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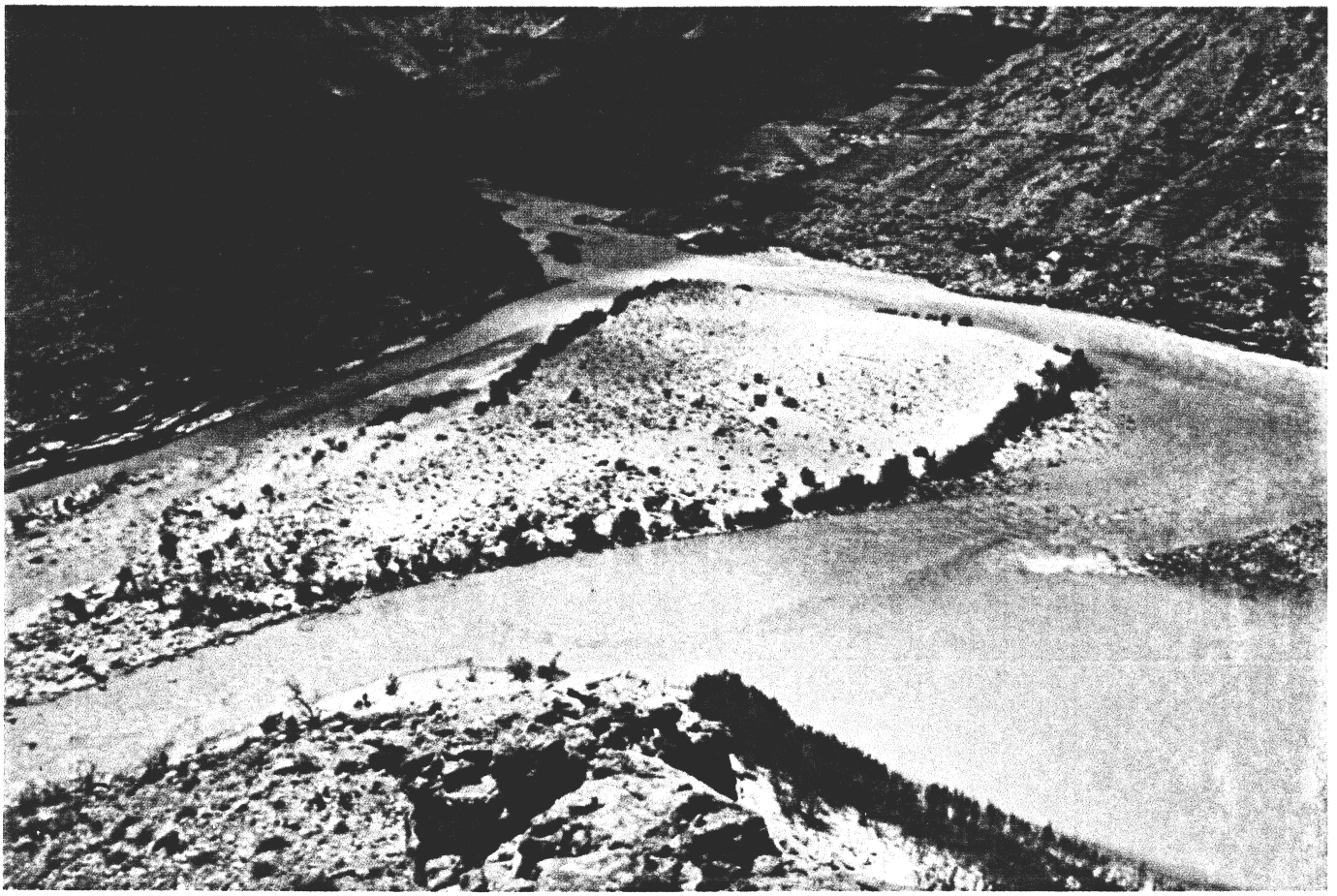

Number 1

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The Humpback Chub, *Gila cypha*, in the Grand Canyon Area of the Colorado River

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ABSTRACT

The humpback chub, *Gila cypha*, is redefined from specimens taken in the Colorado River in the Grand Canyon. Specimens from 24.6 - 320 mm are depicted, and notes on growth and development, sexual dimorphism, breeding tubercles and coloration, and reproduction are presented with standard meristic and morphometric data.

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The Humpback Chub, *Gila cypha*, in the Grand Canyon Area of the Colorado River[1]

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Perhaps the earliest recorded observation of the humpback chub in the Grand Canyon is that of the Kolb brothers (1914). Referring to a May trip (exact date not given), they heard a peculiar noise soon after locating their camp at the mouth of the Little Colorado River. The following are quotations from their writing, "Then Emery discovered what it was. On the opposite side of the pool the fins and tails of numerous fish could be seen above the water. The striking of their tails had caused the noise we had heard. The "bony tail" were spawning. We had hooks and lines in our packs, and caught all we cared to use that evening". "They are otherwise known as Gila Elegans, or Gila Trout, but "bony tail" describes them very well. The Colorado is full of them; so are many other muddy streams of the Southwest. They seldom exceed 16 inches in length, and are silvery white in color. With a small flat head somewhat like a pike, the body swells behind it to a large hump."

The latter statement leads us to believe that they had what is now known as the humpback chub, *Gila cypha*, rather than what is presently known as the bonytail, *Gila elegans*.

Although the holotype of the humpback chub, *Gila cypha*, was taken from the Colorado River near the mouth of Bright Angel Creek sometime prior to the fall of 1942 (Miller, 1946) very few specimens have been taken during the subsequent years. As recently as 1973, Minckley made the following statement, "Almost nothing is known of the biology of this [*Gila cypha*] fish, principally because of the difficulties in collecting in its presumed habitat, and its resulting rarity in collections".

We began our study of the fishes of the Grand Canyon area in 1970 and made 15 float trips by September 1976. In the course of our studies we discovered a *Gila cypha* population and have accumulated a significant amount of biological information which is presented herein.

Methods and Materials

Methods of counting fin rays and scales and methods of measuring follow those of Hubbs and Lagler (1964) with the following exceptions. The width of gape was measured to the lateral side of the lips at the juncture of the upper and lower lips. The middorsal head length was measured from occiput forward to most anterior tip of snout or upper lip. The pre-pelvic length was measured from insertion of left pelvic fin to most anterior tip of snout or upper lip. The tip of chin to isthmus measurement was made from the anteriormost tip of the chin posteriorly to the posterior margin of the rugose area at the "V" of the isthmus. The tip of snout to isthmus measurement was made to the same posterior point as the foregoing measurement. All measurements were made with a dial calipers to the nearest 0.1 mm.

Our earlier collections from the Grand Canyon area contained only young and juvenile *Gila*. In June of 1976 we were fortunate to obtain four adults from the mouth of the Little Colorado River (Suttkus and Clemmer, in press). Two adults, salvage specimens, were obtained from Powell Reservoir. In addition we examined specimens taken in 1967 from below Glen Canyon dam and from Powell Reservoir. These latter two series of specimens were formerly housed at Utah State University and recently have been transferred to the U.S. National Fish and Wildlife Laboratory at Ft. Collins, Colorado. Also we obtained four specimens on loan from the Museum of Northern Arizona. Accurate measurements were difficult or impossible on these latter three series because of improper methods of preservation; thus some dispersion of data on scattergrams is not true variability but a reflection of inability to make accurate measurements. Most specimens were distorted and twisted. Presumably Holden and Stalnaker in the removal of gill arches from some specimens, removed and discarded both left and right opercular elements so head length and post-orbital measurements were not possible on these specimens. Some fins (particularly the caudal) were damaged or broken off, so no measurements could be taken. We did not estimate the measurement when the tip of the fin was missing.

Abbreviations for repositories of examined material are: TU – Tulane University, Museum of Natural History, NFWL – National Fish and Wildlife Laboratory at Ft. Collins, Colorado, and MNA – Museum of Northern Arizona.

[1]Contribution Number 12, Tulane University, Museum of Natural History.

Identification

In view of Holden and Stalnaker's (1970, Table 2 and Figure 4) remarks with regards to extensive 'intergradation' (their usage) in the Powell Reservoir area, we postponed our identification of the young and juveniles until we had sufficient materials for plotting scattergrams of various measurements. Authors in various papers (Miller, 1946; Gaufin, Smith and Dotson, 1960; Miller and Lowe, 1964; Holden and Stalnaker, 1970; and Minckley, 1973) have mentioned or emphasized the nuchal hump as a distinguishing feature of the humpback chub. We now view the nuchal hump as a highly variable character. The small eye, the inferior, nearly horizontal mouth and the combination of several other characters in addition to the hump has enabled us to identify the juvenile and adult specimens from the Grand Canyon area as *Gila cypha*.

Smith (*in:* Gaufin, Smith and Dotson, 1960) in the annotated list of fishes of the Flaming Gorge Reservoir Basin in reference to *Gila cypha* stated that, "Young specimens are difficult to identify because of the lack of development of the characteristic shapes of the nuchal area and caudal peduncle and the overlap in fin ray counts for the three types". Holden and Stalnaker (1970) said that, "Since general body morphology is very different between mature and immature fish, a minimum size of 210 mm standard length was enforced for most fish studied".

Confronted with these various stated difficulties, we proceeded cautiously in our determinations. We decided that the logical way to determine the identity of the young and juveniles was to obtain a graded size series. During the early part of our study we considered the slim-bodied specimens to be *elegans* or hybrids, but as we accumulated more material and became familiar with the variability, we became more and more convinced that we had a single, highly variable form. Our belief was substantiated by our collection of juvenile *Gila elegans* form, *Gila cypha*, and *Gila robusta* from the Green River in Utah (Figure 9). During the last few collecting trips in the Grand Canyon we were selective in our collections attempting to obtain the different body types as well as to fill the gaps in the graded size series. Our specimens range in standard length from 24.6 mm to 320 mm. The largest specimen is one of the salvaged specimens from Powell Reservoir. We have sufficient specimens ranging in size from 26.4 to 110 mm in standard length (Figures 1 to 8) but none between 110 and 164 mm in standard length. All of these up to 110 mm and the 164 mm specimen were obtained with a ten-foot seine. Another gap exists in our data between the 164 mm specimen and the 204 mm. A series of photographs (Figures 10 to 17) illustrate the differences in body shape of the various size fish.

Although we are primarily concerned with an analysis of *Gila cypha* from the Grand Canyon area, we present an illustration (Figure 9) of juvenile specimens of the *elegans* form (upper), *cypha* (middle) and *robusta* (lower). These three specimens are almost the same length (77.5, 71.2, and 70.3 mm in standard length, respectively) and thus are suitable for comparison. The three specimens were collected from the Green River. The *elegans* and *cypha* were taken from near the town of Green River, Utah, and the *robusta* specimen was taken from near the town of Jensen, Utah. Note the relatively small eye of *elegans* and *cypha* versus the large eye of *robusta*. The caudal peduncle is most slender in *elegans* and deepest in *robusta*. The caudal fin lobes are longest and most pointed in *elegans* and shortest and rounded in *robusta*. The mouth is essentially terminal in *elegans* and *robusta* and subterminal or inferior in *cypha*. This brief comparison is presented as background information for the review of the series of illustrated growth stages (Figures 10 to 17) of *Gila cypha* from the Grand Canyon area. These illustrations are arranged starting with smallest (upper illustration in Figure 10) and proceeding to the largest.

Figure 10 illustrates three small specimens of approximately 2.5 centimeters (upper) to three centimeters in standard length. The subterminal mouth is apparent even at this small size. Also the slight concave dip is apparent in the profile of the head. These three specimens exhibit relatively long pectoral and pelvic fins.

Figure 11 illustrates a transition from a nearly scaleless condition (upper) to visible lateral scales (middle and lower). The upper specimen has relatively short pectoral and pelvic fins. The middle and lower illustrations show two different snout shapes. The former has a rather blunt snout and a slightly curved outline from end of snout to nape whereas the latter has a rather hooked and pointed snout and the dorsal outline shows a cephalic dip. Perhaps this latter form represents the juvenile stage of the adult which has the extreme hooked snout and prominently developed hump.

Figure 12 illustrates three different combinations of morphological features. The upper specimen has a blunt snout, long pectoral fins, and moderately deep body. The middle specimen has a moderately sharp snout with a cephalic dip, short pectoral fins and a rather slim body. The lower specimen illustrates a moderately sharp-snouted individual but lacks a marked cephalic dip. It has a moderately deep body and moderate-length pectoral fins.

Figure 13 also illustrates three combinations of morphological features. The upper specimen has a blunt snout, very little cephalic dip, short pectoral fins and a moderately deep body. The middle specimen illustrates a slightly sharper snout than the upper specimen but has about the same degree of cephalic depression. The pectoral fins are long and obviously extend beyond the insertion of the pelvic fins. The body is less deep than the upper specimen but is not considered as a slender form. The lower fish has a sharper snout than either of the above and shows more of a cephalic dip. The body is moderately deep, and the pectoral fins are moderately long.

Figure 14 illustrates the deepest bodied juvenile (lower) that we have from the Grand Canyon area. The upper specimen shows a blunt snout, short pectoral fins and a moderately deep body. The middle specimen has a sharp snout, moderate cephalic dip, long pectoral fins and a moderately deep body. The lower specimen has a blunt snout, slightly less than a moderate cephalic dip, extremely short pectoral fins and an extremely deep body as mentioned above.

Figure 15, upper and middle specimens have a moderate body depth and a relatively sharp snout. However, they differ to some degree in sharpness of snout, hooking of snout, and depth of cephalic dip. The reader should note that the upper and middle illustrations are of specimens that differ approximately five centimeters in standard length. Too, the lower specimen illustrates a specimen approximately twelve centimeters larger than the middle individual. All illustrations in figures 10 through 14 are enlargements of young or juvenile specimens. The upper two illustrations in Figure 15 are also enlargements of juvenile specimens, but the lower illustration in Figure 15 is a reduction of the actual size of an adult female specimen. The three specimens illustrated in Figure 16 and the two specimens illustrated in Figure 17 are adults. The authors had no adult specimens from the Grand Canyon area that exhibited the extreme snout and hump development which was illustrated by Miller (1946) and by Minckley (1973).

Figure 16 illustrates three of the four adults taken from the mouth of the Little Colorado River. The lower illustration of Figure 15 is that of the fourth specimen from the Little Colorado River taken in June 1976. The head profiles are similar for all four. The upper illustration of Figure 16 is that of the male and the middle and lower specimens are females as well as the lower specimen of Figure 15. The male specimen was illustrated in color by Williams and Finnley (1977). The pectoral fins are proportionately shorter in the three females than in the male. The male has small tubercles (pearl organs) on the head, body and fins as described below.

