A PRELIMINARY ANALYSIS OF THE RIVER CARPSUCKER, *CARPIODES CARPIO* (RAFINESQUE), IN THE SOUTHERN PORTION OF ITS RANGE

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SUMMARY

We conducted a preliminary analysis of geographic variation in southern populations of *Carpiodes carpio*, concentrating on samples from the lower Mississippi River Basin and the Rio Grande drainage. We observed little significant variation in meristics over this range, but extensive variation in body proportions. Lower Mississippi River (mode = 24) specimens have a significantly higher average number of dorsal rays than specimens from other southwestern populations (except the Colorado River, mode = 25). Lower Mississippi River specimens exhibited significantly higher means for body depth, body width, head length, head width, head depth, caudal peduncle depth, orbit length, postorbital bony length, dorsal fin base length, dorsal fin height, caudal fin length, pelvic fin length, anal fin length, dorsal origin to postorbital rim, predorsal length, and prepelvic length than Rio Grande specimens. Rio Grande specimens had significantly higher means for caudal peduncle length and pectoral fin length. Number of dorsal rays is positively correlated with proportional length of the dorsal fin. The higher number of dorsal rays in lower Mississippi River specimens is reflected in the longer dorsal base. Our analysis suggests that Red and lower Mississippi River specimens - including specimens from the Mississippi River in the vicinity of the Louisiana-Arkansas state line, which Hubbs and Black (1940) tentatively assigned to *C. c. elongatus* - are referable to *C. c. carpio.*

INTRODUCTION

The river carpsucker *Carpiodes carpio* (Rafinesque, 1820), as presently recognized, is a wide-ranging species comprising two subspecies: the nominal form *C. c. carpio* in the Mississippi River Basin, and a southwestern form *C. c. elongatus*. The taxonomy of *C. carpio* and related species was reviewed by Hubbs (1930). Hubbs and Black (1940), who provided the only systematic treatment of morphological variation within the species complex, considered *C. elongatus* Meek 1904 and *C. microstomus* Meek 1904, to be conspecific with *C. carpio.* They chose *elongatus* to represent the southwestern form, distinguished primarily on the basis of its elongate body. They gave the range of *C. c. elongatus* as Soto la Marina and Sabinas river systems of northern Mexico, Rio Grande system of Texas and Mexico, coastal streams of Texas, and (tentatively) the Mississippi River near the Louisiana-Arkansas line. Hubbs and Black (1940) expressed some doubt about inclusion of the latter - and thus the rest of the lower Mississippi River - in the range of *C. c. elongatus*, because the specimens on which their record was based were small. They referred Arkansas and Red river specimens to *C. c. carpio*, but added that these specimens approached *C. c. elongatus.* Subsequent workers interpreted this to mean that the Mississippi River in the vicinity of the Arkansas state line was a zone of contact between the two subspecies, and that Arkansas and Red river populations may represent intergrades (Robison and Buchanan 1988). Hubbs and Black's (1940) analysis primarily involved body proportions, and concentrated on material housed at the University of Michigan and the United States National Museum.

The purpose of this study is to reevaluate the status of southern populations of *C. carpio*. We present a preliminary analysis of populations in the southwestern portion of the range, concentrating on samples from the lower Mississippi River Basin (Red River system, lower main stem of the Mississippi River, the small tributaries to the lower

Mississippi River) and the Rio Grande drainage from southern Texas and northern Mexico. We present new data on meristic variation, sexual variation, and additional information on morphometrics for this portion of the range, and we resolve a question about the status of populations in the lower Mississippi River Basin.

We are pleased to offer this paper in recognition of the many accomplishments of Dr. Salvador Contreras-Balderas during his professional career at the University of Nuevo Leon, Monterrey, Mexico. We hope that he will find time during his retirement to continue the important conservation activities that occupied so much of his time in recent years.

MATERIALS AND METHODS

Much of the material for this study was collected during the Environmental Biology Training Program through a grant to the senior author. The program was sponsored by the National Institute of Health during the early to middle 1960s. Reconnaissance trips to determine and make arrangements for summer training camps were instrumental in obtaining many valuable collections. More than a few collecting sites are no longer available for study because of impoundment by dams or diminished flow through irrigation diversions.

