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CHANGES WITH GROWTH IN SELECTED BODY PROPORTIONS OF THE WOUNDFIN MINNOW (*PLAGOPTERUS ARGENTISSIMUS* COPE: CYPRINIDAE)

A Thesis
Presented to the
Department of Zoology and Entomology
Brigham Young University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Edward J. Peters

May, 1970

This thesis by Edward J. Peters is accepted in its present form by the Department of Zoology and Entomology of Brigham Young University as satisfying the thesis requirement for the degree of Master of Science.

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Date

Typed by Dianne L. Peters

ACKNOWLEDGMENTS

I wish to thank all the people who made this thesis possible, particularly my fellow graduate students who donated time and energy to help with collections. Special thanks are due to Dr. David A. White, my major professor, who encouraged the research and guided my writing of this thesis. Dr. Clive D. Jorgensen and Joseph R. Murdock gave many suggestions which helped the completion of the manuscript. Finally thanks are due to my wife, Dianne, who actively participated in every phase of research and writing. Without her help and understanding this thesis would never have been possible.

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INTRODUCTION

The woundfin minnow (*Plagopterus argentissimus* Cope) was described in 1874 from specimens which Miller and Hubbs (1960) believed were collected from the Virgin River in Washington County, Utah. Its original distribution included the Virgin and Gila River drainages, but habitat deterioration has resulted in its extirpation from the Gila River. Today it is restricted to the Virgin River and a few of its tributaries in Utah, Arizona and Nevada, where proposed dams and water diversion projects may result in its extinction since it is primarily a mainstream, swift-water fish (Miller and Hubbs, 1960).

Little research has been done on the biology of this fish during the 95 years since it was described (LaRivers, 1962; Sigler and Miller, 1963). Miller and Hubbs (1960) discussed the Plagopterini and reviewed the literature of all species included in the tribe, but their work was mostly taxonomic and distributional. Illick (1956) described the cephalic lateral line system of North American Cyprinids which included *P. argentissimus*. Other incidental references to this species are found in keys (Eddy, 1957), catalogs (Jordan and Evermann, 1896), checklists (Jordan, Evermann and Clark, 1930) and studies of specific geographic areas (Sigler and Miller, 1963).

There have been some studies reported of morphological changes associated with growth of North American fishes (Mansueti, 1963; Koehn and Minckley, 1965; McCart, 1965; Krumholz and Cavanah, 1968), but none on native western species.

The objectives of this study were to describe the morphological changes that occurred during the growth and maturation of the woundfin minnow and, where possible, to correlate them with life history and ecological data.

DESCRIPTION OF COLLECTION STATIONS

Specimens were collected from four stations on the Virgin River between St. George and Hurricane, Washington County, Utah (Fig. 1).

This section of the Virgin River is generally swift, shallow and extremely turbid, with an unstable bottom. Plant life in the river is sparse for most of the year, but during periods of low water when the river is clear, algae are common, especially on the rocks. These clear periods occur during the drier times of the year in late spring and early fall.

Station I (T43S R15W Sec. 6 SW 1/4) is located on the Virgin River at the mouth of the Santa Clara River, near St. George, Utah. The river is rather wide (125 m) and shallow (avg 0.3 m), with a shifting sand bottom and a braided channel. In some places, especially near rocks, there are temporary holes (1-2 m deep). Water temperatures as high as 35.5^{o} C have been recorded at this station.

Station II (T42S R14W Sec. 20 SE 1/4 Sec. 21 SW 1/4) is located on the Virgin River at the Washington diversion dam, near Washington, Utah. The river is dammed to divert water for irrigation. This dam is built on an