Figure 17 illustrates the male and female salvaged specimens from Powell Reservoir. Neither specimen seems to be typical of *Gila cypha* in all respects, but we do not suggest they are hybrids. We interpret the differences as being within the variation of the species. The ventrally arched body of the male tends to negate the height of the nuchal hump. However, the mouth is ventral and the eye small. Although the arching tends to pull the pectoral fins forward, in its appressed position, it nearly reaches the insertion of the pelvic fins whereas the pectoral of the female (lower illustration of Figure 17) is not as long proportionately and extends somewhat short of the insertion of pelvics. The tuberculation of both specimens is described below.

Based on the consistency of data presented in the scattergrams, and our extensive comparisons of various specimens, we conclude that all our material from the Grand Canyon is referable to *Gila cypha*.

Growth and Development

The smallest specimen (24.6 mm SL) does not have pectoral fin rays fully developed. Specimens up to 28 mm in standard length may not have a full complement of pectoral fin rays. Lateral line scale development is the reverse of that in some fishes. Instead of a posterior to anterior development the first lateral line scales develop in the anterior region. Lateral line scales were not sufficiently developed to make a count on 34 of the 74 young and juveniles. Specimens under 30 mm in standard length have fewer than ten lateral line tubes or grooves and no scales. Specimens from 30 to 35 mm have up to 35 scales partially or entirely developed and up to 45 tubes developed. The full lateral line scale series is not developed until a standard length of around 50 mm is attained. Scale development above and below the lateral line is also progressive with age. Specimens from 50 to 100 mm in standard length vary in having a few rows (four to six) below and (six to eight) above the lateral line to seven to ten rows below and ten to twelve rows above. The size and exposure of the scales decrease dorsally and ventrally away from the lateral line. Thus toward the back and belly in general the scales are smaller and embedded. The largest specimens are completely scaled on the back, the breast and the belly. Scales on the back are small, embedded and spaced to some extent. The breast scales vary from small and embedded to well developed; however, they are not as large as lateral body scales. The belly scales are well developed.

The posterior scales in the lateral line at the base of the caudal are nearly typical in shape, but anteriorly on the narrow part of the peduncle, the lateral line scales are very elongate. These elongate scales grade anteriorly into scales of more typical shape which make up the anterior third to half of the lateral line row.

Meristic Characters and Measurements

Frequency distributions of fin rays, vertebrae and scale counts are given in Table 1 and Table 2. Other authors mentioned above have pointed out that fin-ray, scale and vertebral counts are not diagnostic characters for the humpback chub, *Gila cypha*. We present the data partially for the sake of completeness and partially to enable a comparison with additional samples from the same area and particularly with samples from other areas. Miller (1946) gave counts for two specimens. Gaufin, Smith and Dotson (1960) had 15 specimens available, but frequency tabulations of fin-ray counts were not presented. Holden and Stalnaker (1970) gave range and mean values for dorsal and anal fin-ray counts, number of vertebrae and number of gill rakers for 16 specimens, but did not present frequency tabulations. Minckley (1973) presented usual fin-ray counts, and in the key, gave the figure of more than 81 lateral-line scales, but did not state number of specimens examined. Miller (1946) gave lateral-line scale count of 77-80 in Table 2, and we presume the two numbers (77 and 80) are the counts of the two specimens. The dorsal and anal fin-ray

counts presented in Table 1 show agreement with other data by the various authors. Vertebral counts reported by Holden and Stalnaker (1970) did not include the Weberian complex (four vertebrae), thus when four is added to the counts presented in their Table 2 the range in the count becomes 46-49 which is inclusive in our counts (45-49) presented in Table 1.

In addition to the above counts we counted the principal caudal rays and contrary to the count of 20 given by Miller (1946) for the holotype, we found that 95 of the 96 specimens had 19 caudal rays. The one atypical count was 18.

The lateral line scale count was difficult to make on some specimens, but even on those specimens the accuracy is within plus or minus two scales. Many specimens had undulations in the lateral line row of scales, particularly in the anterior portion. On a few specimens the lateral line row had displaced sections of one to several scales.

Pharyngeal arches were removed from twenty specimens to determine nature of dentition. Miller (1946) gave the dental formula of the holotype as 2,5 – 4,1? He said there may have been a second tooth in the minor row on the right arch. Seventeen of the twenty specimens we examined have the typical *Gila* dental formula of 2,5 – 4,2. One specimen has 2,5 – 4,1, another specimen has 1,5 – 4,2, and the remaining specimen of the twenty examined has 2,5 – 5,2. The extra tooth on the right arch is somewhat medial and practically has a common base with the upper tooth of the major row. There is a possibility that the two specimens with the single tooth in the minor row on the one side did have two teeth and one was broken off without leaving a trace of a stump or a socket. However, the count may be correct in that some specimens have very slender, delicate teeth in the minor row and it is conceivable that this may be an indication of a reduction in number.

X-rays of the larger specimens revealed a two-chambered swim bladder.

A review of the 24 scattergrams (Figures 1 - 8) of proportional measurements indicates a linear relationship of all proportions with the standard length. Some observations do not appear on the scattergrams because of overlap, but all data for each proportion were used to compute regression formulae.

Sexual Dimorphism

Some males have decidedly longer pectoral and pelvic fins than most females; however, a few females have rather long paired fins. The relative position, size and shape of the tubular termination of the digestive tract (outlined with ink on illustrations) and the urogenital papilla are quite different in the female and the male. Figure 18 illustrates the anal region of an adult female, and Figure 19 illustrates that of an adult male. The tubular ending of the digestive tract of the female is long and extended posteriorly (overlapping base of first anal fin ray) so that the urogenital papilla is hidden underneath when viewing the ventral surface of the fish. In the male the terminal tube of the digestive tract is not nearly so long and the urogenital papilla (indicated by arrow on illustration) projects ventrally so that its tip is visible just beyond the termination of the digestive tract.

Tuberculation of males and females differ considerably. The nuptial male has larger tubercles and more areas of the fins and body are studded with tubercles than on the nuptial female. One of the four adult specimens (TU 97918) collected from the mouth of Little Colorado River during June of 1976 has small breeding tubercles scattered over the top of the head, laterally to the rim of the orbit and about half way ventrally on the opercle. There is a progressively decreasing number of tubercles on the hump from the nape toward the origin of the dorsal fin. Tubercles extend nearly two-thirds the distance toward the dorsal fin. There are no tubercles on the underside of head, about the lips nor below the orbit on the snout or cheek. Although the anteromedial patches of scales in front of the bases of the pectoral fins (breast patches) are developed with free posterior margins, there are none with developed tubercular ridges. There are small tubercles developed on the upper surface of the second, third and fourth pectoral fin rays and also on the upper surface of the second, third, fourth and fifth pelvic rays. We consider the above male fish to represent an early stage of nuptial development.

The salvage specimens (TU 100542) obtained from Powell Reservoir were near spawning condition if not actually spawning at the time of capture. The larger specimen (Figure 17 lower) is a female (320 mm SL) and the smaller (Figure 17 upper) a male (298 mm SL). Unfortunately we did not obtain the specimens until a number of months after they had been captured on 5 June 1975. The specimens exhibited some breeding color even after having been frozen and stored in a freezer. The entire lower side below dark pigmentation of the body of the male was orange. The bases of pectoral and anal fins were orange. The cheek below the eye was yellowish and the iris was pinkish-orange. The female was light orange on the lower portion of the side and at the base of the anal fin. The base of the pectoral fin was cream color. These colors may have been brighter at the time of capture.

The tubercles and thickened epidermal layer had sloughed off various parts of the body of these two specimens during the delay in getting the specimens from the field to the freezer and then subsequent freezing and thawing. However, sufficient tuberculation remains to allow a description of the sexual dimorphism in this character. The male has rather large tubercles scattered over the entire head (Figures 20 and 21) and smaller ones posteriorly on the hump to about two-thirds the distance toward the origin of the dorsal fin. The thickened epidermal layer is missing from part of this region, and perhaps, tubercles were present all the way to the dorsal fin. These predorsal tubercles are not particularly associated with the embedded scales but are scattered over the surface. Some tubercles occur over the scales

and others occur over inter-spaces between the scales. This is also true of the distribution of predorsal tubercles in the female. There are a few tubercles on the ventral portion of the head of the male. There are a few on the isthmus, rami or lower jaws, on the branchiostegals, and a few on the ventral portion of gill membrane. There are well developed tuberculate ridges on the exposed margins of the scales of breast patches (Figure 22). There are elevated blunt points along these tuberculate ridges as though a row of tubercles became fused at their base. There is a single row of tubercles on the posterior upper margin of the first pectoral fin ray and double rows proximally on the second, third, fourth, fifth and sixth pectoral fin rays. As the rays branch distally the rows of tubercles also branch to some extent. There are a few tubercles on the seventh, eighth, and ninth pectoral fin rays. There are developed tubercles on second, third, fourth and fifth pelvic fin rays. The number of tubercles diminishes from the third to the fifth pelvic fin rays. Because of the extensive lateral area of the body from which the thickened epidermal layer has been lost through handling, the precise extent of tuberculation on the lateral scales cannot be ascertained. We assume there was an elongate tuberculate area extending from the humeral region posteriorly to the region below the middle of the dorsal fin. There are a few lateral line scales with a few small tubercles along their exposed margins, but no scales below the lateral line appear to have any tubercles, thus the major portion of the tuberculate lateral scales is in the intervening area between the lateral line and the small embedded dorsal scales. The tubercles are situated along the exposed margins of the scales and are larger and more numerous on the anterior scales in the described patch. The number of tubercles per scale margin varies from one to seven.

The larger female taken with the male described above also has some tuberculation. There are very small tubercles on anterior pectoral fin rays but none on the pelvic fin rays. The tuberculate ridges are developed on the margins of the scales of the breast patches.

Three of the seven specimens of sample no. 76-11 examined from the July 25-26, 1967 collection obtained from just below Glen Canyon Dam by Stalnaker, Campbell, Holden, and Joe Stone have some tuberculation. These male specimens (metal strap tag nos. 2761, 2763, and 2771) are presently housed at the Ft. Collins, National Fish and Wildlife Laboratory. Specimen number 2761 has slightly developed tubercles on the second, third and fourth pectoral fin rays. There were no tubercles on the head or the pelvic fin rays. Specimen no. 2763 has moderately developed tubercles on the second to fifth pectoral fin rays and the second to fifth pelvic fin rays. There are a few tubercles on the first ray of the right pectoral fin and few tubercles on top of the head on the interorbital area. Specimen no. 2771 has a few tubercles on the second, third and fourth pectoral fin rays, none on the pelvic rays, a few on the top of head, tip of the snout and upper part of the opercle but none on the breast patches of scales.

Another series (sample no. 67-12) taken from Powell Reservoir during 1967 by Rod Stone and Kent Miller does not have a precise date, but by placement between sample no. 67-11 and sample no. 67-13 which was collected a few days after the Glen Canyon Dam collection (cited above), the implied date for sample no. 67-12 is 26 or 27 of July, 1967. The four male specimens (metal tag nos. 2736, 2737, 2739, and 2741) examined had slight to extensive tuberculation. The tuberculation was similar to that described above. Specimen no. 2737 has the best development of breeding tubercles on the fins. There is a single row on the first pectoral ray and a single row proximally to four rows distally on the second to the seventh pectoral ray. There are no tubercles on the first pelvic ray. On the second to the sixth pelvic ray there is a single row of tubercles proximally which soon divides into two rows, one on each branch, and then each of the two rows divide to form four rows and then into eight rows near the distal tips of the rays. There are a few extra tubercles suggesting the beginnings of dividing into sixteen rows of tubercles at the very margin of the fin. The breast patches of scales have tuberculate ridges on their margins. There are approximately fifteen diagonal rows of these tuberculate scales. There are relatively larger tubercles scattered over the top of the head and smaller ones extending posteriorly over the surface of the hump. There is a progressive decrease in number of tubercles, and they occur no farther than about two-thirds the way toward the dorsal fin. Tubercles on the head extend laterally and ventrally over the upper two-thirds of the opercle and the upper third of the cheek. There is a hiatus on the mid-cheek area. The scattering of tubercles on the ventral surface of the head extends laterally and dorsally on to the lower third of the cheek.

The male specimen with metal tag no. 2736 is not as tuberculate on the fins as no. 2737 but has tubercles on the margins of the lateral body scales. The number of tubercles per scale ranges from one to five. This specimen has relatively large tubercles on the top of the head, and the smaller tubercles extending over the hump are scattered all the way to the dorsal fin. There are tubercles on the upper lip, chin, rami of the lower jaws and on the branchiostegals. The tuberculate ridges are developed on the scales of the breast patches. Three of the five female specimens examined (metal tag nos 2734, 2735 and 2740) have tubercles. Small tubercles are scattered over the top of the head and extend back over the nuchal hump toward the dorsal fin. Some tubercles are present on the pectoral fin rays and one specimen has some tuberculate ridges developed on the breast patches of scales. None of the females have any tubercles on the ventral side of the head, on the pelvic fins or on the lateral body scales.

Reproduction

The males with extensive tuberculation described above seem to have fully developed testes. Of the five females studied (metal tag nos. 2732, 2734, 2735, 2738,

and 2740) one specimen 267 mm SL (no. 2732) has only small granular ova. The other four females with standard lengths of 283, 292, 297, and 305 mm have two size groups of ova. Ten ova of the larger size group from female no. 2734 measured, 1.3, (4) 1.4, (3) 1.5 and (2) 1.6 mm in diameter. Ten ova from female no. 2736 measured (4) 1.4, (5) 1.5 and 1.6 mm in diameter. The smaller size group of ova in female no. 2735 measured (4) 1.0, (5) 1.1, 1.2 mm in diameter. This female had no tubercles anywhere on the body or the fins. Female no. 2740 is 305 mm in SL and is the only female of the five that has tuberculate ridges developed on the scales of the breast patches. Ten of the larger ova measured 1.6, 1.7, 1.8, 1.9, (2) 2.0, (3) 2.1 and 2.2 mm in diameter. Six ova of the smaller size group measured 0.9, (2) 1.1, (2) 1.2, and 1.3 mm in diameter. The smaller ova appeared to be very pale whereas the larger ova were yellowish. We believe this female was probably ripe at the time of capture.

Ten ova were removed from the 320 mm SL female (TU 100542) and these measured 1.3, 1.4, (5) 1.5 and (3) 1.6 mm in diameter.

We have no measurements of fresh, non-preserved ova, thus all our measurements above reflect the shrinkage that takes place as a result of preservation.

Spawning probably occurs during June and July in the Grand Canyon area. We presume that the 24.6 and the two 24.7 mm in SL individuals taken on 22 September represent young-of-the-year.