Most of the specimens from the Devils and Pecos rivers were obtained by use of trammel and gill nets. Some lower Mississippi River and western Gulf slope drainages also were sampled with trammel and gill nets. Many other samples were taken with a 10-foot seine, 6 feet deep, with 3/16" ace mesh.

Most of the specimens used in this study are housed in the Tulane University Museum of Natural History (TU). Additional specimens from southern Texas and Mexico were obtained on loan from the University of Nuevo Leon (UNAL) and the University of Texas (TNHC).

Materials Examined: Red River System. Louisiana, Natchitoches Parish: TU 13388 (40 of 43, 34–90 millimeters (mm) in standard length (SL), Red River, 5 mi N of Natchitoches; 9 August 1956. Louisiana, Rapides Parish: TU 99195 (30 of 40, 21–67), Red River a long right bank at River Mile 79.4; 22 September 1976. Louisiana, Rapides Parish: TU 112992 (5, 81–188), Red River along right bank at River Mile 105; 21 June 1979. Oklahoma, Garvin County: TU 147570 (12, 44–65), Washita River, 2.5 mi N of Hwy 19 at Hwy 77 bridge; 19 February 1986. Texas, Wilbarger County: TU 148611 (1, 253), Red River at US Hwy 283; 12 May 1987. Oklahoma, Tillman County: TU 148628 (12, 44–74), North Fork of Red River at Hwy 5; 12 May 1987. Texas, Wilbarger County: TU 149598 (1, 73), Pease River, 1.4 mi N of Vernon at Hwy 283; 18 August 1987. Louisiana, Rapides Parish: TU 185993 (10, 19–37), Red River along left bank at River Mile 108.1; 6 June 1998. Louisiana, Rapides Parish: TU 186008 (40 of 96, 14–45), Red River along left bank at River Mile 106; 6 June 1998.

Mississippi River, lower main stem. Arkansas, Mississippi County: TU 54528 (50 of 155, 13–71), Mississippi River, 2.2 mi NE of Butler; 8 October 1968. Louisiana, West Feliciana Parish: TU 99584 (9, 46–92), Mississippi River at River Mile 293.5; 1 October 1976. Louisiana, West Feliciana Parish: TU 99601 (50 of 62, 34–101), Mississippi River on inside of island bar at River Mile 293.1; 1 October 1976. Louisiana, West Feliciana Parish: TU 99633 (15, 30–59), Mississippi River at upper end of Iowa Point, River Mile 280; 2 October 1976. Louisiana, Pointe Coupee Parish: TU 99650 (31 of 315, 44–71), Mississippi River at head end of St. Maurice Towhead, River Mike 273; 2 October 1976. Louisiana, Pointe Coupee Parish: TU 99663 (20 of 92, 23–57), Mississippi River at lower end of St. Maurice Towhead, River Mile 270.2; 2 October 1976. Arkansas, Chicot County: TU 101110 (16 of 53, 61–98), Mississippi River, 8 mi N of Greenville bridge, US Hwy 82 (TI5S, RIE, Sec 30); 11 July 1975. Louisiana, East Baton Rouge Parish: TU 115658 (9, 60–94), Mississippi River at River Mile 250; 6 December 1979.