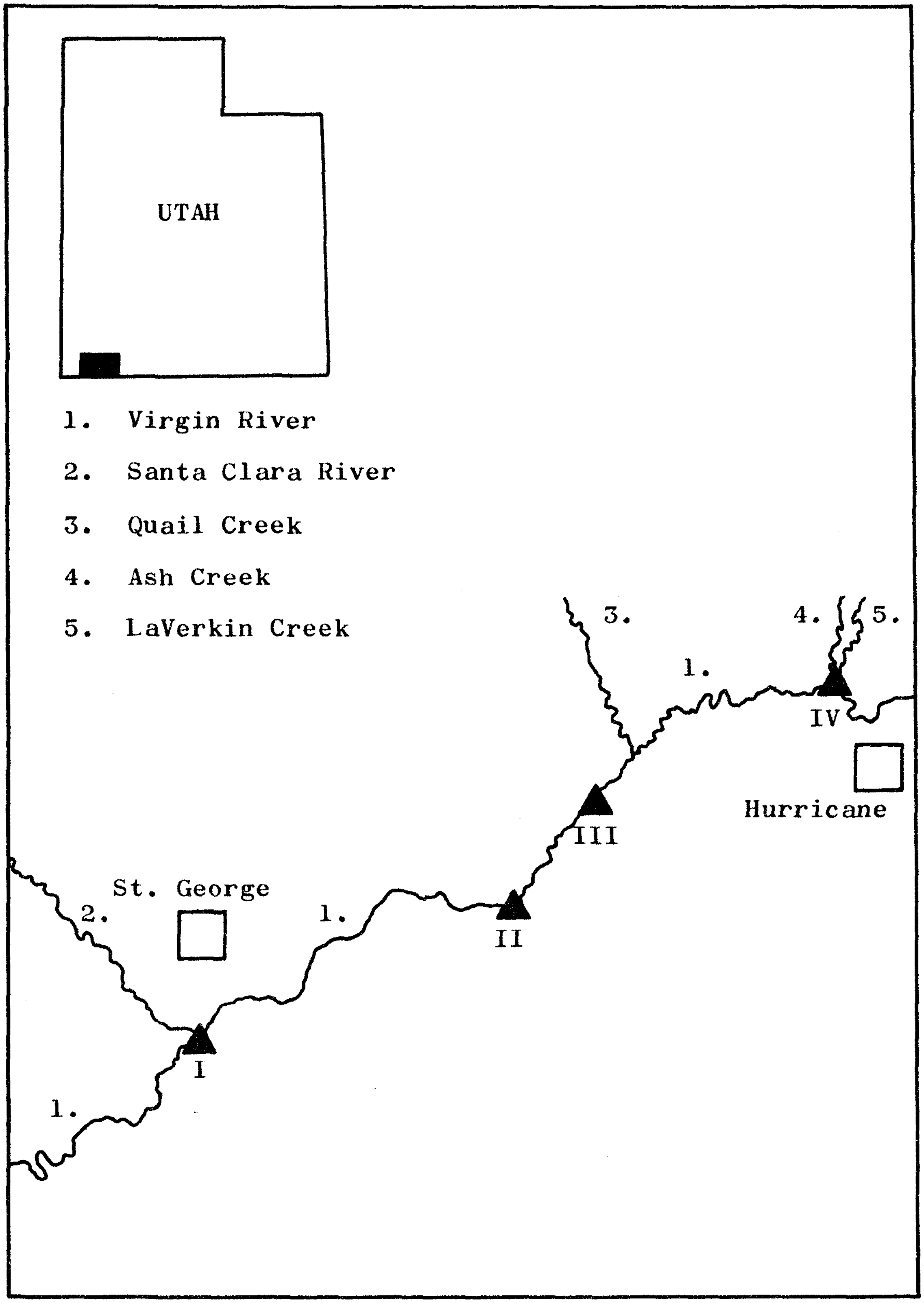

Fig. 1. Location of collection stations on the Virgin River, Washington Co., Utah, 1967-1968.

out-crop of Shinarump shale and conglomerate, which in presettlement times formed a natural falls. The river bottom consists of a mosaic of sand, gravel, rubble and bedrock. In midsummer, large numbers of fish congregate in a series of pools (1-3 m deep) located directly below the dam. The river above the dam is swift and shallow, with a shifting sand bottom.

Station III (T42S R14W Sec. 2 NW 1/4) is located on the Virgin River at the bridge of highway 17 about 9.6 km west of Hurricane, Utah. The river flows in a well defined channel (35 m wide) through a shallow gorge which is formed from Shinarump conglomerate and Quaternary basalt. The substrate is mostly gravel with scattered patches of sand. The current is swift, and the water is relatively shallow (avg 0.6 m).

Station IV (T41S R13W Sec. 23 SW 1/4) is located on the Virgin River at the mouths of Ash and LaVerkin Creeks Hurricane, Utah. The river is relatively narrow (25-30 m) and swift, with a bottom of intermingled areas of sand, gravel and rubble. Both Ash and LaVerkin Creeks discharge considerable quantities of water into the Virgin River.

MATERIALS AND METHODS

Field Methods

Collections were taken each month at all sites, from July, 1967 through July, 1968. Very small specimens were captured using a dishtowel as one would use a seine, although most specimens were collected with 0.625 cm mesh minnow seines 3-8 m long. Attempts were made to sample all possible habitats on each visit to insure obtaining as complete a sample as possible and to sample all woundfin age-groups. Approximately one-half of the specimens were returned to the river. Retained specimens were immediately fixed in 10% formalin. Observations were made on changes in the river's channel and various aspects of the fishes ecology and behavior.

Analytical Methods

Specimens were transferred to 40% Isopropyl alcohol after fixing for several weeks in the formalin solution. After transfer to alcohol, 883 specimens were weighed and measured. Weighing was done on an analytical balance, total weight to the nearest one hundreth of a gram and gonad weight to the nearest one thousandth of a gram. Measurements were determined by using a pair of fine dividers and a millimeter rule. Estimates were made to the nearest one tenth of a millimeter. All fish were measured for total length, standard length, head length, eye length, lateral length of upper jaw, mouth length, gape, body depth, depth of caudal peduncle, length of pectoral fin, length of dorsal fin and height of dorsal fin, according to procedures outlined in Hubbs and Lagler (1958).

Age determinations were estimated with two techniques, the length-frequency and the projection of the opercular bones. A length-frequency diagram was constructed for each months' collections. These showed a clustering around the mean of each years' age-group. The age-groups refer to all individuals hatched during a single spawning season. During their first year of life individuals are in age-group O, during their second year of life, age-group I, etc. Specimens were then selected from overlap areas between the length-frequency age-groups, and their opercular bones were removed and examined with a dissecting microscope or projected with a bioscope so that the year markings could be counted. These data were then compared with spawning time to obtain a reasonably accurate age determination.

Measurements were converted to percentages of standard lengths to facilitate comparison of data between age-groups. Gonad weights were expressed as percentages of total weights. Computations of percentages, mean values and confidence intervals for the means were made with computer programs.

RESULTS AND DISCUSSION

Growth

Growth in the woundfin minnow follows the indeterminant pattern characteristic of most fishes (Fig. 2). The wide variation within an age-group can be attributed to the extended length of the reproductive period. This variation was accentuated, especially in age-groups 0 and I, by growth of individuals of a given age-group during the year of the study.

Life History

Miller and Hubbs (1960) assumed from the size of specimens in their collections made during the months of July and September, that P. argentissimus spawned during late spring and early summer. Specimens from my collections seem to bear out this assumption. For example, collections made on July 24, 1968 contained specimens ranging from 11.8 to 31.1 mm standard length, which are easily included in age-group 0. Further evidence is available from examination of the ratio of gonad weight to total weight. This ratio is used to express the spawning condition of fish. Figure 3 shows the average spawning condition of female woundfins for each month of the study. From the