The future of the humpback chub population in the Grand Canyon area is questionable. Perhaps a coldwater strain may persist in the vicinity of the Little Colorado River. The extreme man-manipulated flow patterns of the main Colorado River can only be viewed as detrimental to the survival of the species. During average to maximum releases from Glen Canyon Dam the volume of extremely cold water is too great for the Little Colorado River water to have much warming effect. If extreme low flows are going to be maintained during the summer of 1977 (spawning time), this may have a temporary benefit in that the warmer Little Colorado River water will elevate more extensively the temperature in the main Colorado River. Undoubtedly the lower Little Colorado River is the major spawning area for the surviving population. We collected and released a single adult *Gila cypha* at the mouth of Shinumo Creek. During all of our sampling at Shinumo a total of three young *Gila cypha* were taken, therefore we assume this area to be marginal as a spawning site primarily because of its small size.

Material Examined

Precise collection sites for Powell Reservoir specimens of *Gila cypha* are not known; some came from Kane County, Utah, and some from Coconino County, Arizona. All Grand Canyon specimens were taken in Coconino County, Arizona.

Powell Reservoir: National Fish and Wildlife Laboratory (NFWL) (metal field tag nos. 2732, 2734, 2735, 2736, 2737, 2738, 2739, 2740, 2741), TU 100542. Colorado River just below Glen Canyon Dam: National Fish and Wildlife Laboratory (metal field tag nos. 2761, 2762, 2763, 2768, 2769, 2770, 2771). Colorado River at Lee's Ferry, River Mile 0: Museum of Northern Arizona, MNA Z5.29. Colorado River, River Mile 31.5: MNA Z5.30. Colorado River, River Mile 31.9: MNA Z5.31 and MNA Z5.32. Colorado River at River Mile 44: TU 92785. Mouth of Little Colorado River, River Mile 61.5: TU 78682, 89793, 95166, 95767, 97592, 97918, 97966, 99078. Colorado River, River Mile 66: TU 99081. Colorado River, River Mile 71: TU 95777, 97921, 97967, 99086. Mouth of Shinumo Creek, River Mile 108.7: TU 95784, 99092. Green River at town of Green River, Grand Co., Utah: TU 99151.

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Table 1. Frequency distributions of fin ray counts, and vertebrae in *Gila cypha*.

Dorsal fin rays			Anal fin rays			Left pectoral fin rays				
8	9	10	9	10	11	15	16	17	18	19
1	77	22	8	78	14	1	24	44	20	1

Pelvic fin rays*							Vertebrae				
8–8	8–9	9–8	9–9	9–10	10–9	10–10	45	46	47	48	49
1	1	1	74	3	4	15	6	29	18	6	2

*One specimen had 9 rays in left fin but no fin on right side.

Table 2. Frequency distribution of lateral line scales in *Gila cypha*.

73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
1	3	1	3	4	3	2	7	7	7	5	1	5	4	4	—	—	3

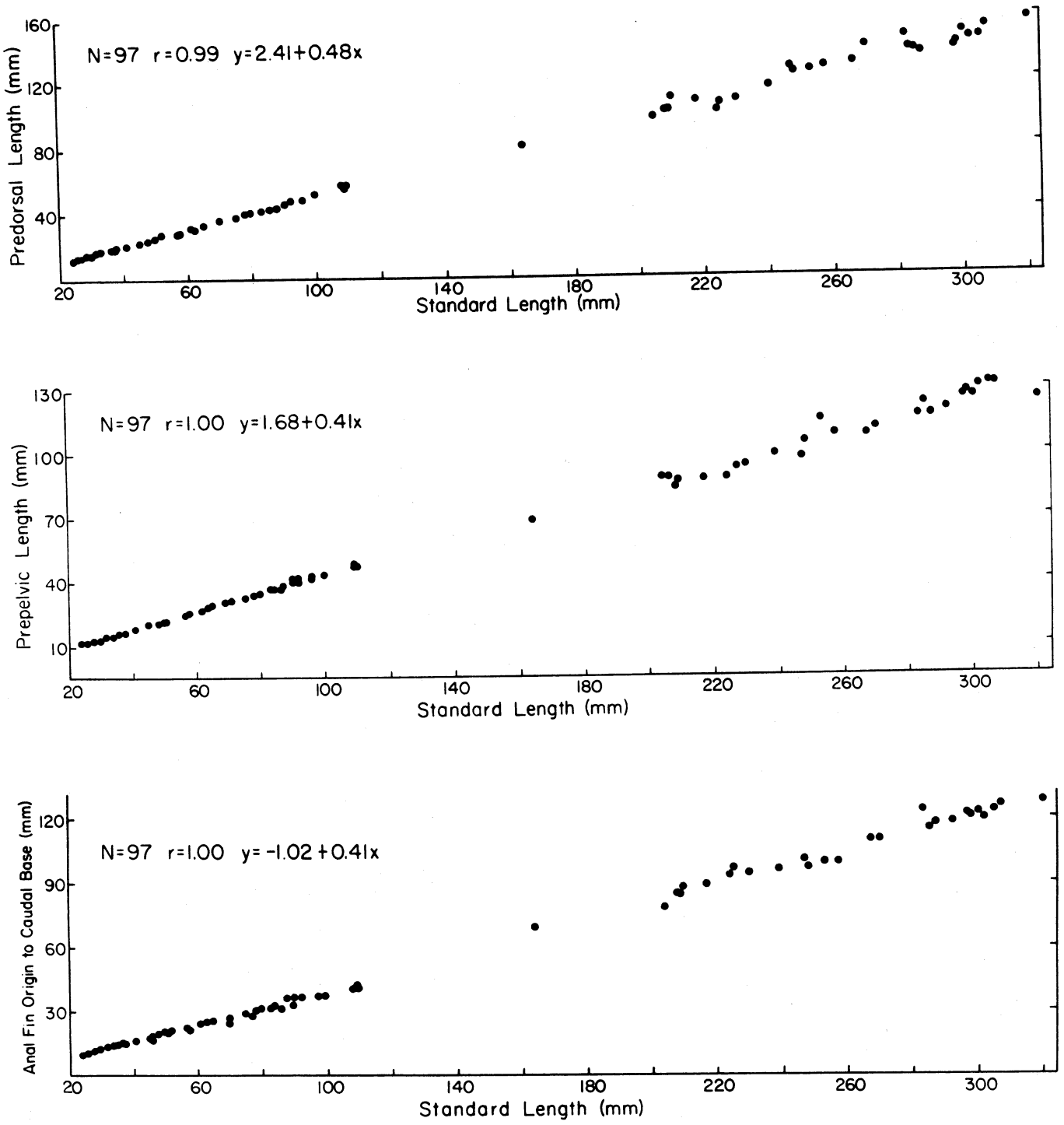

FIGURE 1. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

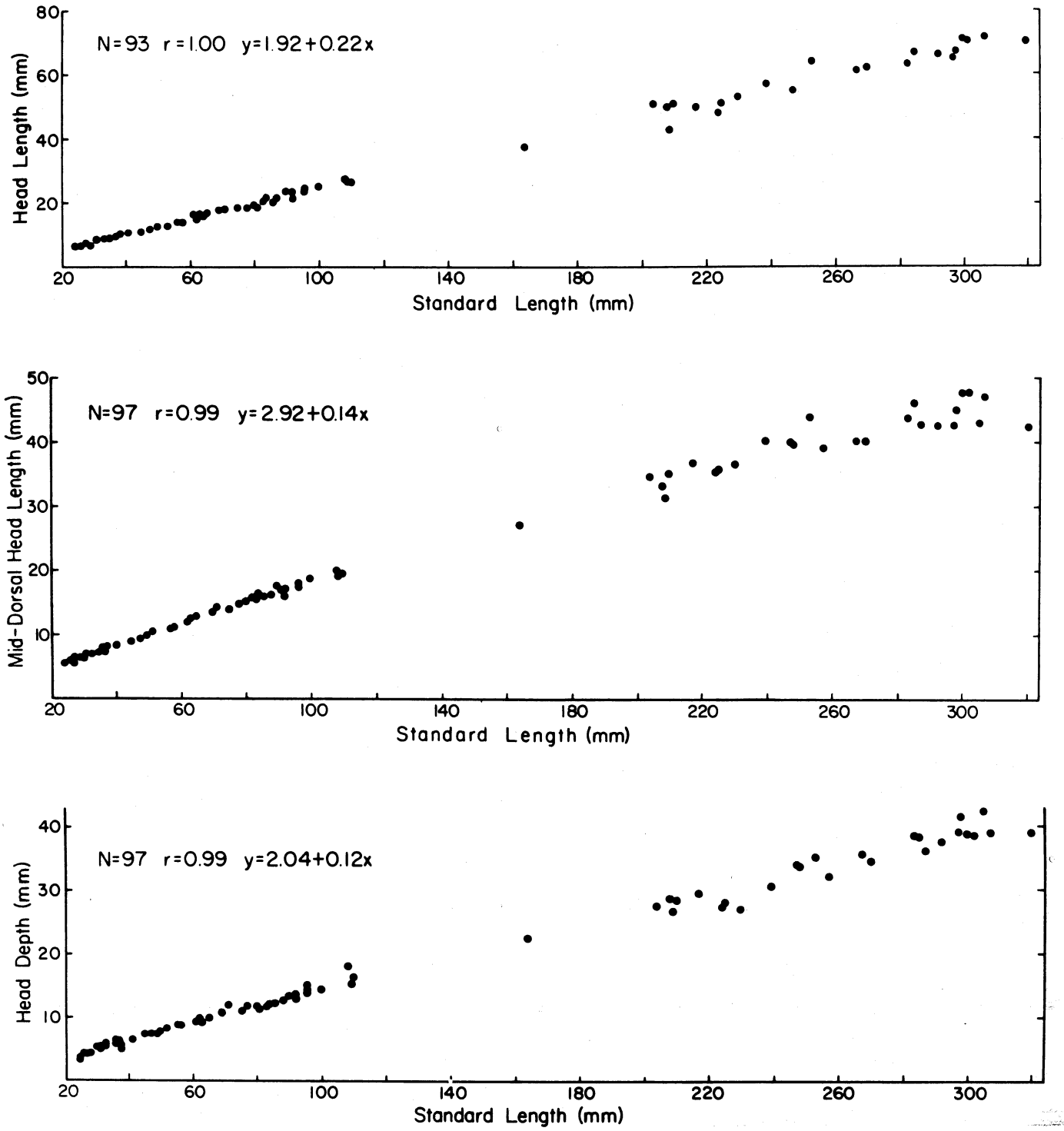

FIGURE 2. Allometric growth of *Gila cypha* from Grand Canyon area of Colorado River.