Mississippi River, lower tributaries. Mississippi, Copiah County: TU 55656 (1, 292), Bayou Pierre, 10.1 mi NE of Hermanville, MS, Hwy 18; 16 November 1968. Mississippi, Jefferson County: TU 55439 (1, 169), South Fork Coles Creek, 9.2 mi SW of Fayette, Hwy 61; 2 November 1968. Mississippi, Jefferson County: TU 66172 (19, 68–214), tributary to South Fork Coles Creek , 7.6 mi SW of Fayette at Hwy 61; 12 December 1970, Mississippi, Wilkinson County: TU 55598 (2, 134 and 220), Homochitto River at US Hwy 61; 15 November 1968. Mississippi, Lincoln County: TU 78760 (5, 166–212), Homochitto River, 4.7 mi E of Union Church, Hwy 550; 27 April 1972. Mississippi, Lincoln County: TU 78790 (1, 220), Homochitto River, 5 mi E of Union Church, Hwy 550; 3 July 1972. Mississippi, Copiah County: TU 84033 (1, 200), Homochitto River, 4 mi N of Caseyville; 14 September 1973. Mississippi, Wilkinson County: TU 55560 (15, 45–235), Buffalo Bayou, 9.6 mi N of Woodville, US Hwy 61; 15 November 1968. Mississippi, Wilkinson County: TU 61631 (1, 212), Buffalo Bayou, 4.1 mi W of Centreville; 30 December 1969. Louisiana, West Feliciana Parish: TU 55305 (64, 53–247), Big Bayou Sara, 4.9 mi NW of St. Francisville, Hwy 66; 1 November 1968. Mississippi, Wilkinson County: TU 59982 (5, 71–82), Bayou Sara, 7.5 mi SW of Woodville; 11 October 1969. Louisiana, West Feliciana Parish: TU 62690 (61, 50–75), Little Bayou Sara, 5.6 mi NW of Bains; 31 January 1970. Louisiana, West Feliciana Parish: TU 63037 (1, 208), Little Bayou Sara, 11.8 mi NW of Bains, Hwy 66; 30 April 1970. Louisiana, West Feliciana Parish: TU 63122 (12, 26–107), Little Bayou Sara at Retreat, 11.8 mi NW of Bains; 30 June 1970. Louisiana, West Feliciana Parish: Bayou Sara, 1.5 mi W of Bains Hwy 66; 30 April 1971. Louisiana, East and West Feliciana Parish: TU55285 (4, 71–194), Thompson Creek, 5.7 mi SE of St. Francisville, Hwy 61; 1 November 1968. Louisiana, West Feliciana Parish: TU 69629 (2, 154 and 164), Thompson Creek, 0.6 mi NW of Jackson, LA Hwy 10; 30 April 1971.

Rio Grande drainage. Texas, Val Verde County: TNHC 4760 (5 of 6, 132–160), above mouth of Jinagus Springs; 29 May 1954. Texas, Val Verde County: TU 42799 (10 of 49, 34–44), Devils River above Dolan Falls, 20.7 mi SE of Loma Alta; 11 July 1966. Texas, Brewster County: TU 90899 (2, 115 and 120), Terlingua Creek about 4 mi NW of Study Butte, Hwy 170; 15 October 1974. Texas, Terrell County: TU 36960 (50 of 92, 195–289), Pecos River at Chandler's ranch, 28 mi SE of Sheffield; 16 July 1963. New Mexico, Eddy County: TU 38872 (10 of 266), Black River, tributary to Pecos River, 7 mi W of Malaga; 30 July 1965. Mexico, Nuevo Leon: UANL 159 (1 of 2, 87), Rio San Juan, 6 km E de los Aldamas; 16 August 1962. Mexico, Chihuahua: UANL 1978 (1, 56), Rio Conchos en Camago (Sta Rosalia); 12 August 1975. Mexico, Chihuahua: UANL 6917 (1 of 19, 58), Rio Conchos en el Pueblito at 34 km A/E de Carr 16; 17 August 1984. Mexico, Nuevo Leon: UANL 11502 (17, 51–84), Rio San Juan en las Enrramadas; 6 April 1977. Mexico, Nuevo Leon: TNHC 1675 (1, 122), Rio Salado, Gonzalez Hacienda, 25 mi SSE of La Gloria; 9 June 1951. Mexico, Chihuahua: TNHC 4056 (8, 16–128), Concho River, 1 km from mouth of Rio Grande; 13 June 1954. Mexico, Durango: TNHC 4643 (25, 46–138), Rio Florida, 11 mi ESE of Villa Ocampo, Mexico 45; 27 June 1954.

In general, we have followed Hubbs and Lagler's (1958) methods for counting fin rays and scales and for determining proportional measurements. Typically, one pored lateral line scale was present posterior to the crease formed by flexing the caudal fin at the posterior margin of the hypural plate. A second pored scale, often smaller, was present on some specimens; neither of these scales was included in the lateral line scale count. Invariably, the posterior dorsal and anal fin rays were divided to the base and in each case was counted as one. Many juvenile specimens were used for fin ray and scale counts. Fin ray counts were usually more difficult to make on adult specimens because the thickness and opaqueness of the fin membrane.