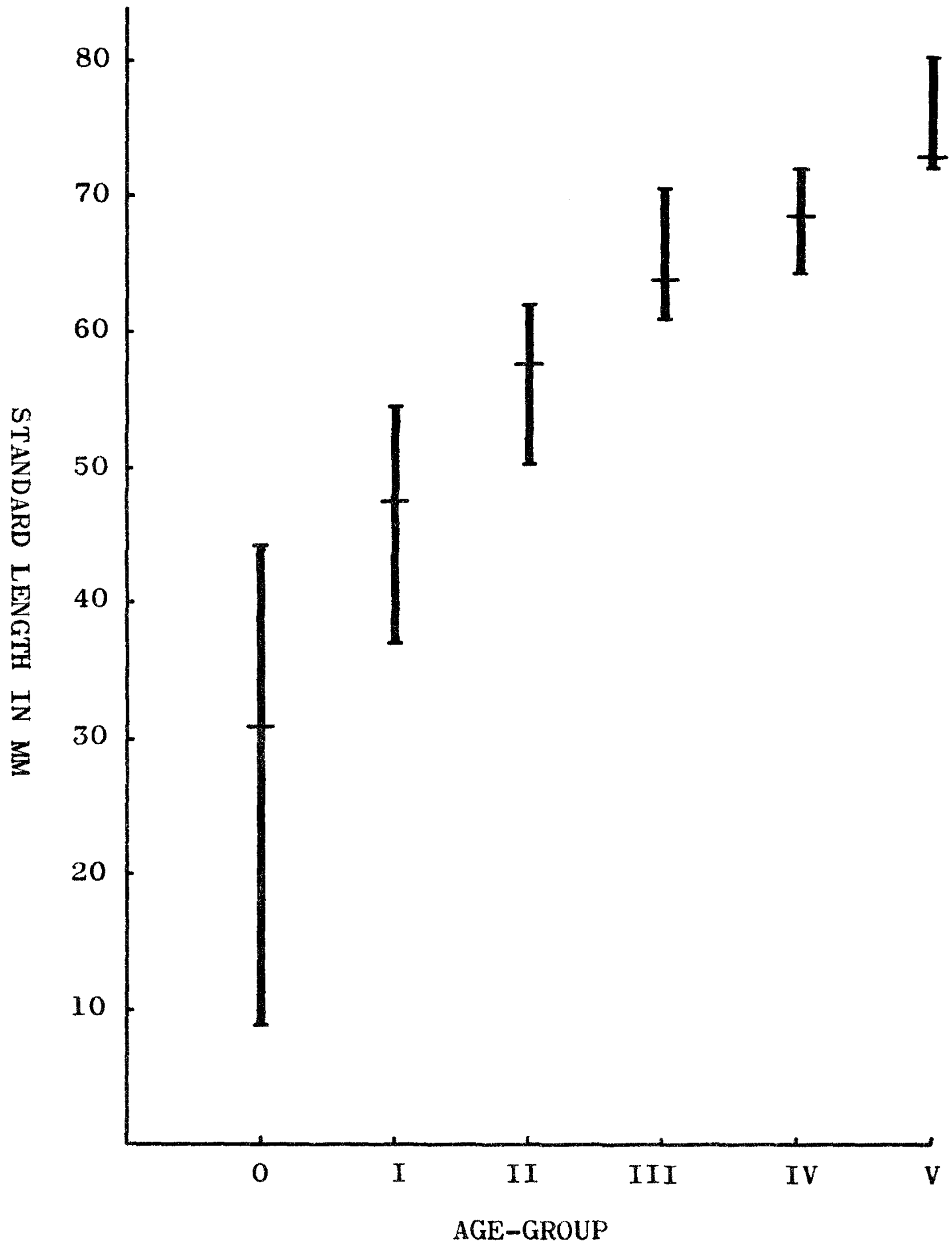

Fig. 2. Ranges, means and 95% confidence intervals of the means of standard lengths for age-groups of *P. argentissimus*; Virgin River, Utah, July, 1967–July, 1968.

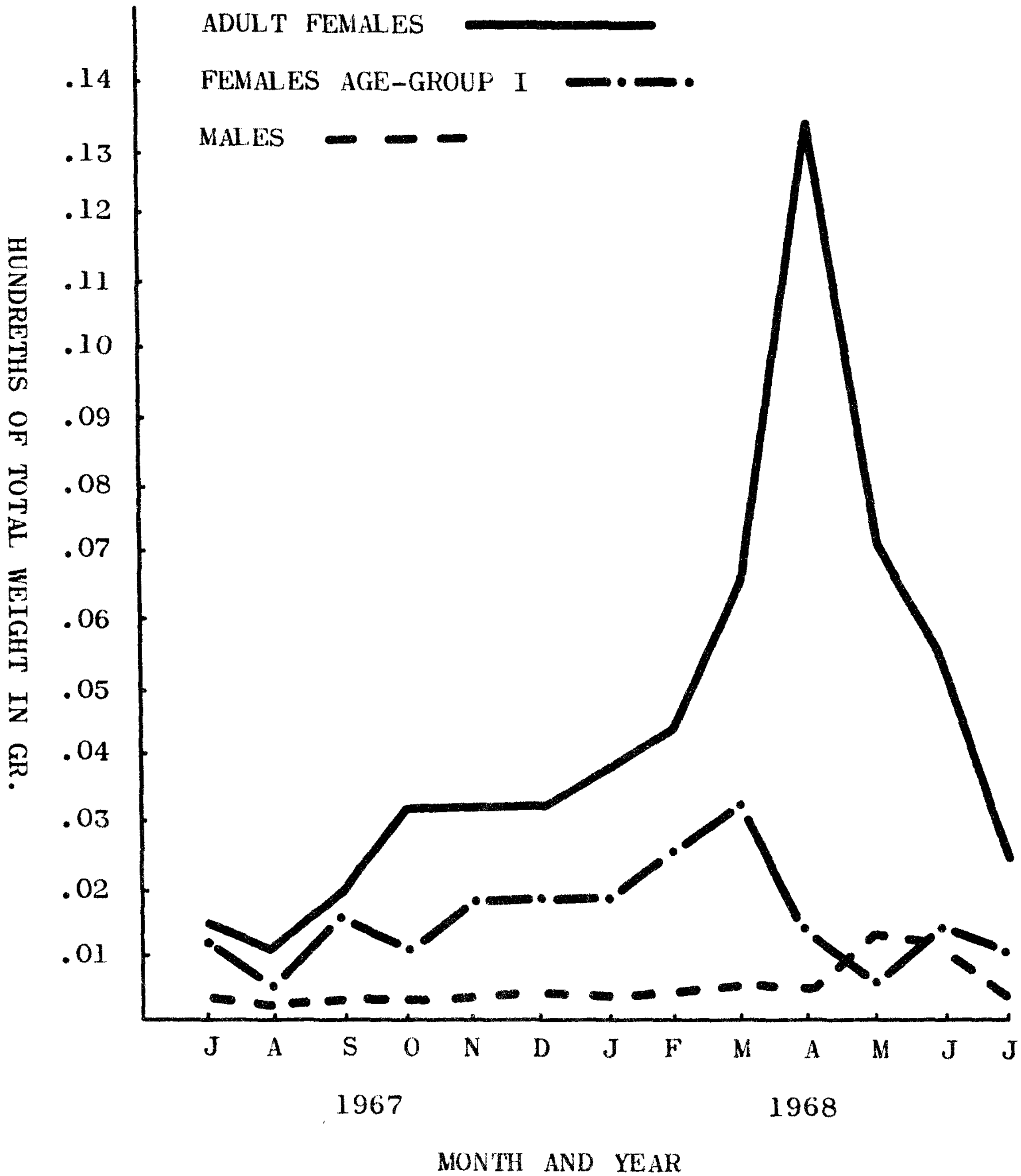

Fig. 3. Monthly mean gonad weight:total weight ratios for male and female P. argentissimus; Virgin River, Utah, July, 1967-July, 1968.

low spawning condition of July and August, 1967 the ovaries gradually increased in relative weight until the winter months of 1967-1968. During the winter months the development slowed probably as the result of reduced food and cold temperatures.