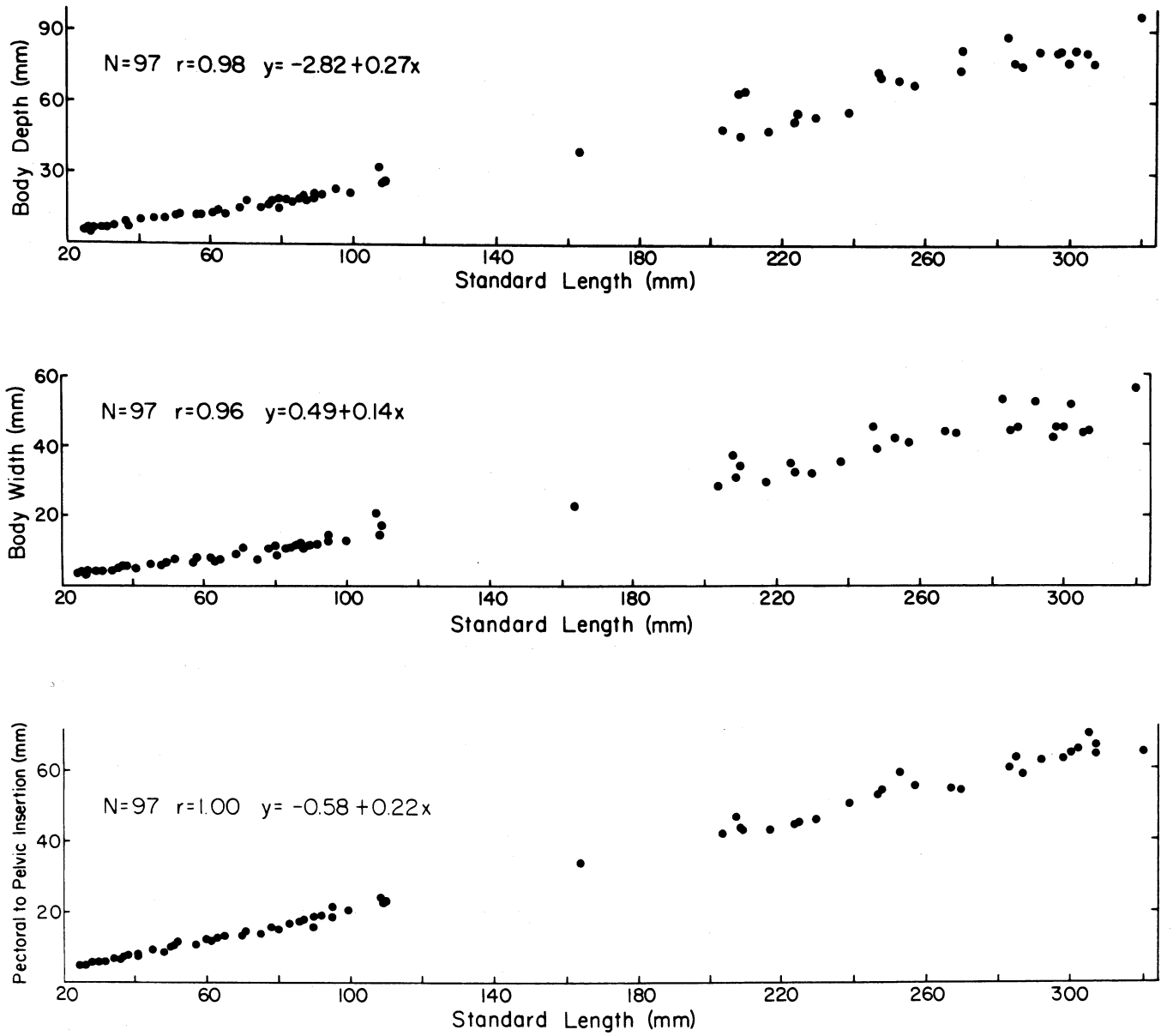

FIGURE 3. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

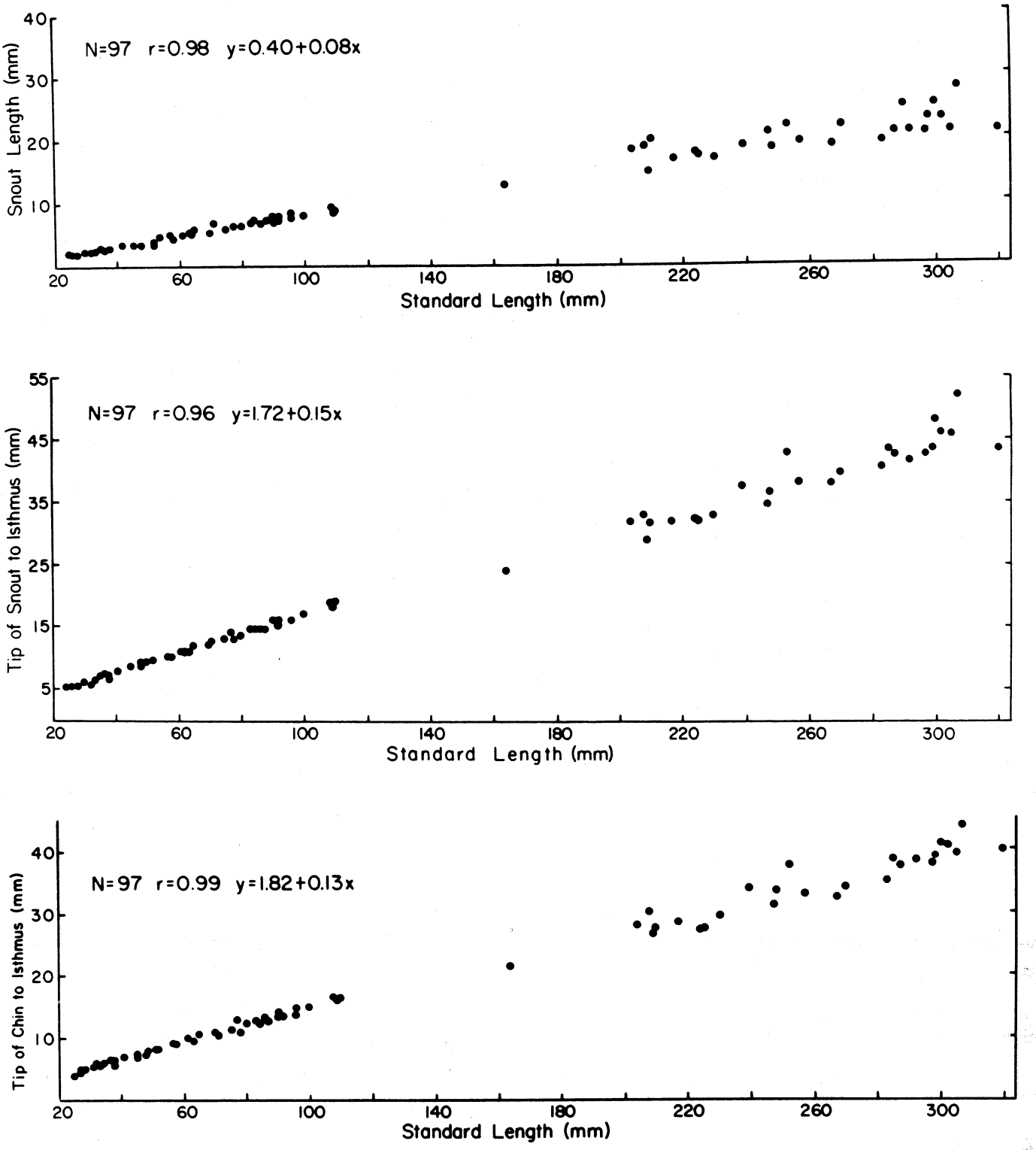

FIGURE 4. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

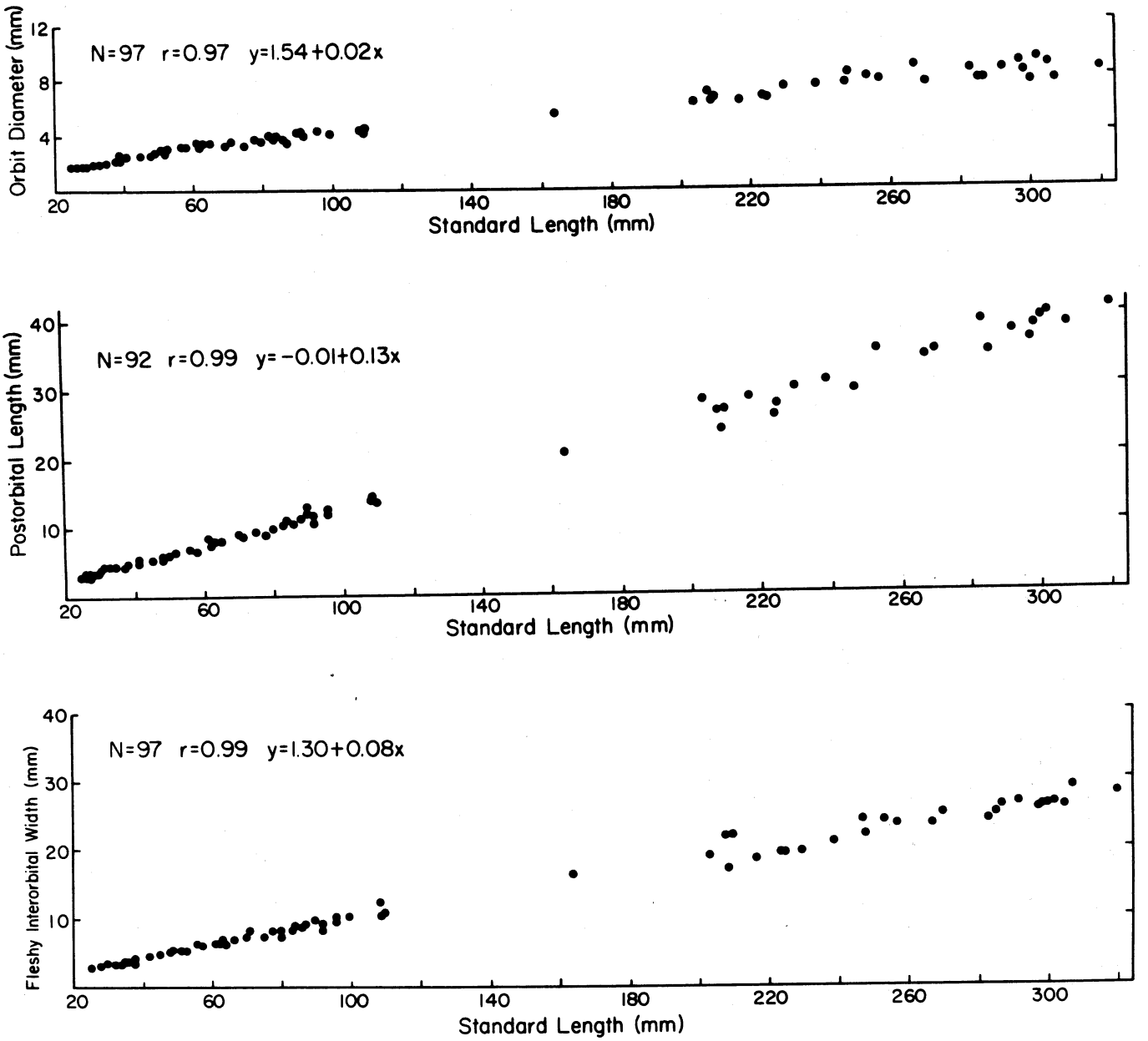

FIGURE 5. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

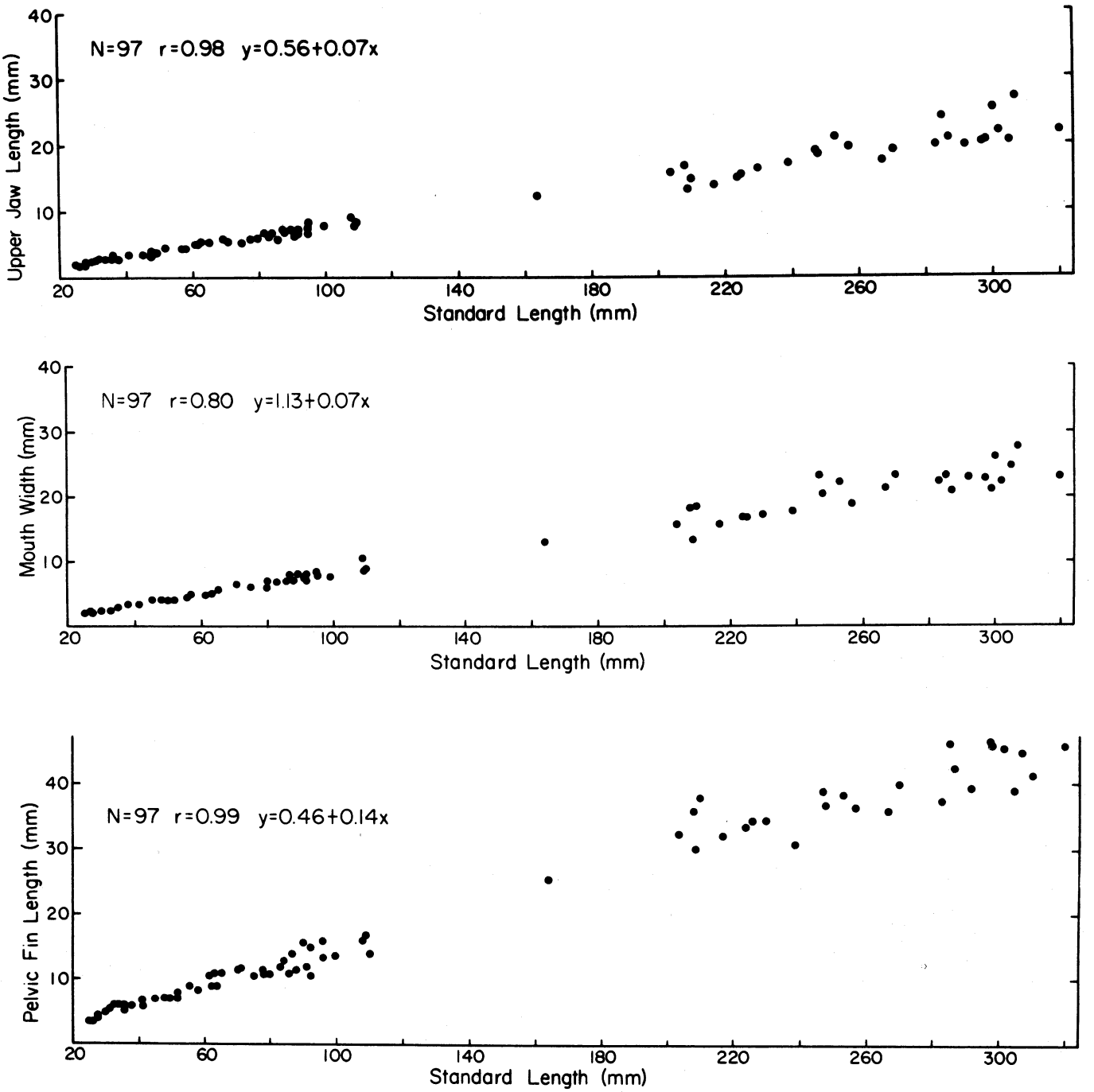

FIGURE 6. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

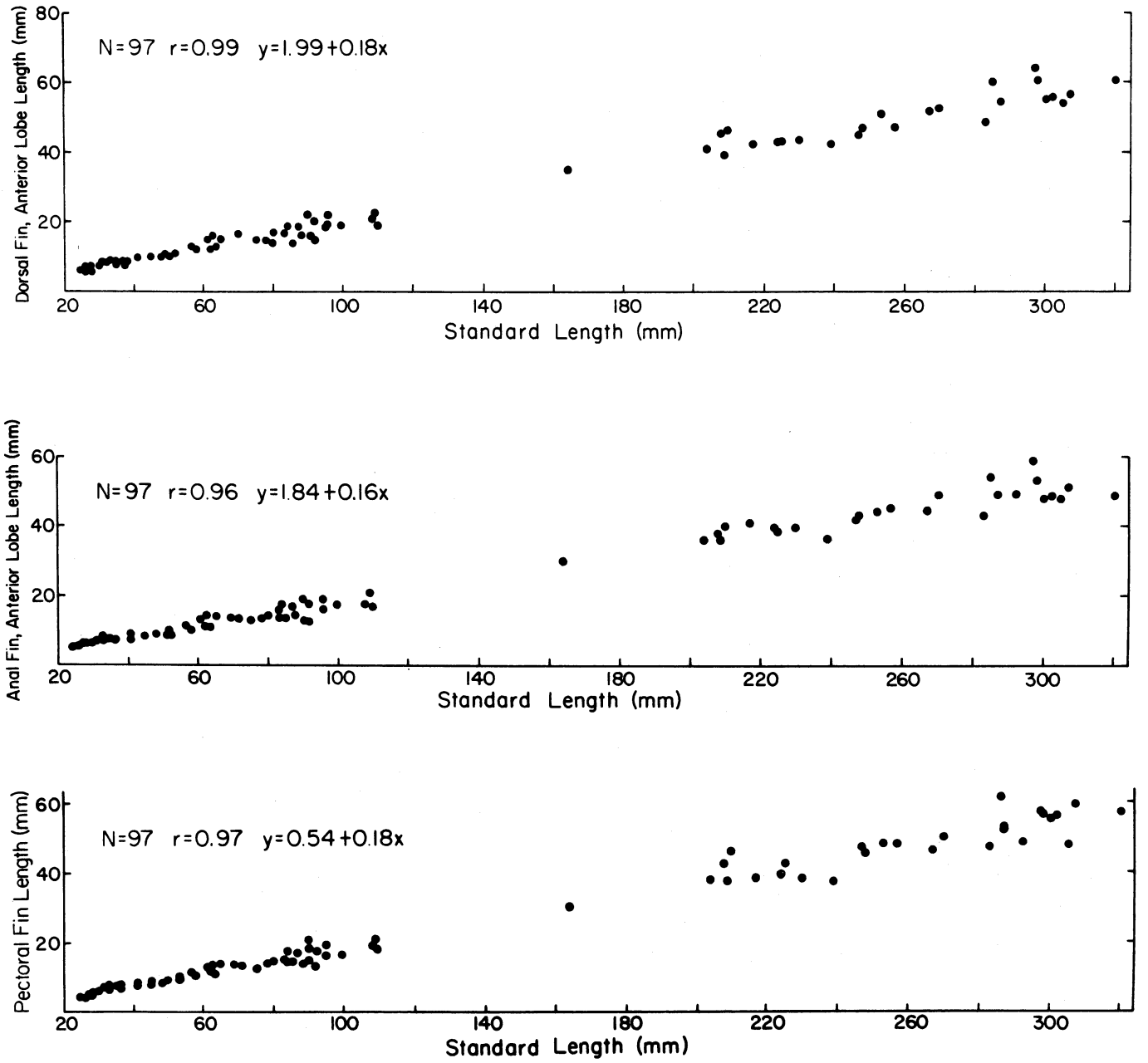

FIGURE 7. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

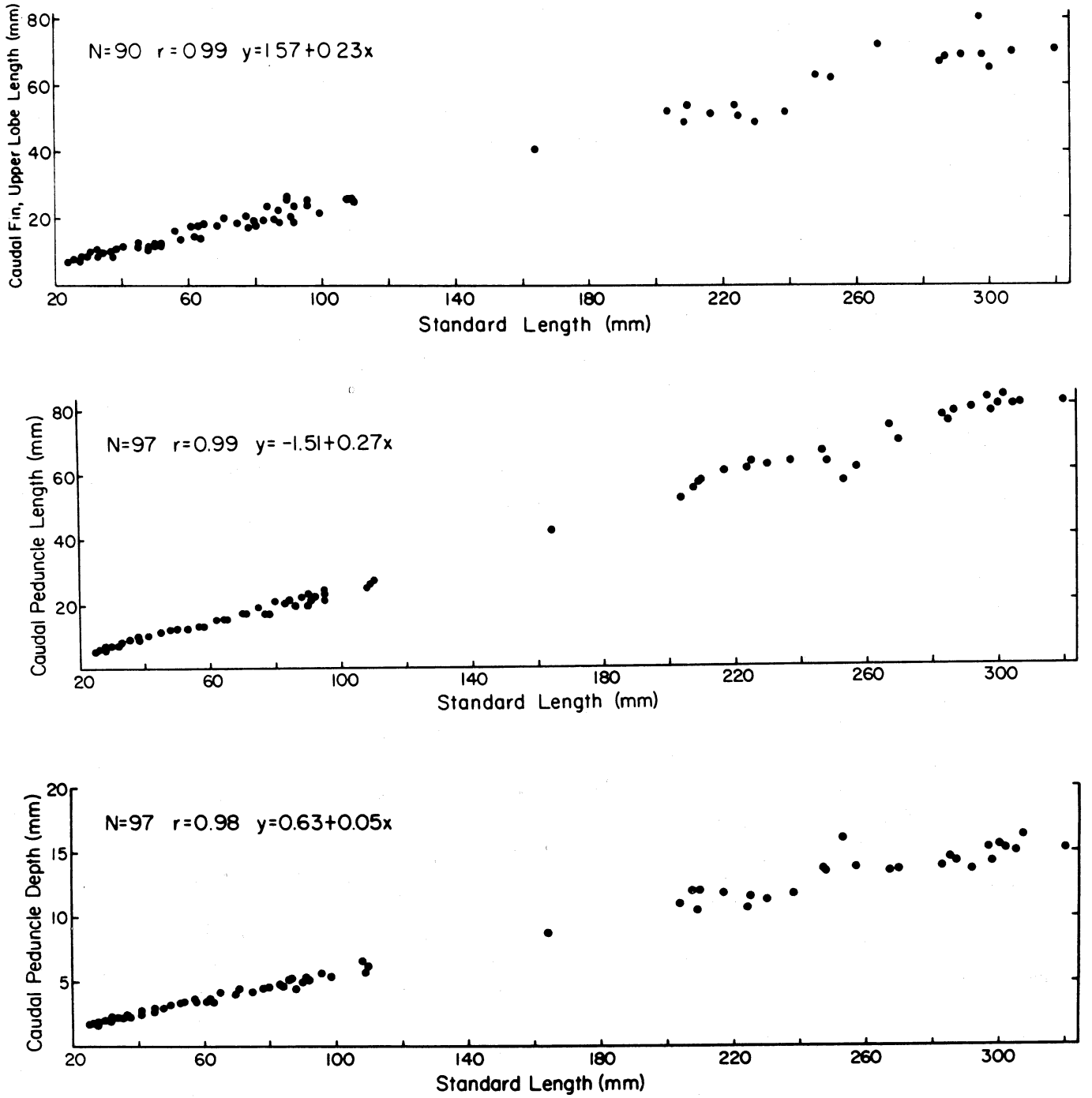