Morphometrics were based on adult specimens that were 190 mm or greater in standard length. Accurate measurements of predorsal, prepelvic, and postdorsal distances were difficult to make on some of the larger specimens because of their curved bodies. In these instances, an average was taken on measurements on both the left and right sides. The position of the mouth (i.e., closed vs. partially open and distended) introduced variation in snout length measurements and, less so, head, predorsal, and prepelvic measurements. Head length measurements were affected slightly by the presence or absence of a fully distended fleshy opercular flap. Our postdorsal measurement is the distance from the anterior point of insertion of the dorsal fin to the middle of the caudal base whereas the postdorsal measurement of Hubbs and Black (1940) was the distance between the [posterior] end of the dorsal base and the middle of the caudal base.

Measurements of lengths and heights of fins were not recorded where the fins were deformed or their tips broken-off. Measurements smaller than 175 mm were made with needle-point dial calipers to the nearest 0.1mm. Measurements in excess of 175 mm were made with a needlepoint sliding bar calipers and recorded to the nearest 1.0 mm.

Data for 21 morphometric characters were expressed as ratios of standard length. Ratio data for each character were then arcsine transformed for statistical comparisons. We first tested for differences between sexes within the Rio Grande and lower Mississippi River Basin populations. We then tested the combined sex data for differences between Rio Grande and lower Mississippi River populations using ANOVA. We also performed Principal Components Analysis (PCA) on the combined data set, using the covariance matrix derived from arcsine-transformed ratio data.

In order to provide a basis for comparing Hubbs and Black's (1940) findings to ours, we also tabulated a ratio obtained by dividing the length of the dorsal fin base into the distance between the anterior insertion of dorsal fin and the posterior rim of orbit. This is analogous to projecting the length of the dorsal base anteriorly and measuring where it falls relative to the eye, as performed by Hubbs and Black (1940).

RESULTS AND DISCUSSION

Populations from the Sabine River to the Rio Grande (exclusive of the Colorado River) have a low average number of dorsal fin rays (mode = 23, Table 1). Dorsal fin rays number significantly higher in the Mississippi River and tributaries (mode = 24). The Colorado River population is unique in showing a high degree of variation in number of dorsal rays and a mean of more than 25. The San Antonio Bay and Nueces drainages flow into the western Gulf of Mexico between the Colorado and Rio Grande drainages. We were not able to study sufficient material from these two drainages to include them in this comparison. Thus, we are not able to comment on variation in dorsal ray counts in this portion of the range. The modes for anal, caudal, pelvic, and pectoral fin rays are the same across the western Gulf Slope. Tables 2 and 3 show variation in these characters for the Red River, lower Mississippi River (main stem), lower Mississippi River tributaries, and Rio Grande specimens.

The lateral line scale count averages slightly, but not significantly, higher in Rio Grande specimens than in lower Mississippi River Basin specimens (Table 4). The modal number of lateral line scales is 36 scales in Rio Grande specimens and 35 in lower Mississippi River Basin specimens.

An analysis of morphometrics for 24 male and 26 female *C. carpio* from the Rio Grande revealed no significant differences in body proportions between sexes (Table 5). In the lower Mississippi River Basin, the head tended to be slightly deeper and wider in females than in males. However, females were underrepresented in our sample from the lower Mississippi River Basin, so the differences may reflect sampling error. Because sexes did not differ significantly for most body proportions, we combined data for males and females from both the Rio Grande and lower Mississippi River Basin in subsequent analyses.

Lower Mississippi River Basin specimens exhibited significantly higher means for body depth, body width, head length, head width, head depth, caudal peduncle depth, orbit length, postorbital bony length, dorsal fin base length, dorsal fin height, caudal fin length, pelvic fin length, anal fin length, dorsal origin to postorbital rim, predorsal length, and prepelvic length (Table 6). Rio Grande specimens had significantly higher means for caudal peduncle length and pectoral fin length.

Hubbs and Black's (1940) major emphasis involved the length of the dorsal fin base to demonstrate the differences between the more attenuate form *C. c. elongatus* as compared to *C. c. carpio*. They stated, "The length of the dorsal base when projected forward usually falls far back of the eye in *elongatus* but reaches almost to or even beyond the back edge of the eye in *C. c. carpio*". However, they go on to state that individual variation in this measurement was too great to allow statistical comparison.

We expressed this measurement as the length of the dorsal base divided into the distance between the anterior insertion of dorsal fin and the posterior rim of orbit. The data are presented in Table 7. Our findings reflect those of Hubbs and Black (1940) to some degree, however, we found more overlap between the two groups of populations than indicated in their analysis. Note that in only two of 55 Rio Grande specimens, the dorsal fin base is equal or exceeds the distance from dorsal fin to posterior orbital rim. However, in 43 of 70 specimens from the lower Mississippi River the dorsal fin base equals (4) or exceeds (39) the distance from dorsal fin insertion to posterior orbital rim. Thus the projected dorsal fin base falls short of the posterior orbital rim in 96% of Rio Grande specimens, but only 39% of the lower Mississippi River specimens. Samples from the other drainages included in Table 7 all show lower percentages of specimens (22 -76%) in which the dorsal base length is less than the distance between dorsal fin and posterior rim of orbit than in the Rio Grande.

Principal components analysis supported the results of univariate morphometric comparisons. Projection of data on the first two components derived in the analysis, which together accounted for 57% of total variability in the data, showed complete separation between Rio Grande and lower Mississippi River populations (Fig 1). Most of the separation was along PC 1. Characters loading highly on this axis were body depth, dorsal base length, and length of anterior dorsal rays.

Interestingly, number of dorsal rays is positively correlated with proportional length of the dorsal fin, both within lower Mississippi River ($r = 0.34$, $P = 0.026$) and Rio Grande populations ($r = 0.28$, $P = 0.046$) and for the combined data for these populations ($r = 0.38$, $P = 0.0002$) . The distance from the anterior insertion of the dorsal fin relative to the posterior portion of the body (as measured by our postdorsal distance) is the same in both the lower Mississippi River and Rio Grande populations. What differs most between populations are the anterior body measurements and the relative length and height of the dorsal fin (all shorter in Rio Grande specimens). The longer dorsal fin base of lower Mississippi River specimens reflects the higher number of dorsal rays. Hubbs and Black (1940) undoubtedly were aware of this correlation; however, they did not present any fin ray data to support it.

Knapp (1953), Trautman (1957), Pflieger (1971), Lee and Platania (1980), Robison and Buchanan (1988), and Etnier and Starnes (1993) followed Hubbs and Black (1940) in interpreting southwestern populations as *C. c. elongatus* or intergrades between this form and *C. c. carpio*. Our analysis suggests that Red and lower Mississippi River specimens - including specimens from the Mississippi River in the vicinity of the Louisiana-Arkansas state line - are referable to *C. c. carpio.*

The name *C. elongatus*, by original designation, applies to populations in the extreme southwestern portion of the range (Rio Grande and Gulf coastal streams of northeastern Mexico). The only remaining questions are how far east does this form extend and does it intergrade with *C. carpio*? Conner and Suttkus (1986) identified seven drainages in the U. S. portion of the western Gulf Slope: the Calcasieu, Sabine Lake, Galveston Bay, Brazos, Colorado, San Antonio Bay, Nueces, and the Rio Grande. Sabine and Neches river systems are part of the Sabine Lake drainage; the Trinity and the San Jacinto river systems form the Galveston Bay drainage. They reported records of *C. carpio* from all seven drainages. We have specimens available for study from all of these drainages, except the Calcasieu, Nueces and San Antonio Bay. Thus, we feel confident that we will be able to resolve the status of coastal populations of Louisiana and Texas between the Mississippi River and the Rio Grande.

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FIGURE LEGEND

Figure 1. Polygons representing projection of arcsine transformed body proportion data from Rio Grande and Mississippi River specimens of *Carpiodes carpio* on the first two components derived in principal components analysis.