The approach of spring began another period of gonadal development that culminated in a peak during April of 1968. This peak most likely represents the beginning of the spawning period. From this peak there was a decline in spawning condition through July, 1968. During the months of April, May and June the highest spawning condition values were .192, .110 and .161 respectively. The eggs of these individuals were firm and well defined which indicated to me that they were viable. This shows that there were individuals capable of spawning through June, 1968, and that the decrease in average spawning condition can be explained by the increased frequency of spawned individuals in the population. In July, 1968 one female specimen had a spawning condition of .095, but the eggs were soft and beginning to break down. From these data I conclude that the spawning period for _P. argentissimus_ was from the end of April through June for 1968.

Another bit of life history information can be gleaned from figure 3. As development of the gonads progressed during the winter and spring months a number of individuals had a lower spawning condition than most of the specimens for that particular month. Those individuals corresponded in almost every case to the specimens of age-group I. From this I concluded that female woundfins do not spawn until they are about to begin their third year of life (age-group II).

As would be expected, the development of the male gonads followed a similar, but less pronounced increase in condition which peaked in May, 1968 (Fig. 3). Unlike the females, there was no noticeable difference between age-group gonad condition. This could indicate possible sexual maturity at age-group I for male woundfins.

Relative Growth

At the beginning of the section on relative growth it must be remembered that in all but the dorsal fin length to dorsal fin height ratio the basis for determination of allometric and isometric growth was based on their relationship to standard length.

The shape of the pectoral fins was used to externally determine the sex of individuals from age-groups I to V. Miller and Hubbs (1960) mentioned a difference in the structure of the pectoral rays of *P. argentissimus* between males and females, but did not completely describe it. In general, the pectoral fins of the male are hardened and more rounded than those of the female (Fig. 4). Pectoral fins of immature specimens (age-group 0) are more like the female than the male.

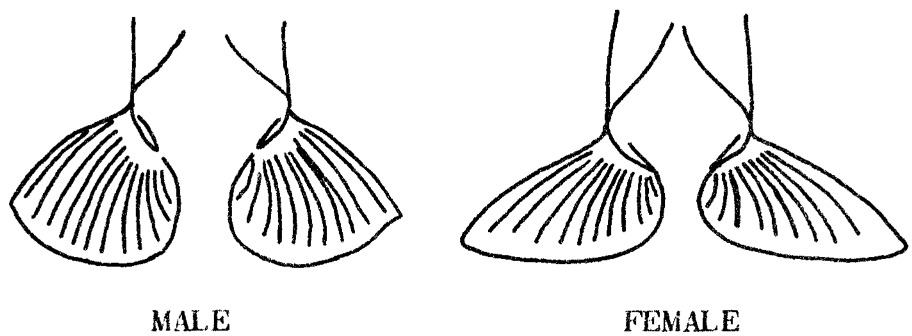

Fig. 4. A diagram illustrating the sexual dimorphic characters of the pectoral fins of *P. argentissimus*.

Development of this dimorphism begins by the end of the first year of life and becomes more prominent with age. The proportional size of the pectoral fins decreased with an increase in the standard length of the fish, and there was also a differential between males and females of a given age-group (Fig. 5). This differential in fin growth was probably due to the slower growth of the hardened pectoral rays in the males.

The total length:standard length ratio illustrates the growth of the caudal fin. There was a decrease in the proportional size of the caudal fin (Fig. 6). As the caudal fin proportionally decreased in size, the caudal peduncle depth (Fig. 7) showed almost isometric growth. These data along with the slight reduction in the proportional size of the head length (Fig. 7) and an increase in relative body depth (Fig. 7), as the fish grows, show a relative increase in the trunk size. These changing proportions can tentatively be explained by an increase in body musculature and hence, strength, which enables the fish to live in the more swiftly flowing portions of the river. The reasons for this hypothesis were observations that the fish were distributed in slow-flowing, shallow water when they were small, and the larger, older specimens were found in more swiftly flowing, deeper water.

The facial proportions showed some variation in changes with growth (Fig. 8+9). Both the eye and mouth lengths showed proportional decreases with growth. On the