FIGURE 8. Allometric growth in *Gila cypha* from Grand Canyon area of Colorado River.

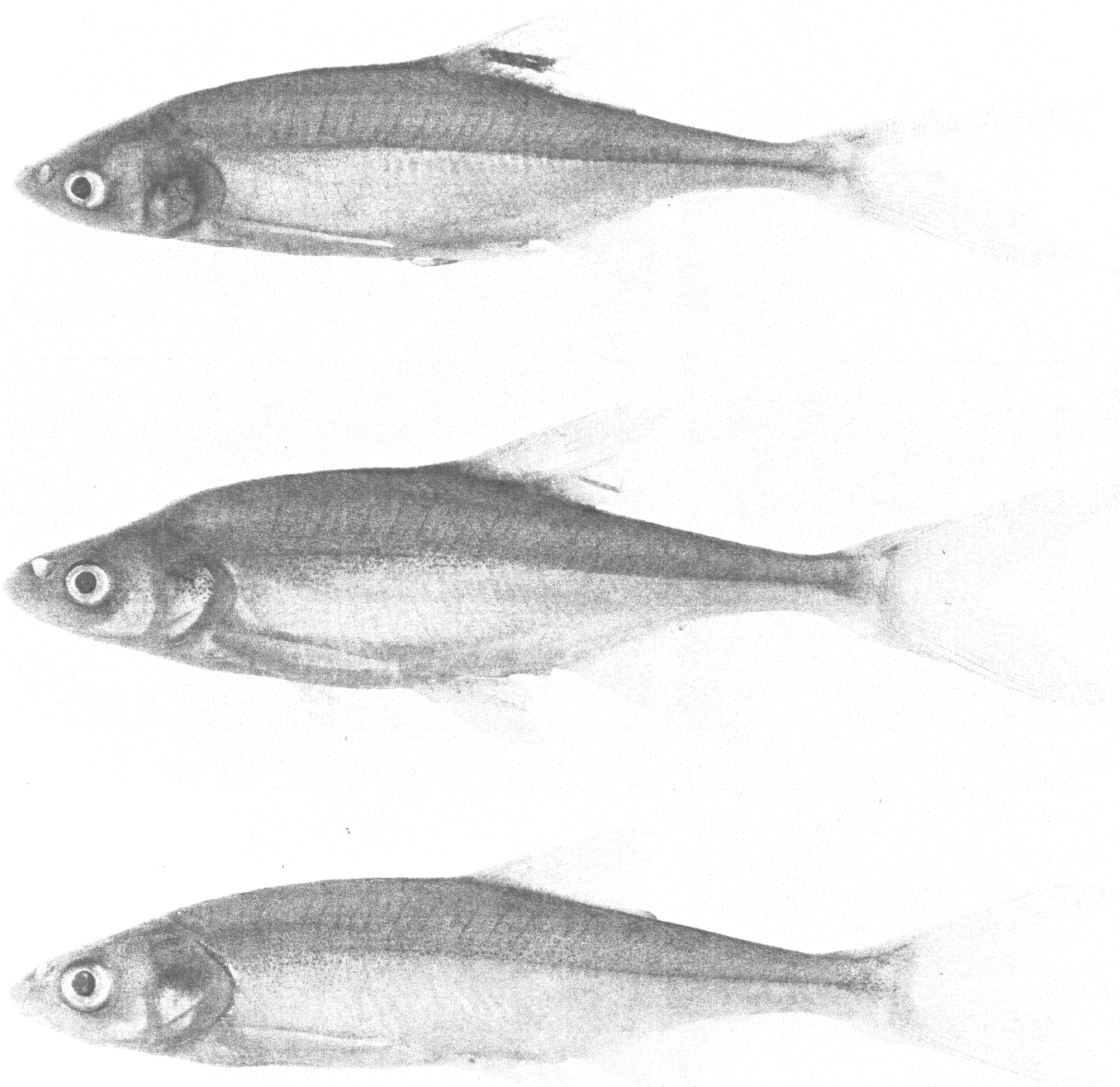

FIGURE 9 — upper — *Gila elegans* TU 101404: 77.5 mm SL
middle — *Gila cypha* TU 99151 : 71.2 mm SL
lower — *Gila robusta* TU 99135 : 70.3 mm SL

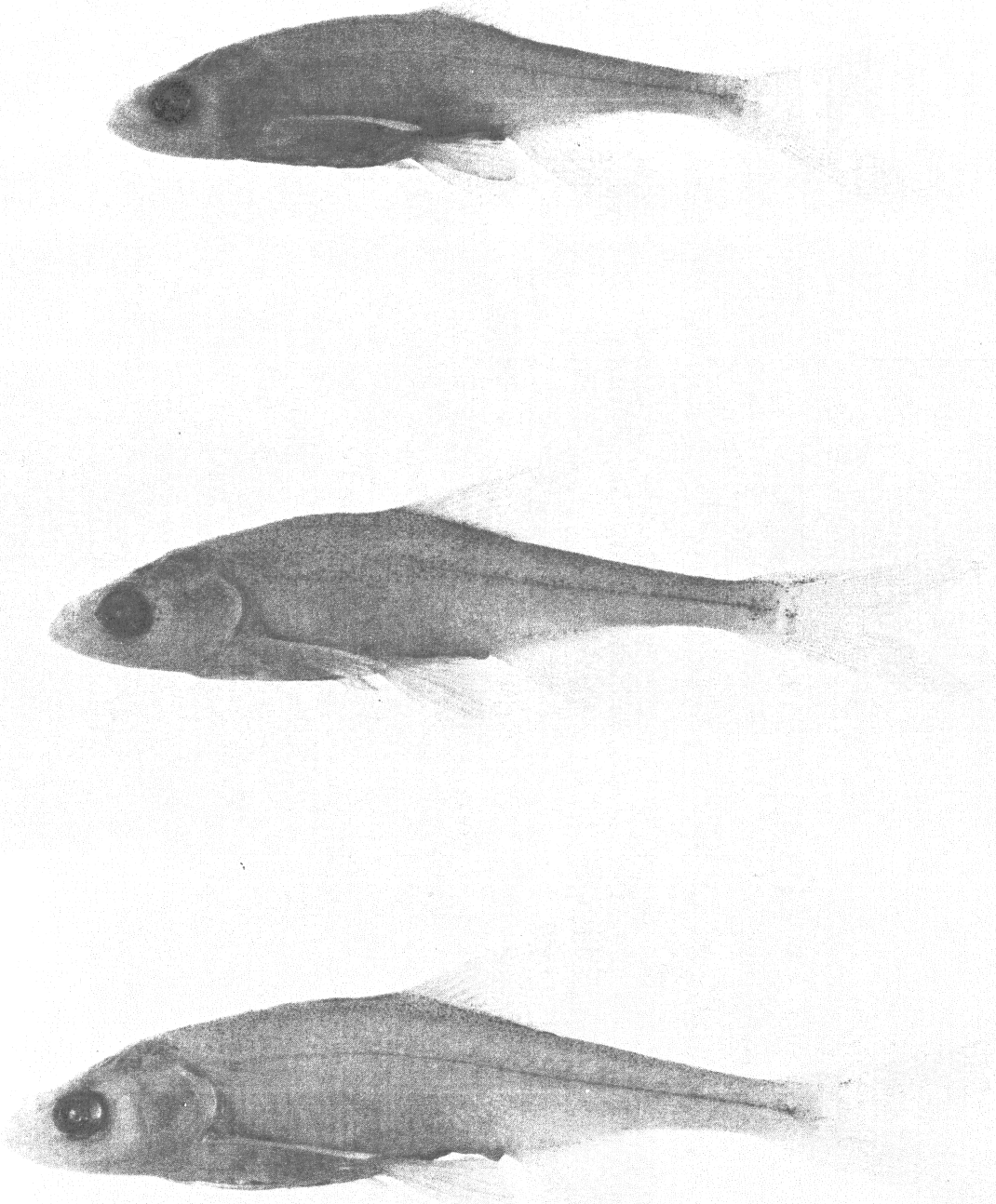

FIGURE 10 – *Gila cypha* upper – TU 95166: 26.5 mm SL
middle – TU 95166: 30.0 mm SL
lower – TU 95166: 34.2 mm SL

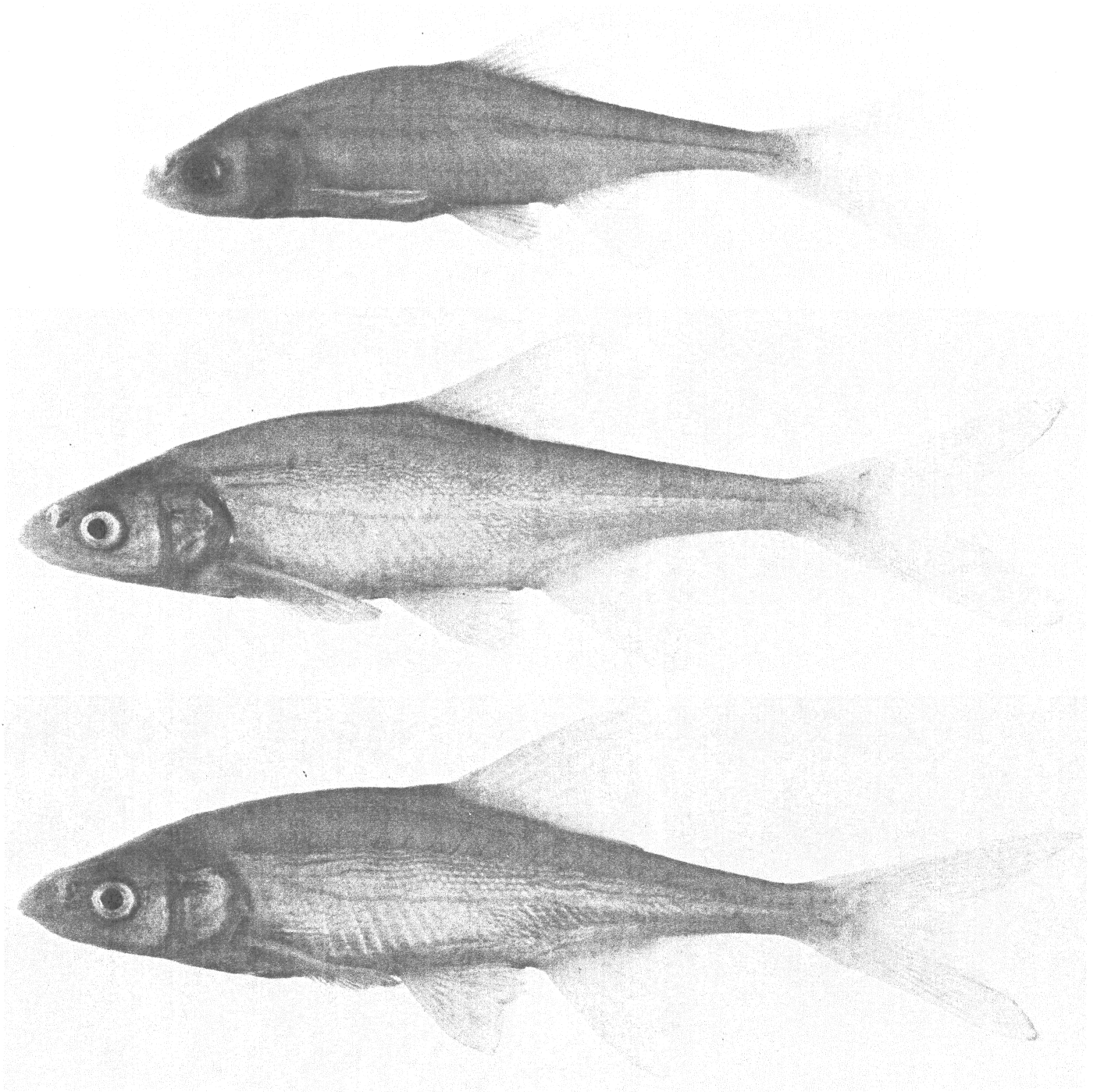

FIGURE 11 – *Gila cypha* upper – TU 95777: 40.8 mm SL
middle – TU 97592: 56.6 mm SL
lower – TU 97592: 65.2 mm SL

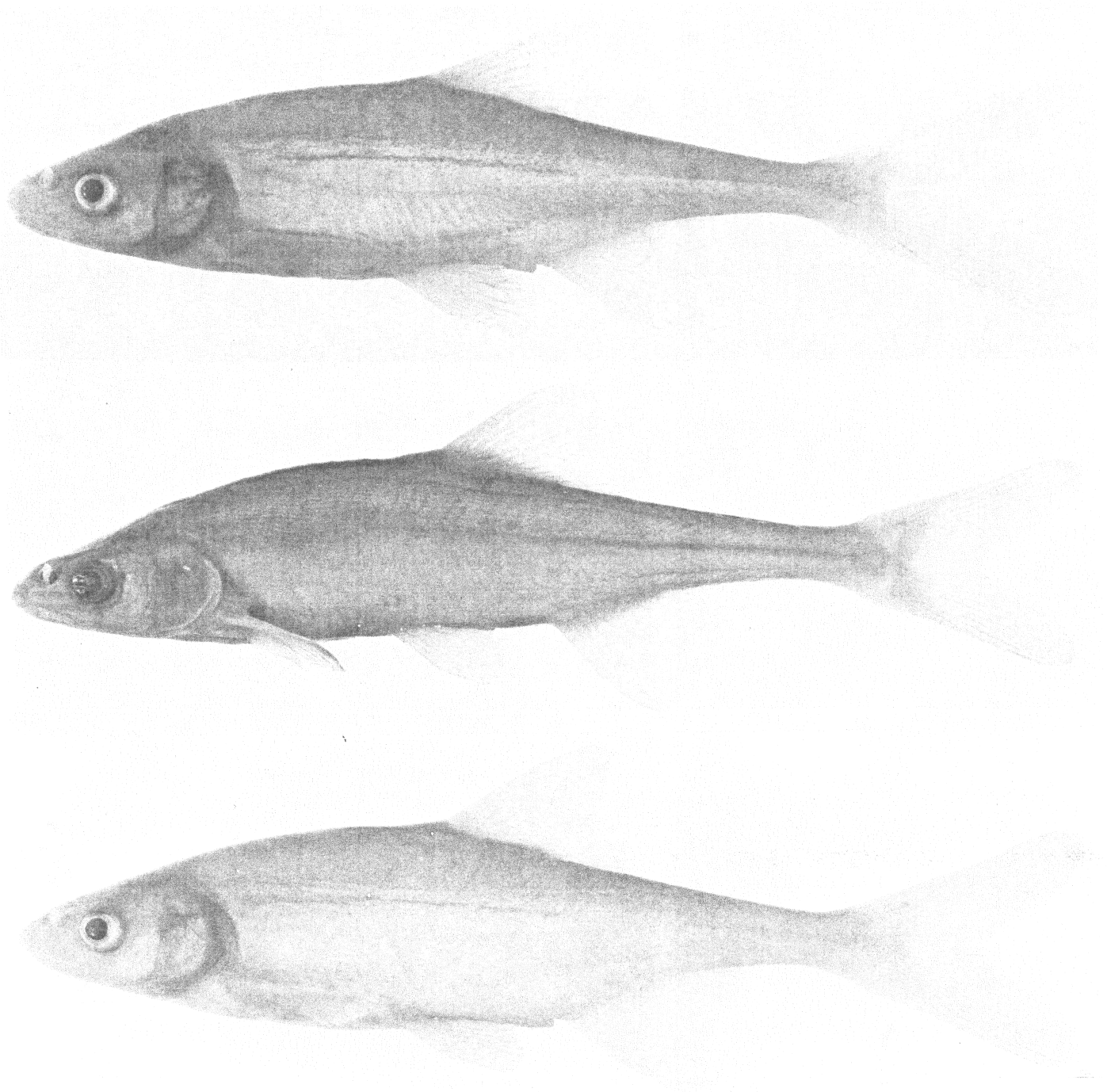

FIGURE 12 – *Gila cypha* upper – TU 99078: 69.6 mm SL
middle – TU 78682: 80.3 mm SL
lower – TU 99078: 82.5 mm SL

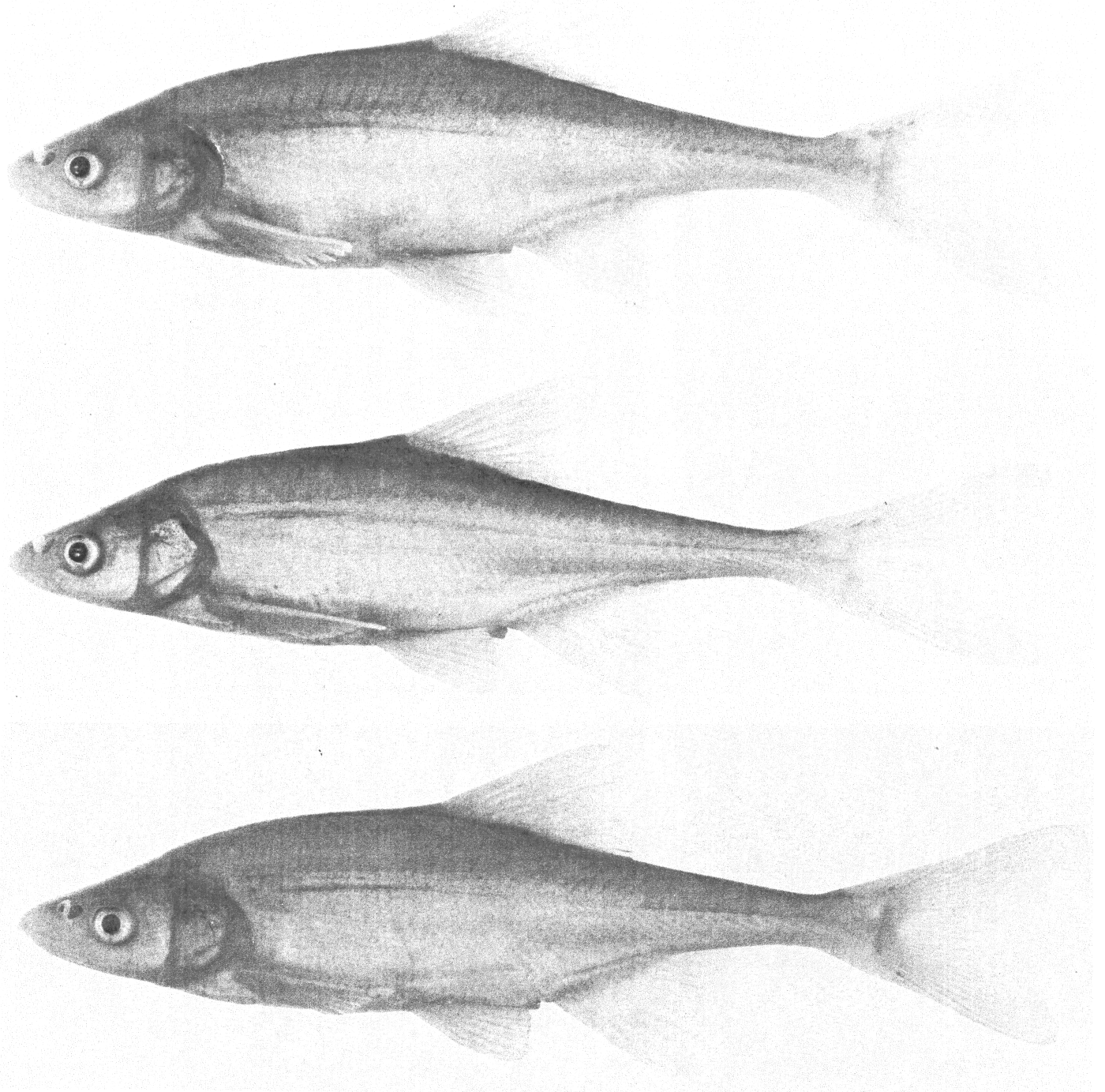

FIGURE 13 – *Gila cypha* upper – TU 99078: 87.1 mm SL
middle – TU 99078: 89.9 mm SL
lower – TU 99078: 92.1 mm SL

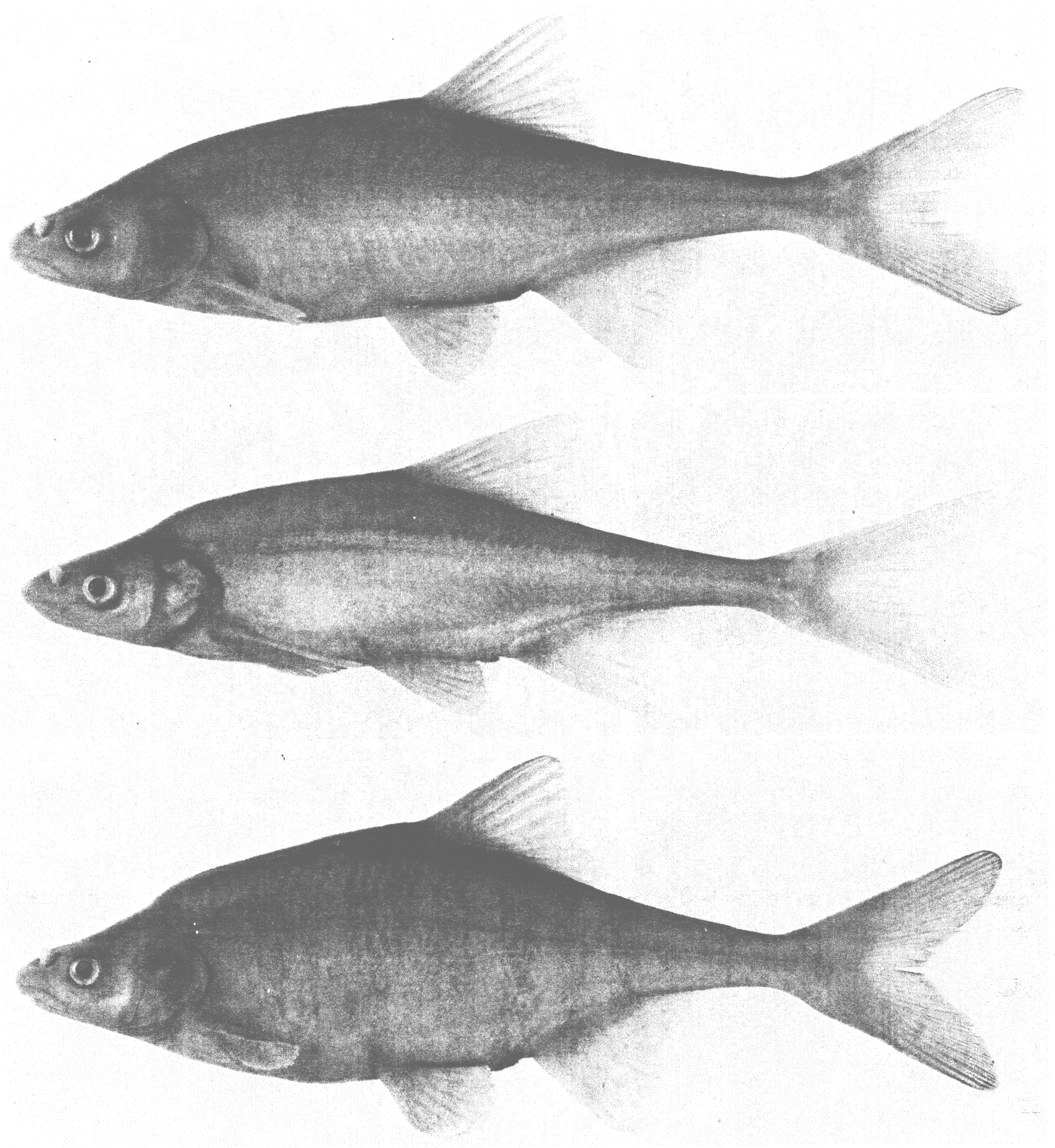

FIGURE 14 – *Gila cypha* upper – TU 95772: 94.4 mm SL
middle – TU 99078: 95.6 mm SL
lower – TU 95772: 107.0 mm SL

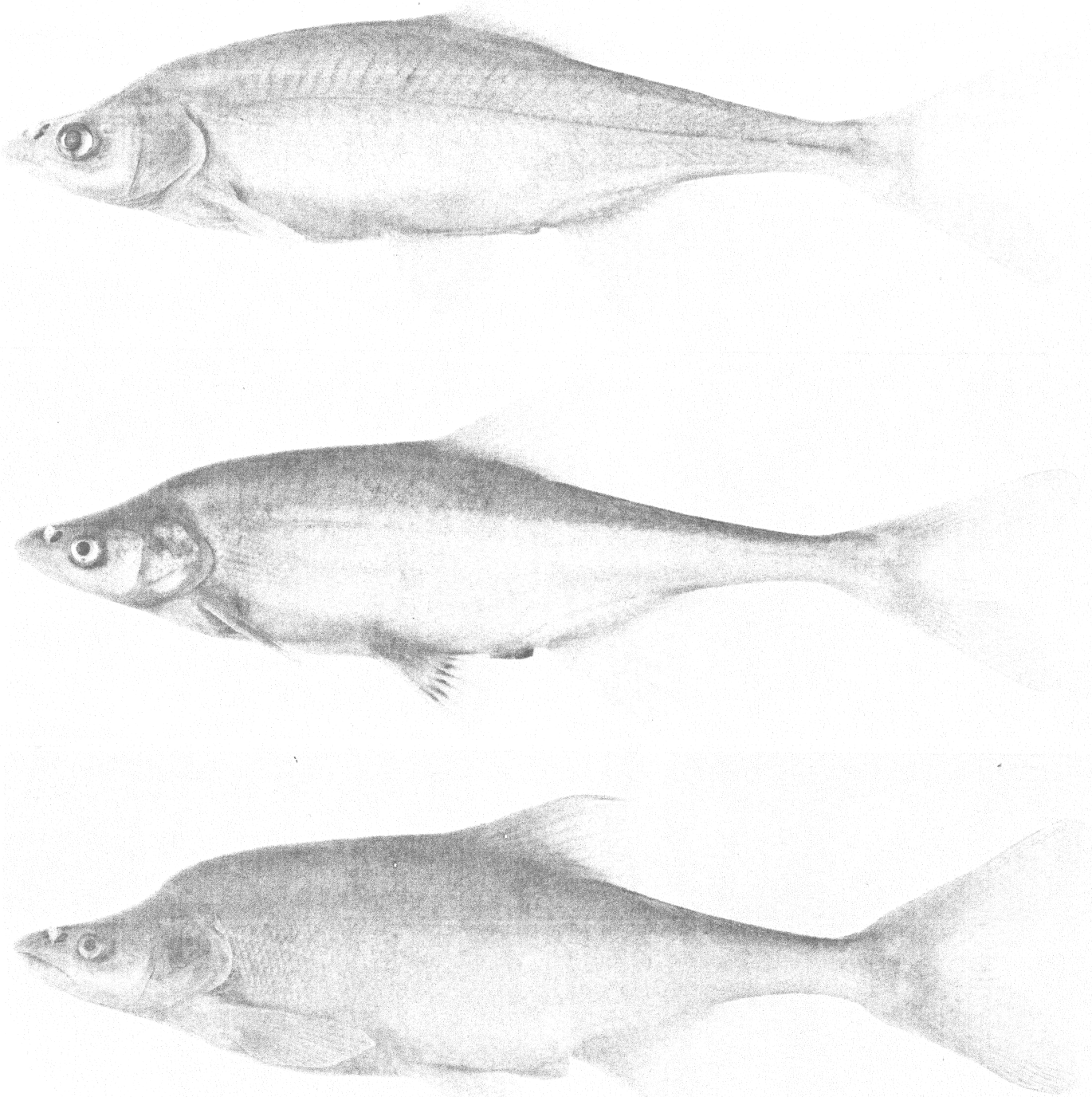

FIGURE 15 – *Gila cypha* upper – TU 95767: 110 mm SL
middle – TU 99078: 164 mm SL
lower – TU 97918: 253 mm SL, adult ♀

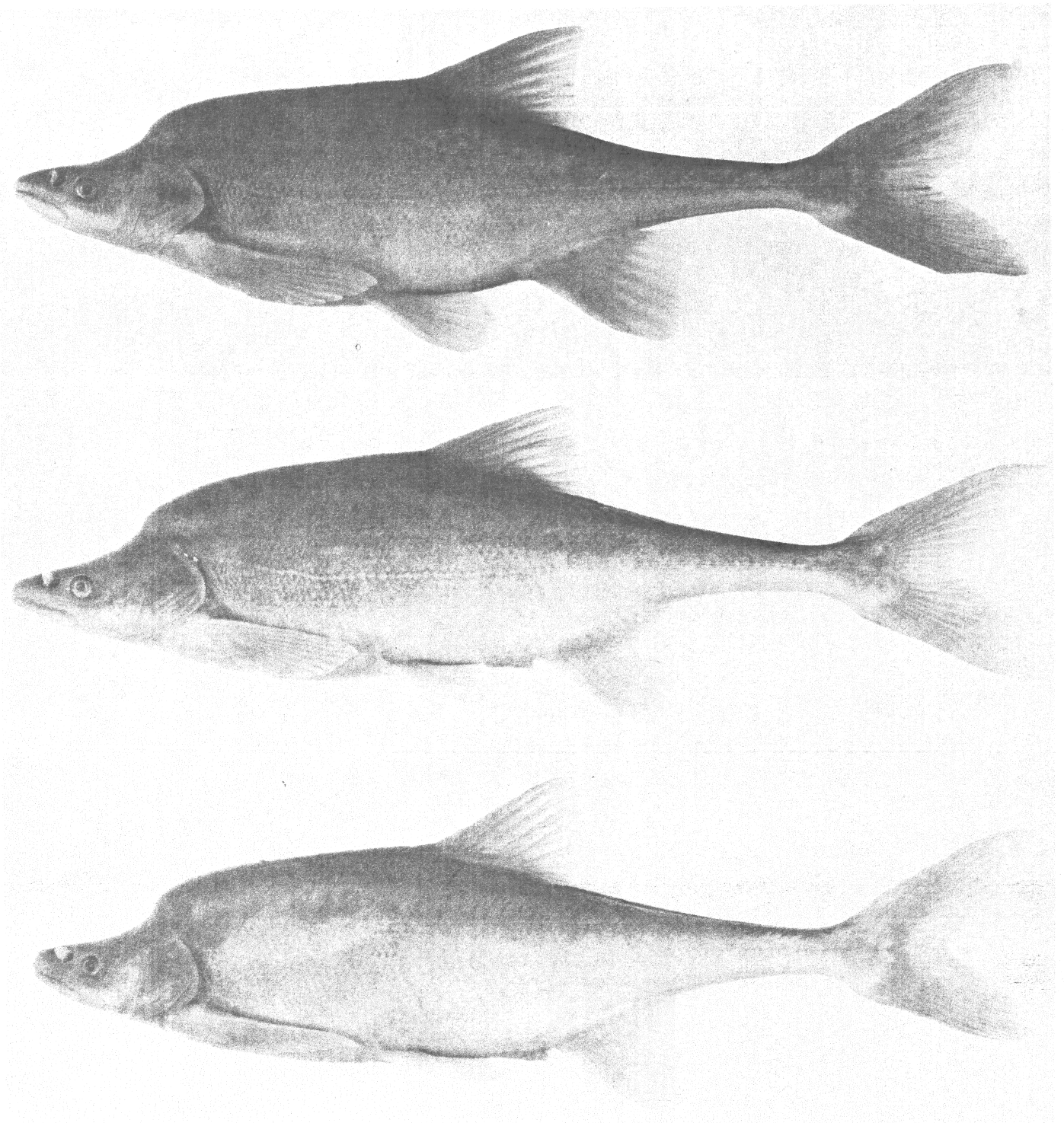

FIGURE 16 — *Gila cypha* upper — TU 97918: 285 mm SL, adult ♂
middle — TU 97918: 300 mm SL, adult ♀
lower — TU 97918: 307 mm SL, adult ♀

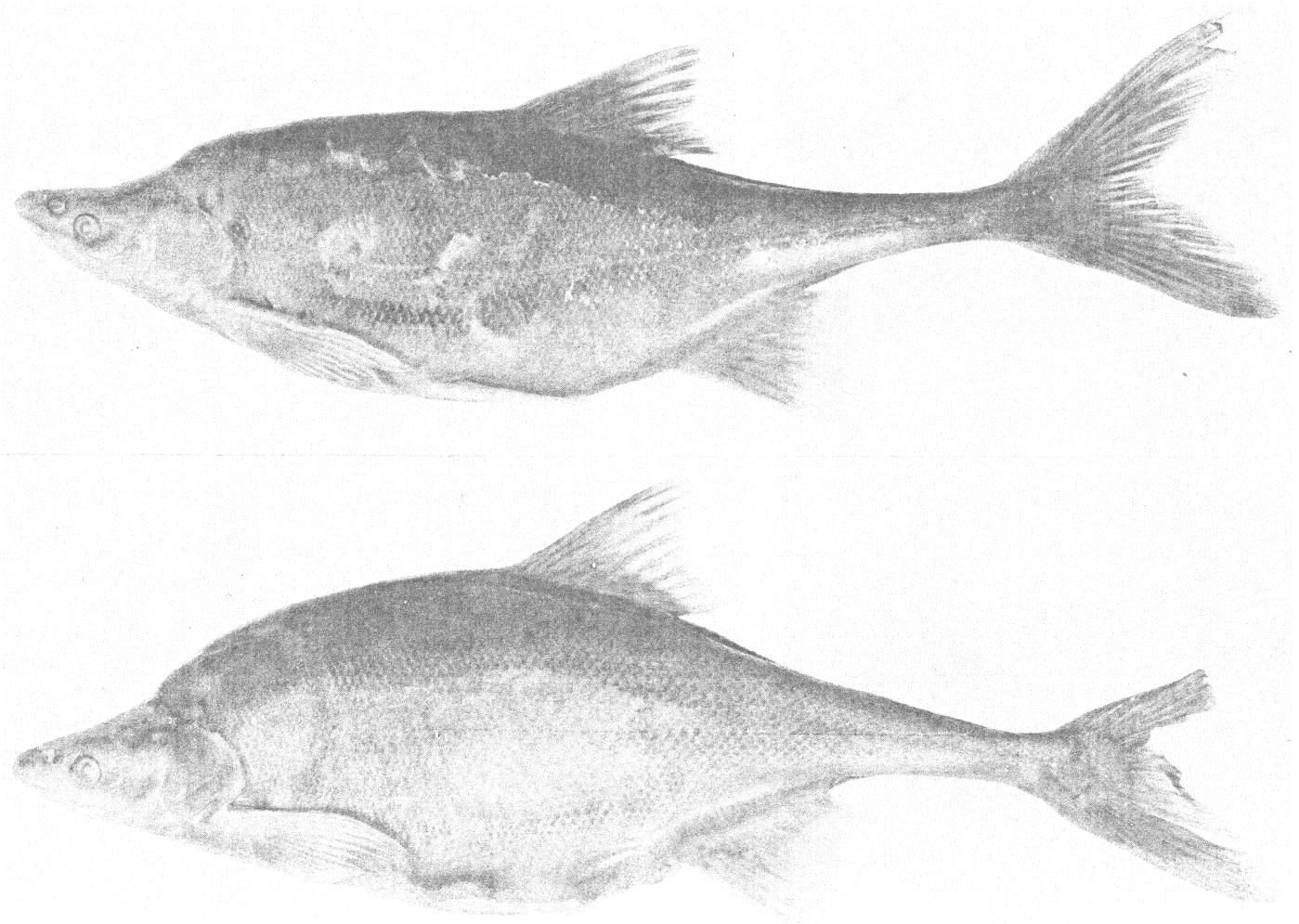

FIGURE 17 — *Gila cypha* upper — TU 100542: 293 mm SL, adult ♂
lower — TU 100542: 320 mm SL, adult ♀

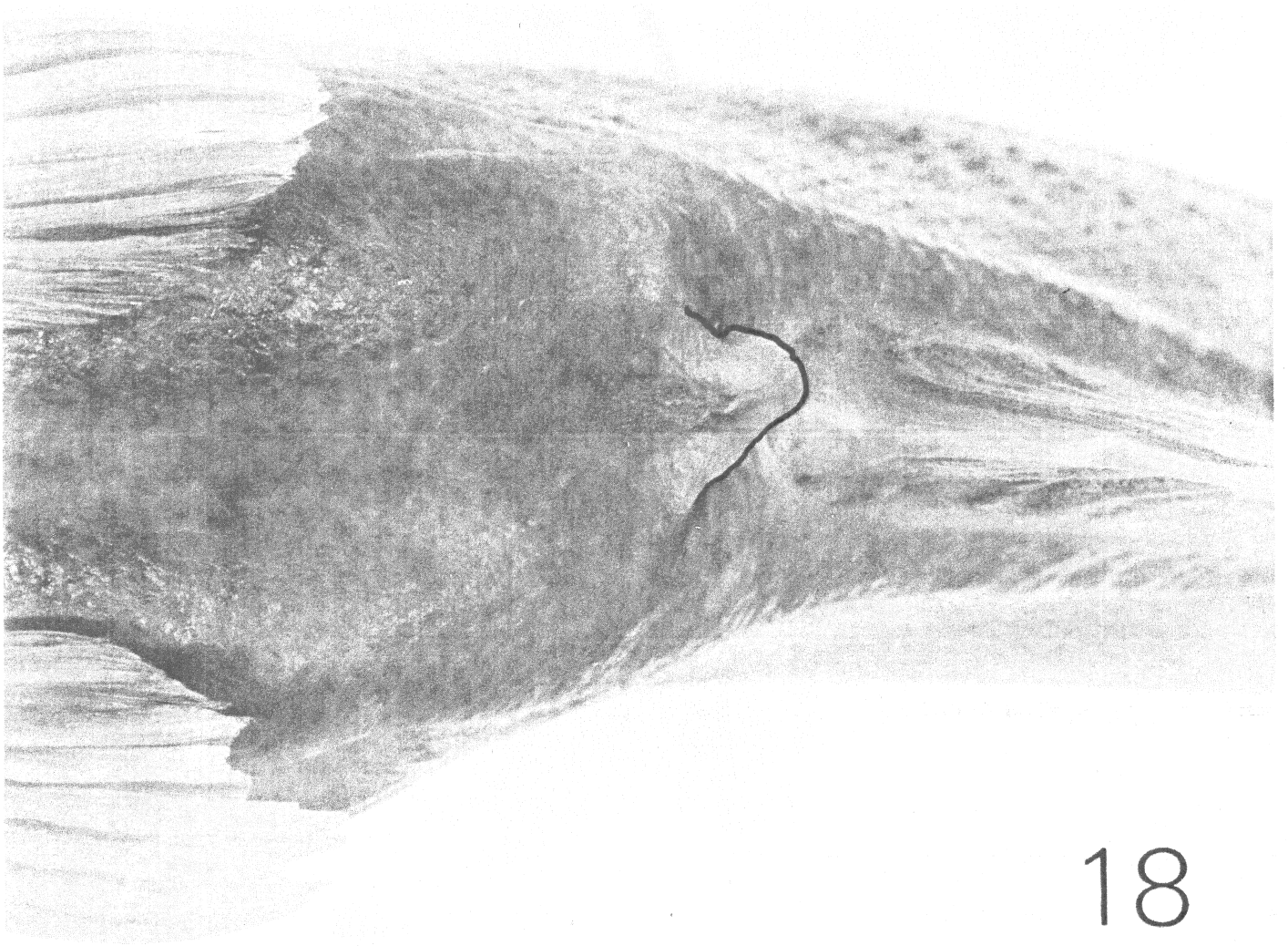

FIGURE 18 – *Gila cypha* TU 100542: adult ♀, anal region

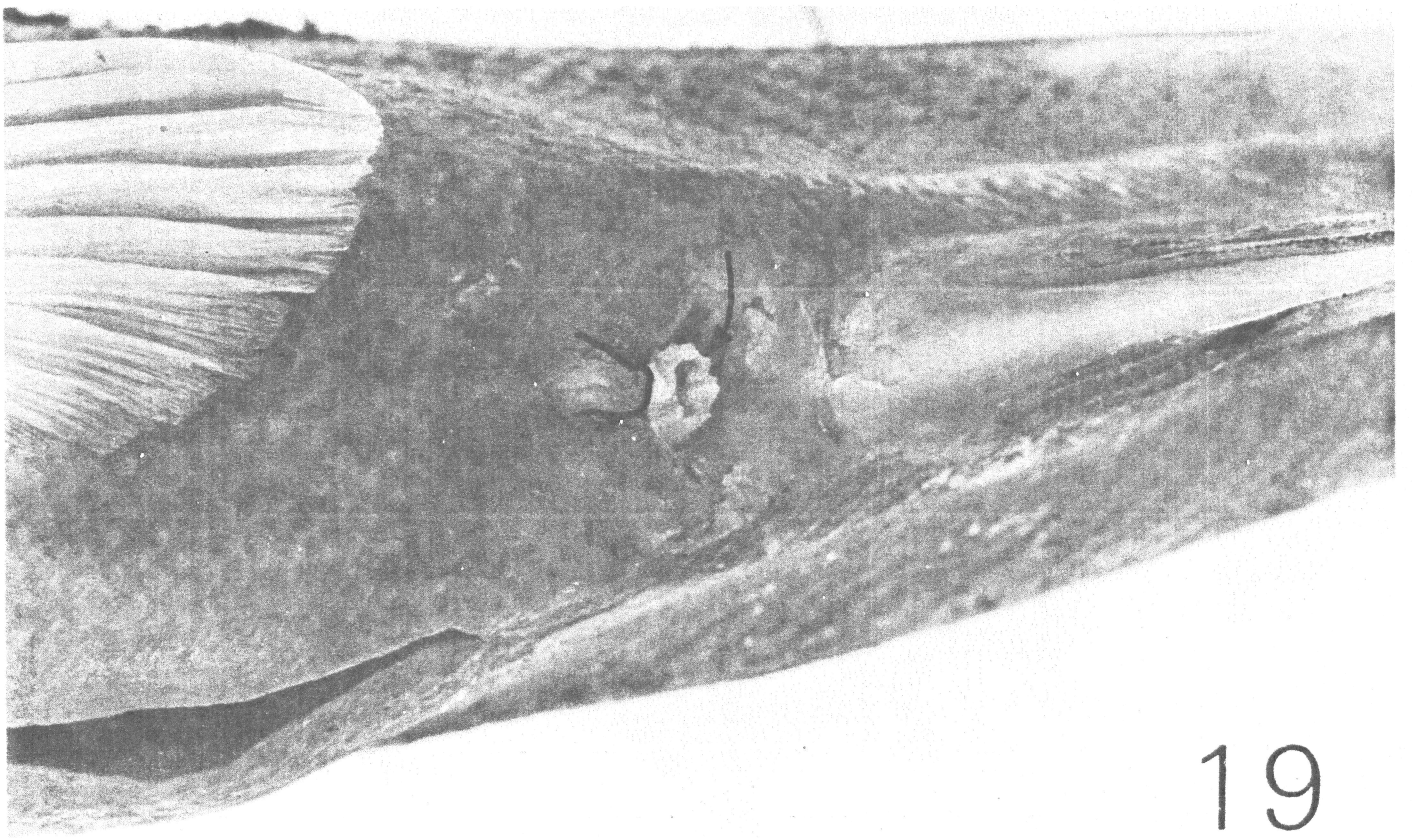

FIGURE 19 – *Gila cypha* TU 100542: adult ♂, anal region

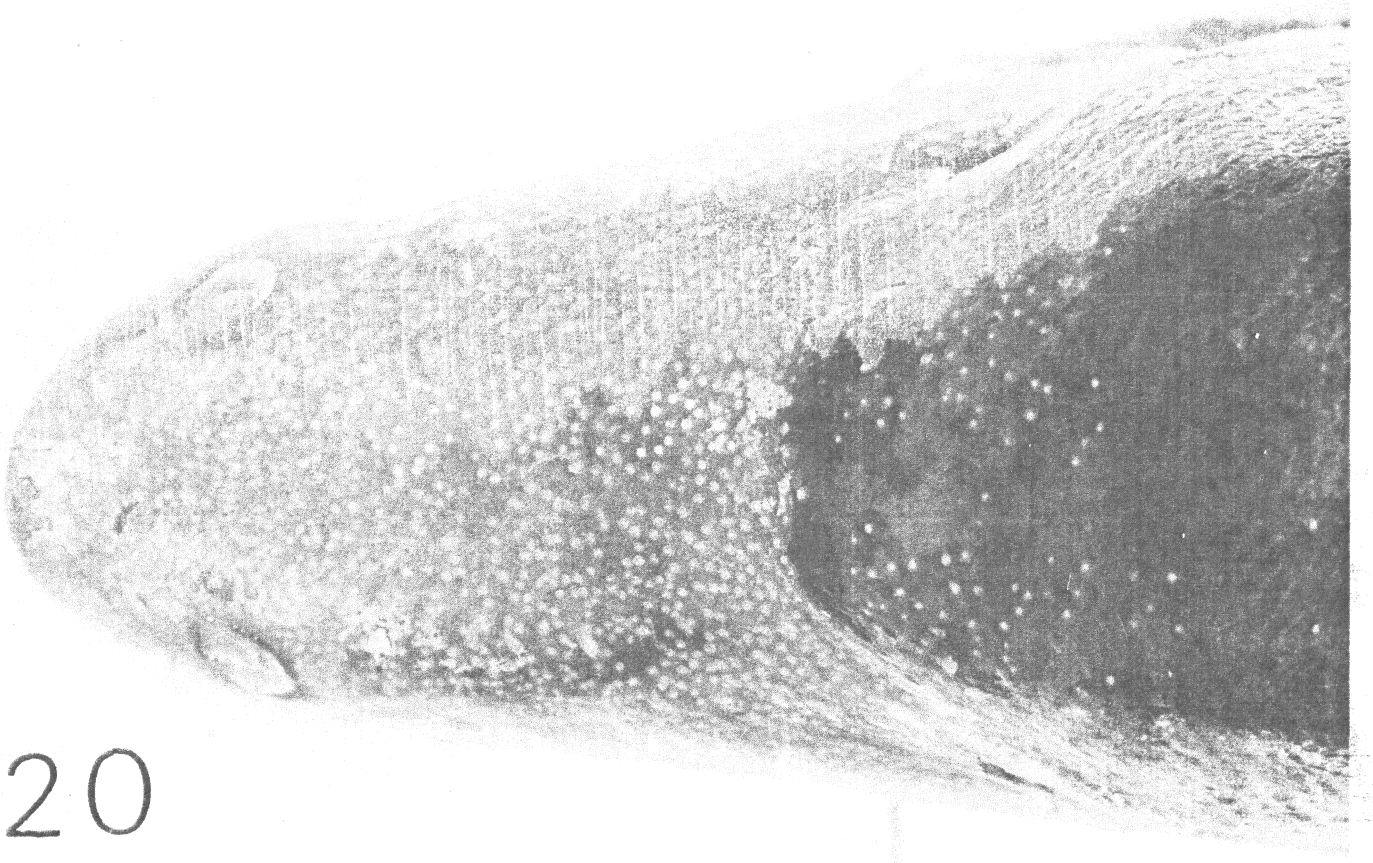

FIGURE 20 — *Gila cypha* TU 100542: adult ♂, dorsal view of head

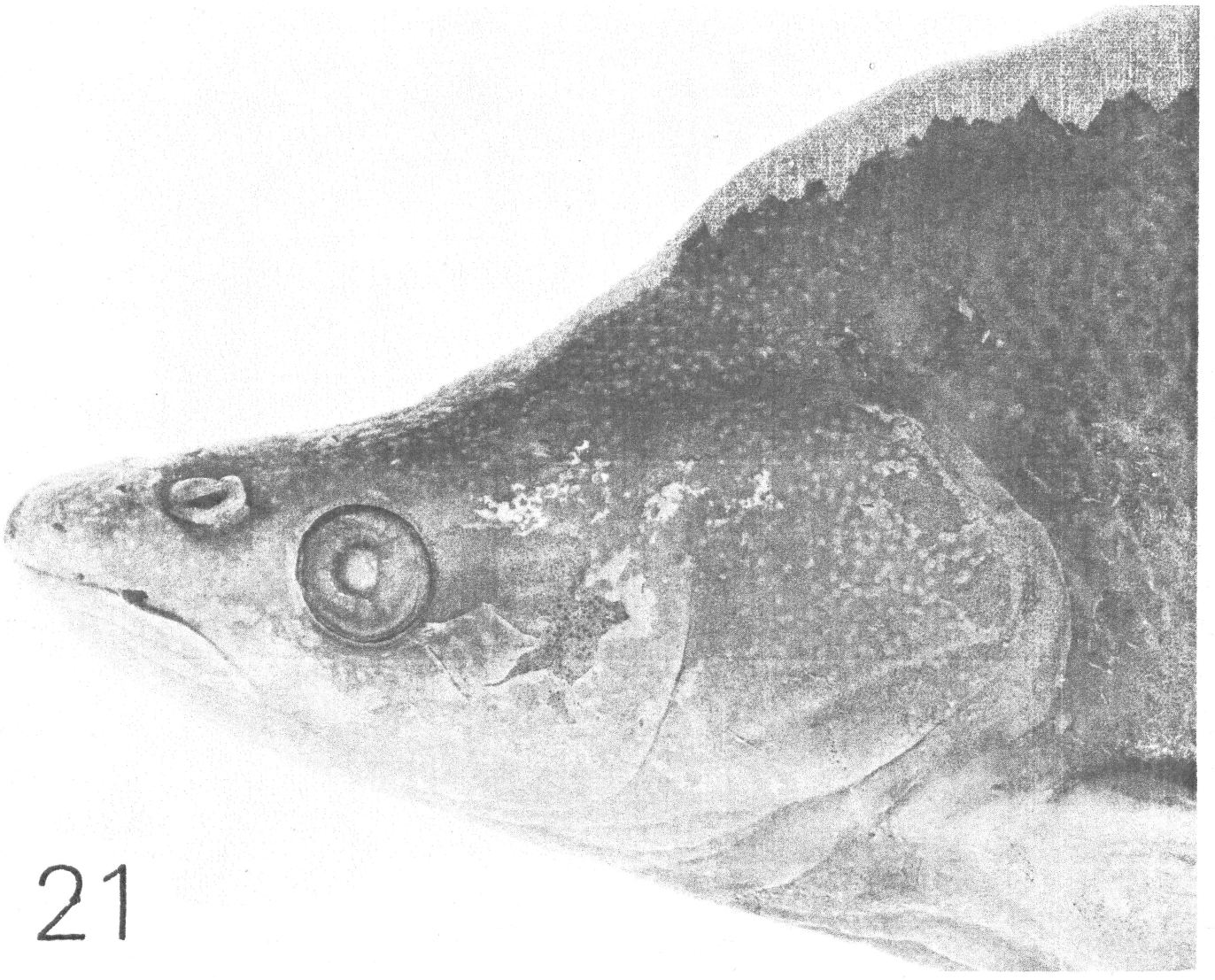

FIGURE 21 – *Gila cypha* TU 100542: adult ♂, lateral view of head

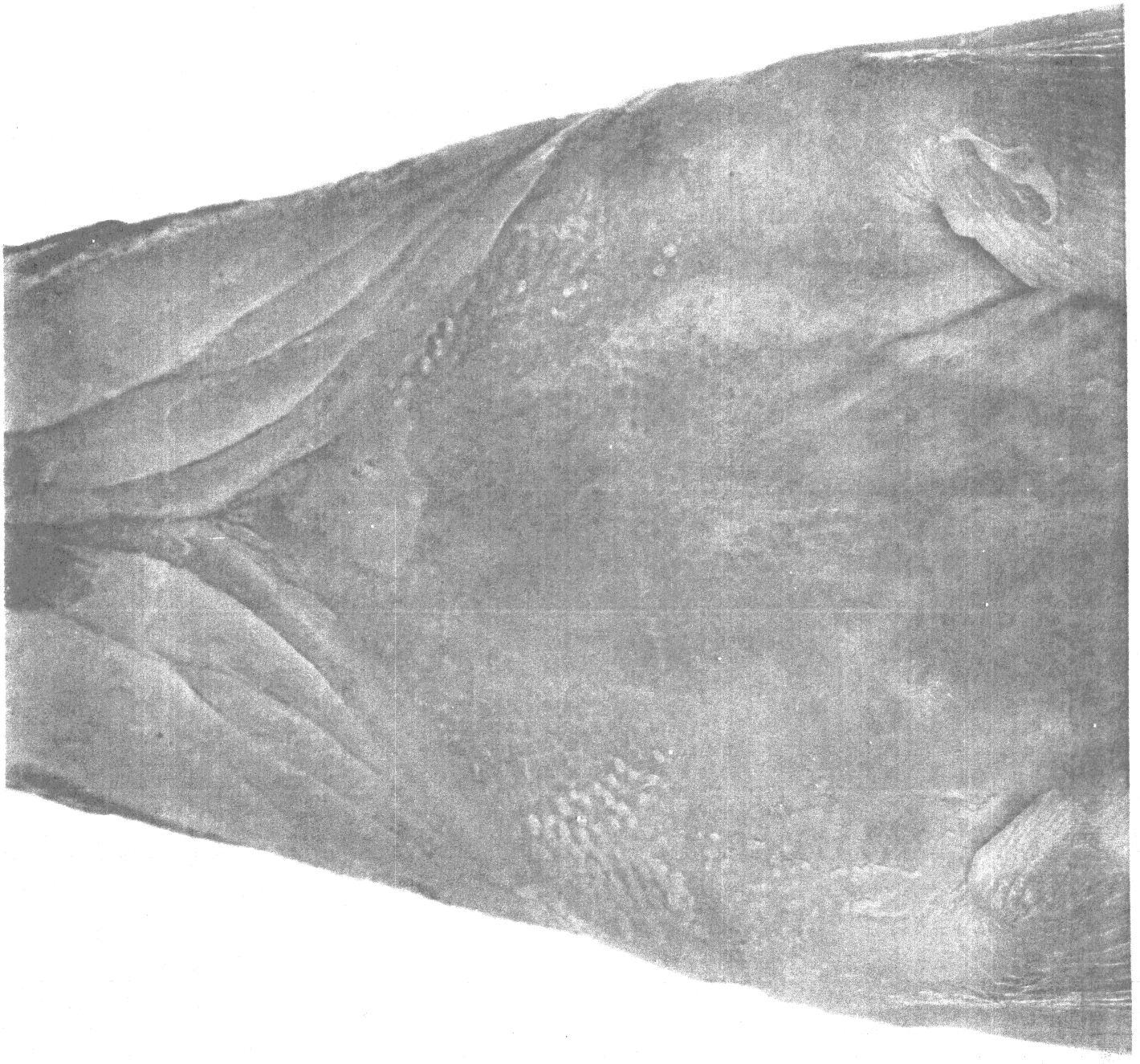

FIGURE 22 – *Gila cypha* TU 100542: adult♂, ventral part of head and breast