.4	2.6
Lower James R.	53		3	11	26	13			100.2	1.1
P. n. montuosa										
Upper James R.	36				6	23	5	2	104.9	1.0

Table 14. Frequency distribution of body depth expressed as a proportion of standard length by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Body Depth as a Proportion of Standard Length							$\bar{x}$	S.D.
		4.3-4.6	4.7-5.0	5.1-5.4	5.5-5.8	5.9-6.2	6.3-6.6	6.7 6.8		
P. n. notogramma										
Patuxent R.	7			2	5				5.5	0.4
Potomac R.	4			1	2	1			5.8	0.4
Rappahannock R.	14	3	2	2	4	3			5.3	0.4
York R.	95		2	16	36	29	10	2	5.8	0.3
Lower James R.	75		6	31	21	12	4		5.6	0.3
P. n. montuosa										
Upper James R.	46			6	16	19	5		5.9	0.6

Table 15. Frequency distribution of length of head expressed as a proportion of standard length by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Length of Head as a Proportion of Standard Length										$\bar{x}$	S.D.
		3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9		
P. n. notogramma													
Patuxent R.	7				2	1	3		1	1		3.4	0.6
Potomac R.	4				1	2	1					3.4	-
Rappahannock R.	14					10	4					3.4	0.4
York R.	95	1	1	11	21	36	10	7	3	5		3.4	0.2
Lower James R.	75			7	10	16	9	12	6	12	3	3.5	0.4
P. n. montuosa													
Upper James R.	50			2	3	17	16	12				3.5	0.4

Table 16. Frequency distribution of depth of caudal peduncle expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Depth of Caudal Peduncle as a Proportion of Length of Head														$\bar{x}$	S.D.
		2.6	2.7	2.8	2.9	3.0	3.1	3.2	.3.3	3.4	3.5	3.6	3.7	3.8	3.9		
P. n. notogramma																	
Patuxent R.	7					1	3	2	1							3.1	0.6
Potomac R.	4					1	2	1								3.1	-
Rappahannock R.	14			1		6	2	3	2							3.1	0.3
York R.	95	1	1	3		8	17	18	15	20	6	4	1		1	3.2	0.6
Lower James R.	75		2	3	13	19	13	17	4	3		1				3.1	0.4
P. n. montuosa																	
Upper James R.	50				2	6	5	18	5	10	4					3.2	0.4

Table 17. Frequency distribution of highest dorsal spine expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Highest Dorsal Spine as a Proportion of Length of Head																$\bar{x}$	S.D.
		1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2		
P. n. notogramma																			
Patuxent R.	7				1		1	2	1	1			1					2.4	0.4
Potomac R.	4				1	1	1											2.4	-
Rappahannock R.	14	1			1	2	6		2	1	1							2.2	0.3
York R.	95			3	11	11	16	17	16	7	9	2		2	1			2.3	-
Lower James R.	75	1		2	7	14	19	10	14	2	5	1						2.2	0.4
P. n. montuosa																			
Upper James R.	50				1	1	7	5	13	12	5	1	5					2.5	0.4

Table 18. Frequency distribution of highest dorsal soft ray expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Highest Dorsal Soft Ray as a Proportion of Length of Head												$\bar{x}$	S.D.
		1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8		
P. n. notogramma															
Patuxent R.	7				1	5	1							2.1	-
Potomac R.	4			2		1			1					2.1	-
Rappahannock R.	14			1	3	3	6	1						2.1	0.3
York R.	95	2	5	8	22	22	13	7	10	3	1	1	1	2.1	0.4
Lower James R.	75		5	15	17	14	6	3						2.1	0.3
P. n. montuosa															
Upper James R.	50			1	11	12	16	4	3	3				2.2	0.3

Table 19. Frequency distribution of highest anal soft ray expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Highest Anal Soft Ray as a Proportion of Length of Head											
		1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	$\bar{x}$	S.D.
P. n. notogramma													
Patuxent R.	7				3	2	2					1.9	0.3
Potomac R.	4			1	1		1	1				1.9	-
Rappahannock R.	14		1	2	4	1	2	3	1			1.9	-
York R.	95		5	10	27	29	12	8	3		1	1.9	0.3
Lower James R.	75	1	5	13	23	12	13	2	3	3		1.9	0.3
P. n. montuosa													
Upper James R.	50		1	3	15	10	7	8	5	1		1.9	0.4

Table 20. Frequency distribution of longest caudal ray expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	Longest Caudal Ray as a Porportion of Length of Head No.							$\bar{x}$	S.D.
		1.2	1.3	1.4	1.5	1.6	1.7		
P. n. notogramma									
Patuxent R.	7			3	4			1.4	0.3
Potomac R.	4			1	3			1.5	-
Rappahannock R.	14	1	3	5	4	1		1.4	-
York R.	95	1	6	38	31	15	4	1.5	-
Lower James R.	75		19	33	16	7		1.4	-
P. n. montuosa									
Upper James R.	50		4	20	18	7	1	1.5	-

Table 21. Frequency distribution of length of pectoral fin expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Length of Pectoral Fin as a Proportion of Length of Head						
		1.0	1.1	1.2	1.3	1.4	$\bar{x}$	S.D.
P. n. notogramma								
Patuxent R.	7			4	3		1.2	0.3
Potomac R.	4		1	1	2		1.2	0.3
Rappahannock R.	14		2	9	3		1.2	-
York R.	95	2	8	57	23	5	1.2	0.3
Lower James R.	75		26	32	11	6	1.2	-
P. n. montuosa								
Upper James R.	50		7	33	8	1	1.2	-

Table 22. Frequency distribution of length of snout expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Length of Snout							$\bar{x}$	S.D.
		3.4-3.7	3.8-4.1	4.2-4.5	4.6-4.9	5.0-5.3	5.4	5.5		
P. n. notogramma										
Patuxent R.	7		2	3	1	1			4.4	0.7
Potomac R.	4			2		1	1		4.8	-
Rappahannock R.	14			4	8	2			4.7	-
York R.	95	1	8	34	37	14		1	4.6	0.4
Lower James R.	75	4	21	33	12	4	1		4.3	0.4
P. n. montuosa										
Upper James R.	50		7	22	18	3			4.5	0.4

Table 23. Frequency distribution of length of upper jaw expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Length of Upper Jaw															$\bar{x}$	S.D.
		2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1		
P. n. notogramma																		
Patuxent R.	7							1	2	1	1	1	1				3.5	0.6
Potomac R.	4						1	1	1				1				3.4	0.4
Rappahannock R.	14					1	2	3	3	2	2	1					3.4	0.3
York R.	95					6	3	11	18	21	13	7	7	3	1	1	3.5	0.3
Lower James R.	75	2	3	7	4	6	10	8	13	6	8	3	4			1	3.3	0.3
P. n. montuosa																		
Upper James R.	50				1	7	9	10	10	9	2	2					3.3	0.4

Table 24. Frequency distribution of length of pelvic fin expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Length of Pelvic Fin 1.2	1.3	1.4	1.5	1.6	$\bar{x}$	S.D.
P. n. notogramma								
Patuxent R.	7	1	2	4			1.3	0.3
Potomac R.	4	1	1	1		1	1.4	0.3
Rappahannock R.	14	1	8	2	2	1	1.4	0.4
York R.	95	6	28	50	10	1	1.4	0.3
Lower James R.	75	9	28	25	9	4	1.4	0.3
P. n. montuosa								
Upper James R.	50	2	16	26	5	1	1.4	0.3

Table 25. Frequency distribution of depth of head expressed as a proportion of length of head by river system in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

Location	No.	Depth of Head 1.3-1.6	1.7-2.0	2.1-2.4	2.5-2.8	$\bar{x}$	S.D.
P. n. notogramma							
Patuxent R.	7		1	5	1	2.2	0.4
Potomac R.	4			4		2.3	0.3
Rappahannock R.	14		2	11	1	2.2	0.4
York R.	95		14	69	12	2.3	0.3
Lower James R.	75	1	27	43	4	2.1	0.3
P. n. montuosa							
Upper James R.	50		1	43	6	2.3	0.3

Table 26. Frequency distribution of width of head expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Width of Head						$\bar{x}$	S.D.
		1.7-2.0	2.1-2.4	2.5-2.8	2.9-3.2	3.3	3.4		
P. n. notogramma									
Patuxent R.	7		2	4			1	2.7	-
Potomac R.	4		1	2	1			2.6	0.4
Rappahannock R.	14	3	7	3	1			2.2	1.0
York R.	95	1	16	62	15	1		2.6	0.4
Lower James R.	75	4	32	32	5	1	1	2.5	0.4
P. n. montuosa									
Upper James R.	50	3	30	17				2.4	0.3

Table 27. Frequency distribution of length of eye expressed as a proportion of length of head by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Length of Eye					$\bar{x}$	S.D.
		2.8-31	3.2-3.5	3.6-3.9	4.0-4.3	4.4-4.7		
P. n. notogramma								
Patuxent R.	7		2	4	1		3.7	0.3
Potomac R.	4		4				3.4	-
Rappahannock R.	14		5	7	2		3.7	0.3
York R.	95	12	37	32	12	2	3.5	0.7
Lower James R.	75	2	18	42	13		3.8	0.9
P. n. montuosa								
Upper James R.	50		9	28	9	4	3.8	0.6

Table 28. Frequency distribution of Length of eye expressed as a proportion of length of snout by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Length of Eye .5	.6	.7	.8	.9	1.0	1.1	1.2	$\bar{x}$	S.D.
P. n. notogramma											
Patuxent R.	7				5	1	1			0.8	0.3
Potomac R.	4		1	1	1	1				0.8	0.2
Rappahannock R.	14			6	4	4				0.8	0.1
York R.	95	1	10	28	35	14	4	2	1	0.8	0.1
Lower James R.	75	1	2	9	27	21	11	3	1	0.8	0.3
P. n. montuosa											
Upper James R.	50			6	21	14	7	1	1	0.9	0.2

Table 29. Frequency distribution of least fleshy interorbital width expressed as a proportion of length of eye by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Least Fleshy Interorbital Width												$\bar{x}$	S.D.
		1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4		
P. n. notogramma															
Patuxent R.	7			2	2	1	1		1					1.7	0.3
Potomac R.	4				2	1	1							1.7	0.3
Rappahannock R.	14		2	1		2	5	1	2	1				1.8	0.3
York R.	95	2	4	10	22	16	14	12	9	5			1	1.7	0.3
Lower James R.	75			10	14	19	13	5	5	3	4	2		1.8	0.3
P. n. montuosa															
Upper James R.	50	2	3	10	9	8	6	1	6	2	3			1.7	0.3

Table 30. Frequency distribution of least bony interorbital width expressed as a proportion of length of eye by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Least Bony Interorbital Width															$\bar{x}$	S.D.
		1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2		
P. n. notogramma																		
Patuxent R.	2						1		1								2.4	-
Potomac R.	4						1	2				1					2.5	-
Rappahannock R.	14					1	3	3	2	4		1					2.5	0.3
York R.	95	3	3	1	7	9	13	15	18	6	8	9	1	1		1	2.4	0.3
Lower James R.	49	1		1	6	4	8	12	6	4	2	2	1	1		1	2.4	-
P. n. montuosa																		
Upper James R.	40		1	3	3	5	2	9	5	4	4	2	1	1			2.4	0.3

Table 31. Frequency distribution of distance from insertion of pelvic fin to union of gill membranes expressed as a proportion of distance from tip of mandible to union of gill membranes by river system in Percina notogramma notogramma and Percina notogramma montuosa.

Location	No.	Distance from Insertion of Pelvic Fin .4	.5	.6	.7	.8	$\bar{x}$	S.D.
P. n. notogramma								
Patuxent R.	7		1	6			0.6	0.1
Potomac R.	4	1	3				0.5	0.1
Rappahannock R.	14		5	6	2	1	0.6	-
York R.	95	10	48	35	2	1	0.5	0.2
Lower James R.	71	7	33	27	4		0.5	0.2
P. n. montuosa								
Upper James R.	50	2	31	15	2		0.5	0.2

Table 32. Frequency distributions of meristic characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

A. Lateral-Line Scales

	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	3	3	5	10	22	19	26	30	23	18	9	9	5	7	3	1				193	55.9	3.3	0.24
P. n. montuosa										2	6	6	4	10	10	6	3	1	2	50	62.1	0.4	0.06

B. Scales Above Lateral-Line

	5	6	7	8	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	11	121	55	5	192	6.3	0.3	0.02
P. n. montuosa		13	30	7	50	6.9	0.3	0.05

C. Scales Below Lateral-Line

	7	8	9	10	11	12	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	17	75	76	22	2	194	9.5	1.3	0.09
P. n. montuosa		6	10	28	6		50	9.7	0.6	0.08

Table 32 (Continued). Frequency distributions of meristic characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

D.	Scales Around Caudal Peduncle										
	18	19	20	21	22	23	24	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	4	2	86	51	43	5	2	193	20.8	0.3	0.11
P. n. montuosa			2	8	32	8		50	21.9	1.2	0.12

E.	Dorsal Spines										
	11	12	13	14	15	16	17	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	7	66	78	35	6	1	194	13.8	1.3	0.09
P. n. montuosa			7	21	20	2		50	14.3	1.3	0.19

F.	Dorsal Rays							
	11	12	13	14	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	3	49	114	28	194	12.9	0.8	0.06
P. n. montuosa		4	30	16	50	13.2	1.2	0.17

Table 32 (continued). Frequency distributions of meristic characters of Percina notogramma notogramma and Percina notogramma montuosa.

G. Total Dorsal Rays

	24	25	26	27	28	29	30	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	6	20	66	54	35	11	2	194	26.7	0.8	0.06
P. n. montuosa		1	4	16	22	7		50	27.6	0.8	0.12

H. Anal Soft Rays

	9	10	11	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	47	131	16	194	9.8	1.0	0.07
P. n. montuosa	2	38	10	50	10.2	0.8	0.11

I. Anal Spines

	1	2	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	3	191	194	2.0	0.1	--
P. n. montuosa		50	50	2.0	-	--

Table 32 (continued). Frequency distributions of meristic characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

J. Total Anal Rays

	11	12	13	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	48	132	14	194	11.8	1.0	0.07
P. n. montuosa	2	38	10	50	12.2	0.8	0.12

K. Total Pectoral Rays

	25	26	27	28	29	30	31	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	17	21	134	12	8	1	194	27.9	1.2	0.09
P. n. montuosa		2	2	42	2	2		50	28.0	0.6	0.09

L. Vertebrae

	40	41	42	43	44	45	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	10	63	54	40		1	168	41.8	1.5	0.12
P. n. montuosa			7	21	7	1	36	43.1	1.8	0.30

Table 32 (continued). Frequency distributions of meristic characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

M.	Meristic Index									
	87-90	91-94	95-98	99-102	103-106	107-111	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	5	52	50	45	15	1	168	96.7	4.0	0.31
P. n. montuosa				6	23	7	36	104.9	1.0	0.17

Table 33. Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

A. Depth of Body as a Proportion of Standard Length

	4.3-4.6	4.7-5.0	5.1-5.4	5.5-5.8	5.9-6.2	6.3-6.6	6.7	6.8	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	3	10	52	66	46	14	1	2	194	5.7	0.6	0.04
P. n. montuosa			6	16	19	5			46	5.9	0.6	0.08

B. Length of Head as a Proportion of Standard Length

	3.0	3.1	3.2	3.3	3.4	3.4	3.6	3.7	3.8	3.9	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	1	18	33	65	27	19	10	17	3	194	3.4	0.6	0.04
P. n. montuosa			2	3	17	16	12				50	3.5	0.4	0.06

C. Depth of Caudal Peduncle as a Proportion of Length of Head

	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	3	7	13	35	36	41	22	23	6	5	1		1	194	3.2	0.4	-
P. n. montuosa				2	6	5	18	5	10	4					50	3.2	0.4	-

Table 33 (continued). Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

D. Highest Dorsal Spine as a Proportion of Length of Head

	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2		5	21	28	42	29	33	11	15	4	1	2	1	194	2.3	0.3	0.02
P. n. montuosa				1	1	7	5	13	12	5	1	5			50	2.5	0.4	0.06

E. Highest Dorsal Soft Ray as a Proportion of Length of Head

	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	10	25	43	46	35	14	13	3	1	1	1	194	2.1	-	-
P. n. montuosa			1	11	12	16	4	3	3				50	2.2	0.3	0.05

F. Highest Anal Ray as a Proportion of Length of Head

	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	11	26	58	44	30	13	7	3	1	194	1.9	0.3	-
P. n. montuosa		1	3	15	10	7	8	5	1		50	1.9	0.4	-

Table 33 (continued). Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

G. Longest Caudal Ray as a Proportion of Length of Head

	1.2	1.3	1.4	1.5	1.6	1.7	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	28	80	57	23	4	194	1.4	0.3	0.02
P. n. montuosa		4	20	18	7	1	50	1.5	-	-

H. Length of Pectoral Fin as a Proportion of Length of Head

	1.0	1.1	1.2	1.3	1.4	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	37	103	41	11	194	1.2	-	-
P. n. montuosa	1	7	33	8	1	50	1.2	-	-

I. Length of Pelvic Fin as a Proportion of Length of Head

	1.2	1.3	1.4	1.5	1.6	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	18	66	83	21	6	194	1.4	0.3	-
P. n. montuosa	2	16	26	5	1	50	1.4	0.3	-

Table 33 (continued). Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

J. Depth of Head as a Proportion of Length of Head

	1.3-1.6	1.7-2.0	2.1-2.4	2.5-2.8	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	1	44	131	18	194	2.2	0.3	0.02
P. n. montuosa		1	43	6	50	2.3	0.3	0.05

K. Width of Head as a Proportion of Length of Head

	1.7-2.0	2.1-2.4	2.5-2.8	2.9-3.2	3.3	3.4	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	8	58	102	22	2	2	194	2.6	0.3	0.02
P. n. montuosa	3	30	17				50	2.4	0.3	0.05

L. Length of Eye as a Proportion of Length of Head

	2.8-3.1	3.2-3.5	3.6-3.9	4.0-4.3	4.4-4.7	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	14	64	86	28	2	194	3.6	0.3	0.02
P. n. montuosa		9	28	9	4	50	3.8	0.6	0.09

Table 33 (continued). Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

M. Length of Snout as a Proportion of Length of Head

	3.4-3.7	3.8-4.1	4.2-4.5	4.6-4.9	5.0-5.3	5.4	5.5	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	5	31	73	59	22	1	1	192	4.5	0.3	-
P. n. montuosa		7	22	18	3			50	4.5	0.4	-

N. Length of Upper Jaw as a Proportion of Length of Head

	2.7-3.0	3.1-3.4	3.5-3.8	3.9-4.1	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	16	89	79	6	190	3.4	0.3	0.02
P. n. montuosa	1	36	13		50	3.3	0.4	0.06

O. Length of Eye as a Proportion of Length of Snout

	.5	.6	.7	.8	.9	1.0	1.1	1.2	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	12	45	71	41	16	5	2	194	0.8	0.2	0.01
P. n. montuosa			6	21	14	7	1	1	50	0.9	0.2	0.04

Table 33 (continued). Frequency distributions of proportional characters of *Percina notogramma notogramma* and *Percina notogramma montuosa*.

P. Least Fleshy Interorbital Width as a Proportion of Length of Head

	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	2	6	23	40	38	34	18	17	9	4	2	1	194	1.7	0.4	-
P. n. montuosa	2	3	10	9	8	6	1	6	2	3			50	1.7	0.3	-

Q. Least Bony Interorbital Width as a Proportion of Length of Head

	1.8-2.1	2.2-2.5	2.6-2.9	3.0-3.2	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	22	98	39	4	163	2.4	0.3	-
P. n. montuosa	7	21	11	1	40	2.4	0.3	-

R. Distance from Insertion of Pelvic Fin to Union of Gill Membranes as a Proportion of Distance from Tip of Mandible to Union of Gill Membranes

	.4	.5	.6	.7	.8	No.	$\bar{x}$	S.D.	S.E.
P. n. notogramma	18	89	74	8	1	190	0.5	0.2	-
P. n. montuosa	2	31	15	2		50	0.5	0.2	-

Table 34. Meristic characters by river system in Percina peltata.

A. Location	No.	Lateral-Line Scales													
		49	50	51	52	53	54	55	56	57	58	59	60	$\bar{x}$	S.D.
Rappahannock R.	21	1	1	3	1	1	5	4	1	3	1			53.9	2.5
York R.	16			2	3		5	2	2	1		1		54.1	2.6
Lower James R.	13		1	1	2	2	2		2		2		1	54.5	3.7
Upper James R.	12				2	2		2	3	1	1	1		55.2	1.1

B. Location	No.	Scales Above Lateral-Line				
		5	6	7	$\bar{x}$	S.D.
Rappahannock R.	21	2	15	4	6.1	0.4
York R.	16	4	11	1	5.8	0.7
Lower James R.	13	3	10		5.8	0.3
Upper James R.	12	2	9	1	5.9	0.6

Table 34 (continued). Meristic characters by river system in *Percina peltata*.

C. Location	No..	Scales Below Lateral-Line 7	8	9	10	$\bar{x}$	S.D.
Rappahannock R.	21		5	14	2	8.8	1.2
York R.	16	1	6	8	1	8.6	0.4
Lower James R.	13	1	5	7		8.5	0.4
Upper James R.	12		2	7	3	9.1	0.3

D. Location	No.	Scales Around Caudal Peduncle 17	18	19	20	21	$\bar{x}$	S.D.
Rappahannock R.	21		5	11	4	1	19.0	1.5
York R.	16		4	7	5		19.1	1.0
Lower James R.	13		5	2	6		19.1	-
Upper James R.	12	1	5	4	2		18.6	1.1

F. Location	No.	Dorsal Soft Rays 11	12	13	14	$\bar{x}$	S.D.
Rappahannock R.	21	1	2	12	6	13.1	0.6
York R.	16	1	2	10	3	12.9	1.2
Lower James R.	13			10	3	13.2	1.0
Upper James R.	12			7	5	13.4	0.8

Table 34 (continued). Meristic characters by river system in *Percina peltata*.

F. Location	No.	Dorsal Spines 11	12	13	14	$\bar{x}$	S.D.
Rappahannock R.	21		7	12	2	12.8	0.8
York R.	16		7	7	2	12.7	0.3
Lower James R.	13	1	4	5	3	12.8	-
Upper James R.	12		4	8		12.7	0.8

G. Location	No.	Total Dorsal Elements 23	24	25	26	27	28	$\bar{x}$	S.D.
Rappahannock R.	21	1		5	11	3	1	25.9	1.1
York R.	16		1	8	3	4		25.6	1.4
Lower James R.	13		1	3	5	3	1	26.0	1.0
Upper James R.	12			1	9	2		26.1	0.8

H. Location	No.	Anal Soft Rays 9	10	11	$\bar{x}$	S.D.
Rappahannock R.	21	3	17	1	9.9	0.6
York R.	16	2	12	2	10.0	0.4
Lower James R.	13	1	11	1	10.0	0.4
Upper James R.	12	1	11		9.9	0.6

Table 34 (continued). Meristic characters by river system in *Percina peltata*.

I. Location	No.	Anal Spines 2	$\bar{x}$	S.D.
Rappahannock R.	21	21	2.0	-
York R.	16	16	2.0	-
Lower James R.	13	13	2.0	-
Upper James R.	12	12	2.0	-

J. Location	No.	Total Anal Rays 11	12	13	$\bar{x}$	S.D.
Rappahannock R.	21	3	17	1	11.9	0.6
York R.	16	2	12	2	12.0	0.4
Lower James R.	13	1	11	1	12.0	0.4
Upper James R.	12	1	11		11.9	0.7

K.		Total Pectoral Rays 26	27	28	29	30	$\bar{x}$	S.D.
Rappahannock R.	21		1	9	2	9	28.9	1.1
York R.	16		1	6	5	4	28.8	1.4
Lower James R.	13		2	7	2	2	28.3	1.1
Upper James R.	12	1		7	4		28.2	1.1

Table 34. (continued). Meristic characters by river system in *Percina peltata*.

Location	No.	Vertebrae				
		42	43	44	$\bar{x}$	S.D.
Rappahannock R.	-					
York R.	14	1	11	2	43.1	1.5
Lower James R.	8	2	3	3	43.1	1.7
Upper James R.	5		4	1	43.2	0.4

Figure 1. Holotype of Percina notogramma montuosa Collected in Beaver Creek in Campbell County, Upper James River.

A. Lateral view

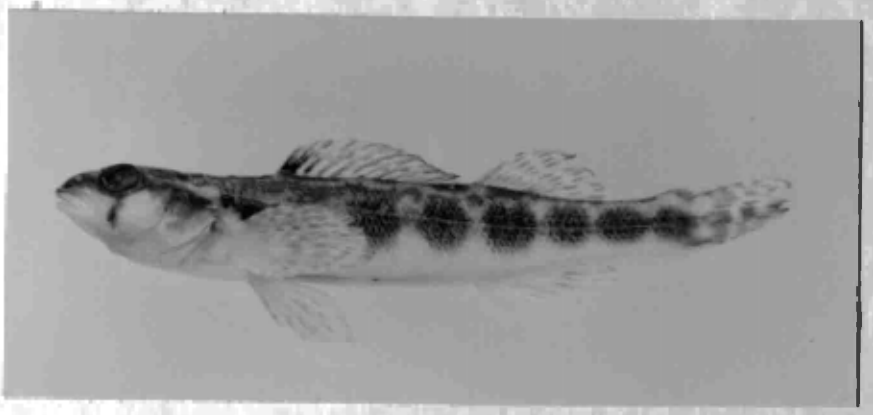
B. Dorsal View

Figure 2. Percina notogramma notogramma collected in South Anna River in Hanover County, Tributary of York River.

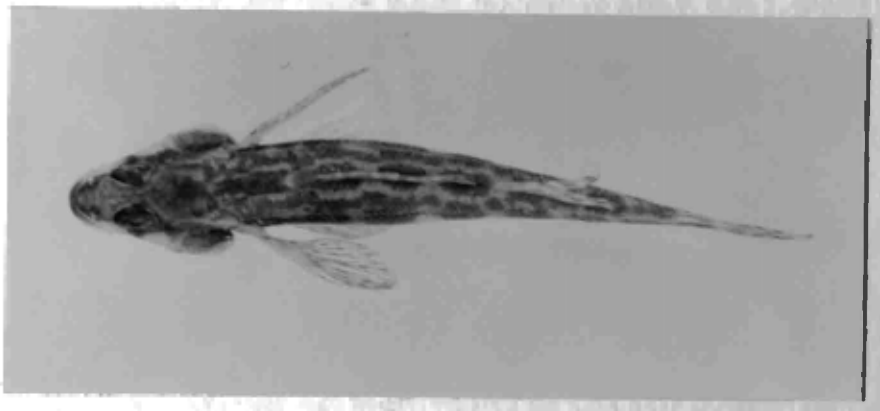
A. Dorsal view

B. Lateral view

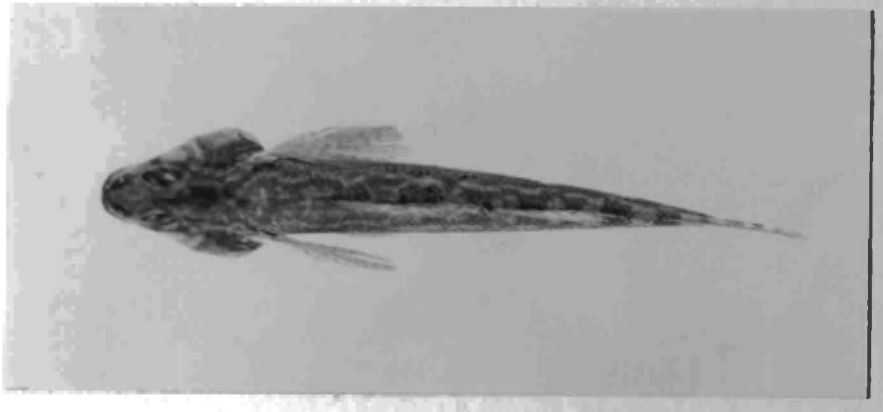
A



B



A



B

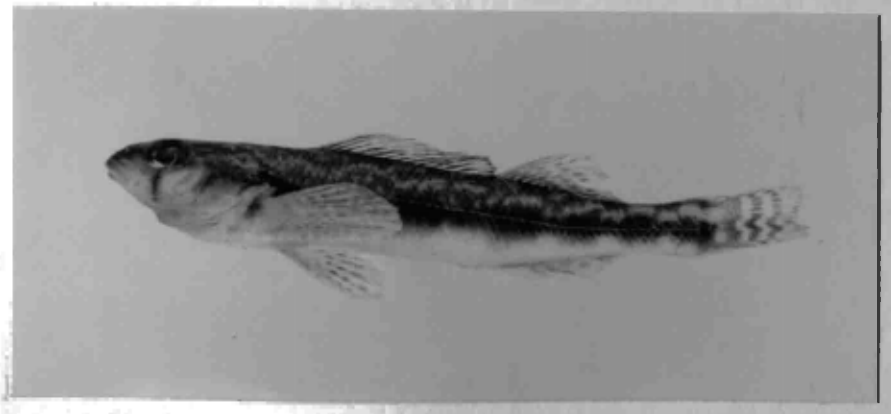


Figure 3. Distribution of *Percina notogramma notogramma* (triangles) and *Percina notogramma montuosa* (circle). Holotype locality for *Percina notogramma montuosa* is shown by star.

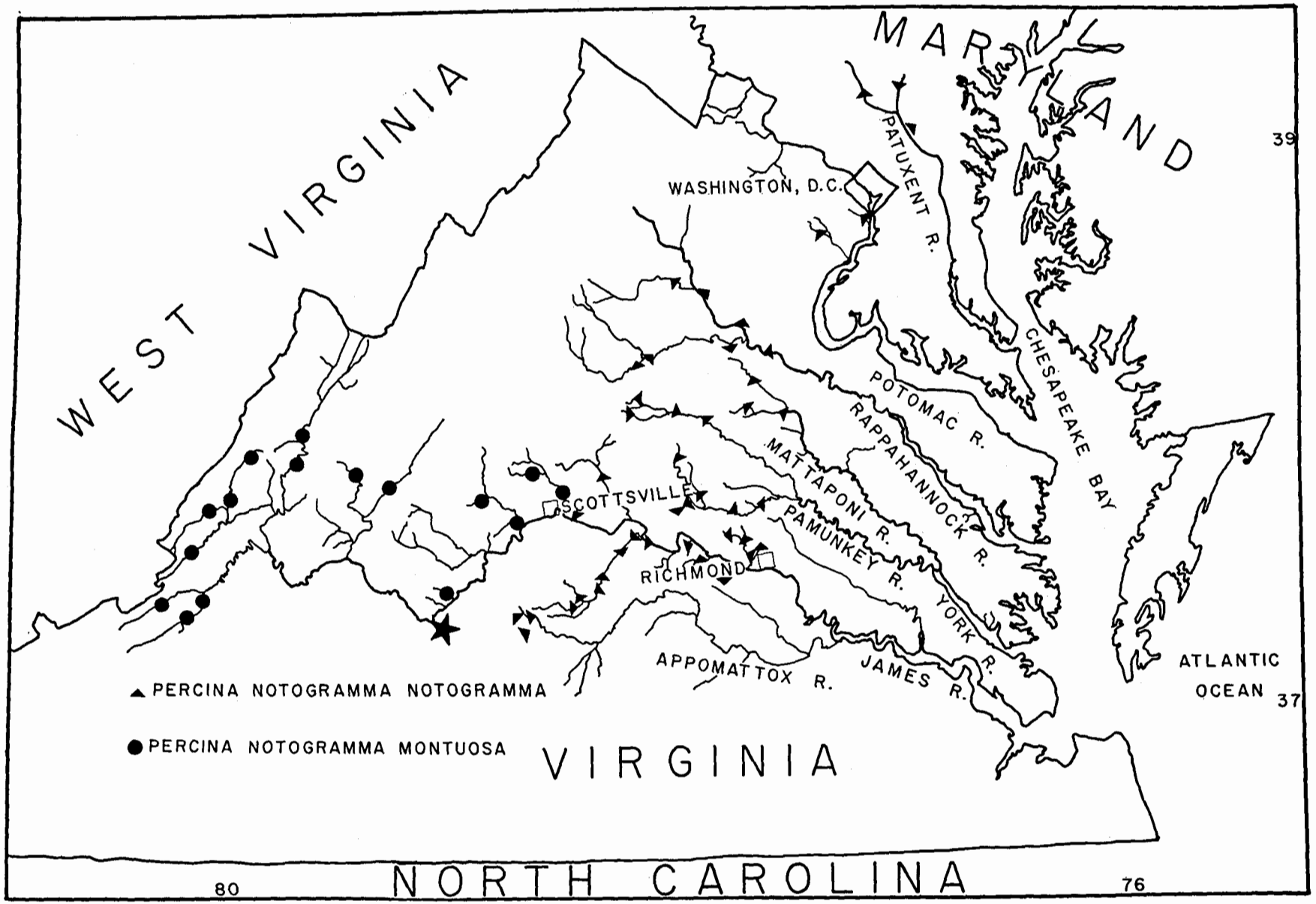

WEST VIRGINIA
MARYLAND
WASHINGTON, D.C.
PATUXENT R.
POTOMAC R.
RAPPAHANNOCK R.
MATTAPONI R.
PAMUNKEY R.
YORK R.
JAMES R.
CHESAPEAKE BAY
SCOTTSVILLE
RICHMOND
APPOMATTOX R.
ATLANTIC OCEAN
PERCINA NOTOGRAMMA NOTOGRAMMA
PERCINA NOTOGRAMMA MONTUOSA
VIRGINIA
NORTH CAROLINA
39
37
80
76

Figure 4. A comparison by river systems of the lateral-line scales in Percina notogramma notogramma and Percina notogramma montuosa.

River

A. Patuxent

B. Potomac

C. Rappahannock

D. York

E. Lower James

F. Upper James

Figure 5. A comparison by subspecies of the lateral-line scales in Percina notogramma notogramma and Percina notogramma montuosa.