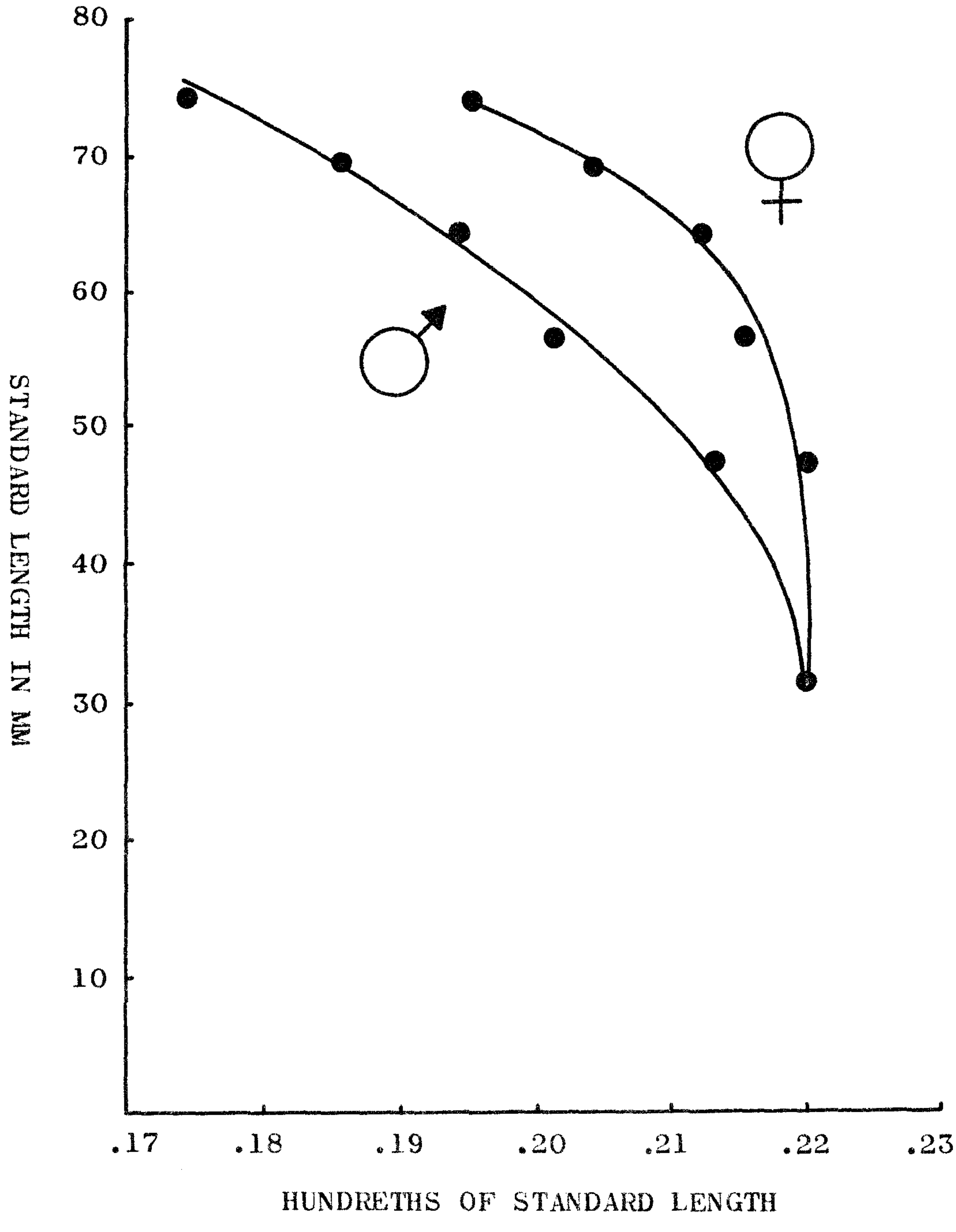

Fig. 5. Changes with growth in the relative size of the pectoral fins in P. argentissimus, comparing the mean values for males and females of each age-group.

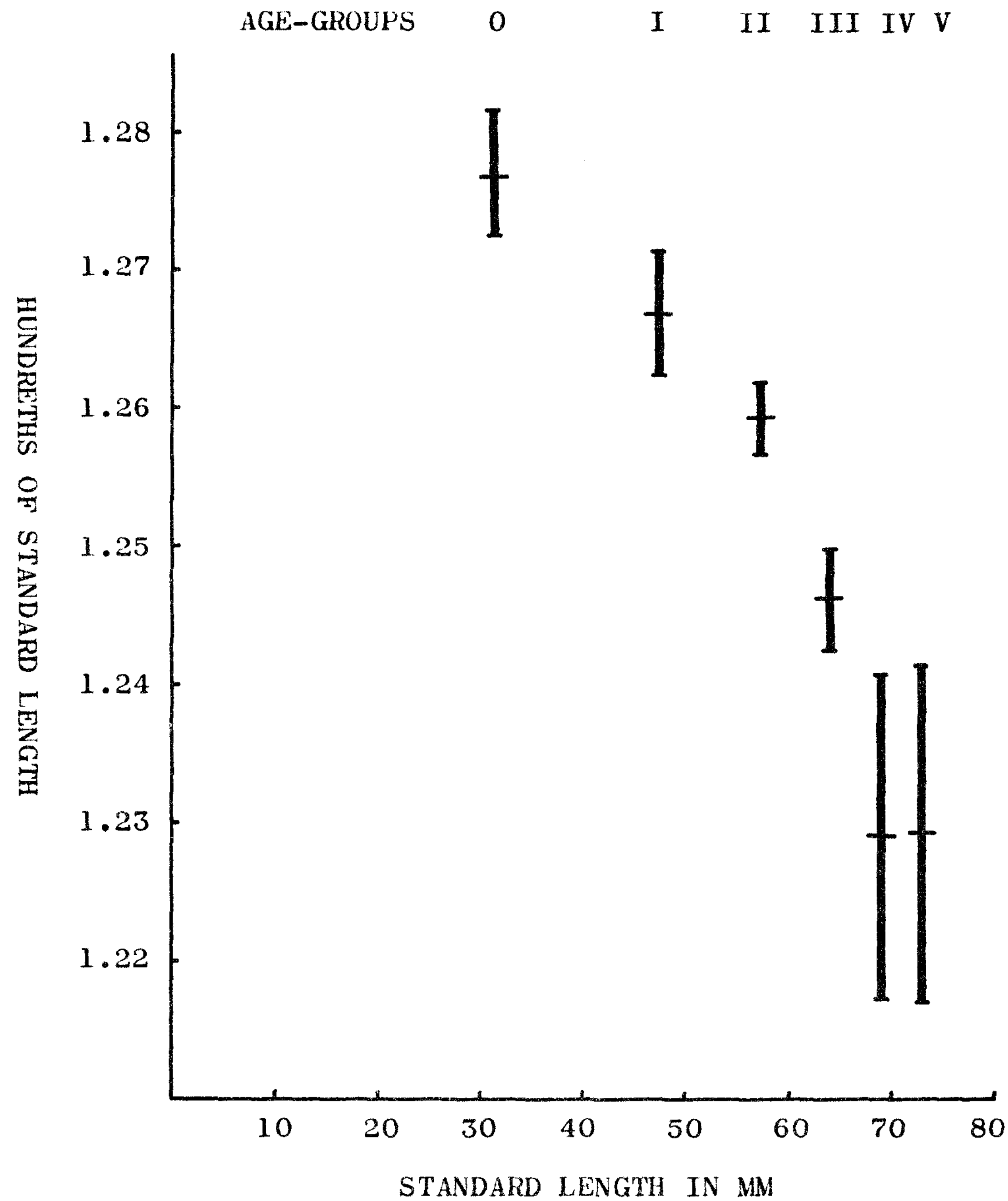

Fig. 6. Changes with growth in the relative size of the caudal fin in P. argentissimus, as expressed by the total length:standard length ratio. This graph shows the mean and 95% confidence interval for the mean of each age-group.

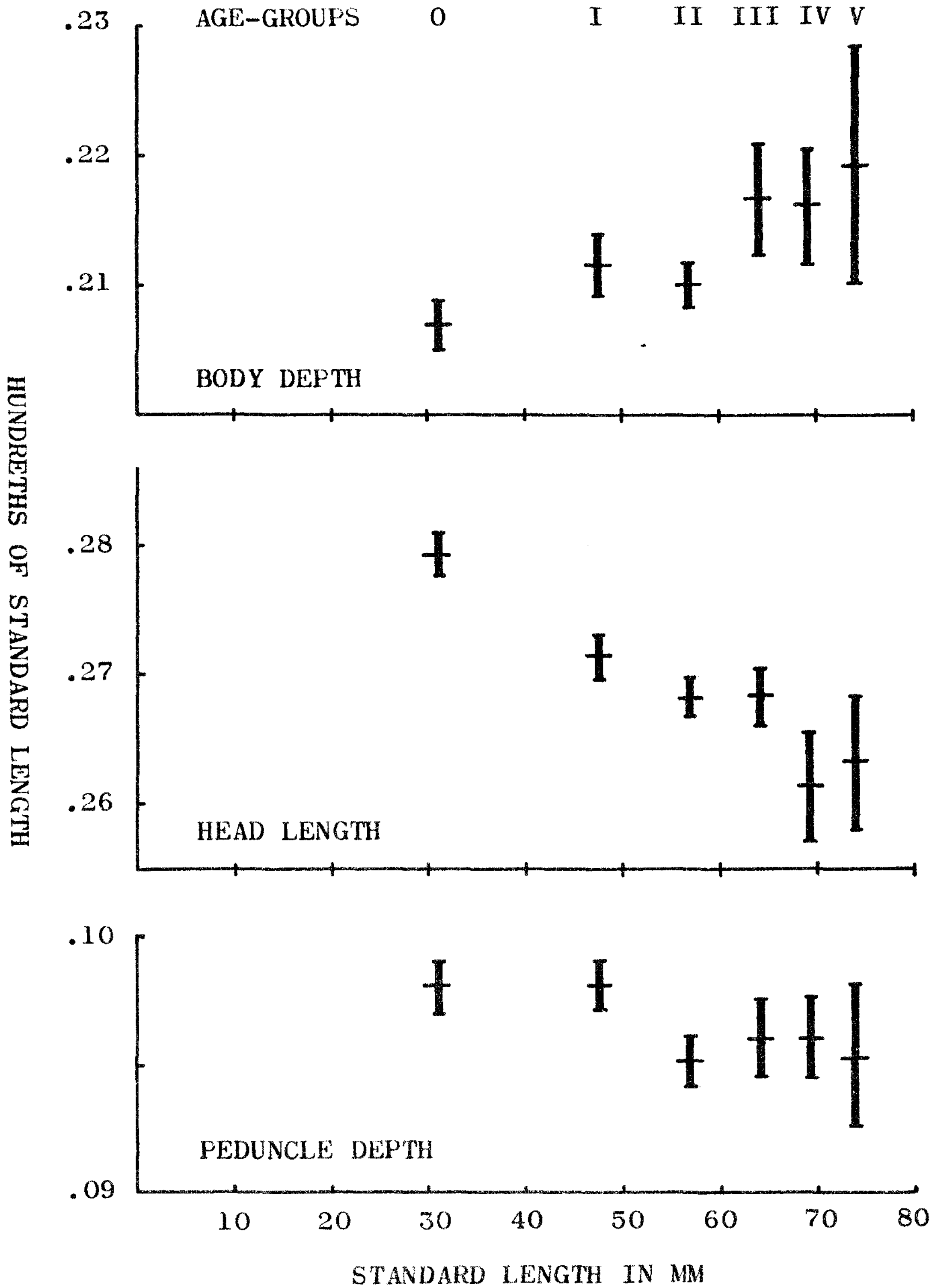

Fig. 7. Changes with growth in the relative sizes of three body measurements in P. argentissimus, showing the mean and 95% confidence interval for the mean of each age-group.