Subspecies

A Percina notogramma notogramma

B Percina notogramma montuosa

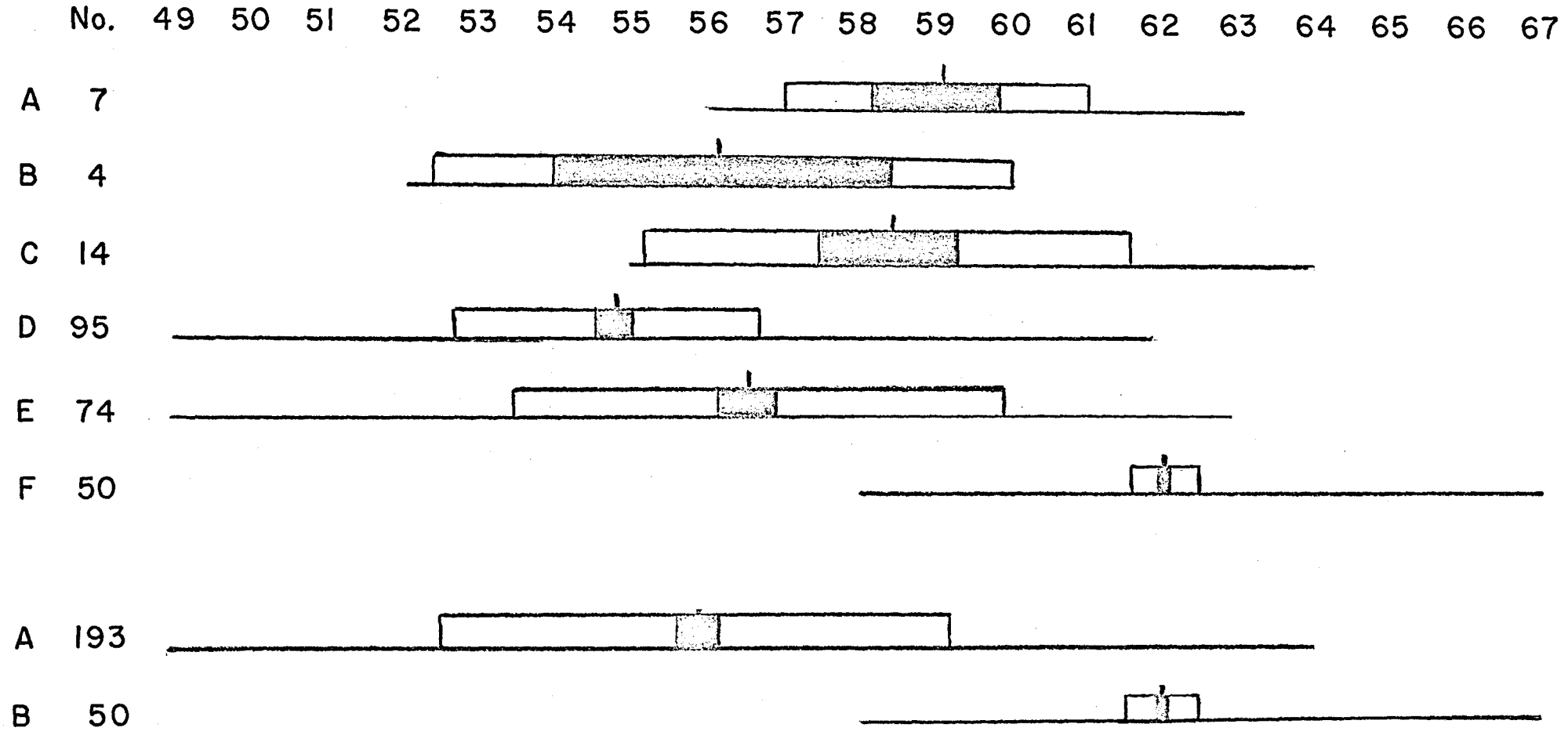
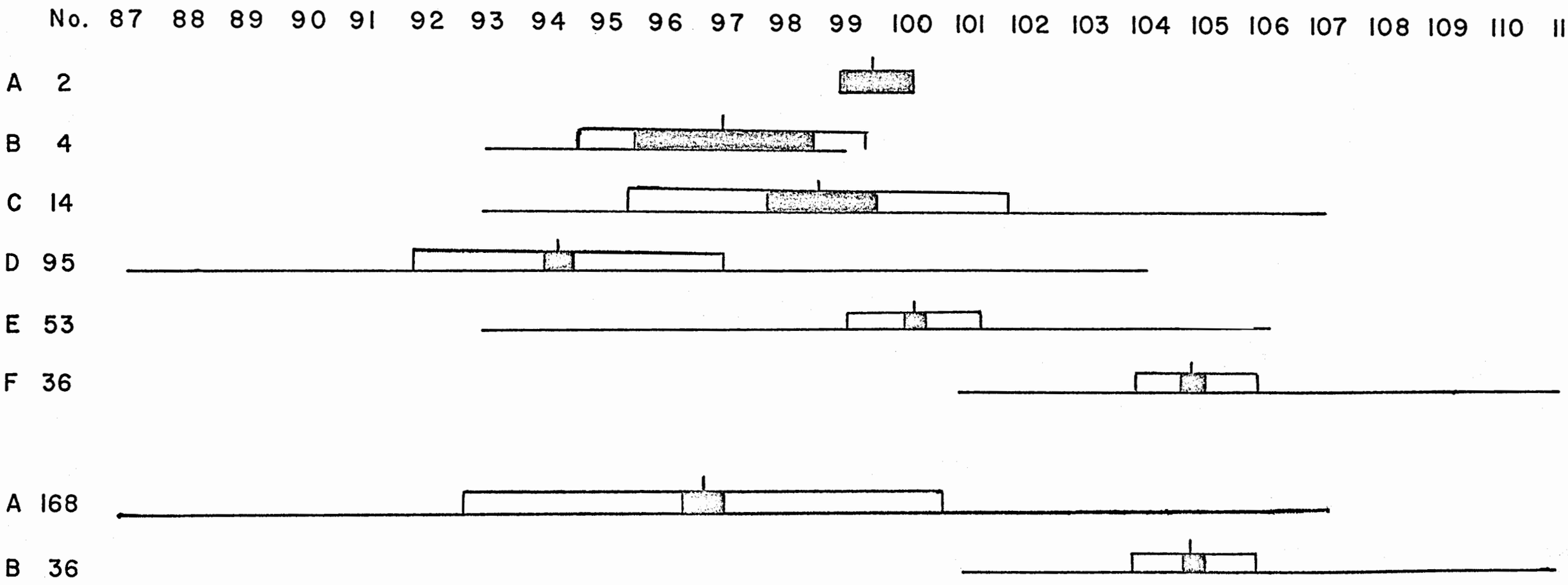

No.
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
A 7
B 4
C 14
D 95
E 74
F 50
A 193
B 50

Figure 6. A comparison by river systems of the meristic index in *Percina notogramma notogramma* and *Percina notogramma montuosa*.

	River
A	Patuxent
B	Potomac
C	Rappahannock
D	York
E	Lower James
F	Upper James

Figure 7. A comparison by subspecies of the meristic index in *Percina notogramma notogramma* and *Percina notogramma montousa*.

	Subspecies
A	*Percina notogramma notogramma*
B	*Percina notogramma montuosa*


No. 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111
A 2
B 4
C 14
D 95
E 53
F 36
A 168
B 36

VITA

William Thomas Hogarth was born March 7, 1939 in Jarratt, Virginia. He received his elementary and secondary education at Jarratt, Virginia and attended the University of Richmond as an undergraduate from 1957 to 1959. He entered the U.S. Army Reserve in March 1960 and upon completion of his active duty training, was employed as a supervisor by Philip Morris. In September 1961 he re-entered the University of Richmond and received his B.S. degree in August 1963. He began graduate work at the University of Richmond in 1963 and received his M.S. in August 1965. He was President of Beta∧Beta Honorary Biological Society, laboratory assistant in General Biology and Comparative Anatomy, and assistant coordinator for the General Biology Laboratories. He was the recipient of a Williams Fellowship for 1964-65. He is a member of the American Society of Ichthyologists and Herpetologists, the Virginia Academy of Science and Phi Gamma Delta Social Fraternity. He received a research appointment at Solomons Marine Station of the University of Maryland for the summer of 1965. In September 1965 he will enter Oklahoma State University where he will major in Ichthyology.