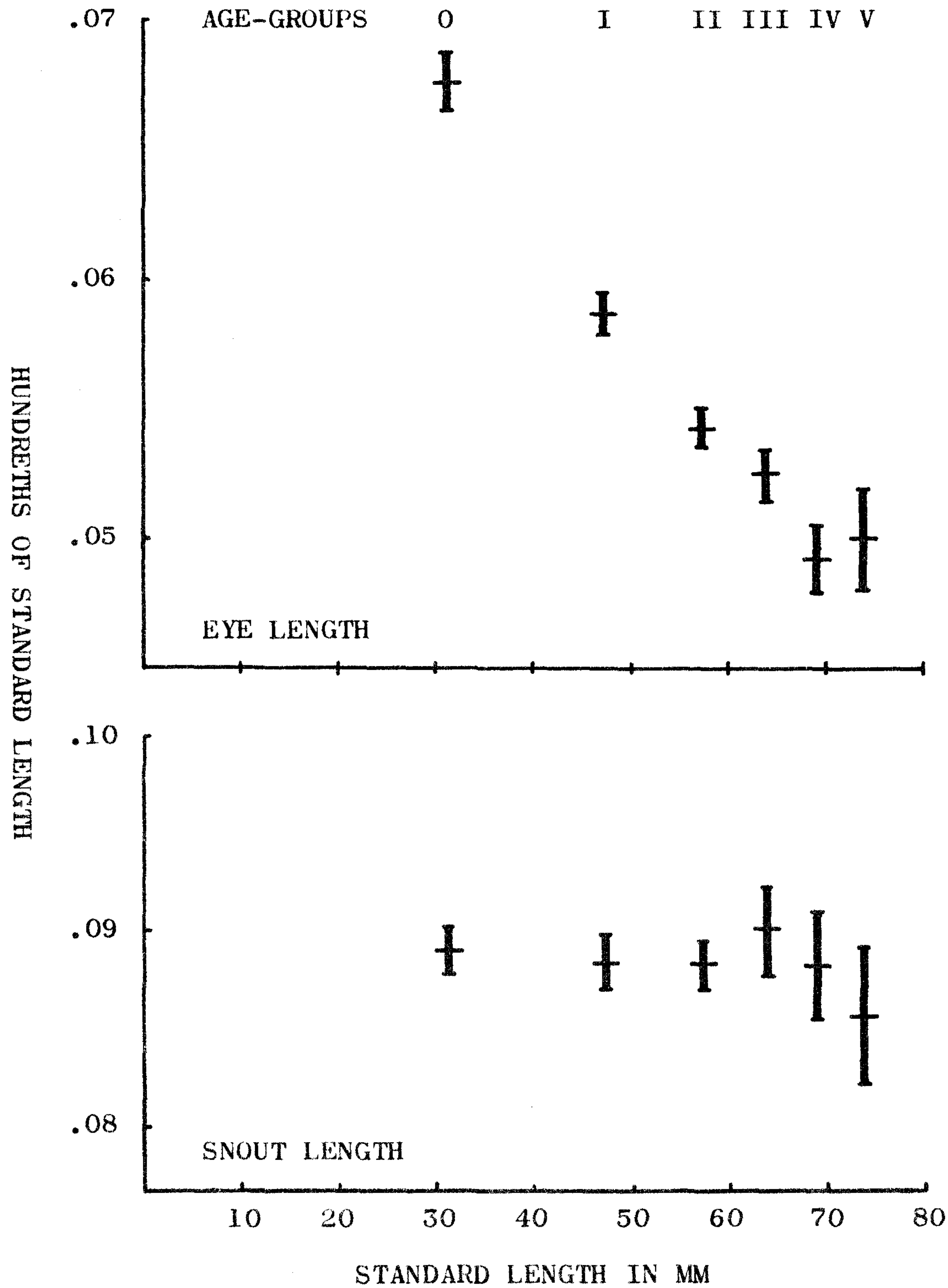

Fig. 8. Changes with growth in the relative sizes of two head measurements in P. argentissimus, showing the mean and 95% confidence interval for the mean of each age-group.

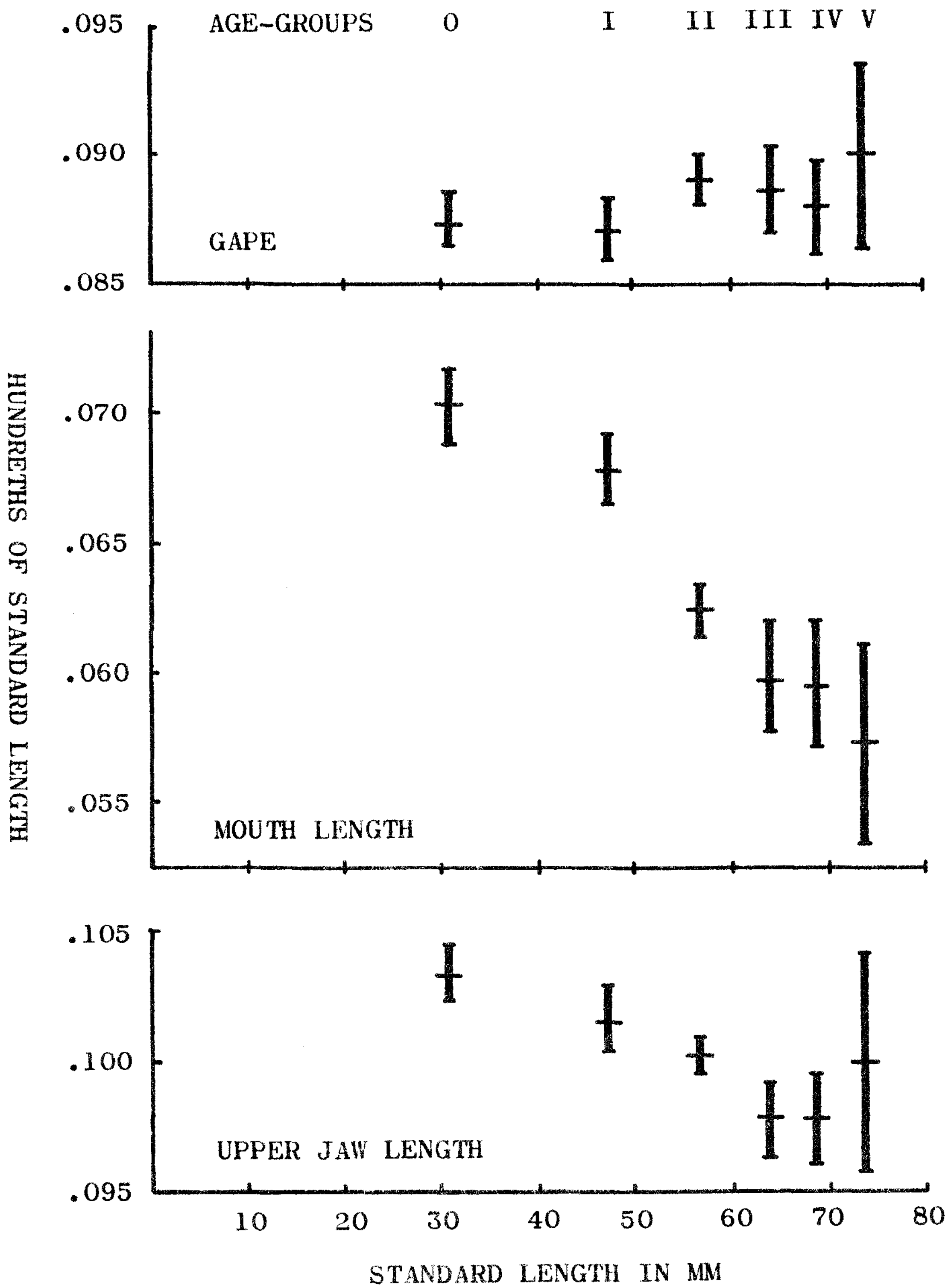

Fig. 9. Changes with growth in the relative sizes of three head measurements in P. argentissimus, showing the mean and 95% confidence interval for the mean of each age-group.

other hand, snout length, gape and lateral length of upper jaw showed almost isometric growth. The reasons for these changes were not clear, but further study into the food habits of these fish may reveal some reasons for these growth patterns.

The ratio of length of dorsal fin to height of dorsal fin showed a marked increase during growth from about 1.00 to 1.34 (Fig. 10). The reason for this seemed to be the presence of the dorsal spine which did not grow as rapidly as the soft rays of the dorsal fin.

The changes in body proportions of P. argentissimus are not dramatic. Many of the proportions studied grew almost isometrically, and those proportions that changed did so gradually. However, some proportions showed rather dramatic shifts from allometry to isometry in the larger specimens. This phenomenon was also noted by Koehn and Minckley (1965) in their study of Notropis lutrensis (Baird and Girard). A possible reason for the slight or gradual changes may be the rigorous conditions in which this species lives and develops. The main changes in the environment, as the fish grows, seem to be swifter current and greater water depth. If this is the case, a small fish adapted to the current, silt and other environmental factors need only increase its strength to exist in this constantly harsh environment.

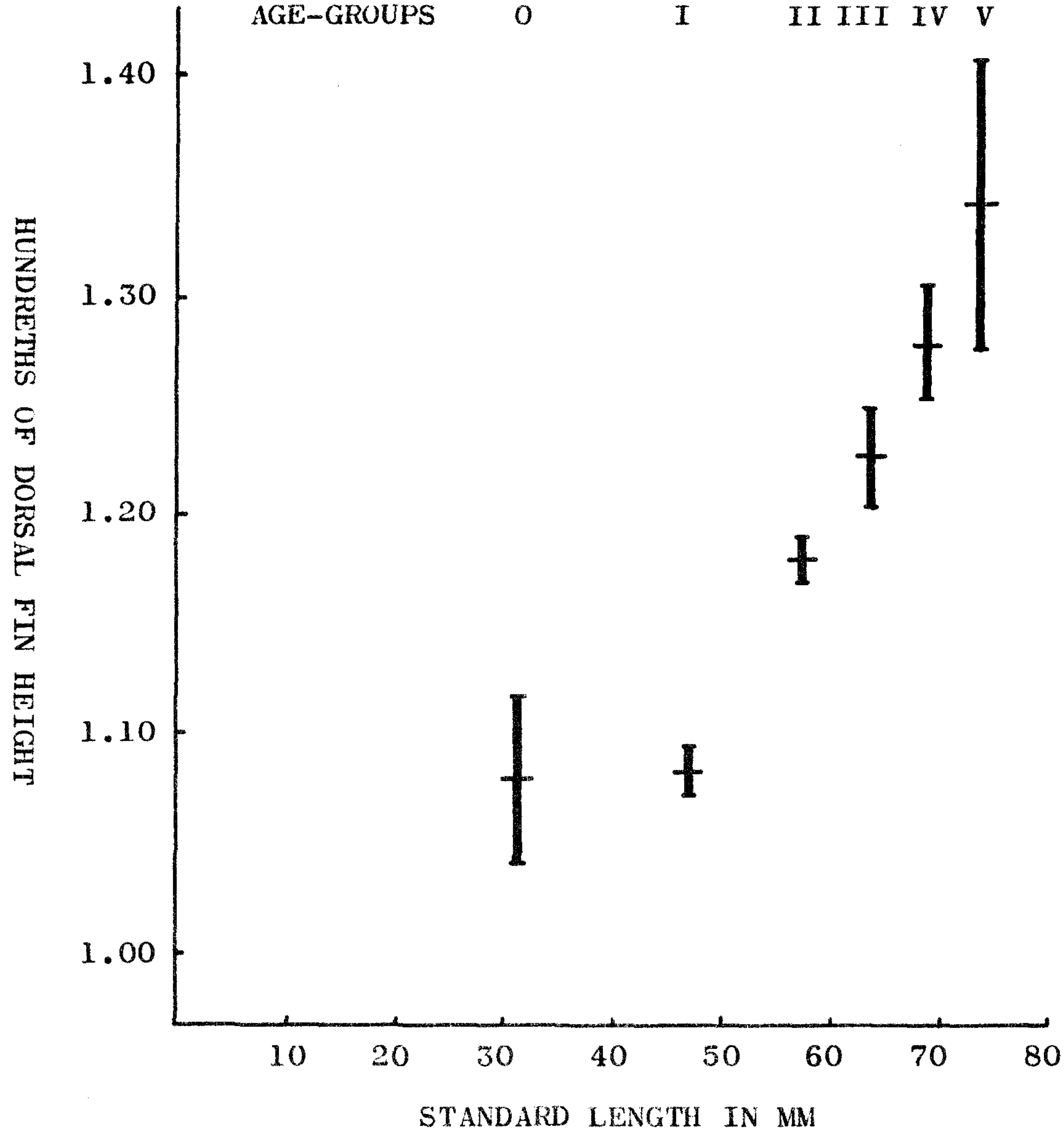

Fig. 10. Changes with growth in the shape of the dorsal fin of P. argentissimus, showing the mean and the 95% confidence intervals for the mean of each age-group.

SUMMARY

During this study I discovered several facts which were previously unknown to science. From a combination of gonad weight:total weight ratios and size of age-group 0 specimens, I was able to determine that during 1968 *Plagopterus argentissimus* spawned during a period from late April through June. Gonad weight:total weight ratios also showed that the gonads in female specimens do not develop until the fish are in age-group II (during their third year of life).

Woundfins age-group I and older can be easily sexed by means of the shape of the pectoral fins. The pectoral fins of the male are hardened and rounded while the fins of the female are soft and pointed. Most of the body proportions grow in a nearly isometric fashion, but trunk size increases with growth of the organism. This may give the fish more power because of the increase in proportional volume of body muscle.

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VITA

Edward James Peters

CHANGES WITH GROWTH IN SELECTED BODY PROPORTIONS OF THE WOUNDFIN MINNOW (PLAGOPTERUS ARGENTISSIMUS COPE: CYPRINIDAE)

Edward James Peters

Department of Zoology and Entomology

Masters Degree, May, 1970

ABSTRACT

In this study 883 specimens of the woundfin minnow (*Plagopterus argentissimus* Cope) from the Virgin River in Utah, were weighed and measured. Ratios of body measurements to standard length, and gonad weight to total weight were calculated. From the gonad weight:total weight ratios it was determined that woundfins spawn during a period from April through June, and that the first significant gonad development is during the third year of life. Several body proportions such as, snout length, gape, upper jaw length and peduncle depth grew nearly isometrically. Growth of other body proportions was more or less allometric. Head length, body depth and mouth length showed gradual changes. Pectoral fin length, eye length and total length showed rather marked allometry. The ratio of dorsal fin height to dorsal fin length also showed rather marked allometry.

COMMITTEE APPROVAL: