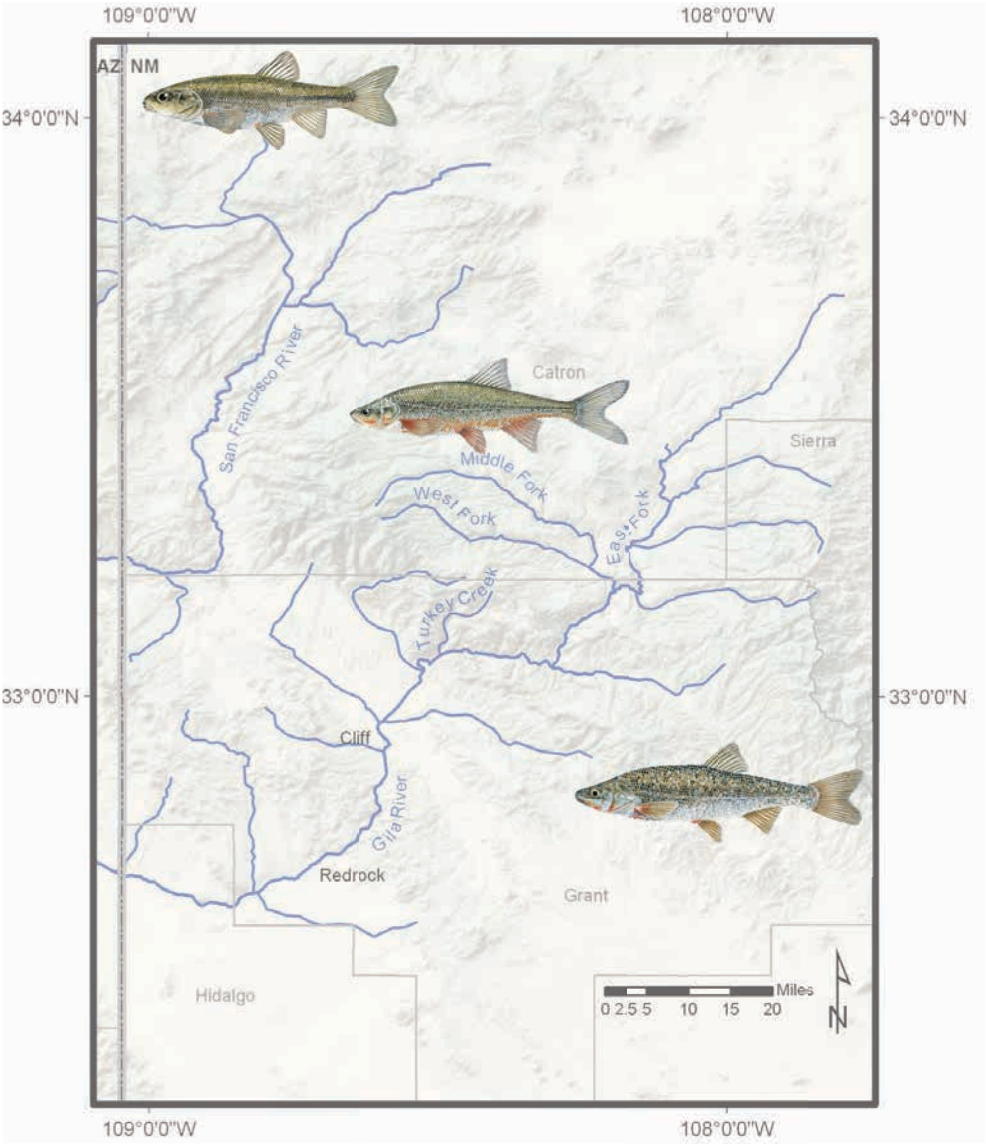
Determining the historical distribution of the *Gila robusta* complex
(Gila Chub, *Gila intermedia,* Headwater Chub, *Gila nigra*, and Roundtail Chub, *Gila robusta*)
in the Gila River Basin, New Mexico, using morphological analysis



FINAL REPORT

A New Mexico Department of Game and Fish
2013 Share with Wildlife Project

14 February 2015

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A New Mexico Department of Game and Fish
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EXECUTIVE SUMMARY

Collections of the *Gila robusta* complex from the Gila River drainage, New Mexico, were acquired in an effort to determine the historical distribution of the three taxa that currently comprise this taxonomic guild (Gila Chub, Headwater Chub, and Roundtail Chub). Study material from the 1930s to 1960s was acquired from the Museum of Southwestern Biology (MSB), University of New Mexico (n = 187), and the University of Michigan Museum of Zoology (UMMZ, n = 96). Supplemental Turkey Creek *Gila* sp. collections from 1983, 1984, and 2001 (all MSB) were also examined (n = 102). The 1983–1984 Turkey Creek collections (n = 97) represented the oldest museum curated samples of *Gila* sp. from that system. These two sets of samples (1930s–1960s and Turkey Creek) comprise the study material (n = 385) for this project. Specimens <50 mm SL (n = 112) were excluded from the Discriminant Function Analysis (DFA) portion of the study to minimize allometric similarities of young individuals. In addition, 10 specimens were excluded from the study as accurate measures could not be acquired from those damaged individuals.

The suite of five morphologic measures and meristic values recorded from specimens were those Minckley and DeMarais (2000) reported as the most valuable for separating the three Gila River forms of *Gila* sp. In this study, specimens were classified (Gila Chub, Headwater Chub, or Roundtail Chub) based on meeting criteria of morphologic (n = 2) and meristic (n = 3) variables. Conversely, specimens that did not achieve the combined suite of five counts and ratios were instead classified as the species to which they shared the greatest number of those characters.

About 81% (n = 213) of specimens presented all five characters. Of those individuals, 54.9% (n = 117) were Roundtail Chub, 26.8% (n = 61) were Headwater Chub, and 16.4% (n = 35) were Gila Chub. Fifty specimens (19.0%) exhibited a mix of species characters and were classified based on the best fit of characters. The majority of those 50 individuals were classified as Roundtail Chub (68%, n = 34), followed by Headwater Chub 20% (n = 10), and Gila Chub 12% (n = 6).

Discriminant Function Analysis was also used to classify individual specimens (to species) and those scores computed to determine the relative classification success of identifications based on morphology and meristic data. The DFA indicated correct morphometric classification 236 of the 263 (89.7%) *Gila* specimens. The DFA classified the majority of specimens as Roundtail Chub (n= 140, 53.2%) and the fewest specimens as Gila Chub (n = 42, 16.0%). The former taxon was present in all five Gila Basin River systems while the latter species was in three of the five systems (Gila River mainstem, East Fork Gila River, and Turkey Creek). Headwater Chub was 30.7% (n=81) of specimens analyzed and was present in all systems except West Fork Gila River.

Of the five morphological and meristic values recorded, lateral line scale count and the ratio of head length (HL) to caudal peduncle length (CPL) were the most predictive variables for determining species. The ratio of caudal peduncle length (CPL) to caudal peduncle depth (CPD) was not particularly useful in separating species. Dorsal and anal fin ray counts were the least predictive characters with anal fin ray counts explaining negligible variation. The morphological similarity of the three species is evident in the DFA as numerous individuals exhibited intermediate characters along the species gradient. This overlap was compounded by the relatively small size of many specimens.

This study showed, in contrast to Rinne (1969), DeMarais (1986), and Minckley and DeMarais (2000), the three *Gila* species are not allopatric in the New Mexico portion of the Gila River drainage. There is overlap in several morphologic and meristic values used to distinguish species, and even those species-specific characters that do not overlap are separated by very small margins. The narrow delineation in morphologic and meristic characters currently used to distinguish these three taxa presumes little intraspecific variation in populations both within and between systems. The strong evidence of hybridization in this suite of fishes further complicates species-specific determination.

INTRODUCTION

The *Gila robusta* species complex is comprised of seven endemic Colorado River Basin cyprinid species (Humpback Chub, *Gila cypha,* Bonytail, *G. elegans,* Gila Chub*, G. intermedia,* Pahranagat Roundtail Chub, *G. jordani,* Headwater Chub*, G. nigra*, Roundtail Chub, *G. robusta*, and Virgin River Chub, *G. seminuda)*. Each species in this taxonomic complex exhibits a gradation of genotypic and phenotypic variation (DeMarais 1992). The high degree of variation is a product of evolution, natural hybridization, and population fragmentation in unique aquatic environments (Gerber et al. 2001, Schwemm 2006).

Roundtail Chub is the most widespread species in the complex occurring from Wyoming south to northern Mexico. Bonytail and Humpback Chub were, historically, present throughout the Colorado River Basin and exhibit extremes in body morphology in the *robusta* complex. The allopatric Pahranagat Roundtail Chub and Virgin River Chub occur in the southwestern drainages of the Colorado River Basin and the Pluvial White and Virgin Rivers, respectively. Headwater Chub and Gila Chub inhabit the Lower Colorado River Basin, Gila River Basin, of Arizona and New Mexico.

In the Gila River Basin, the distribution pattern of Gila Chub, Headwater Chub, and Roundtail Chub has been referred to as a mosaic (Dowling et al. 2008). Gila Chub occupies spring and cienega habitats and has a more widespread distribution in southern Arizona than the other two species (DeMarais 1992). Conversely, Roundtail Chub mostly occupies mainstem habitats and is broadly distributed in the Colorado River Basin (Bestgen and Propst 1989). Headwater Chub appears to be an intermediate (phenotypic and genotypic) between Gila Chub and Roundtail Chub and is thought to have resulted from natural hybridization between those two species (Minckley and DeMarais 2000). Its distribution is associated with small, headwater streams and tributaries of the Gila River.

In New Mexico, distribution and abundance of members of the *Gila robusta* complex have declined. Historical collections of *Gila* sp. (1935–1965) include samples from the San Francisco River and the Gila River system in New Mexico. During the 1980s and 1990s, *Gila* sp. were absent from San Francisco River collections and apparently restricted to the middle and upper portions of the Gila River and its tributaries. Paroz and Propst (2007) documented a further reduction in distribution of *Gila* sp. from 2000–2007 with populations being restricted to upper portions of the Gila River Basin (Turkey Creek, and the East, West, and Middle forks of the Gila River). Significant reductions in *Gila* sp. distribution and abundance have also been recorded in portions of the Gila River Basin in Arizona (Arizona Game and Fish Department 2006).

The decline of this complex lead to the listing of Gila Chub as federally endangered (U.S. Department of the Interior, 2002) and Headwater Chub and Roundtail Chub as a candidate species for listing (U.S. Department of the Interior 2011). Roundtail Chub, while more broadly distributed than other chub in the *G. robusta* complex, is declining in range and abundance. This decline has led to Roundtail Chub being protected under state endangered and threatened species statutes and creation of multi-state agreements to monitor populations (i.e., Range-wide Conservation Agreement and Strategy For Roundtail Chub, Bluehead Sucker, and Flannelmouth Sucker). In addition, a Colorado River Basin Chubs Recovery Plan for New Mexico was developed (Carman 2006) under the authority of the New Mexico Wildlife Conservation Act amendments of 1995 (New Mexico Department of Game and Fish 2006). This recovery plan was developed to guide efforts to restore and maintain viable Gila Chub, Headwater Chub, and Roundtail Chub populations in New Mexico so that these species could be delisted.

The distribution of members of the *G. robusta* complex in the Gila River Basin is not fully understood. Numerous phylogenetic investigations have indicated a long history of fragmentation and periodic admixture of these closely related taxa. Morphometric studies found populations were allopatric despite a closely allied range of characters and combination of morphometric, meristic, and phenotypic traits that distinguish taxa (Rinne 1969, DeMarais 1986, Minckley and DeMarais 2000).

In the Gila River Basin, Roundtail Chub and Gila Chub are at opposite ends of the morphological spectrum. Roundtail Chub is a large fish with a streamlined body, narrow caudal peduncle, and head length greater than the other two taxa. Roundtail chub also has more lateral line scales and medial fin rays (dorsal and anal fins) than the other two species in the complex. Body shape ratios of head length (HL)/caudal peduncle depth (CPD) and caudal peduncle depth/caudal peduncle length (CPL) further separate this species from Headwater Chub and Gila Chub.

Gila Chub occupies small spring systems and cienegas, has a small, thick body shape. Head morphology and caudal peduncle depth (HD/CPD) can be used to separate this species from Roundtail Chub and Headwater Chub. In addition, the number of lateral line scales and dorsal and anal fin rays of Gila Chub are lower than Roundtail Chub.

The intermediate body morphology of Headwater Chub led to it being considered a subspecies, *Gila robusta grahami*, of Roundtail Chub (Rinne 1969). Minckley and DeMarais (2000) elevated Headwater Chub to full species status and assigned the specific epithet *nigra* as *grahami* was unavailable. Headwater Chub was likely the product of multiple discrete hybridization events between Roundtail Chub and Gila Chub (Minckley and DeMarais 2000). Morphologically, Headwater Chub supports this hypothesis as it is defined as possessing intermediate characters between Gila Chub and Roundtail Chub. Despite overlap in some morphometric characters and in meristic values this form was definable using the identification key of Minckley and DeMarais (2000).

Insight into species-specific differentiation among the three Gila River Basin chub has been enhanced by genetic investigations of these forms. Analysis of allozyme loci indicated an array of variation in the *G. robusta* complex, however, the variation was not attributable to species morphology or drainage but rather locality (DeMarais 1992). Further analysis using morphometric, molecular, and distributional data concluded that the three taxa warranted full species status in part because of the lack of overlapping distributions (Minckley and DeMarais 2000). More recent investigations using mitochondrial and nuclear DNA sequences indicated patterns of sequence variation were not associated with morphology or hydrographic connection, but were best explained by fragmentation and independent evolution of many subpopulations (Schwemm 2006). Additional analysis of microsatellites in the *G. robusta* complex support the importance of distinct independent evolving populations in which geography plays an important role (Dowling et al. 2008).

These morphological and phylogenetic studies have been useful for understanding the complex relationships and evolutionary history of these fishes. Despite the work that has been recently accomplished, the status and distribution of Gila River Basin *Gila* species in New Mexico is still uncertain and particularly important due to the rapid decline in their distribution and abundance. Current threats include competition and predation from invasive fish and habitat loss from water development (Propst 1999). Projections of a warming, dryer climate in the southwestern United States of America predict further alterations to the hydrologic cycle due to decreased annual snow accumulations and habitat degradation from the effects of drought induced wildfires (Comte et al. 2013). Furthermore, proposal for a major diversion structure on the mainstem Gila River by the New Mexico Interstate Stream Commission (NMISC) could result in river fragmentation, aquatic habitat degradation, and further alterations to the hydrologic cycle.

Of the numerous Gila River tributaries in New Mexico, Turkey Creek has been identified as an important stronghold for *Gila* chub populations. Paroz et al. (2006) and Paroz and Propst (2007) identified this creek as having the highest densities and downstream most populations of *Gila* sp. remaining in New Mexico. Recent phylogenetic analysis of the *Gila* sp. population in Turkey Creek indicated this population is unique in relation to other *Gila* sp. populations in New Mexico (Dowling et al. 2008) and that further examination of this population is important.

The morphological and genetic similarity of the Gila River Basin *Gila* sp. complex not only adds to confusion regarding species identification but also impedes determination of species-specific distributions and conservation status (Carman 2006, Paroz and Propst, 2007). The morphometric examination of historical chub collections from the lower Colorado River Basin, initially analyzed by John N. Rinne (1969), was the first intensive analysis of the *G. robusta* complex in the Gila River Basin in Arizona and New Mexico. Rinne (1969) examined a number of historical (1940–1950) Gila River Basin *Gila* sp. collections from New Mexico (Appendix I). Understandably, not all available fish collections were analyzed and many specimens from studied collections were not measured.

While a basin-wide investigation of the historical and current distribution and conservation status of the three taxa is needed, the modest scope of our study was tailored to fit the provincial objectives of the funding agency. New Mexico Department of Game and Fish's Share with Wildlife Program (SwW) provides small (financial compensation) one-year grants primarily to study New Mexico species that do not receive funding from other sources. One of the stated purposes of SwW funds are "to provide for conservation and management efforts in New Mexico that would otherwise be lacking in support." Research funds of SwW are administered by the New Mexico Department of Game and Fish acquired exclusively by citizen donations.

In June 2012, the project proposal "Determining the historical distribution of Colorado River chubs of the *Gila robusta* complex (*Gila intermedia*, Gila Chub, *Gila nigra*, Headwater Chub, and *Gila robusta*, Roundtail Chub) in the Gila River Basin, New Mexico" was submitted to SwW in response to their call for potential 2013 projects. As per the scope of the proposal, the study area was limited to New Mexico and historical distributions of the study taxa were to be determined using museum specimens collected prior to the 1970s. Historical specimens were to be analyzed and identifications verified or re-assigned using published morphometric and meristic keys describing these species. In addition to compiling the morphological analysis of historical collections in New Mexico, a preliminary morphometric investigation the Turkey Creek *Gila* sp. chub population was to be undertaken using recent material (1983–2001).

In the study reported herein, the earliest museum collections of chub specimens from Turkey Creek (1983) were analyzed together with historical collections from throughout the Gila River Basin (1935–1966). Species-specific morphologic and meristic characters presented in Minckley and DeMarais (2000) were the primary identification tool employed in this study.

STUDY AREA

The Gila River Basin in southwestern New Mexico drains Catron, Grant, Hidalgo, and Sierra counties. The San Francisco River is the largest drainage in the New Mexico portion of the basin followed by the mainstem Gila River (Figure 1). Numerous small headwater streams feed the Gila and San Francisco rivers. Headwater tributaries originate at high elevations in the Mogollon Mountains and the Black Range. These tributaries are high gradient creeks with cobble and bedrock substrates. Under some low flow scenarios, natural barriers develop in some of these headwater tributaries and function to fragment and isolate fish populations. Several small man-made reservoirs are also present in the Gila River Basin including Snow, Roberts, Wall, and Bill Evans.

METHODS

Collections of the *Gila robusta* complex from the 1930s to the 1960s were acquired from the Division of Fishes at the Museum of Southwestern Biology (MSB), University of New Mexico (n = 187), and the University of Michigan Museum of Zoology (UMMZ, n = 96). For this study, those collections constitute the "historical material" and are deemed to indicate the native, non-transplanted taxa. In addition to the aforementioned collections, seven Turkey Creek, New Mexico, collections of *Gila* sp. from 1983, 1984, and 2001 (all MSB) were also examined and included in this study. The 1983–1984 Turkey Creek collections (n = 102) are the oldest museum curated samples of *Gila* sp. from that system. A list of material examined (Appendix II) and photographs (Appendix IV) are provided.

For analytical purposes, specimens examined in this study were separated by lotic system. Collections from the San Francisco River, Turkey Creek, West Fork Gila River, and East Fork Gila River were each individually grouped. (East Fork Gila River included Beaver Creek and Taylor Creek). The mainstem Gila River sample was comprised of collections from the New Mexico/Arizona border upstream to Cliff, New Mexico.

Specimens acquired for this study were housed at the MSB, Division of Fishes, and maintained following museum protocols and best practice methodology. Each specimen examined received a paper gill tag (right side of fish) to allow tracking of individual specimen and associated measures. The suite of morphometric measures and meristic values recorded from specimens in this study were those that Minckley and DeMarais (2000) reported as being most valuable for separating the three Gila River forms of *Gila* sp. Straight-line measures and meristic values were recorded from the left lateral side of each specimen. Mitutoyo Absolute Digimatic electronic calipers (Series 572) equipped with an RS232 computer interface cable with data switch for single function were used to determine and record lengths which are reported to the nearest 0.1 mm.

Length measures acquired from each specimen were: Standard Length (SL), Total Length (TL), Caudal Peduncle Depth (CPD), Caudal Peduncle Length (CPL), and Head Length (HL; Table 1). Morphometric values were converted to ratios of HL/CPD and CPL/CPD. Meristic values recorded were the number of lateral line scales (LLS), dorsal fin rays (D), and anal fin rays (A).

Specimen measures and counts were filtered through a modified version of the key presented in Minckley and DeMarais (2000) that only contained three species (Figure 2). Using this identification tool, specimens were identified, based on meeting the criteria of the two morphometric (HL/CPL, CPL/CPD) and three meristic (LLS, D, A) variables, as Headwater Chub, Gila Chub, or Roundtail Chub. Specimens that did not exhibit the five characters unique to each of the three species were assigned an identification based on the greatest number of unifying characters.

Discriminant Function Analysis (DFA; SAS, 2007) was used to classify individual specimens (to species) and scores were computed to determine the relative classification success of specimen identifications that had been based on morphology and meristic data. The DFA was performed on 263 New Mexico specimens using the previously mentioned suite of five morphometric/meristic variables (Minckley and DeMarais 2000). Only fish >50 mm SL were used in the DFA to minimize allometric similarities of young individuals (DeMarais 1986).

Canonical plots, including elliptical 95% confidence limits, were generated to illustrate general differences among the suite of species-specific characters along the first two axes. Bi-plot rays, for individual morphometric variables, were also plotted to indicate the direction and relative importance (i.e., shorter less important than longer) of each variable along the two canonical axes. Discriminant scores were computed to determine the relative classification success among species based on the morphometric data.

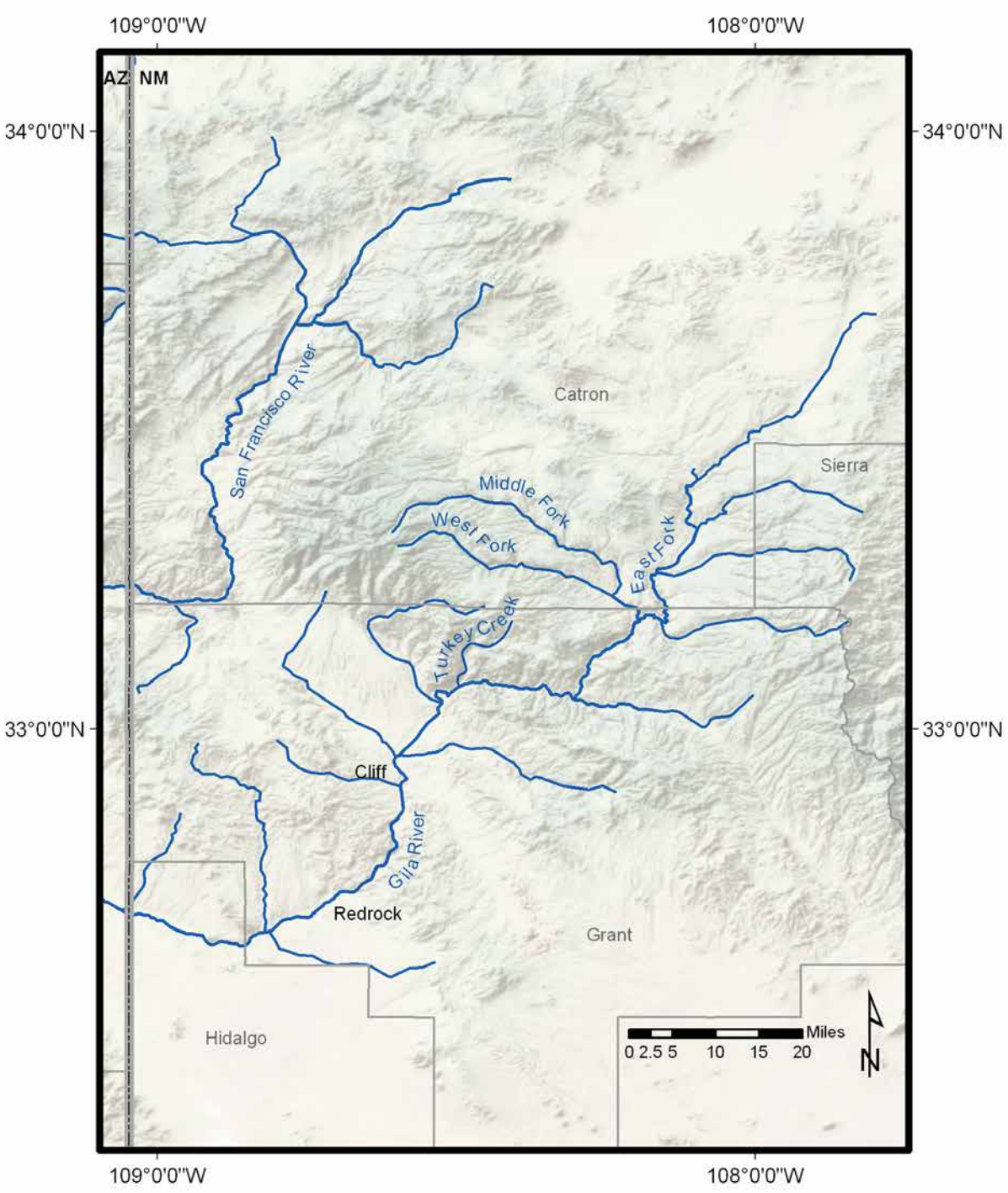

Figure 1. The Gila River Basin in New Mexico.

Table 1. Morphometric measures and meristic values recorded from specimens examined.

Feature	Code	Description
Standard Length	SL	Anterior edge of snout to posterior edge of the hypural plates
Total Length	TL	Anterior edge of snout to posterior edge of caudal fin
Caudal Peduncle Length	CPL	Insertion of posterior anal ray to posterior edge of hypural plate
Caudal Peduncle Depth	CPD	Least depth of the caudal peduncle
Head Length	HL	Anterior edge of snout to posterior portion of the opercular flap
Lateral Line Scale Count	LLS	Count of pored lateral line scales from posterior of opercular flap to posterior edge of caudal peduncle
Dorsal ray count	D	Number of principle rays in the dorsal fin
Anal ray count	A	Number of principle rays in the anal fin

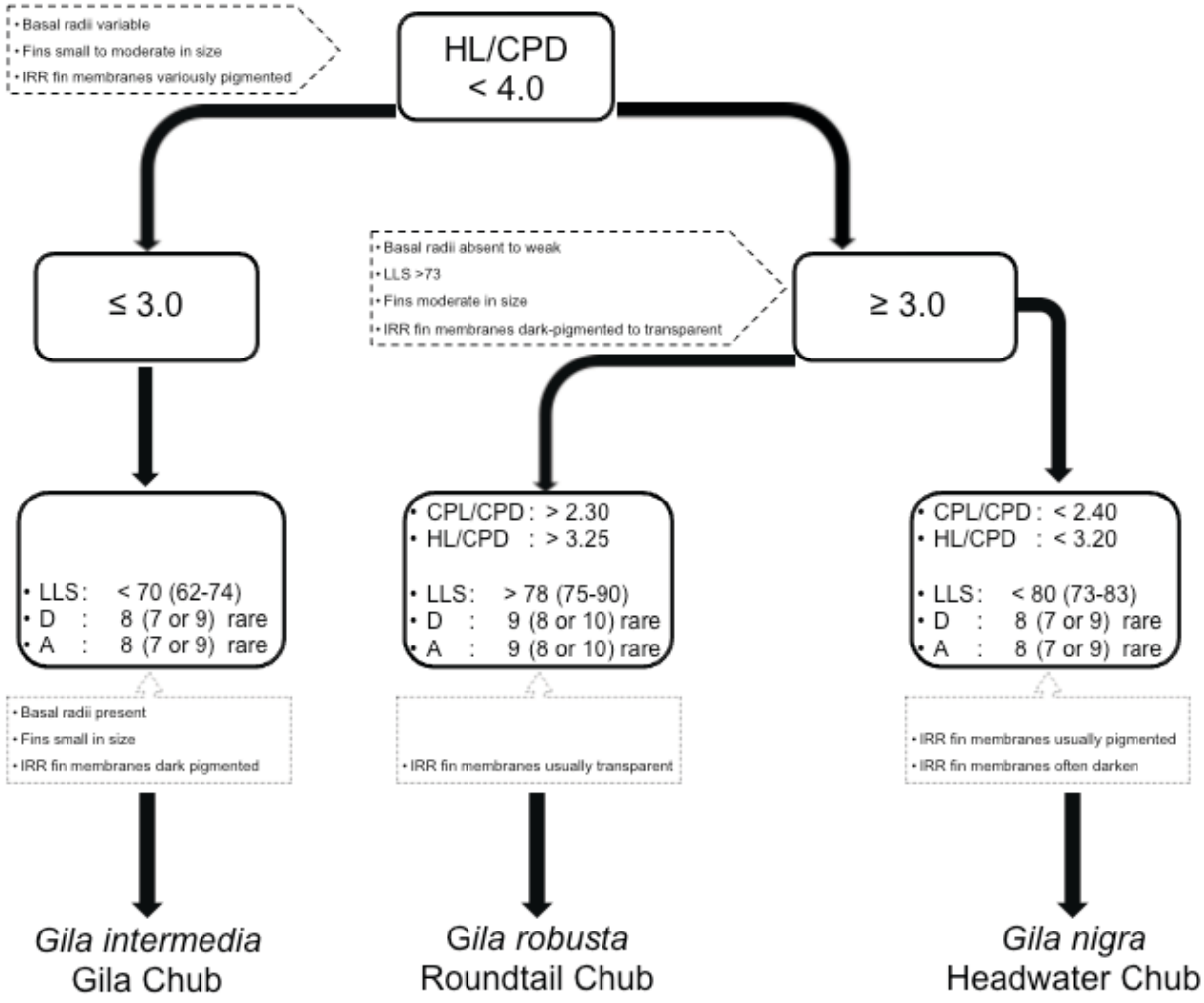

Figure 2. Characters used to differentiate Gila River Basin *Gila* sp. (IRR = interradial membranes). Adapted from Minckley and DeMarais (2000).

RESULTS

Ten fish were excluded from the study due to poor quality of the specimens (MSB 1729, n = 7; MSB 1752, n = 1; MSB 77046, n = 1, and UMMZ 124744, n = 1). A total of 375 specimens from 31 collections across five Gila River Basin systems in New Mexico were examined and included in the final analysis presented in this report. The exclusion of fishes less than 50 mm SL precluded the use of eight collections and 112 specimens in the DFA (n = 263). While fish <50 mm SL were not included in the DFA, most counts and measures were recorded from these fish and reported in Appendix III.

Three museum collections and 21 specimens from the San Francisco River were available of which 19 were from a single collection (MSB 1731). All San Francisco River *Gila* sp. >50 mm SL (n = 10; 52–183 mm SL) were in MSB 1731. Eleven collections containing 105 specimens were analyzed from the mainstem Gila River. Eight collections containing 52 specimens were analyzed from East Fork Gila River. Two collections were available from the West Fork Gila River, each with single specimens, but only one of those fish was >50 mm SL and used in the DFA. There were seven collections and 95 specimens available from Turkey Creek.

About 81% (n= 213) of the specimens meet each of five criteria identified by Minckley and DeMarais (2000) as necessary to be assigned to one of three taxonomic categories. Of those 213 specimens, 54.9% (n = 117) were Roundtail Chub, 26.8% (n = 61) were Headwater Chub, and 16.4% (n = 35) were Gila Chub. The 50 specimens (19.0%) that did not meet all five criteria were classified based on the best fit of characters. The majority of those 50 individuals were classified as Roundtail Chub (68%, n = 34), followed by Headwater Chub 20% (n = 10), and Gila Chub 12% (n = 6).

Wilk's Lambda test showed a significant difference (F=42.46, p<0.0001) among the three taxa (Figure 3) with 70% of the variation among taxa being predicted by the DFA. Correct morphometric classification in the DFA occurred in 236 of 263 *Gila* specimens (89.7%). The DFA classified 16.0% of specimens (n = 42) as Gila Chub (the fewest) while the majority of the samples were classified as Roundtail Chub (53.2%, n= 140). The former taxon was identified in three of the five systems (Gila River mainstem, East Fork Gila River, and Turkey Creek) while the latter was present in all five systems. Headwater Chub comprised 30.7% (n=81) of the total specimens analyzed and was present in all systems except West Fork Gila River.

In the San Francisco River, DFA assigned nine specimens as Roundtail Chub (90.0%; Figure 4). The second highest percent occurrence of Roundtail Chub was in the mainstem Gila River (50.7%, n= 71) followed by Turkey Creek (33.6%, n= 47). The highest percent occurrence of Gila Chub was in the East Fork Gila River (42.9%, n= 18) followed by Turkey Creek (33.3%, n= 14). Headwater Chub comprised 27.2% (n= 22) of the East Fork Gila River collections and 42.0% of Turkey Creek collections. Combined, Headwater Chub and Gila Chub comprised 32.4% (n=34) of the mainstem Gila River collections.

Canonical axis 1 accounted for 94.8% of species variation. The remaining variation was described along the canonical axis 2. Of the five morphological and meristic values, LLS and HL/CPD were the most predictive variables for classification of species. The CPL/CPD measurement explained some of the variation in species (i.e., along the second canonical axis) but was not particularly useful in separating species (i.e., along the first canonical axis). Dorsal and anal fin ray counts were the least predictive characters with anal fin ray counts explaining negligible variation along either axis.

Characters that defined Headwater Chub were intermediate between the other two species. The DFA depicted overlap in Headwater Chub with the other species, particularly along outer margins of canonical space. Comparing DFA results by river system suggested separation of values along a hydro-geographic gradient. Specimens from the East Fork Gila River exhibited a shift and in both canonical axes compared to downstream localities (Figure 5). In the mainstem Gila River, the canonical scores of Gila Chub and Headwater Chub shifted on both axes compressing the canonical distribution of the three species and indicating less morphological differences among species.

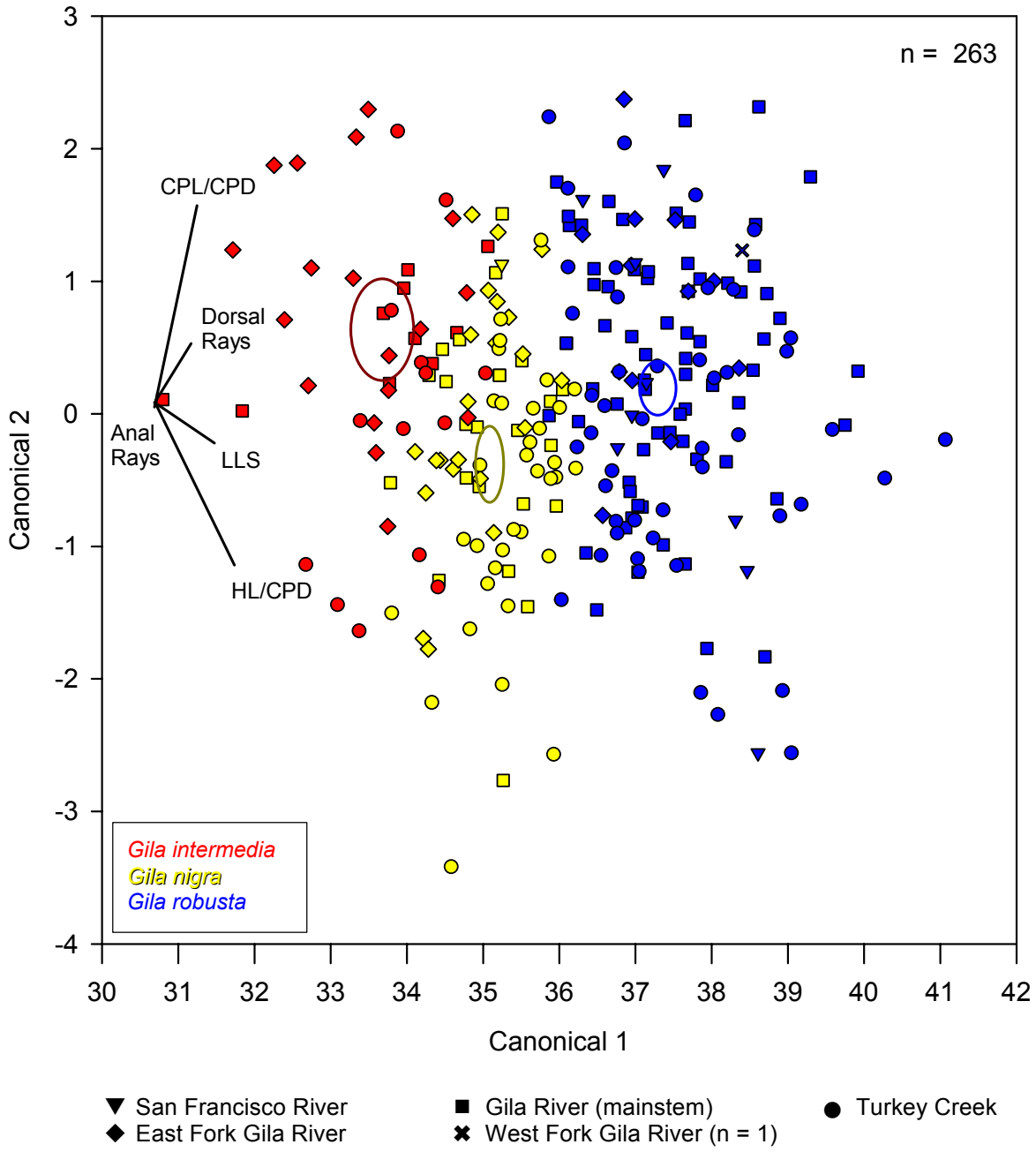

Figure 3. Discriminant function analysis of *Gila robusta* complex specimens >50 mm SL. Colors represent different species and symbols denote river systems.

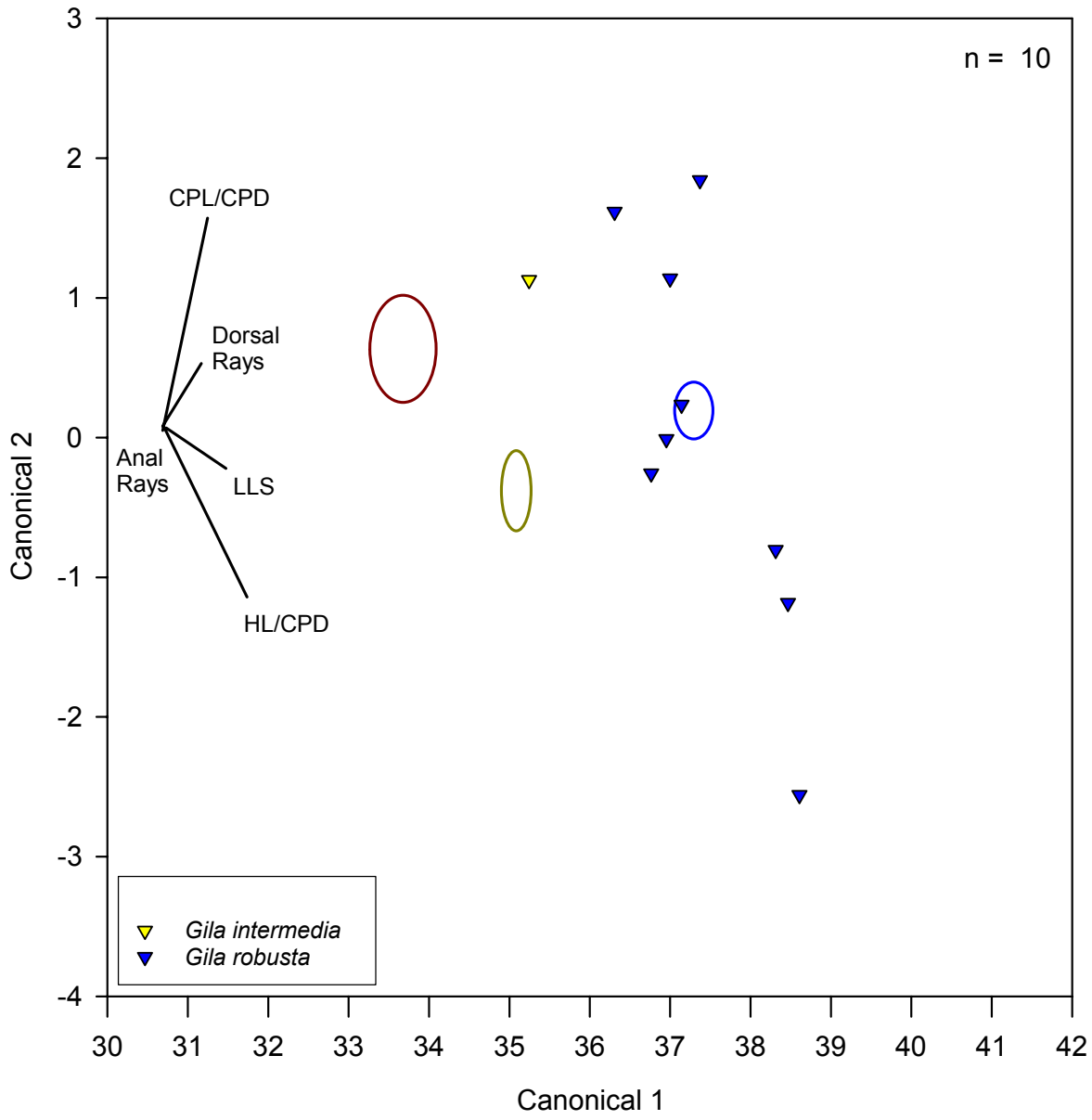

Figure 4. Discriminant function analysis of *Gila robusta* complex specimens >50 mm SL from the San Francisco River. Colors represent different species.

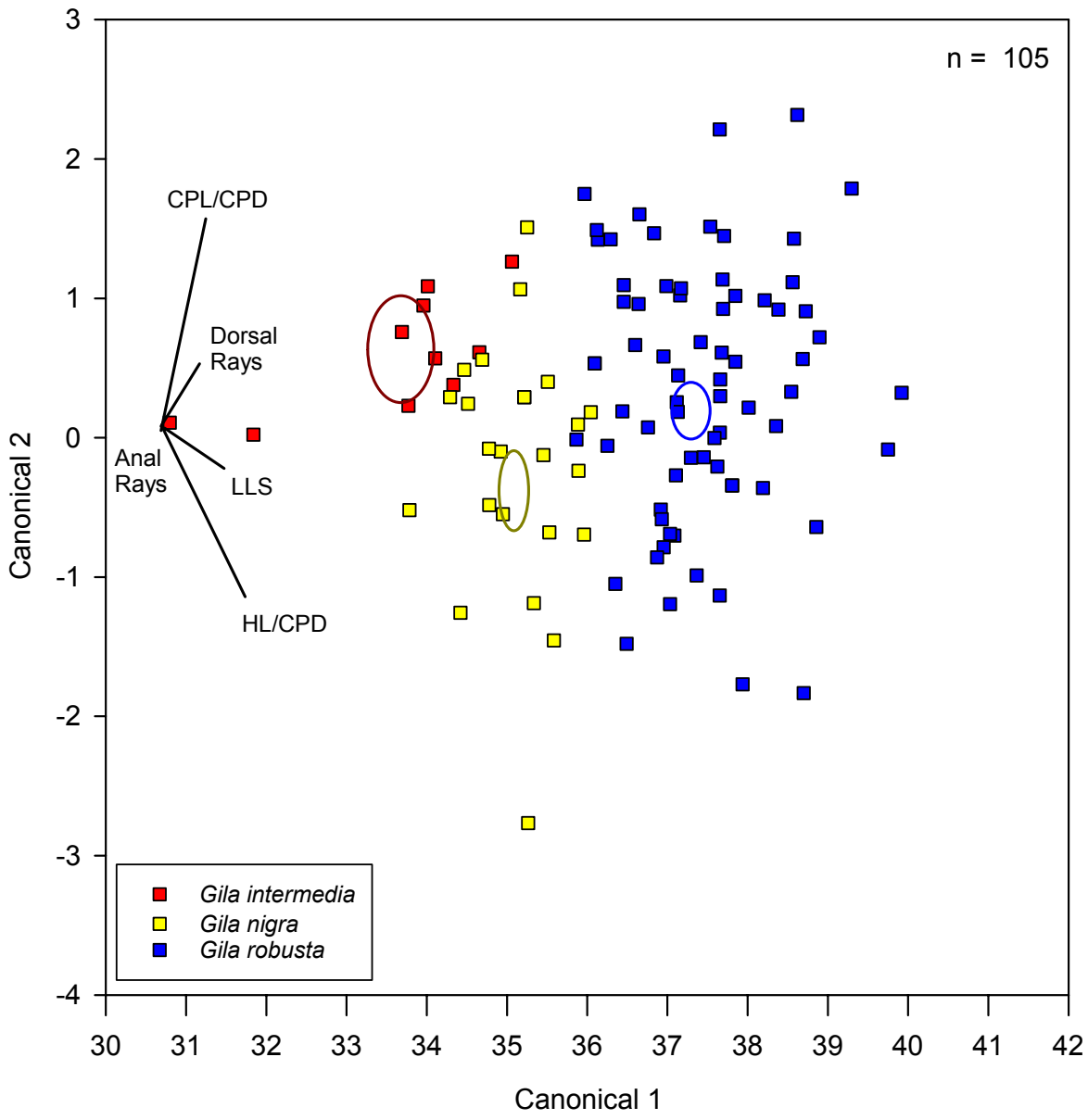

Figure 5. Discriminant function analysis of *Gila robusta* complex specimens >50 mm SL from the mainstem Gila River. Colors represent different species.

Turkey Creek had the broadest variation in canonical scores compared with the other river systems. There was greater overlap among Turkey Creek *Gila* sp. than all other systems except the mainstem Gila River. Morphotypes from Turkey Creek were broadly scattered throughout the canonical plane (Figure 6). Unfortunately, there was only one West Fork Gila River specimen thereby precluding any meaningful interpretation (Figure 7). Similarly, there were few (n = 10) specimens >50 mm SL available from the San Francisco River and nine were Roundtail Chub.

The length of specimens available for this study ranged from 21.5 to 294.7 mm SL. About 30% (n = 112) of those specimens were <50 mm SL and, because of their small size, they were not used in DFA (Figure 8). The length frequency distribution of the remaining 263 specimens was non-symmetric and strongly skewed right (Figure 9). Overall, about 48% (n = 180) of the total sample was between 50 and 100 mm SL and those 180 individuals comprised 68% of the specimens used in the DFA. There were 83 individuals between 100 and 200 mm SL (22.1% of total sample) and only 14 specimens >200 mm SL (3.7% of total sample).

About half (n = 191) the fish examined for this study were from the mainstem Gila River, while 26.5% (n = 102) originated in Turkey Creek, and about 18% (n = 69) in the East Fork Gila River. Collectively, these three systems yielded 94.0% of the sample examined in this study. There were only two individuals (22.4, 109.9 mm SL) available from the West Fork Gila River with the remaining specimens (n = 21, 5.5%) collected in the San Francisco River.

Of the 83 fish >100 mm, 82.1% (n= 69) were from either the mainstem or East Fork Gila River. Turkey Creek produced 11 fish >100 mm SL (13.1%) while the San Francisco River and West Fork Gila River were represented by three and one specimens, respectively. All 14 *Gila* sp. >200 mm SL (212.0–294.7 mm SL) and 19 of 21 (90.5%) specimens >180 mm SL were from the mainstem Gila River (Figure 10).

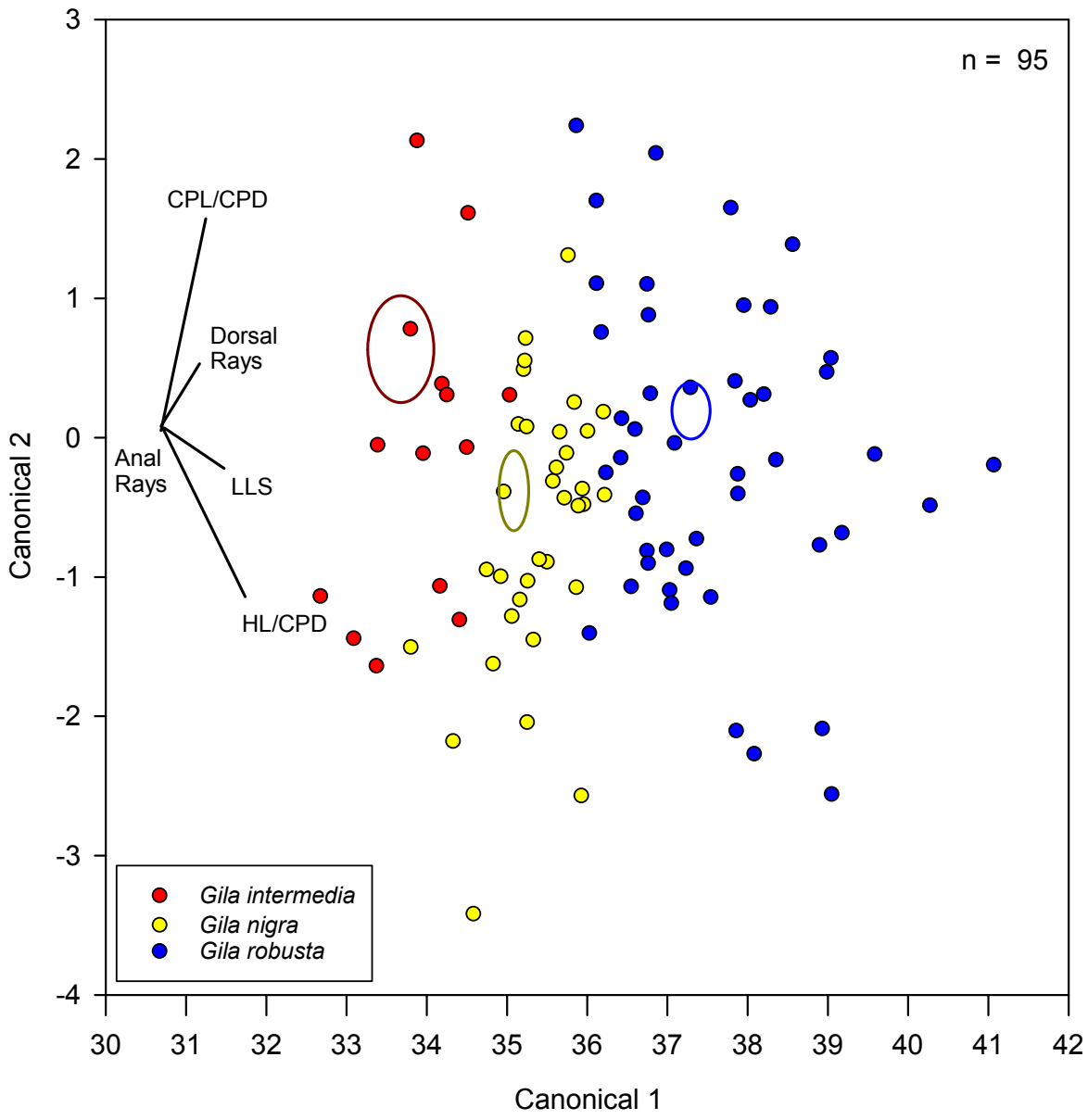

Figure 6. Discriminant function analysis of *Gila robusta* complex specimens >50 mm SL from Turkey Creek. Colors represent different species.

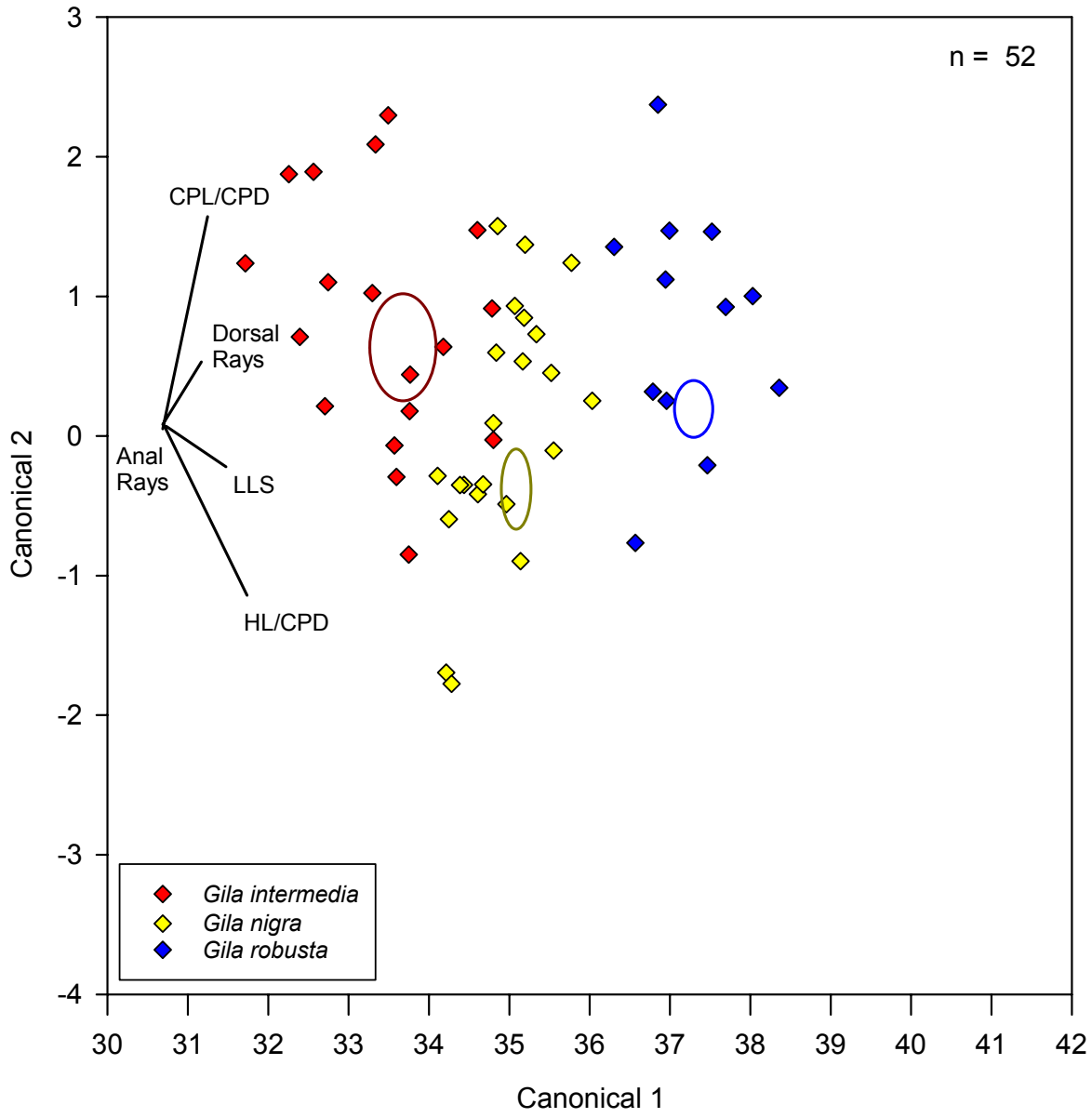

Figure 7. Discriminant function analysis of *Gila robusta* complex specimens >50 mm SL from the East Fork Gila River. Colors represent different species.

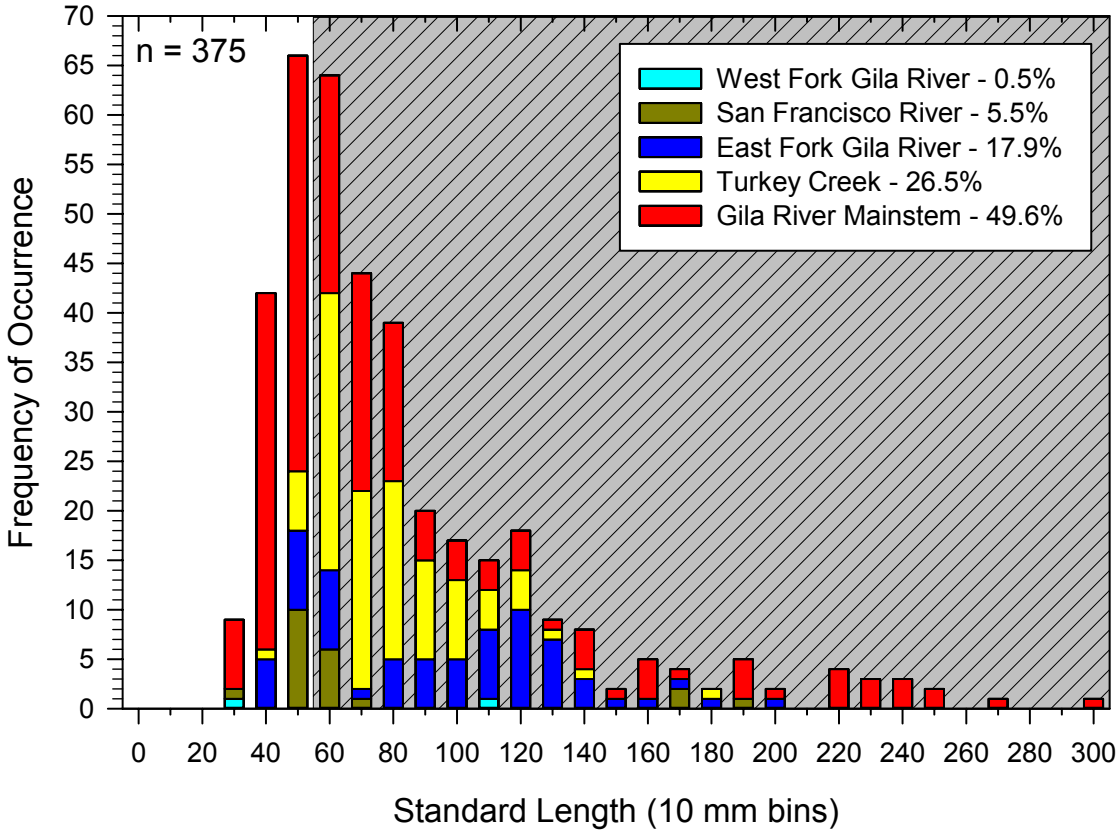

Figure 8. Length frequency distribution of *Gila* sp. examined in this study. Gray background indicates specimens used in discriminate function analysis. Colors represent different river systems.

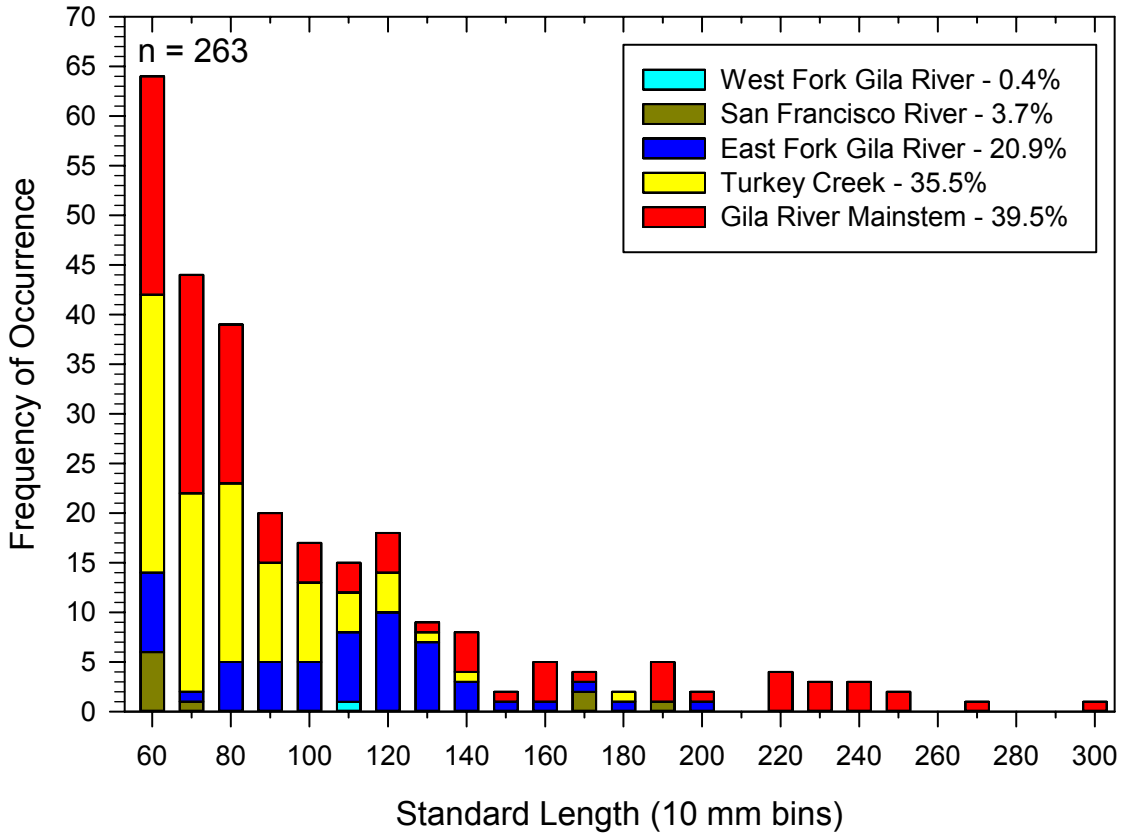

Figure 9. Length frequency distribution of *Gila* sp. >50 mm SL examined in this study. Colors represent different river systems.

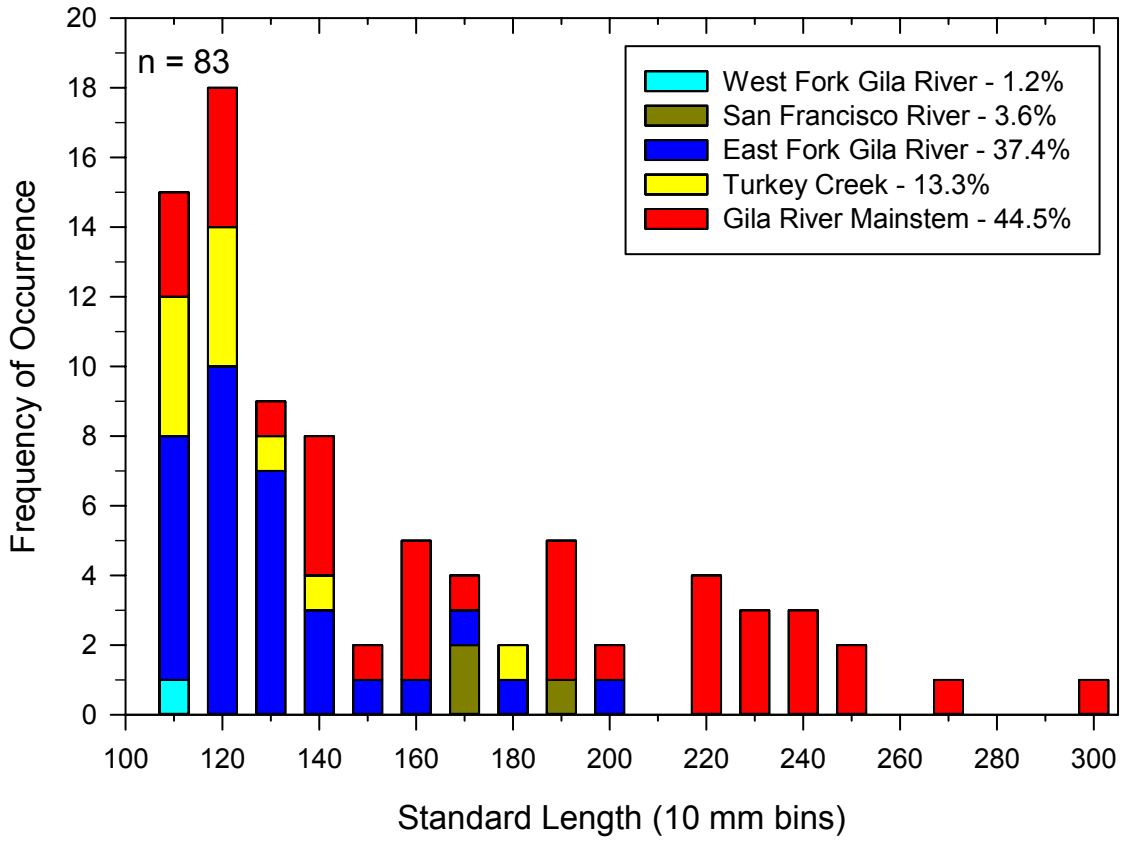

Figure 10. Length frequency distribution of *Gila* sp. >100 mm SL examined in this study. Colors represent different river systems.

DISCUSSION

The few studies addressing genotypic and phenotypic attributes of the *Gila robusta* complex in the Gila River Basin have not yet clarified distributional patterns of these species. Those works have shown, in some cases, that there is greater genetic variability in a species than between species (Dowling et al. 2008). Likewise, genetic analysis has not aligned itself with morphotype (DeMarais 1992) or locality (Schwemm 2006). Assessing microsatellites in Headwater Chub, Dowling et al. (2008) identified individuals in the East Fork Gila River that were more closely allied to Roundtail Chub or Gila Chub than Headwater Chub. This same study concluded the need for a morphological reassessment of the Gila River chub populations.

Additional confusion regarding distribution of these forms in the Gila River, New Mexico stem from previous reports which state that the three *Gila* sp. are allopatric (Rinne 1969, DeMarais 1986, Minckley and DeMarais 2000). The results of our study in the Gila River, New Mexico, demonstrate that the three species are sympatric. This conclusion is particularly interesting as a portion of the fish analyzed in our study were the same Rinne (1969) used to discern differences between species.

There is overlap in some morphologic and meristic characters used to distinguish the three chub species (HL/CPD, LLS, and dorsal and anal fin rays) and species-specific characters that do not overlap are only separated by very small margins. The ratio of HL/CPD, which is important in separating Gila Chub ($\leq$ 3.0) from the other two species ($\geq$ 3.0), is of little value (particularly between Gila Chub and Headwater Chub) when specimen ratio is 3.0. Similarly, the range in number of lateral line scales often overlaps between Headwater Chub (typically < 80) and Roundtail Chub (typically > 78). The narrow delineation in morphologic and meristic characters available to distinguish these three taxa presumes little intraspecific variation in populations in and between systems. Strong evidence of hybridization in this suite of fishes further complicates species-specific determination. Investigations into alternative morphometric techniques, such as landmark-based geometric morphometrics, may be able to provide better resolution to these morphologically similar taxa.

Molecular investigations reveal a wide range of genetic variation among subpopulations. This variation may also be reflected in morphology. The DFA supports the morphologic ratio of HL/CPD as one of the most important characters to separate species. The identification key provided by Minckley and DeMarais 2000 does not provide data relative to the variation in a species group. Rinne (1969) reports means and ranges for specimens used in his study and it is noteworthy that those range of values are greater than those reported in the identification key of Minckley and DeMarais (2000).

The morphological relatedness of the three chub species is evident in the DFA. There are numerous individuals whose morphology reside on an intermediate spectrum. These areas of overlap may be a reflection of size and development of each species. It is expected that the degree of morphological separation is greater (i.e., more evident) as individuals grew; at least until they reached length at sexual maturity. Such age/length dependent differences apply to morphology as most meristic values should not vary through development. Unfortunately, the varying degrees of morphologic value overlap between the three species dilute the predictive (species determination) ability of these conservative values.

Dowling et al. (2008) noted the importance of small-localized subpopulations of *Gila* sp. in the Gila River drainage, particularly those that may be isolated from mainstem systems. Turkey Creek represents one of those tributary subpopulations. Purported barriers to upstream fish movement in Turkey Creek may have isolated this subpopulation for some time (Dowling et al. 2008). Results of recent genetic analysis of *Gila* sp. in Turkey Creek indicate this to be a unique and highly variable genotype in New Mexico (Dowling et al. 2008, personal communication M.R. Schwemm 2013). The lack of historical collections (pre 1960) of *Gila* sp. from Turkey Creek precluded this stream from analysis so the use of more recent materials (earliest available collection was 1983) was warranted to determine if morphological characters reflected genotypic observations.
Numerous recent *Gila* sp. collections from Turkey Creek, acquired in 2010 when wildfires threatened

the fish populations in the creek, contain *Gila* specimens from up-and downstream of a natural barrier. Those fish represent the most comprehensive set of material from this tributary and analysis of those specimens may provide a clearer picture of species distribution. (*Authors Note: The lack of historical collections from Turkey Creek originally precluded Turkey Creek samples from this study. The authors recognized [soon after the award of this project] the value of recent Turkey Creek collections to this study and added, at no cost, those samples to the pool of study material*).

Historical collections of the *Gila robusta* complex in New Mexico, especially in the Gila River drainage, are limited in their temporal and spatial distribution. Greater resolution to chub morphology, distribution, and identity may be acquired through the analysis of more recent collections of chub from the Gila River Basin. The numerous small tributaries to the Gila and San Francisco rivers may yet maintain populations of *Gila* sp. whose geographic distributions are allopatric. Assessment of all collections of Gila River chub will help to define the distribution.

Dowling et al. (2008) outlined the need for conservation of the three chub species as a complex verses geographic or taxonomic units and stressed the importance of preserving the process that has lead to the complex genotypic and phenotypic nature of these species. The results of this survey also support this recommendation, as the three species seem to have a greater degree of geographic overlap than previously reported. Preforming morphologic and meristic analysis on all *Gila* sp. collections would potentially clarify some of the distribution pattern among these species, particularly in smaller tributaries and may also help codify the inter-relatedness of the *Gila robusta* complex.

ACKNOWLEDGEMENTS

The Division of Fishes, Museum of Southwestern Biology (MSB), at the University of New Mexico was paramount to the completion of this project. Alexandra M. Snyder (Collections Manager, MSB), compiled relevant specimens and collection data for this study and Dr. Thomas F. Turner (Curator of Fishes, MSB) granted access to historical specimens. Dr. William L. Fink, Curator of Fishes, Museum of Zoology at the University of Michigan provided historical specimens from the UMMZ collections for use in this study. Tracy A. Diver was instrumental in analyzing chub specimens and Rachel E. Gray provided laboratory assistance. Robert K. Dudley, Steven P. Platania, and David L. Propst provided valuable discussion and review of this document.

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Appendix I. Comparison of New Mexico chub specimens used in morphological studies by Rinne (1969) and herein (LL = lateral line).

Rinne 1969	n = Specimens Examined			ASIR 2013	n = Specimens Examined			Total # specimens
Museum Number	LL scale counts	Fin Ray Counts	Body Measures	Museum Number	LL scale counts	Fin Ray Counts	Body Measures	
MSB 1729	9	9	9	MSB 1729	10	10	10	17
MSB 1748				MSB 1730	1	1	1	1
MSB 1731	4	15	15	MSB 1731	11	19	19	19
MSB 1738		2	-	MSB 1732	6	8	8	8
MSB 1732	15	23	6	MSB 1736	-	4	4	4
MSB 1752			17	MSB 1737	-	11	11	11
MSB 1739		3	-	MSB 1738	-	-	-	1
MSB 2010			2	MSB 1739	-	1	1	1
MSB 1743	22	23	8	MSB 1743	8	8	8	8
MSB 1745			5	MSB 1745	14	14	14	14
MSB 1747			-	MSB 1747	1	1	1	1
MSB 1751			9	MSB 1748	1	1	1	1
				MSB 1751	-	-	-	-
				MSB 1752	15	70	70	70
MSB 2007	5	15	15	MSB 2007	19	19	19	19
				MSB 2010	2	6	6	6
				MSB 2624	1	1	1	1
				MSB 2767	-	2	2	2
				MSB 3130	1	1	1	1
				MSB 49890	5	5	5	5
				MSB 62754	10	10	10	10
				MSB 62958	7	10	10	10
				MSB 63002	11	11	11	11
				MSB 63189	10	12	12	12
				MSB 77046	14	16	16	16
				MSB 77050	38	38	38	38
UMMZ 110434	7	8	8	UMMZ 110434	8	8	8	8
				UMMZ 113528	2	2	2	2
				UMMZ 118180	13	13	13	13
				UMMZ 118182	10	10	10	10
UMMZ 124744	17	25	25	UMMZ 124744	27	27	27	27
				UMMZ 162740	39	39	39	39

Appendix II. Museum collections examined for *Gila robusta* complex analysis.

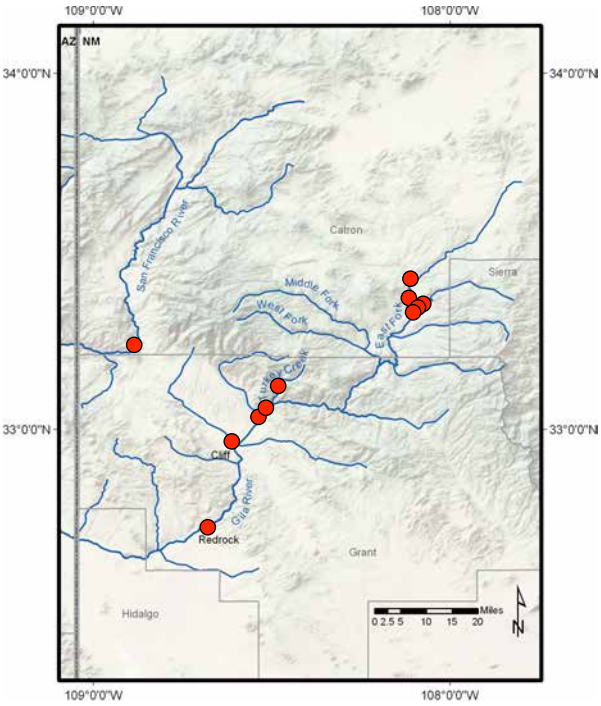
Catalog Number	County	Locality	Collector	Date Collected
MSB 1729	Catron	East Fork Gila River, 0.5 mile above confluence with Taylor Creek, west of Forest Road 150, Gila Wilderness, Gila National Forest.	E.H. Huntington	16-Sep-52
MSB 1730	Catron	San Francisco River, at San Francisco Hot Springs, off U.S. HWY 180, south of Pleasanton, Gila Wilderness, Gila National Forest.	W.J. Koster and K. Rafferty, Jr.	7-Sep-48
MSB 1731	Catron	San Francisco River, 0.75 mile below San Francisco Hot Springs, off U.S. HWY 180, south of Pleasanton, Gila Wilderness.	W.J. Koster and K. Rafferty, Jr.	8-Sep-48
MSB 1732	Grant	Gila River, at Cliff on U.S. HWY 180.	W.J. Koster and K.R. Coburn	25-Aug-49
MSB 1736	Grant	Gila River, 5.0 miles below Cliff, on U.S. HWY 180.	W.J. Koster and K.R. Coburn	26-Aug-49
MSB 1737	Grant	Gila River, ca. 1.1 miles south of Cliff on U.S. HWY 180.	W.J. Koster and K.R. Coburn	26-Aug-49
MSB 1738	Catron	San Francisco River, 1.0 mile above Reserve, town at junction of NM State HWY 12, 32, and 435, Gila National Forest.	W.J. Koster and K. Rafferty, Jr.	4-Sep-48
MSB 1739	Hidalgo	Gila River, 1.0 mile east of Arizona border, on NM State HWY 92.	W.J. Koster and K.R. Coburn	23-Aug-49
MSB 1743	Grant	Gila River, 5.0 to 6.0 miles above town of Gila.	J. Sands and E.H. Huntington	11-Jun-53
MSB 1745	Grant	Gila River, 4.5 miles below Cliff, on U.S. HWY 180.	J. Sands, J. Sherman, and E.H. Huntington	11-Jun-53
MSB 1747	Grant	Gila River, 9.0 miles below Cliff, on U.S. HWY 180.	J. Sands and E.H. Huntington	12-Jun-53
MSB 1748	Catron	West Fork Gila River, Gila Wilderness, Gila National Forest.	E.H. Huntington	18-Aug-51
MSB 1752	Grant	Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153.	W.J. Koster and K.R. Coburn	27-Aug-49
MSB 2007	Catron	Beaver Creek, ca. junction of Forest Road 150 and NM State HWY 59, Gila National Forest.	W.J. Koster and K.R. Coburn	4-Sep-49
MSB 2010	Grant	Gila River, at Red Rock, on NM State HWY 464.	W.J. Koster and K.R. Coburn	24-Aug-49
MSB 2624	Grant	East Fork Gila River, 0.25 mile below Lyons Hunting Lodge Hot Spring, ca. 2.5 miles upstream from West Fork Gila River.	G.C. Kobetich, J. White, and S. Henry	8-Oct-66
MSB 2767	Grant	East Fork Gila River, 0.25 mile below Lyons Hunting Lodge Hot Spring, ca. 2.5 miles upstream from West Fork Gila River.	G.C. Kobetich	20-Aug-66

Appendix II. continued.

Catalog Number	County	Locality	Collector	Date Collected
MSB 3130	Grant	West Fork Gila River, from its confluence with the Gila River to 4.0 miles above this confluence, off NM State HWY 15, Gila Wilderness.	G.C. Kobetich	28-Oct-65
MSB 49890	Grant	Turkey Creek, Gila Wilderness, Gila National Forest.	J.A. Monzingo, R.D. Ward, K.C. Ward, and G.S. Jimenez	27-Jun-01
MSB 62754	Grant	Turkey Creek, ca. 0.1 kilometers upstream of a hot springs, Gila Wilderness, Gila National Forest.	D.L. Propst	5-May-83
MSB 62958	Grant	Turkey Creek, ca. 0.5 kilometers downstream of confluence with Sycamore Canyon.	D.L. Propst and K.R. Bestgen	5-Jul-83
MSB 63002	Grant	Turkey Creek, ca. 0.8 kilometers downstream of hot springs, Gila Wilderness, Gila National Forest.	D.L. Propst	7-Sep-83
MSB 63189	Grant	Turkey Creek, below hot springs, Gila Wilderness, Gila National Forest.	D.L. Propst	12-Nov-83
MSB 77046	Grant	Turkey Creek, at hot springs, Gila Wilderness.	D.L. Propst and K.R. Bestgen	5-Jul-83
MSB 77050	Grant	Turkey Creek, at hot springs, Gila Wilderness.	D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler	30-Jan-84
UMMZ 110434	Catron	Taylor Creek, near road between Beaverhead and Silver City, Gila National Forest; Gila River system.	C.M. Tarzwell	16-Aug-35
UMMZ 113528	Catron	Beaver Creek, at jct of Beaver Creek and Taylor Creek, Gila National Forest, 90 mi S of Magdalena; Gila drainage.	M.A. Gee	17-Mar-36
UMMZ 118180	Catron	Taylor Creek, tributary to East Fork of the Gila River.	M.A. Gee and Carr	26-Aug-37
UMMZ 118182	Catron	Beaver Creek, tributary of East Fork of Gila River, Gila River drainage.	M.A. Gee and Carr	27-Aug-37
UMMZ 124744	Grant	Gila River, on US 260, at Cliff.	Hubbs family	30-Jun-38
UMMZ 162740	Grant	Gila River, ca. 6 mi above Redrock, at mouth of box canyon	R.R. Miller and H.E. Winn	5-Jun-50

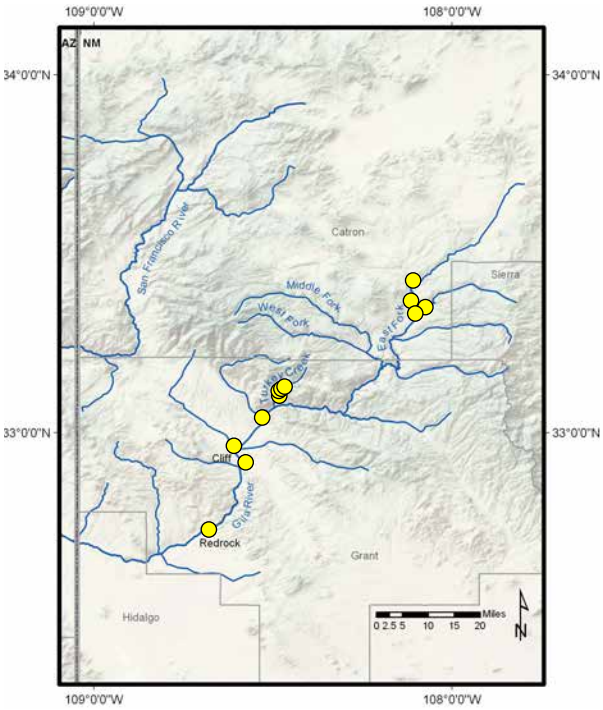
Appendix III. Morphologic and meristic values of characters analyzed in this study. Distribution maps based on identifications determined herein. Dots on maps (map from Figure 1) indicate presence of specimen.

	Gila intermedia Gila Chub	
HL/CPD	Mean	2.78
	Std Dev	0.13
	Std Err Mean	0.02
	upper 95% Mean	2.82
	lower 95% Mean	2.74
	n=	42
CPL/CPD	Mean	2.24
	Std Dev	0.18
	Std Err Mean	0.03
	upper 95% Mean	2.29
	lower 95% Mean	2.18
	n=	42
LLS	Mean	78.68
	Std Dev	4.10
	Std Err Mean	0.65
	upper 95% Mean	79.99
	lower 95% Mean	77.36
	n=	42
Dorsal Rays	Mean	8.43
	Std Dev	0.50
	Std Err Mean	0.08
	upper 95% Mean	8.59
	lower 95% Mean	8.26
	n=	42
Anal Rays	Mean	8.28
	Std Dev	0.45
	Std Err Mean	0.07
	upper 95% Mean	8.42
	lower 95% Mean	8.13
	n=	42



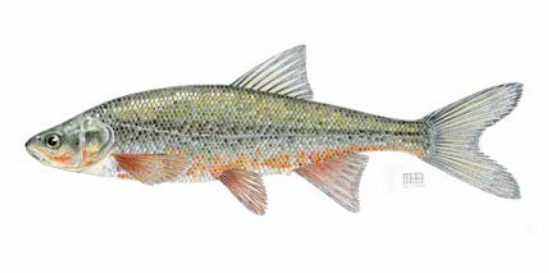
Appendix III. continued.

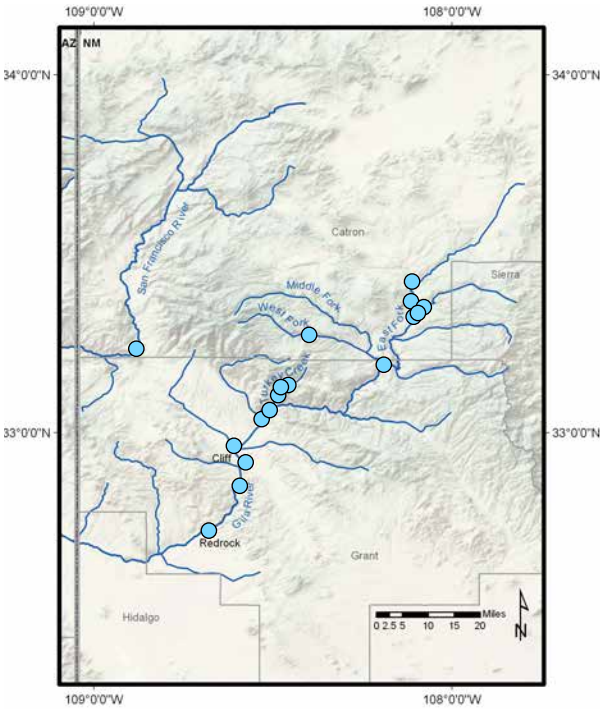
	Gila nigra Headwater Chub	
HL/CPD	Mean	3.06
	Std Dev	0.10
	Std Err Mean	0.01
	upper 95% Mean	3.08
	lower 95% Mean	3.04
	n=	81
CPL/CPD	Mean	2.26
	Std Dev	0.17
	Std Err Mean	0.02
	upper 95% Mean	2.30
	lower 95% Mean	2.22
	n=	81
LLS	Mean	80.51
	Std Dev	2.40
	Std Err Mean	0.27
	upper 95% Mean	81.05
	lower 95% Mean	79.97
	n=	81
Dorsal Rays	Mean	8.54
	Std Dev	0.50
	Std Err Mean	0.06
	upper 95% Mean	8.65
	lower 95% Mean	8.43
	n=	81
Anal Rays	Mean	8.45
	Std Dev	0.50
	Std Err Mean	0.06
	upper 95% Mean	8.56
	lower 95% Mean	8.34
	n=	81



Appendix III. continued.

	Gila robusta Roundtail Chub	
HL/CPD	Mean	3.34
	Std Dev	0.25
	Std Err Mean	0.02
	upper 95% Mean	3.38
	lower 95% Mean	3.30
	n=	140
CPL/CPD	Mean	2.58
	Std Dev	0.21
	Std Err Mean	0.02
	upper 95% Mean	2.62
	lower 95% Mean	2.55
	n=	140
LLS	Mean	82.90
	Std Dev	3.05
	Std Err Mean	0.24
	upper 95% Mean	83.37
	lower 95% Mean	82.42
	n=	140
Dorsal Rays	Mean	8.85
	Std Dev	0.37
	Std Err Mean	0.03
	upper 95% Mean	8.91
	lower 95% Mean	8.80
	n=	140
Anal Rays	Mean	8.72
	Std Dev	0.45
	Std Err Mean	0.04
	upper 95% Mean	8.79
	lower 95% Mean	8.65
	n=	140





Appendix IV. Photographs of specimens examined in this study. Scientific names appearing on the tags in the photographs are those under which the specimen was catalogued into its respective museum and are not necessarily indicative of the results of this study.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1729. New Mexico, Catron County, East Fork Gila River, 0.5 mile above confluence with Taylor Creek, west of Forest Road 150, Gila Wilderness, Gila National Forest. E.H. Huntington. 16 September 1952. n = 10.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

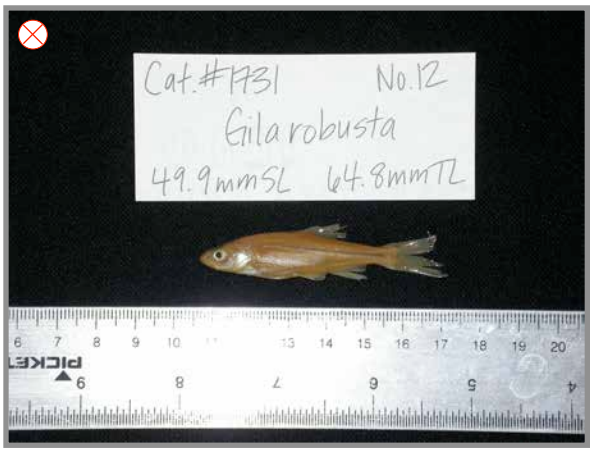
MSB 1729. New Mexico, Catron County, East Fork Gila River, 0.5 mile above confluence with Taylor Creek, west of Forest Road 150, Gila Wilderness, Gila National Forest. E.H. Huntington. 16 September 1952. n = 10.

⊗ = specimen <50 mm SL; species not determined

MSB 1730. New Mexico, Catron County, San Francisco River, at San Francisco Hot Springs, off U.S. HWY 180, south of Pleasanton, Gila Wilderness, Gila National Forest. W.J. Koster and K. Rafferty, Jr. 7 September 1948. n = 1.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1731. New Mexico, Catron County, San Francisco River, 0.75 mile below San Francisco Hot Springs, off U.S. HWY 180, south of Pleasanton, Gila Wilderness. W.J. Koster and K. Rafferty, Jr. 8 September 1948. n = 19.



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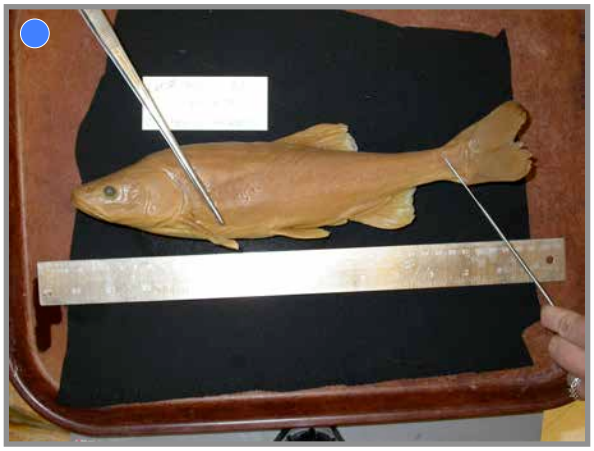


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1732. New Mexico, Grant County, Gila River, at Cliff on U.S. HWY 180. W.J. Koster and K.R. Coburn. 25 August 1949. n = 8.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1732. New Mexico, Grant County, Gila River, at Cliff on U.S. HWY 180. W.J. Koster and K.R. Coburn. 25 August 1949. n = 8.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1736. New Mexico, Grant County, Gila River, 5.0 miles below Cliff, on U.S. HWY 180. W.J. Koster and K. R. Coburn. 26 August 1949. n = 4.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1737. New Mexico, Grant County, ca. 1.1 miles south of Cliff on U.S. HWY 180. W.J. Koster and K.R. Coburn. 26 August 1949. n = 11.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1737. New Mexico, Grant County, ca. 1.1 miles south of Cliff on U.S. HWY 180. W.J. Koster and K.R. Coburn. 26 August 1949. n = 11.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1738. New Mexico, Catron County, San Francisco River, 1.0 mile above Reserve, town at junction of NM State HWY 12, 32, and 435, Gila National Forest. W.J. Koster and K. Rafferty, Jr. 4 September 1948. n = 1.

MSB 1739. New Mexico, Hidalgo County, Gila River, 1.0 mile east of Arizona border, on NM State HWY 92. W.J. Koster and K.R. Coburn. 23 August 1949. n = 1.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

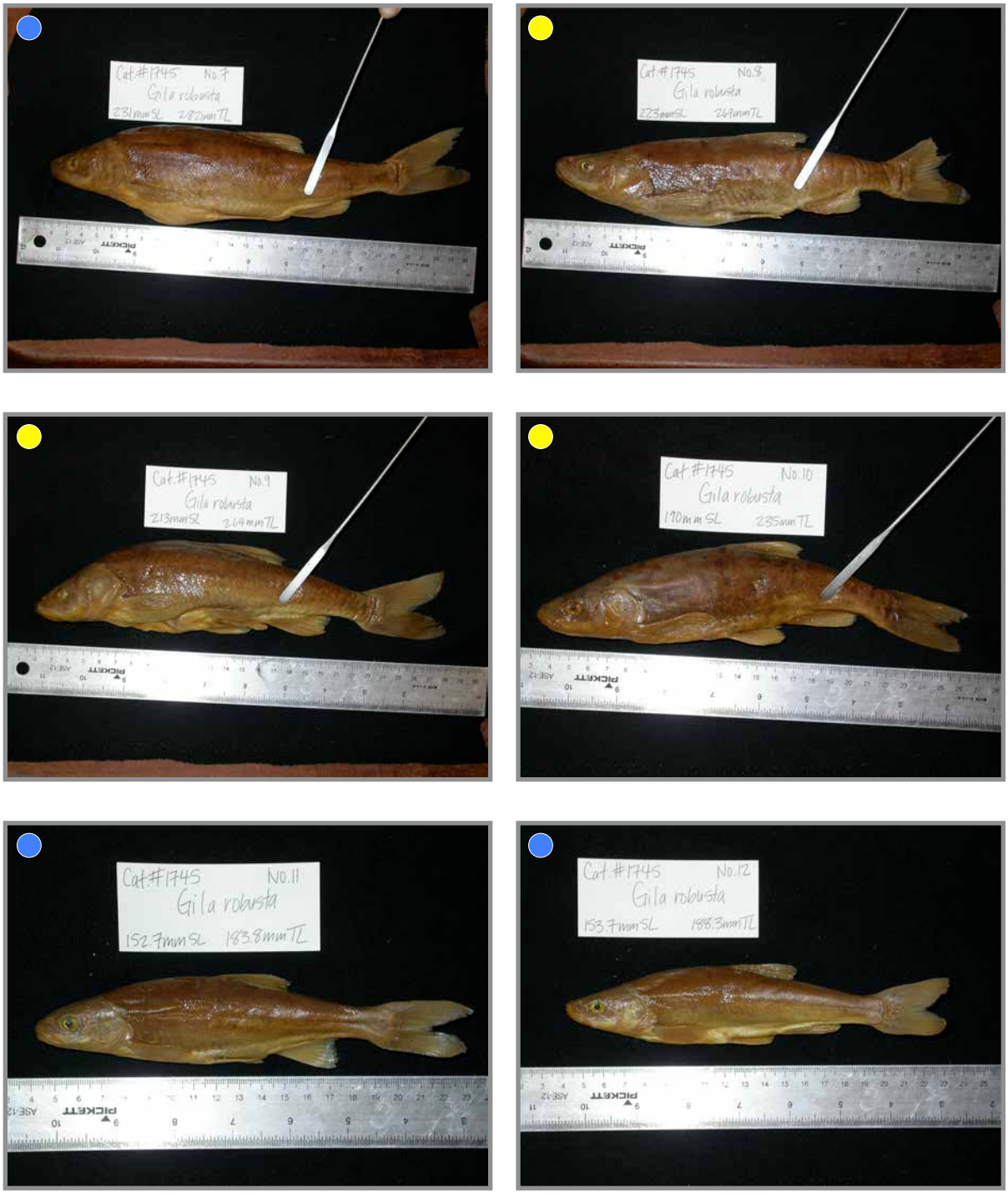
MSB 1743. New Mexico, Catron County, Gila River, 5.0 to 6.0 miles above town of Gila. J. Sands and E.H. Huntington. 11 June 1953. n = 8.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1743. New Mexico, Catron County, Gila River, 5.0 to 6.0 miles above town of Gila. J. Sands and E.H. Huntington. 11 June 1953. n = 8.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1745. New Mexico, Grant County, Gila River, 4.5 miles below Cliff, on U.S. HWY 180. J. Sands, J. Sherman, and E.H. Huntington. 11 June 1943. n = 14.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1745. New Mexico, Grant County, Gila River, 4.5 miles below Cliff, on U.S. HWY 180. J. Sands, J. Sherman, and E.H. Huntington. 11 June 1943. n = 14.

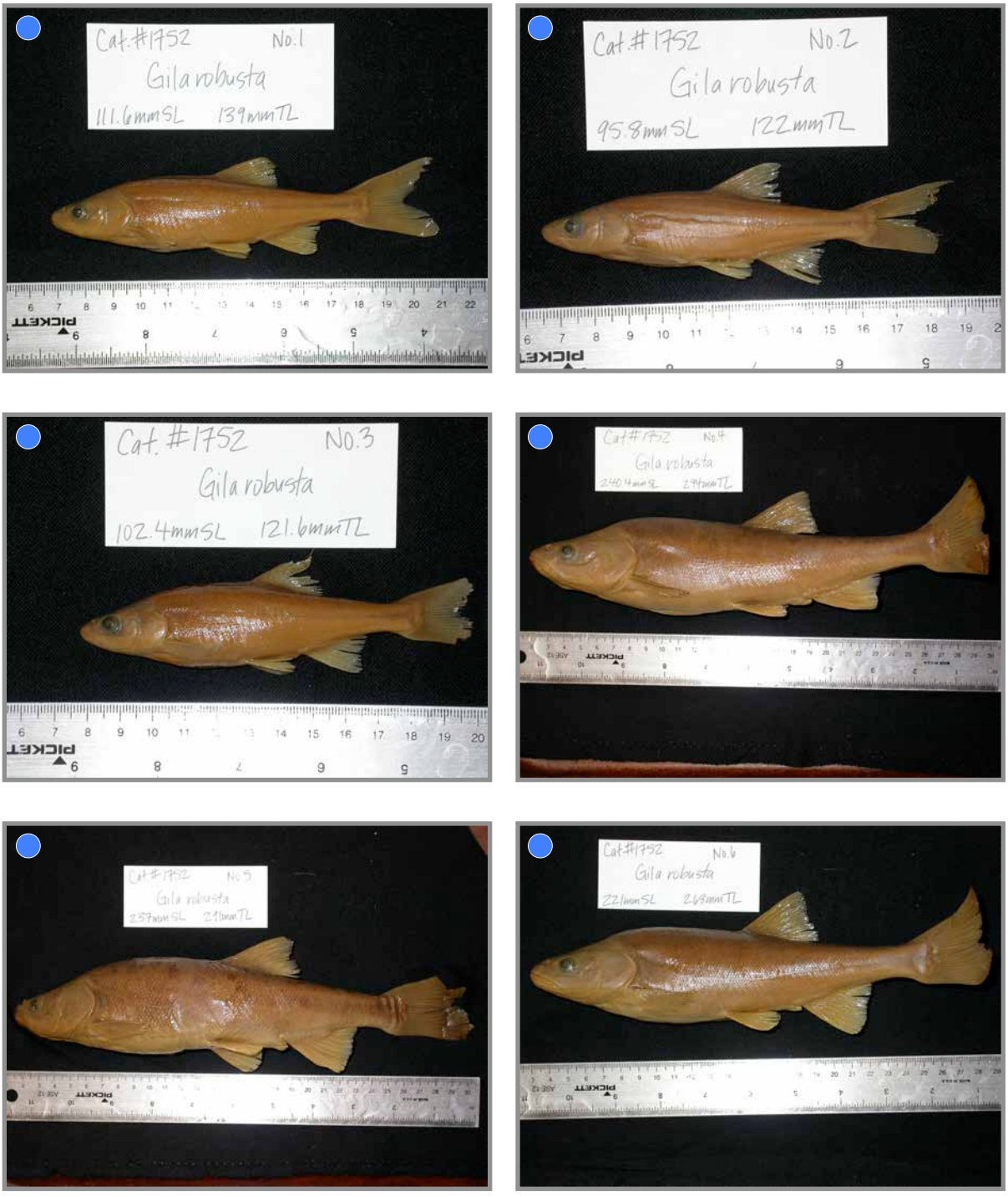
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1745. New Mexico, Grant County, Gila River, 4.5 miles below Cliff, on U.S. HWY 180. J. Sands, J. Sherman, and E.H. Huntington. 11 June 1943. n = 14.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1747. New Mexico, Grant County, Gila River, 9.0 miles below Cliff, on U.S. HWY 180. J. Sands and E.H. Huntington. 12 June 1953. n = 1.

MSB 1748. New Mexico, Catron County, West Fork Gila River, Gila Wilderness, Gila National Forest. E.H. Huntington. 18 June 1951. n = 1.

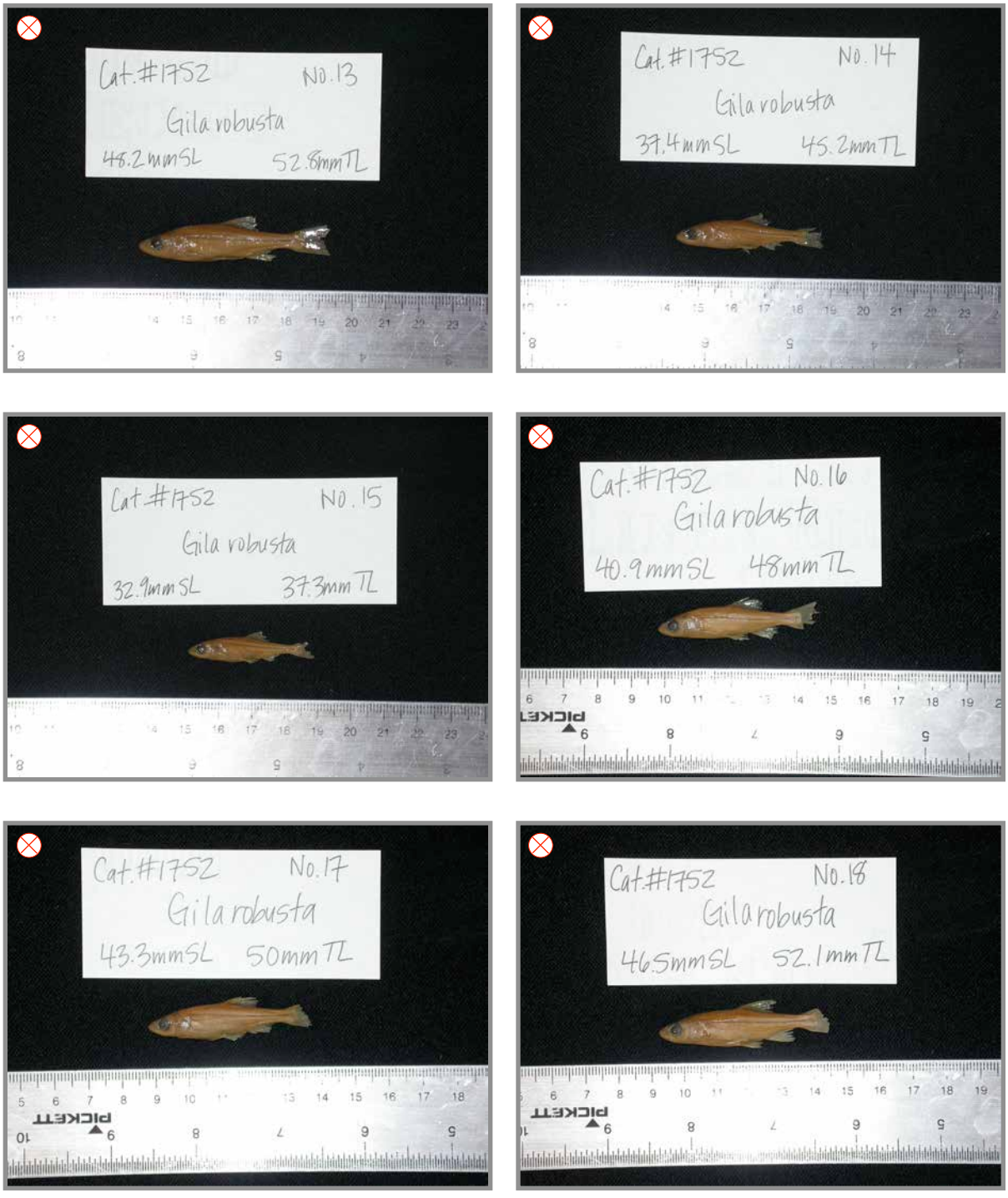


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

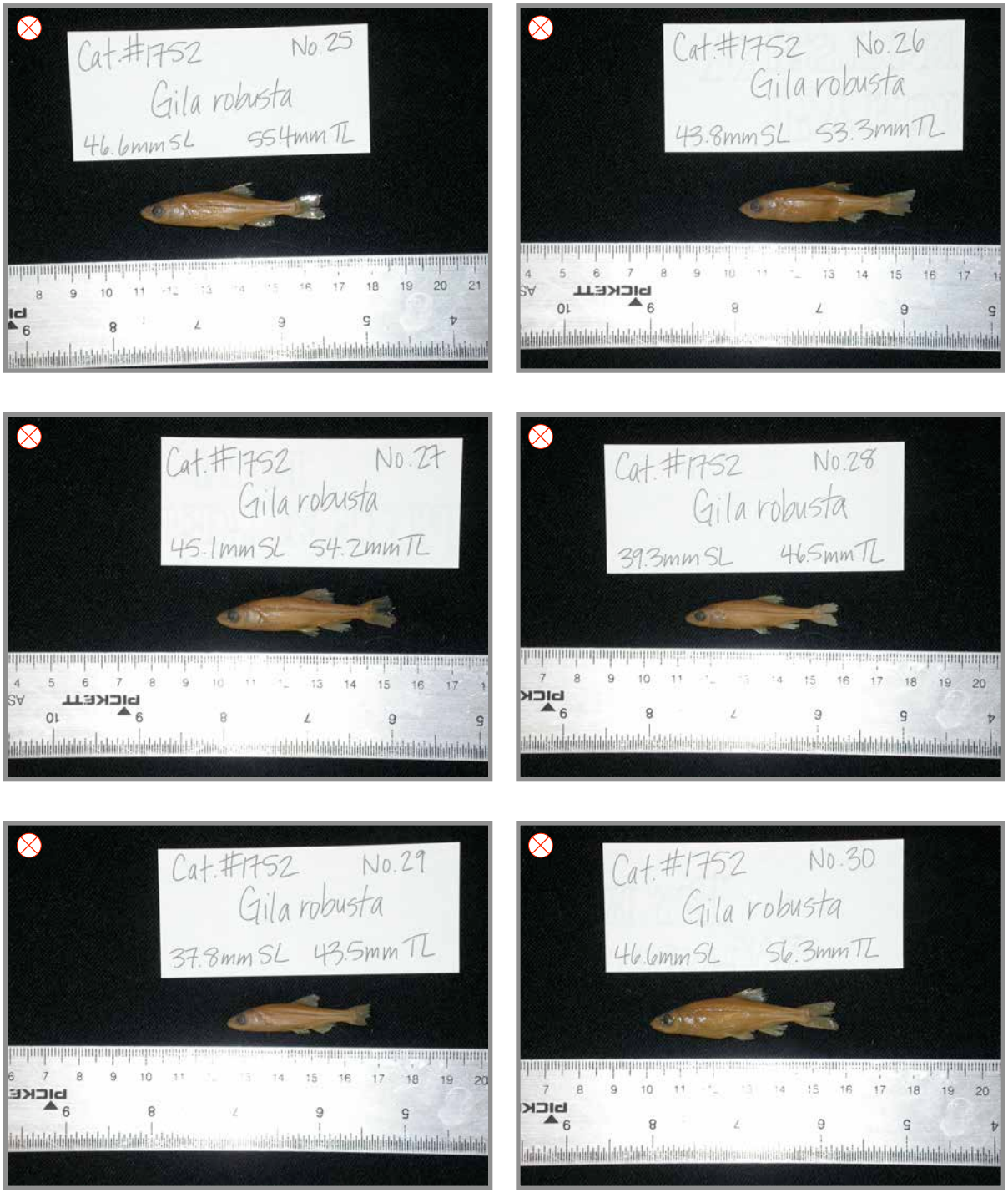


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

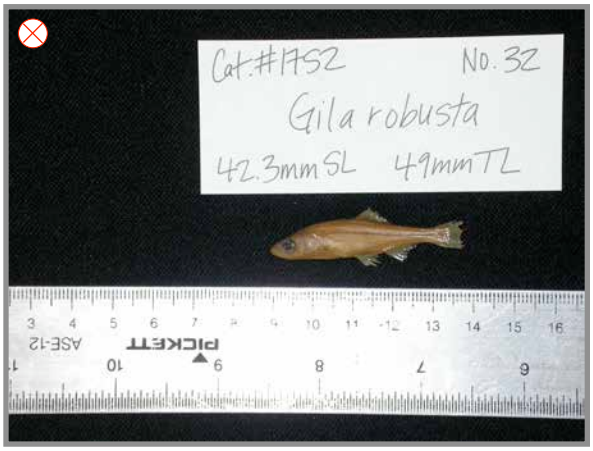
= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.



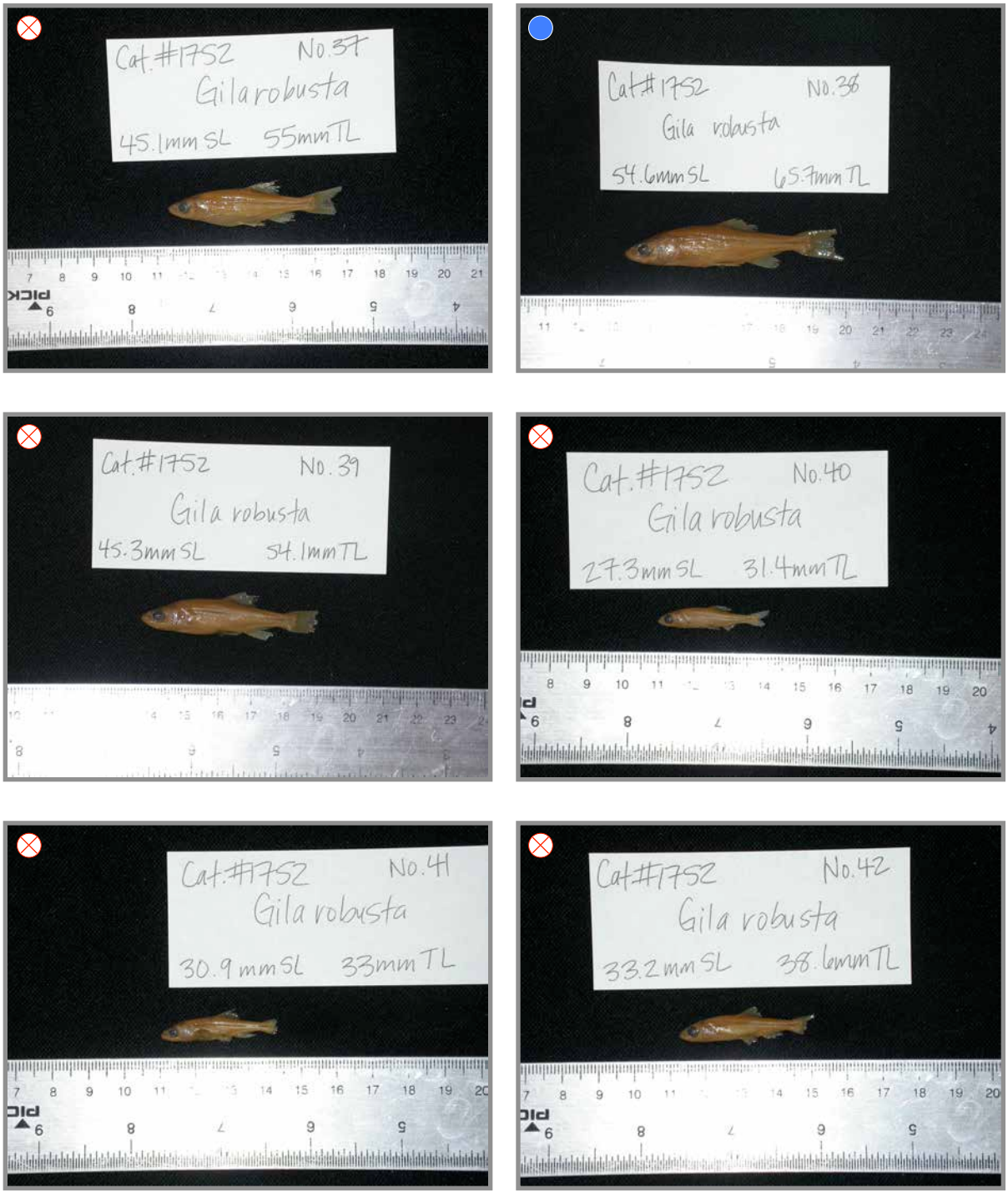
= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

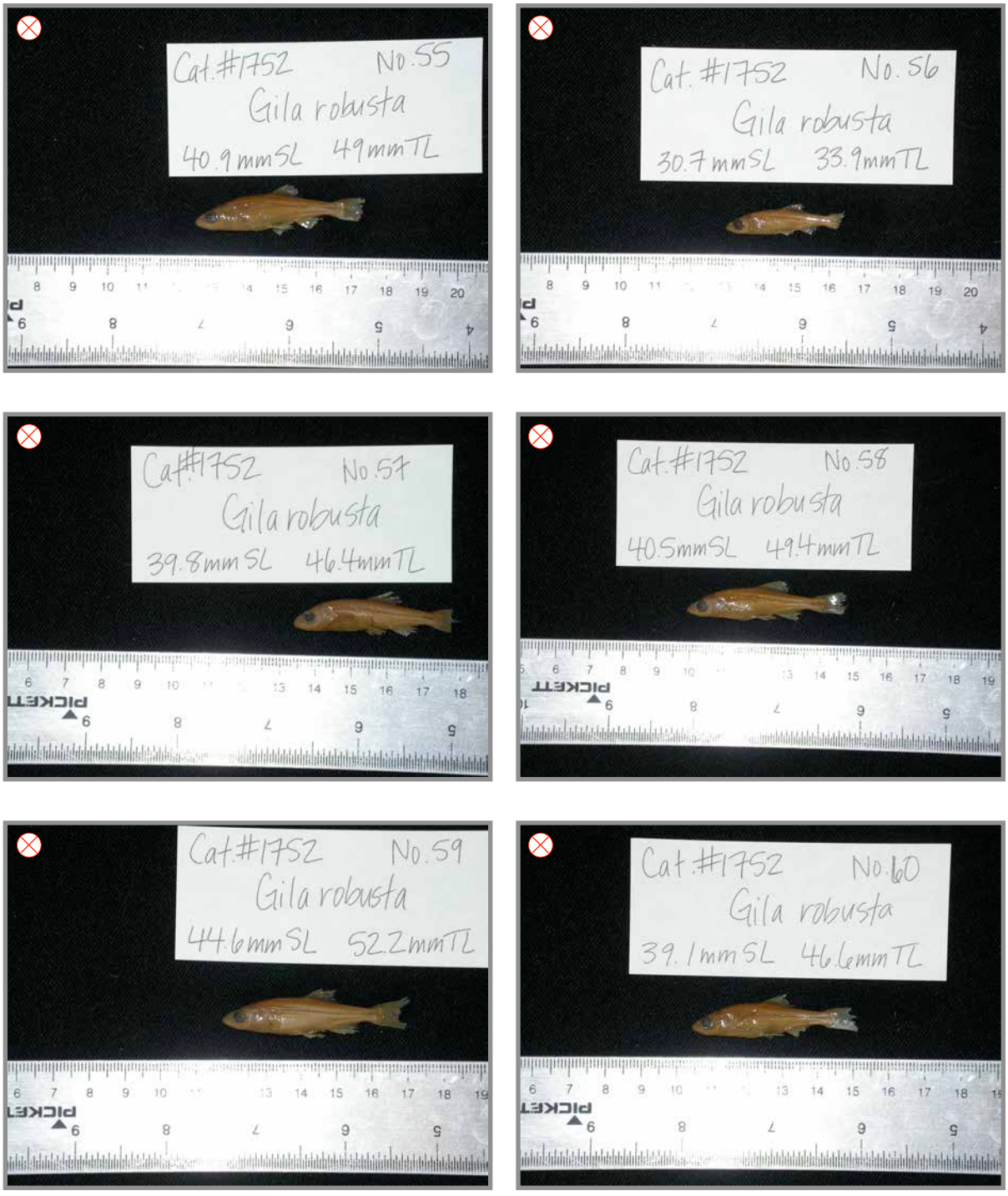
MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

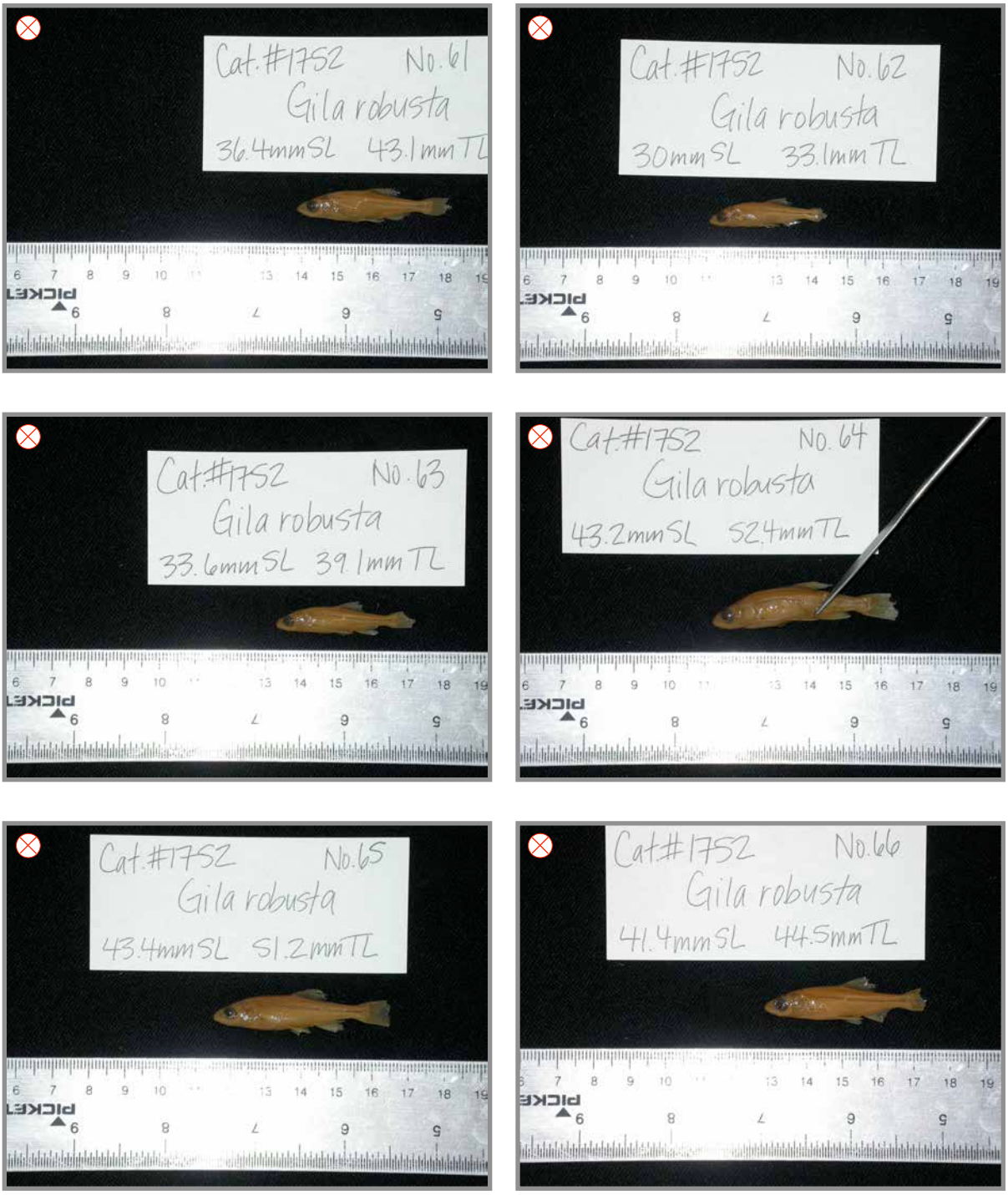
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

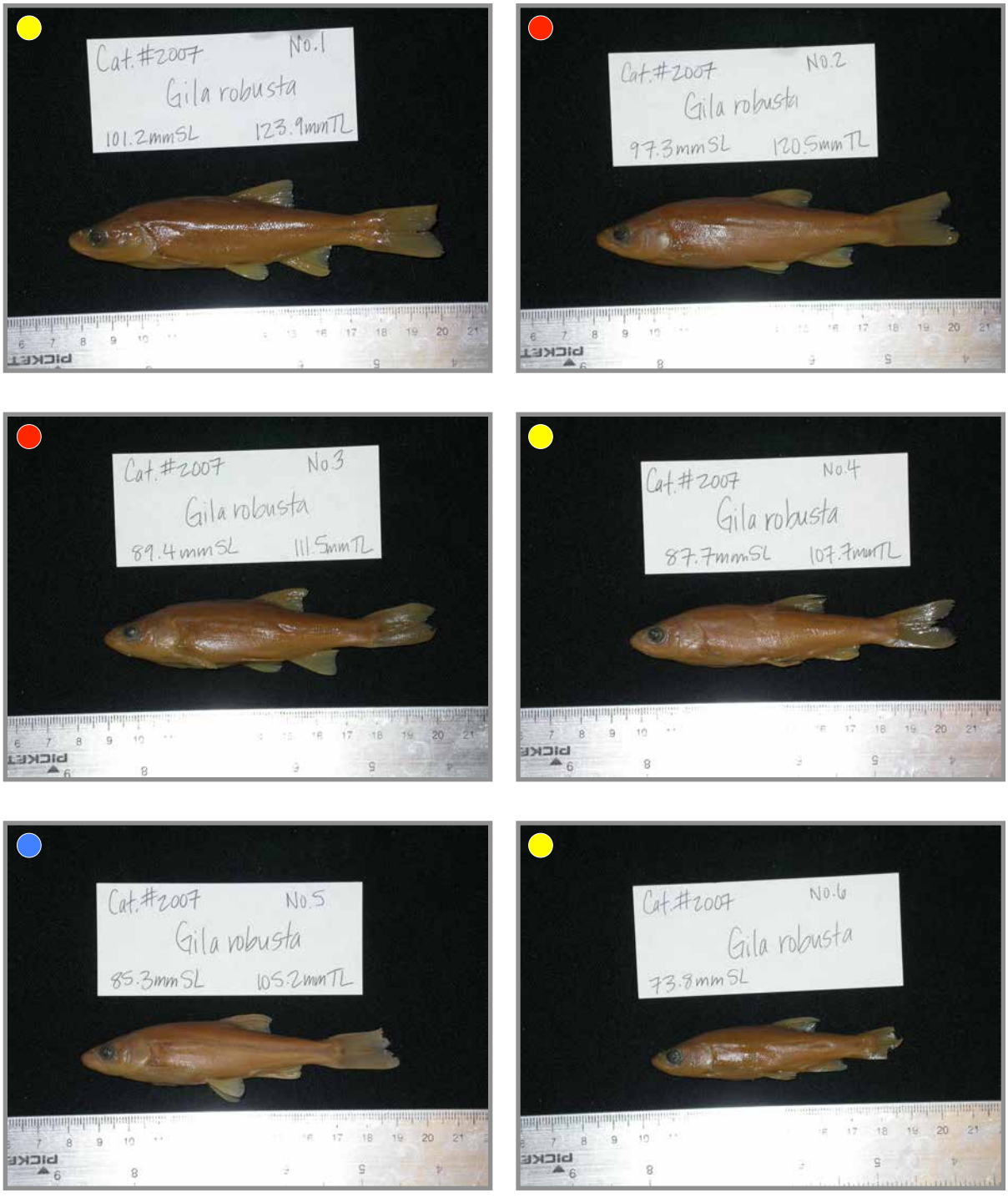


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.

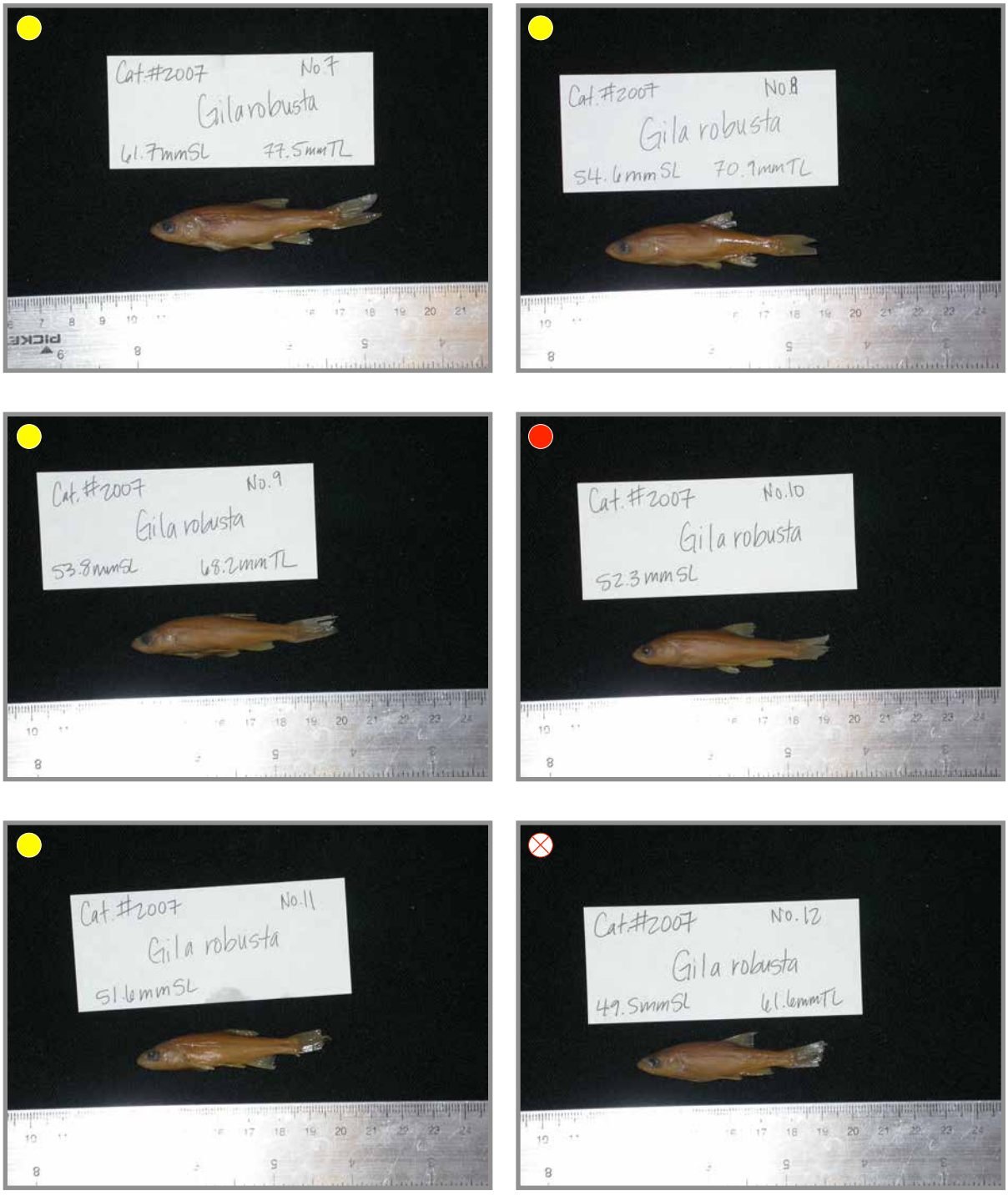
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 1752. New Mexico, Grant County, Gila River, ca. 7.0 miles northeast of Gila, on NM State HWY 153. W.J. Koster and K.R. Coburn. 27 August 1949. n = 70.



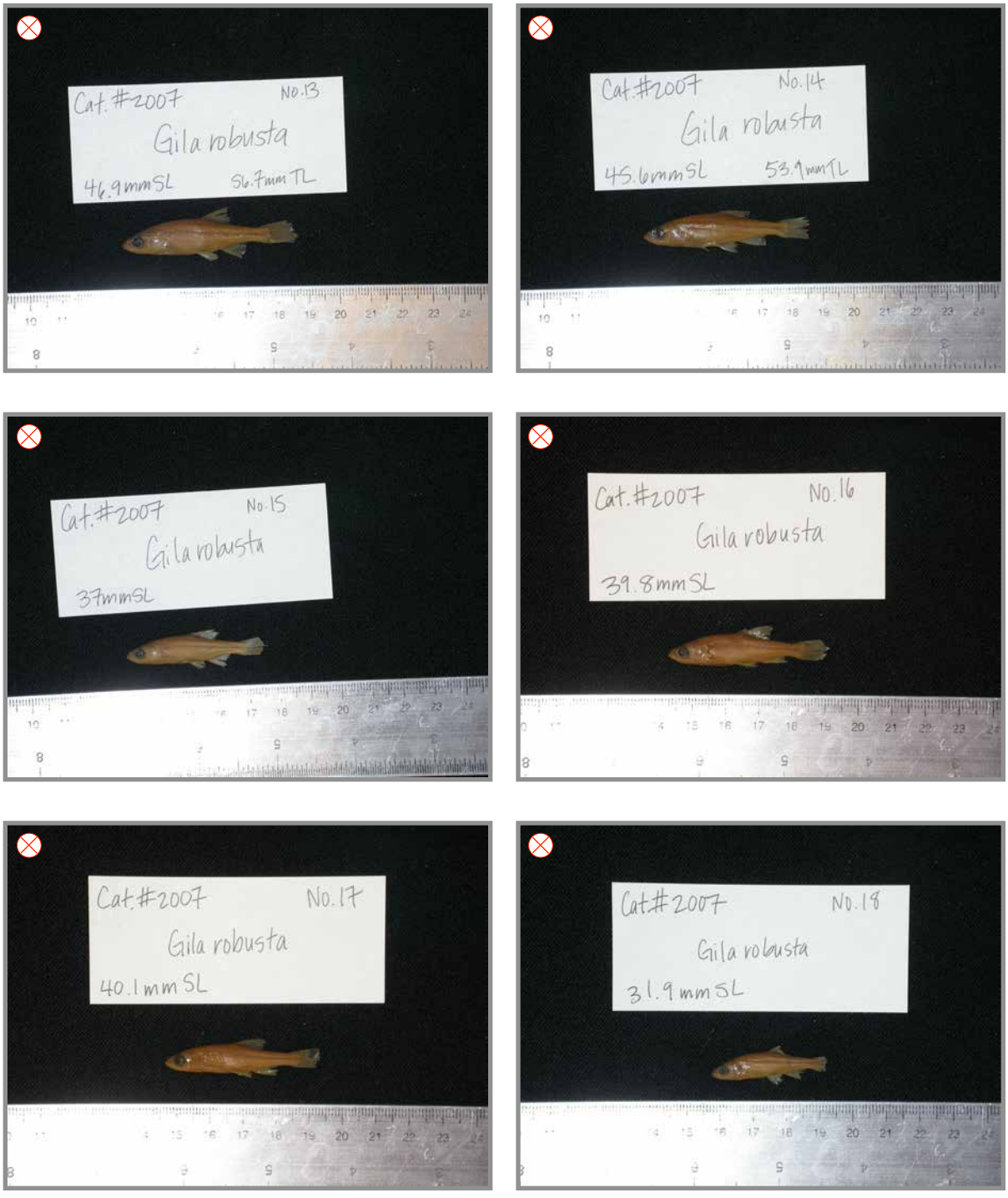
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 2007. New Mexico, Catron County, Beaver Creek, ca. junction of Forest Road 150 and NM State HWY 59, Gila National Forest. W.J. Koster and K.R. Coburn. 4 September 1949. n = 19.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 2007. New Mexico, Catron County, Beaver Creek, ca. junction of Forest Road 150 and NM State HWY 59, Gila National Forest. W.J. Koster and K.R. Coburn. 4 September 1949. n = 19.



= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 2007. New Mexico, Catron County, Beaver Creek, ca. junction of Forest Road 150 and NM State HWY 59, Gila National Forest. W.J. Koster and K.R. Coburn. 4 September 1949. n = 19.

⊗ = specimen <50 mm SL; species not determined

MSB 2007. New Mexico, Catron County, Beaver Creek, ca. junction of Forest Road 150 and NM State HWY 59, Gila National Forest. W.J. Koster and K.R. Coburn. 4 September 1949. n = 19.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 2010. New Mexico, Grant County, Gila River, at Red Rock, on NM State HWY 464. W.J. Koster and K.R. Coburn. 24 August 1949. n = 6.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 2624. New Mexico, Grant County, East Fork Gila River, 0.25 mile below Lyons Hunting Lodge Hot Spring, ca. 2.5 miles upstream from West Fork Gila River. G.C. Kobetich, J. White, and S. Henry. 8 October 1966 n = 1.

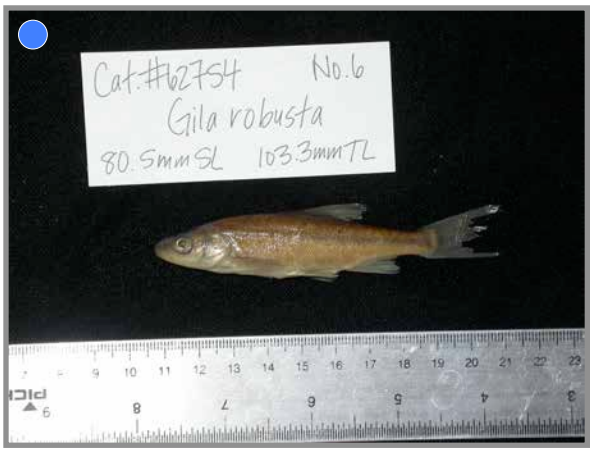
MSB 2767. New Mexico, Grant County, East Fork Gila River, 0.25 mile below Lyons Hunting Lodge Hot Spring, ca. 2.5 miles upstream from West Fork Gila River. G.C. Kobetich. 20 August 1966 n = 2.

= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 3130. New Mexico, Grant County, East Fork Gila River, 0.25 mile below Lyons Hunting Lodge Hot Spring, ca. 2.5 miles upstream from West Fork Gila River. G.C. Kobetich. 28 October 1965 n = 1.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 49890. New Mexico, Grant County, Turkey Creek, Gila Wilderness, Gila National Forest. J.A. Monzingo, R.D. Ward, K.C. Ward, and G.S. Jimenez. 27 June 2001. n = 5.

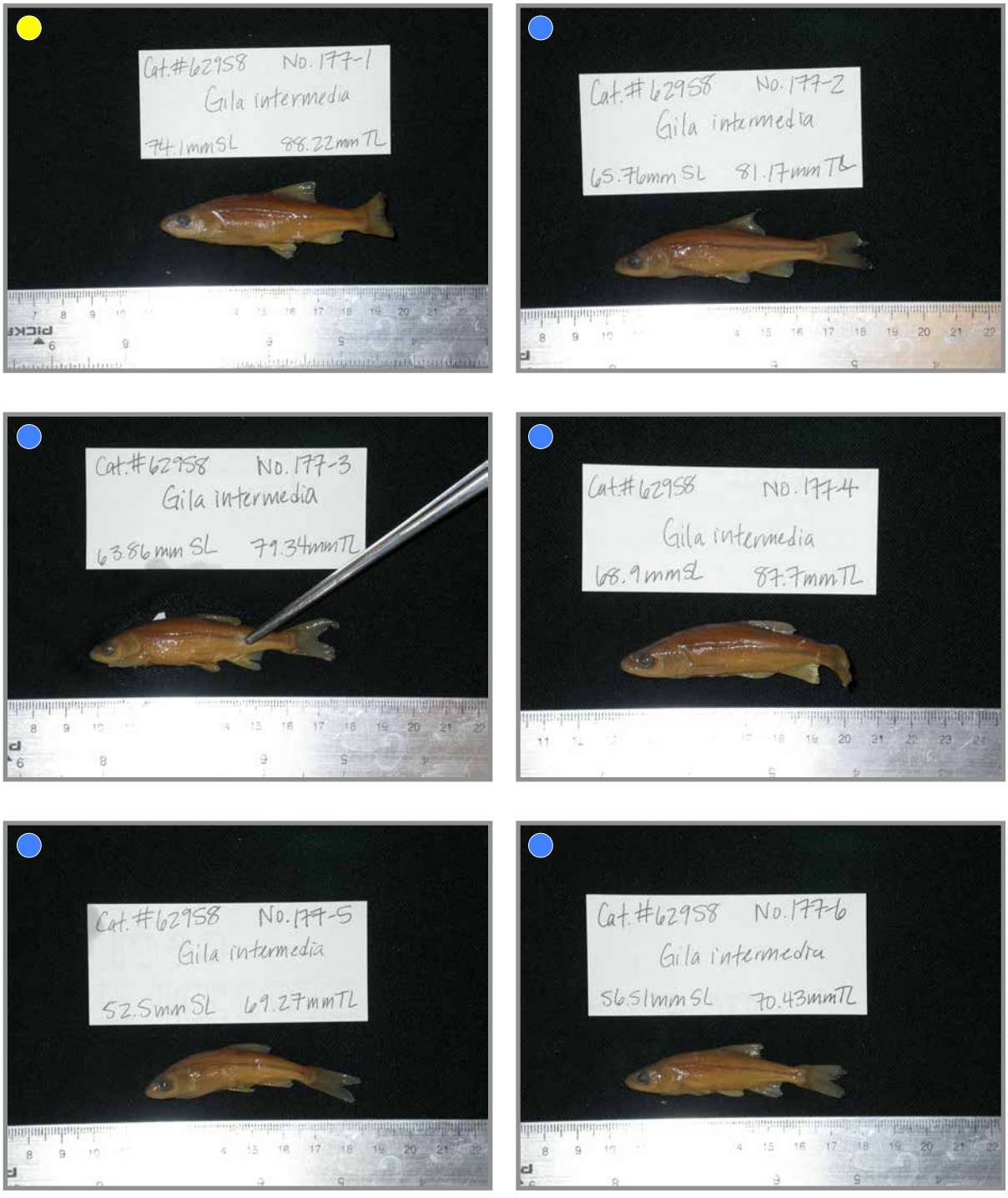


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 62754. New Mexico, Grant County, Turkey Creek, ca. 0.1 kilometers upstream of a hot springs, Gila Wilderness, Gila National Forest. D.L. Propst. 5 May 1983. n = 10.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 62754. New Mexico, Grant County, Turkey Creek, ca. 0.1 kilometers upstream of a hot springs, Gila Wilderness, Gila National Forest. D.L. Propst. 5 May 1983. n = 10.

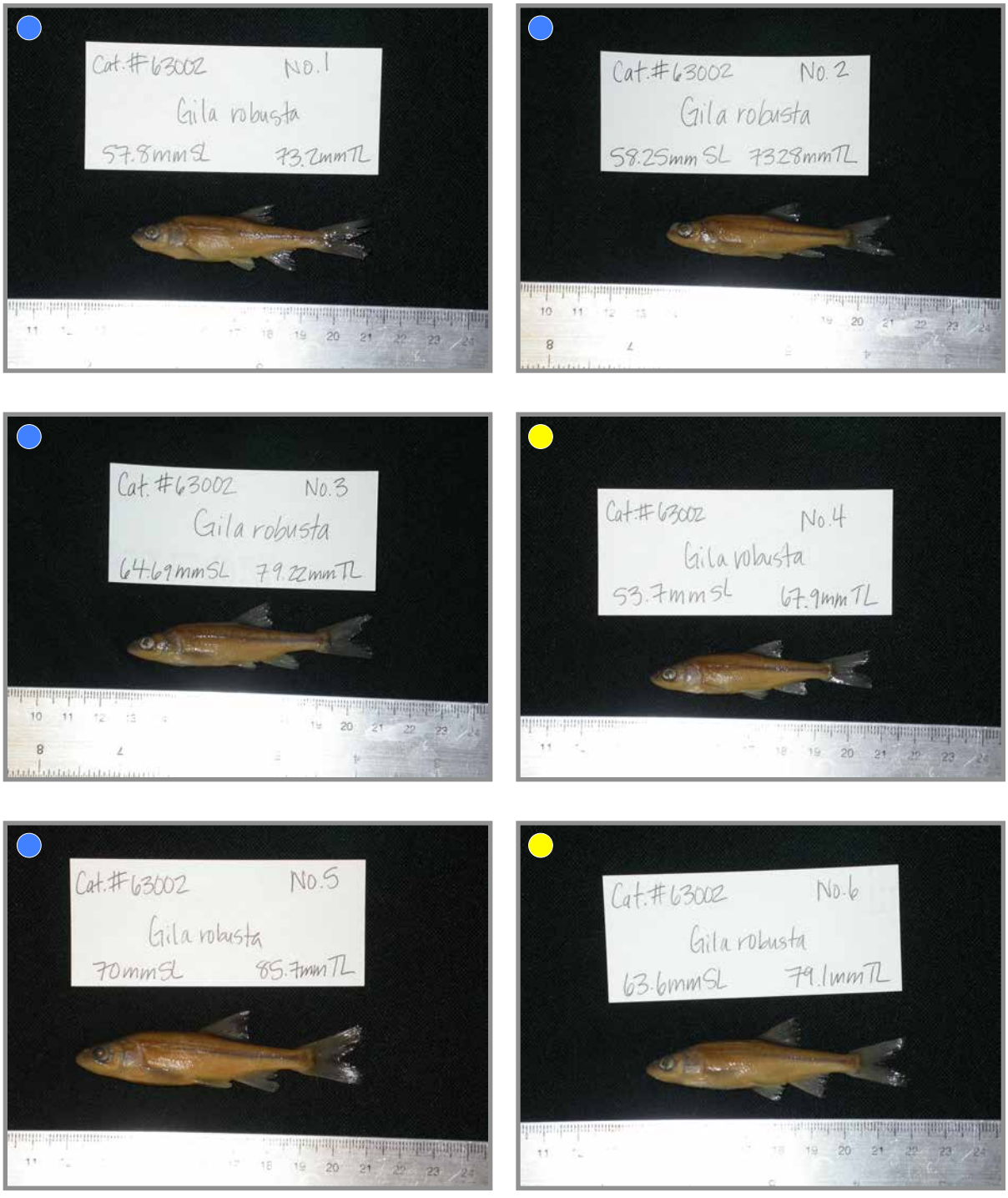


= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 62958. New Mexico, Grant County, Turkey Creek, ca. 0.5 kilometers downstream of confluence with Sycamore Canyon. D.L. Propst and K.R. Bestgen. 5 July 1983. n = 10.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 62958. New Mexico, Grant County, Turkey Creek, ca. 0.5 kilometers downstream of confluence with Sycamore Canyon. D.L. Propst and K.R. Bestgen. 5 July 1983. n = 10.

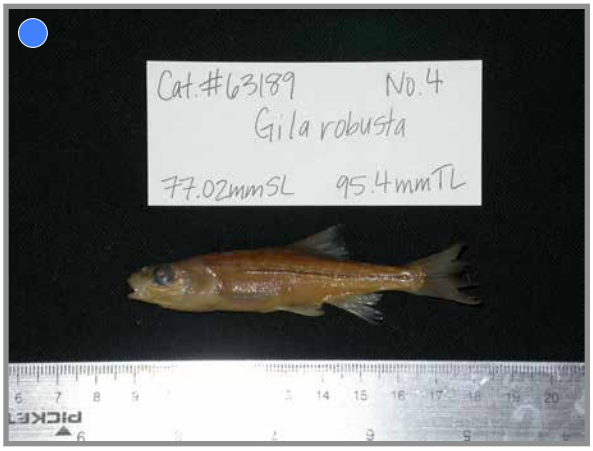


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 63002. New Mexico, Grant County, Turkey Creek, ca. 0.8 kilometers downstream of hot springs, Gila Wilderness, Gila National Forest. D.L.Propst. 7 September 1983. n = 11.

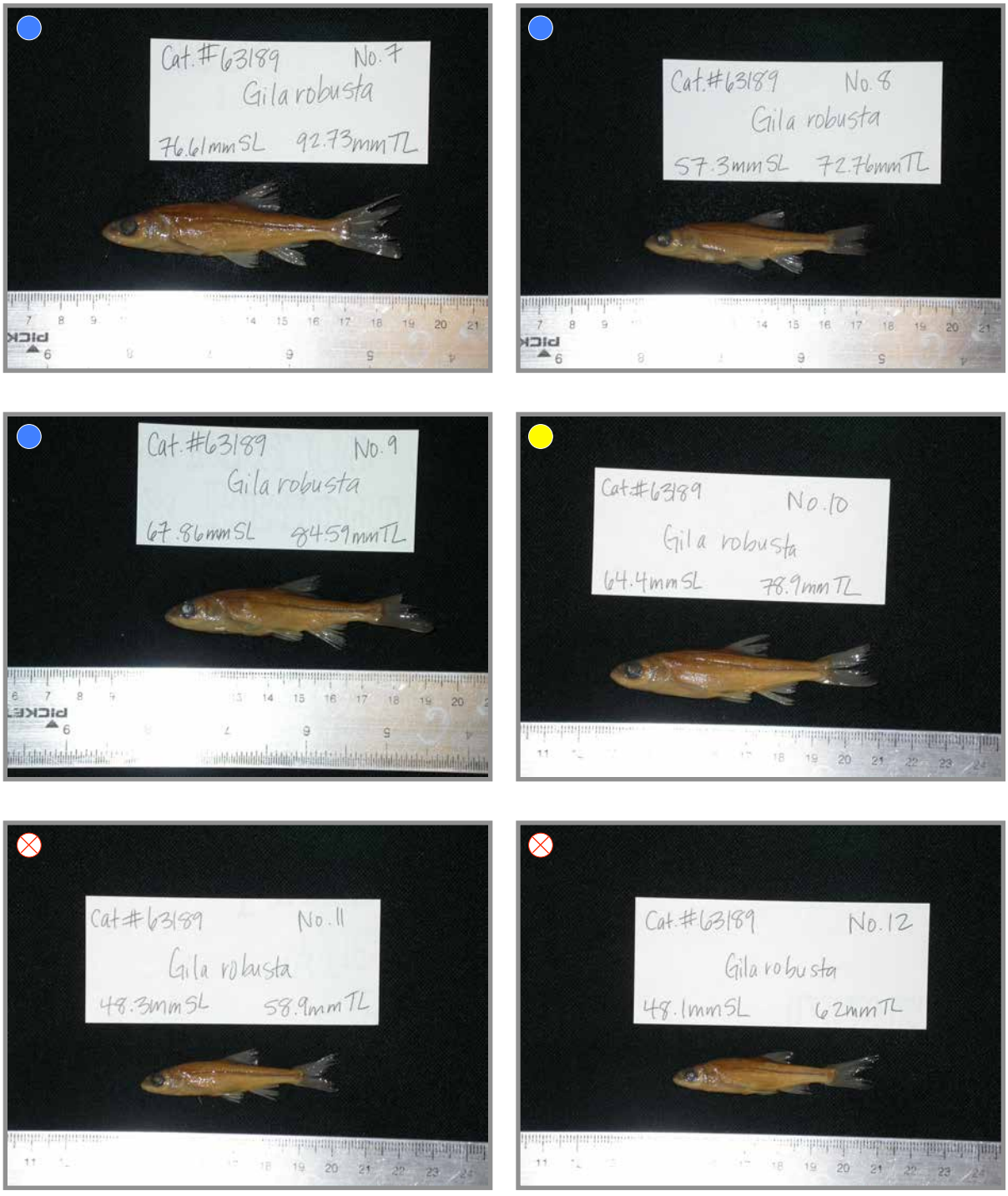
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 63002. New Mexico, Grant County, Turkey Creek, ca. 0.8 kilometers downstream of hot springs, Gila Wilderness, Gila National Forest. D.L.Propst. 7 September 1983. n = 11.



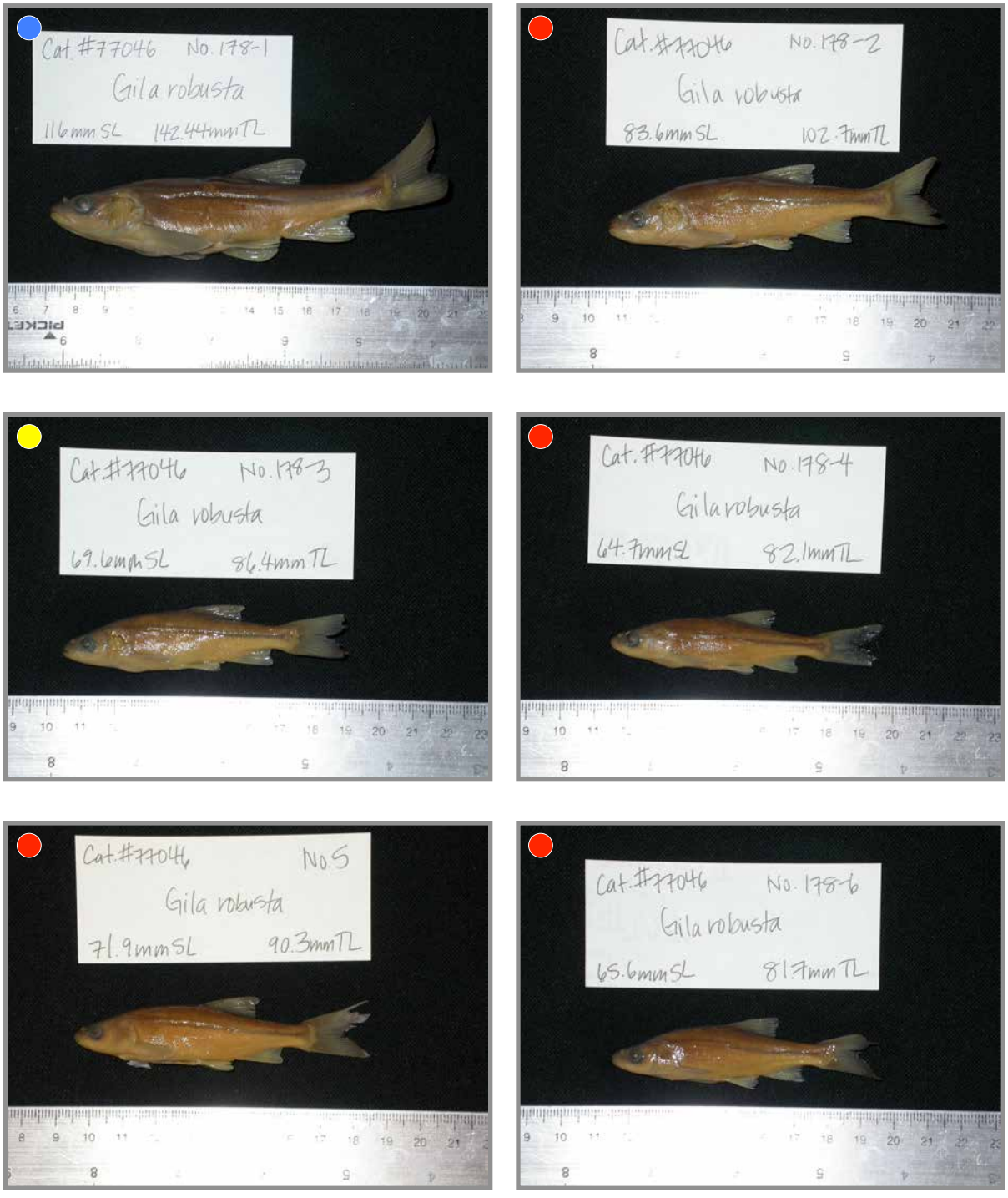
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 63189. New Mexico, Grant County, Turkey Creek, below hot springs, Gila Wilderness, Gila National Forest. D.L. Propst. 12 November 1983. n = 12.



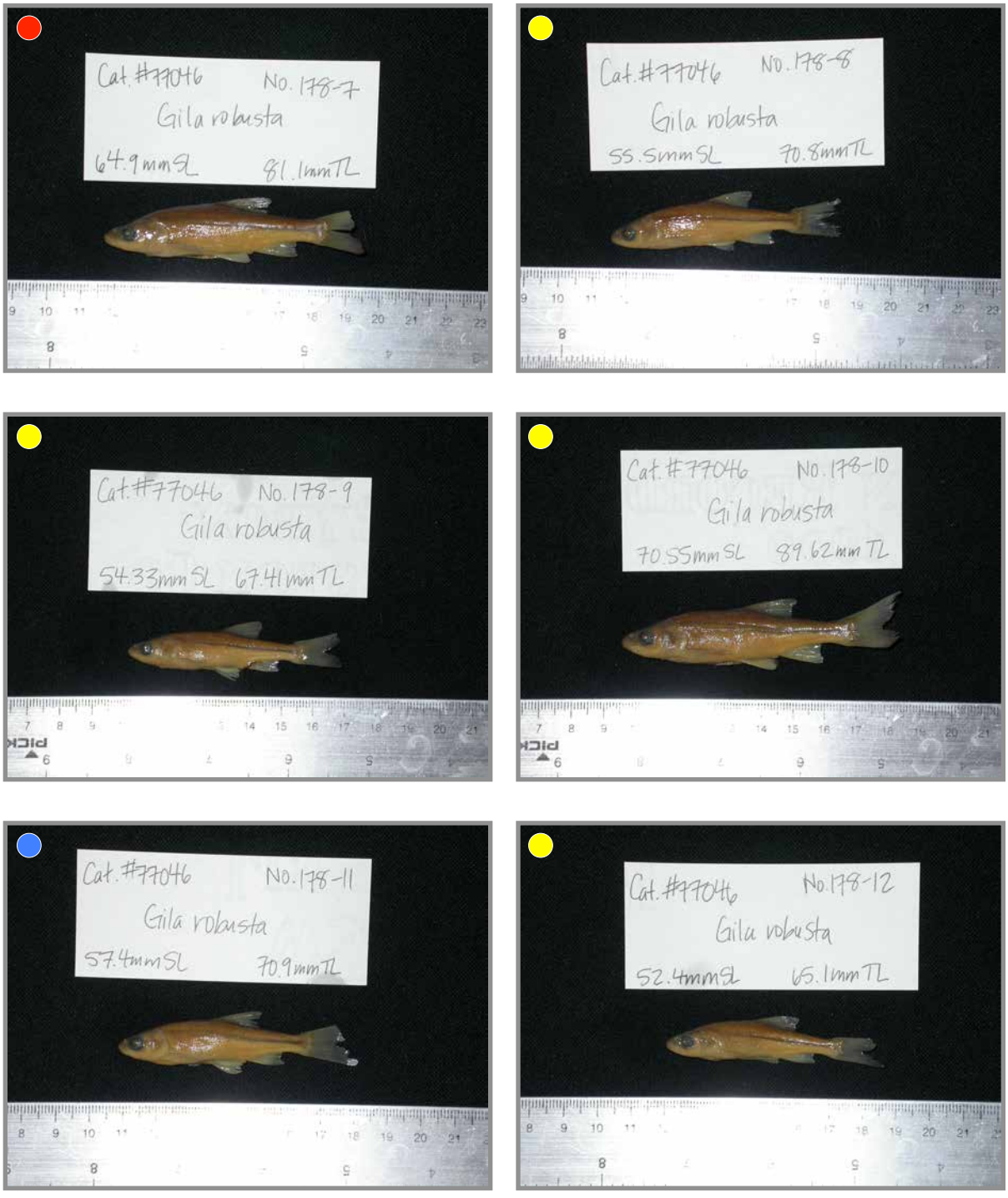
= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

MSB 63189. New Mexico, Grant County, Turkey Creek, below hot springs, Gila Wilderness, Gila National Forest. D.L. Propst. 12 November 1983. n = 12.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77046. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst and K.R. Bestgen. 5 July 1983. n = 16.

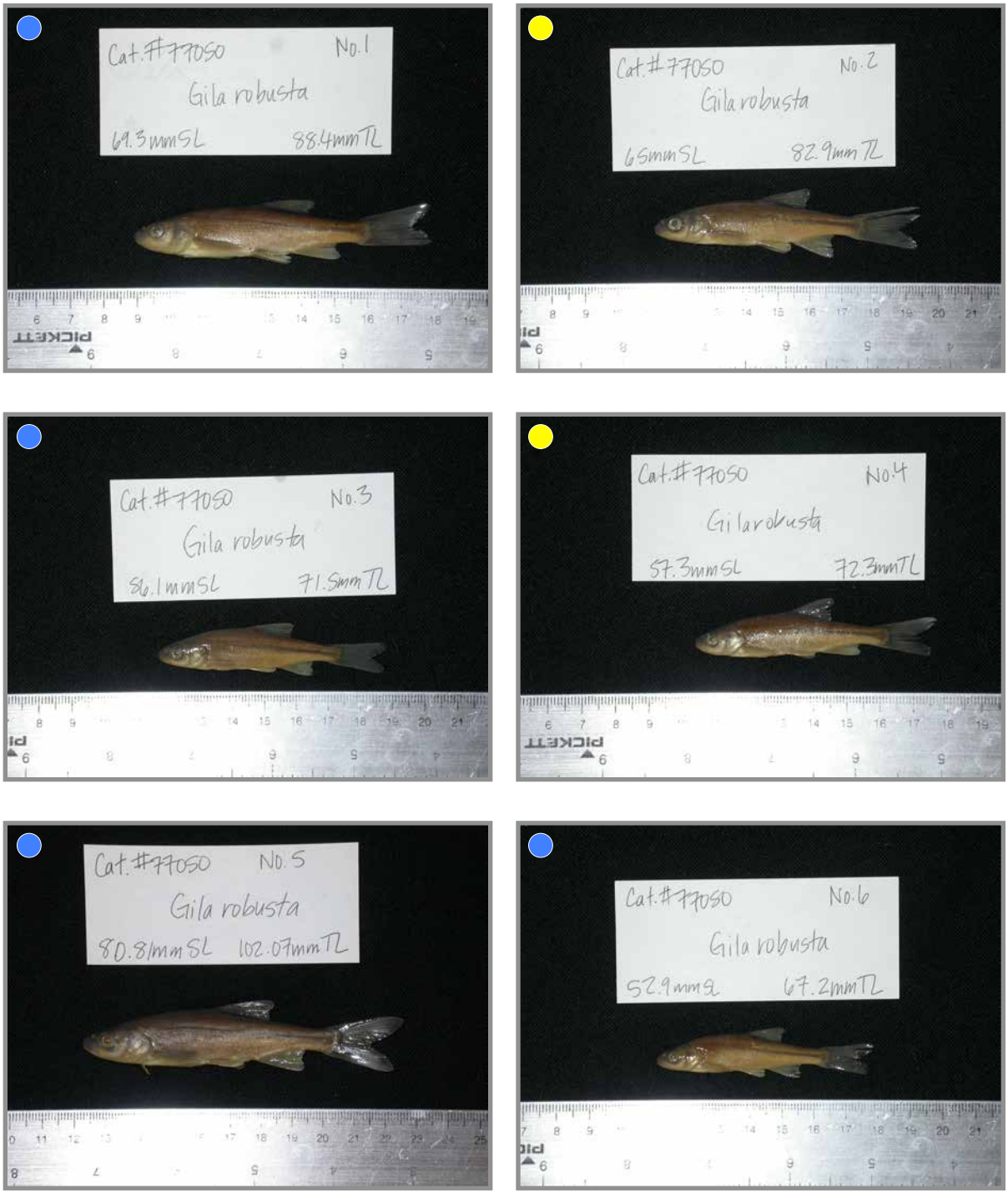


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77046. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst and K.R. Bestgen. 5 July 1983. n = 16.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77046. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst and K.R. Bestgen. 5 July 1983. n = 16.

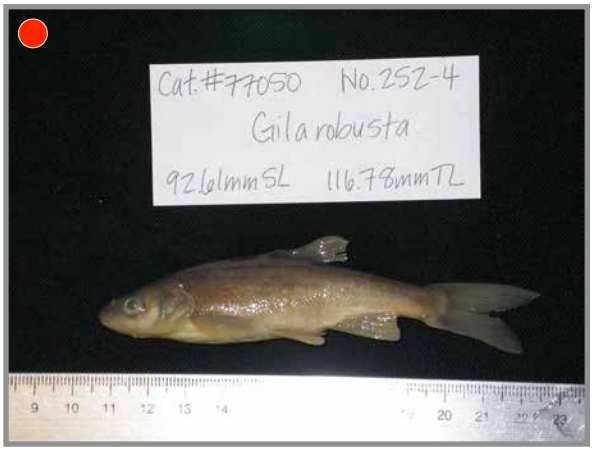


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.

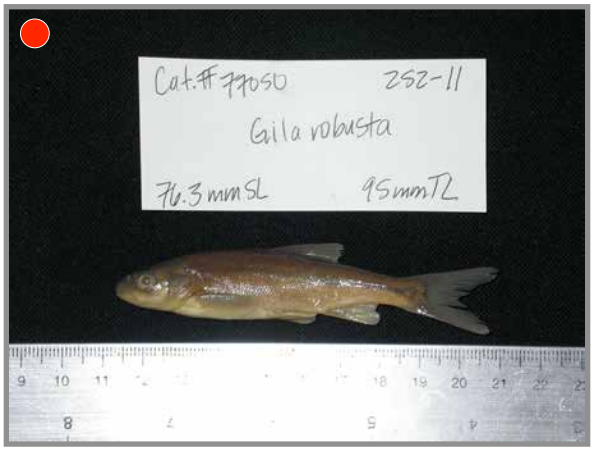
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
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MSB 77050. New Mexico, Grant County, Turkey Creek, at hot springs, Gila Wilderness. D.L. Propst, K.R. Bestgen, C.W. Painter, and J.A. Fowler. 30 January 1984. n = 38.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 110434. New Mexico, Catron County, Taylor Creek, near road between Beaverhead and Silver City, Gila National Forest; Gila River system. C.M. Tarzwell.. 16 August 1935. n = 7.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

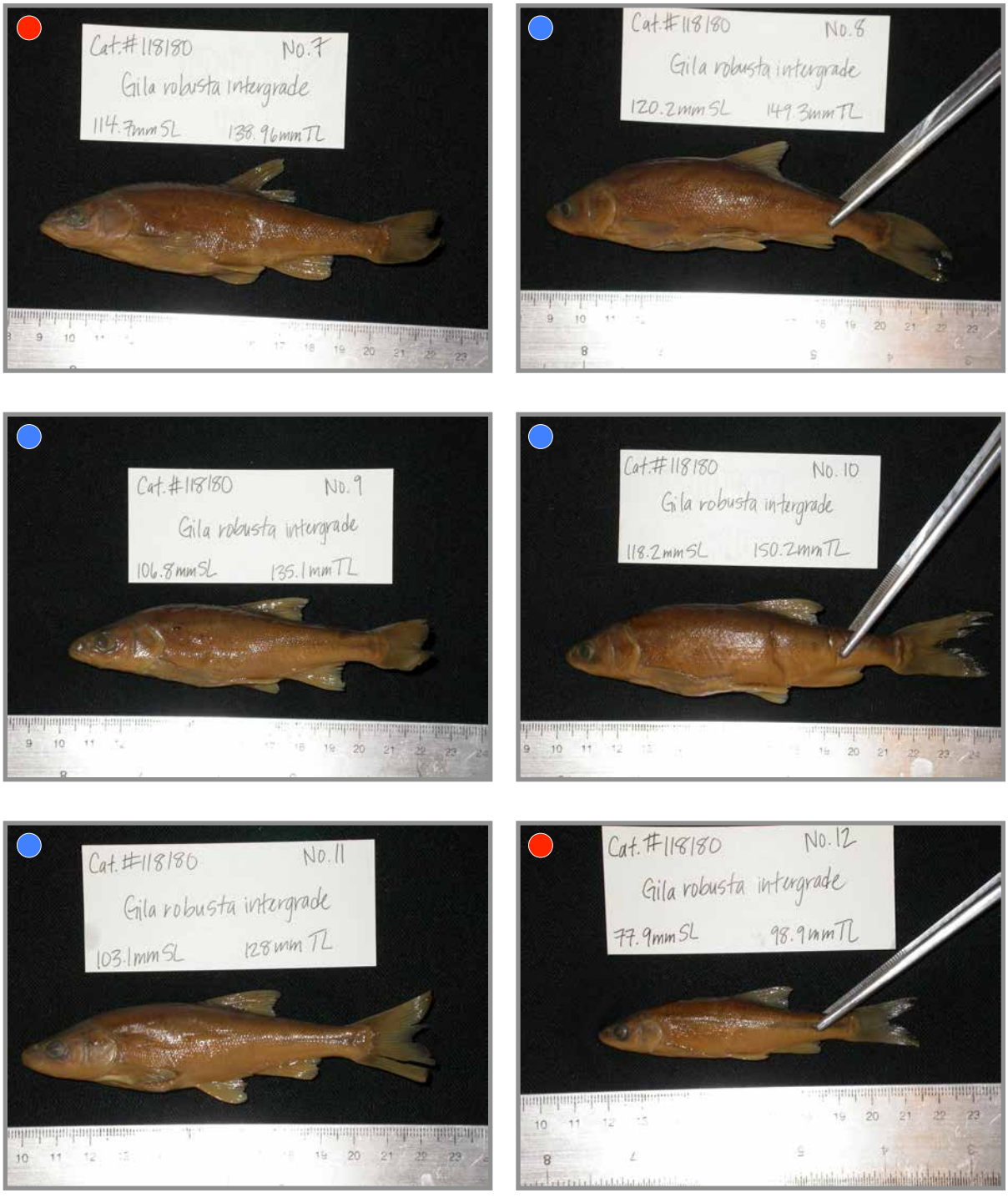
UMMZ 110434. New Mexico, Catron County, Taylor Creek, near road between Beaverhead and Silver City, Gila National Forest; Gila River system. C.M. Tarzwell..
16 August 1935. n = 7.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 113528. New Mexico, Catron County, Beaver Creek, at jct of Beaver Creek and Taylor Creek, Gila National Forest, 90 mi S of Magdalena; Gila drainage. M.A. Gee. 17 March 1936. n = 2.

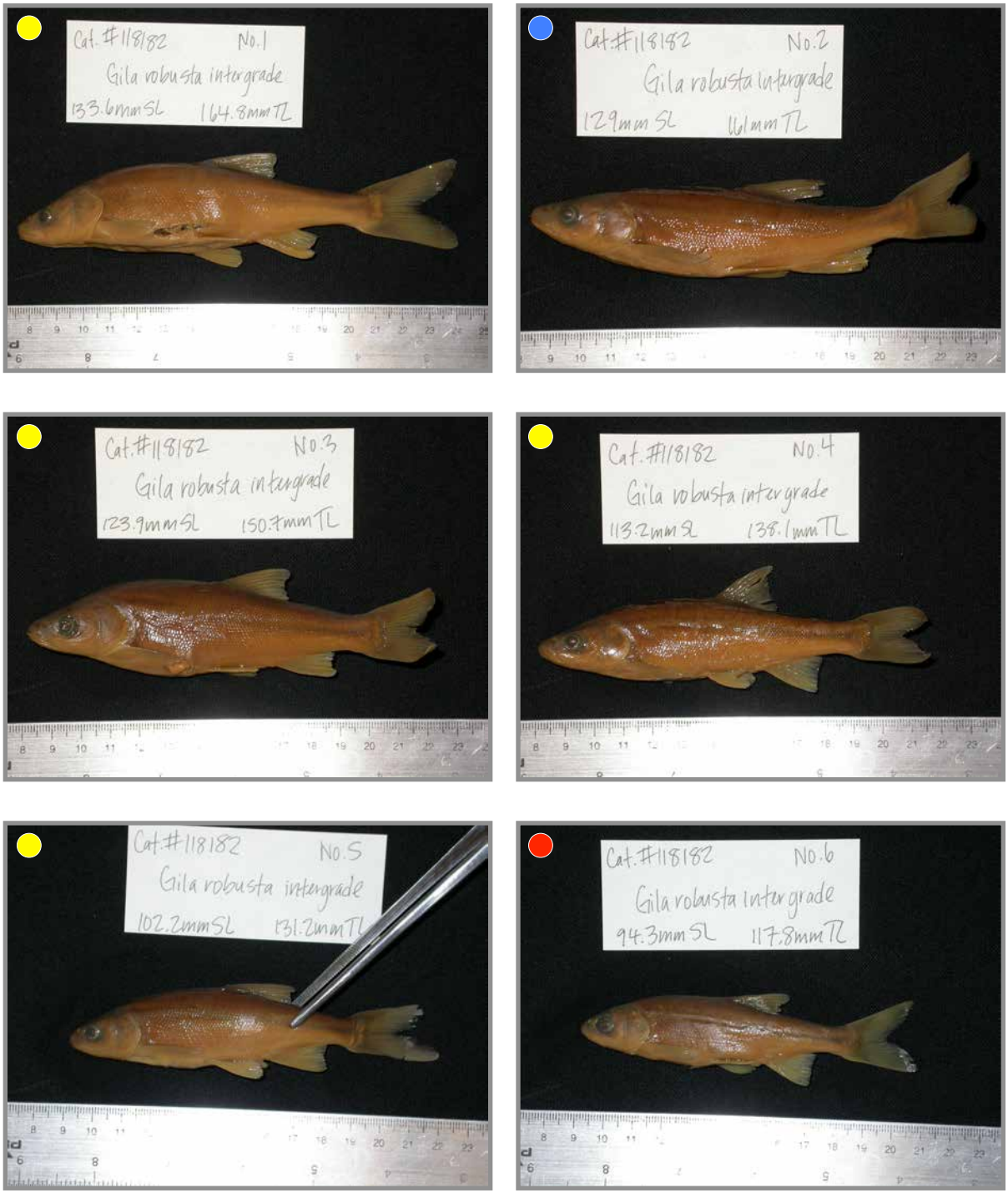
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 118180. New Mexico, Catron County, Taylor Creek, tributary to East Fork of the Gila River. M.A. Gee and Carr. 26 August 1937. n = 12.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 118180. New Mexico, Catron County, Taylor Creek, tributary to East Fork of the Gila River. M.A. Gee and Carr. 26 August 1937. n = 12.

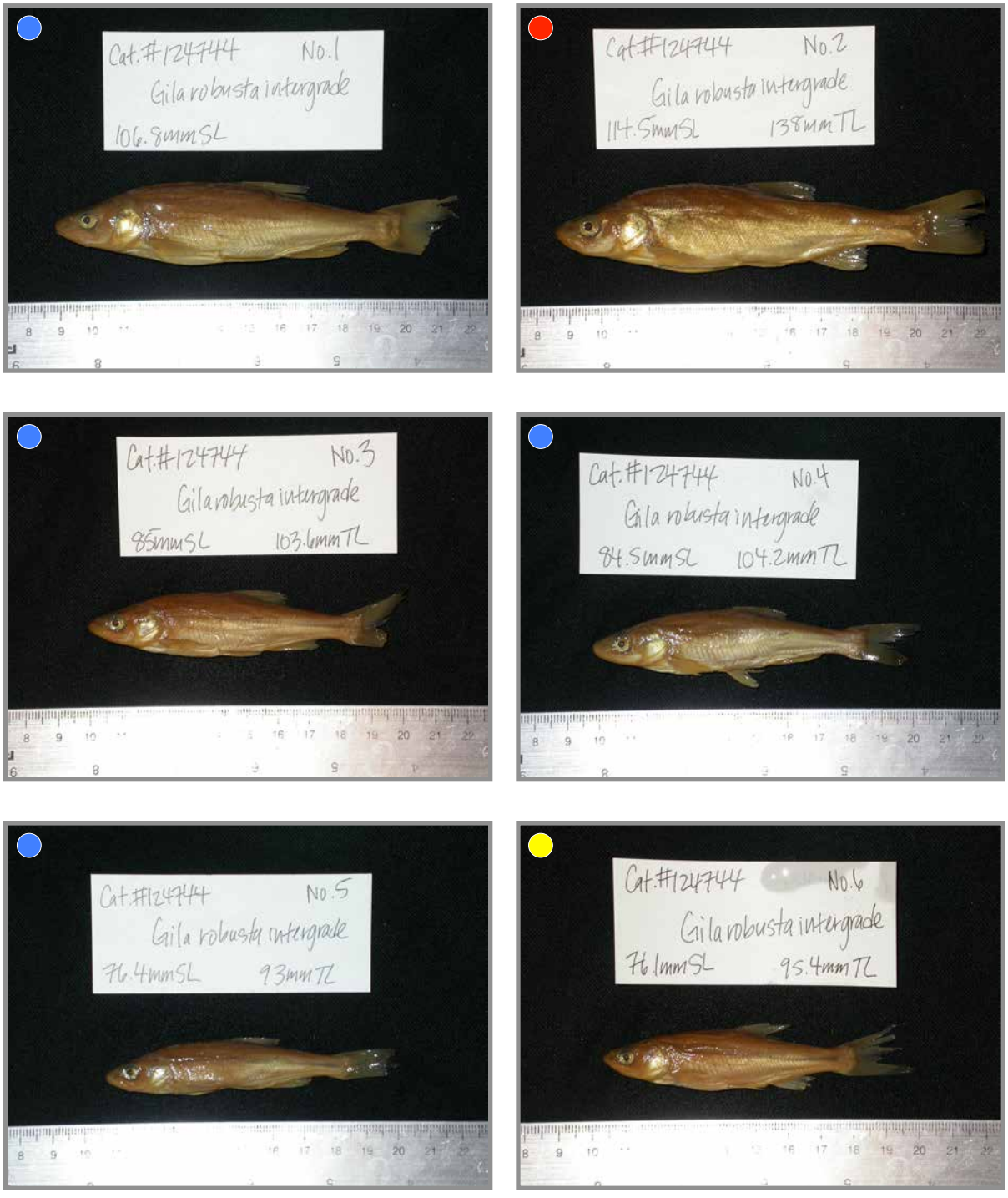


● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 118182. New Mexico, Catron County, Beaver Creek, tributary to East Fork of the Gila River, Gila River drainage. M.A. Gee and Carr. 27 August 1937. n = 9.

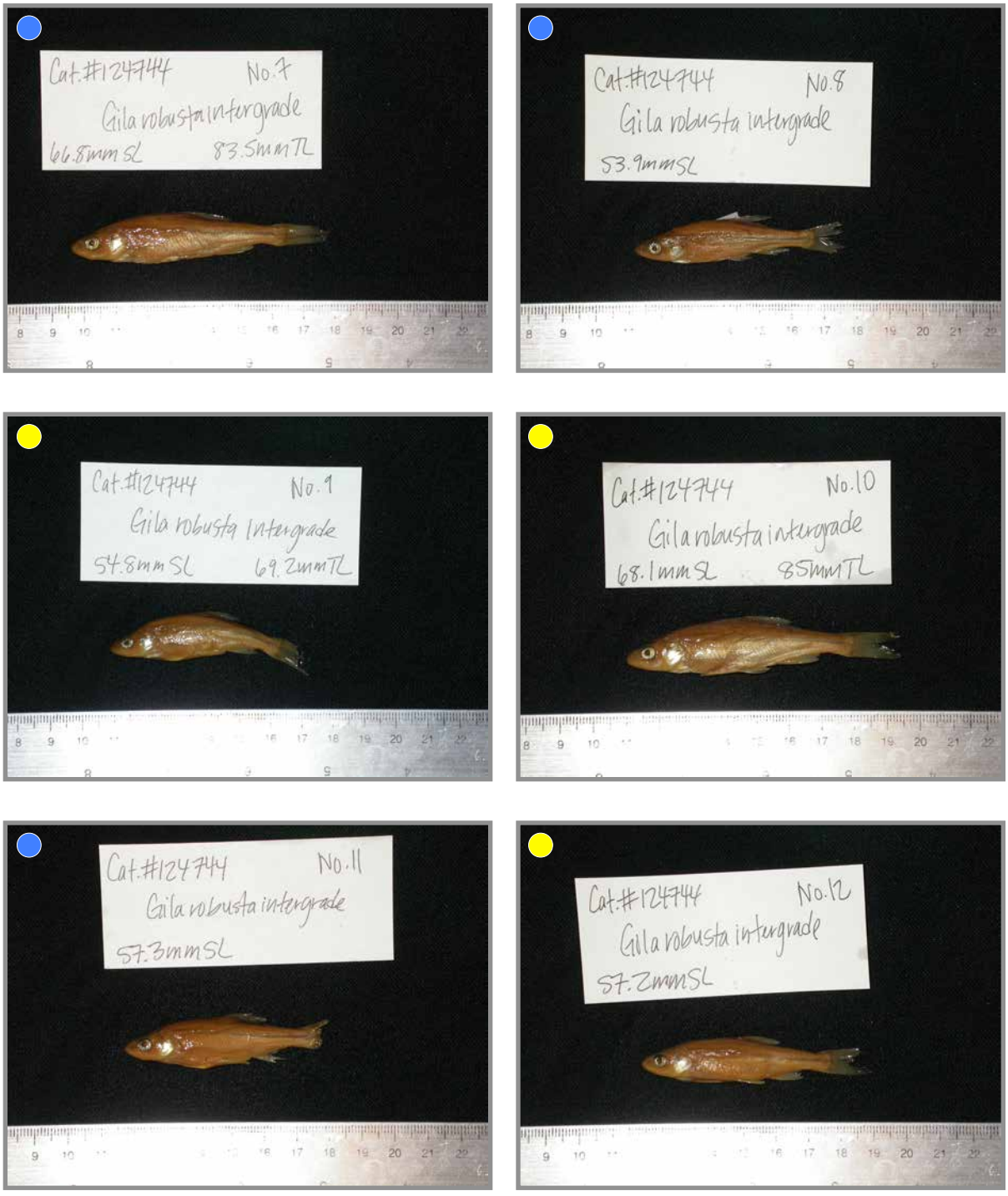
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 118182. New Mexico, Catron County, Beaver Creek, tributary to East Fork of the Gila River, Gila River drainage. M.A. Gee and Carr. 27 August 1937. n = 9.



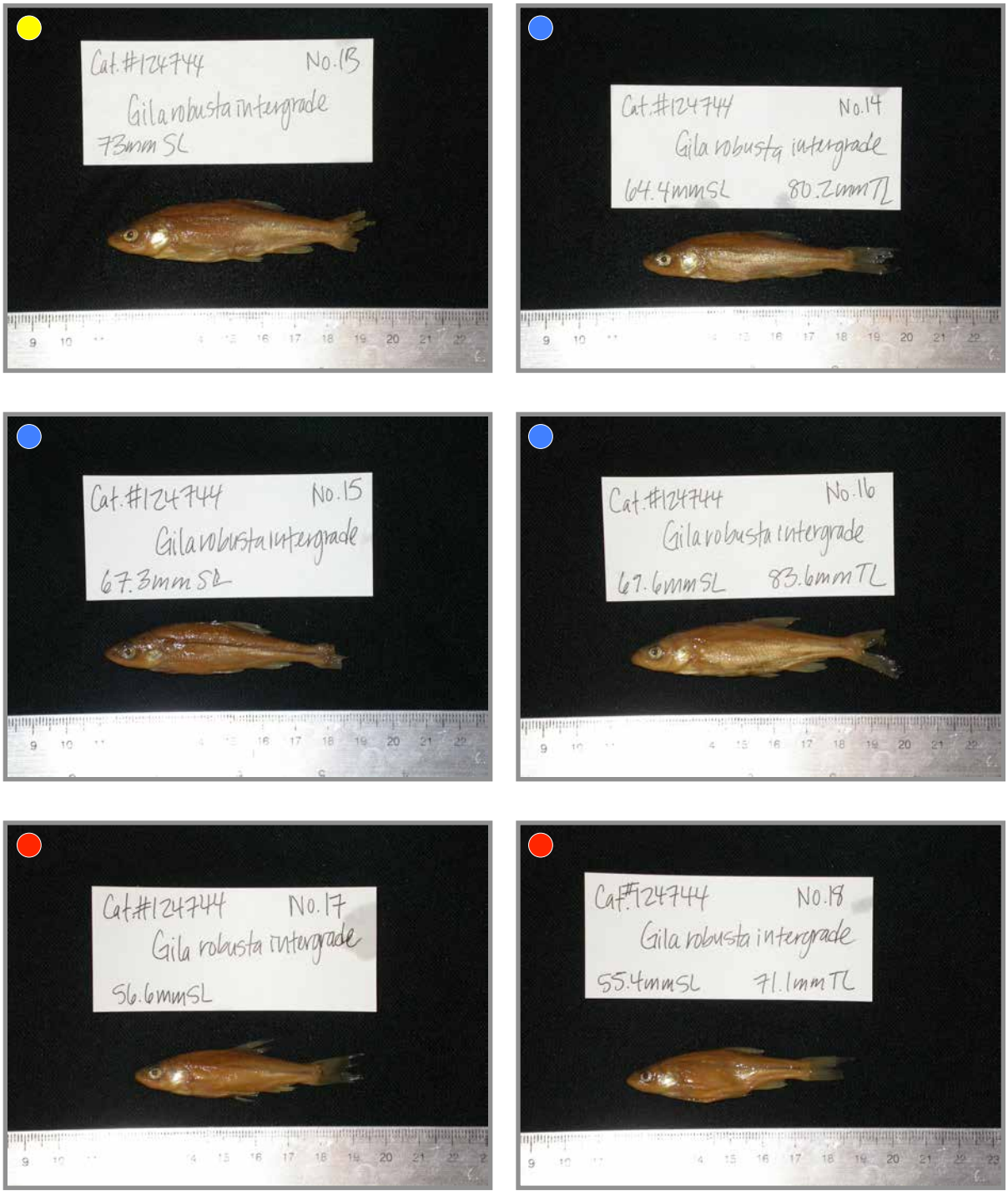
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 124744. New Mexico, Grant County, Gila River, on US 260, at Cliff. Hubbs family. 30 June 1938. n = 27.



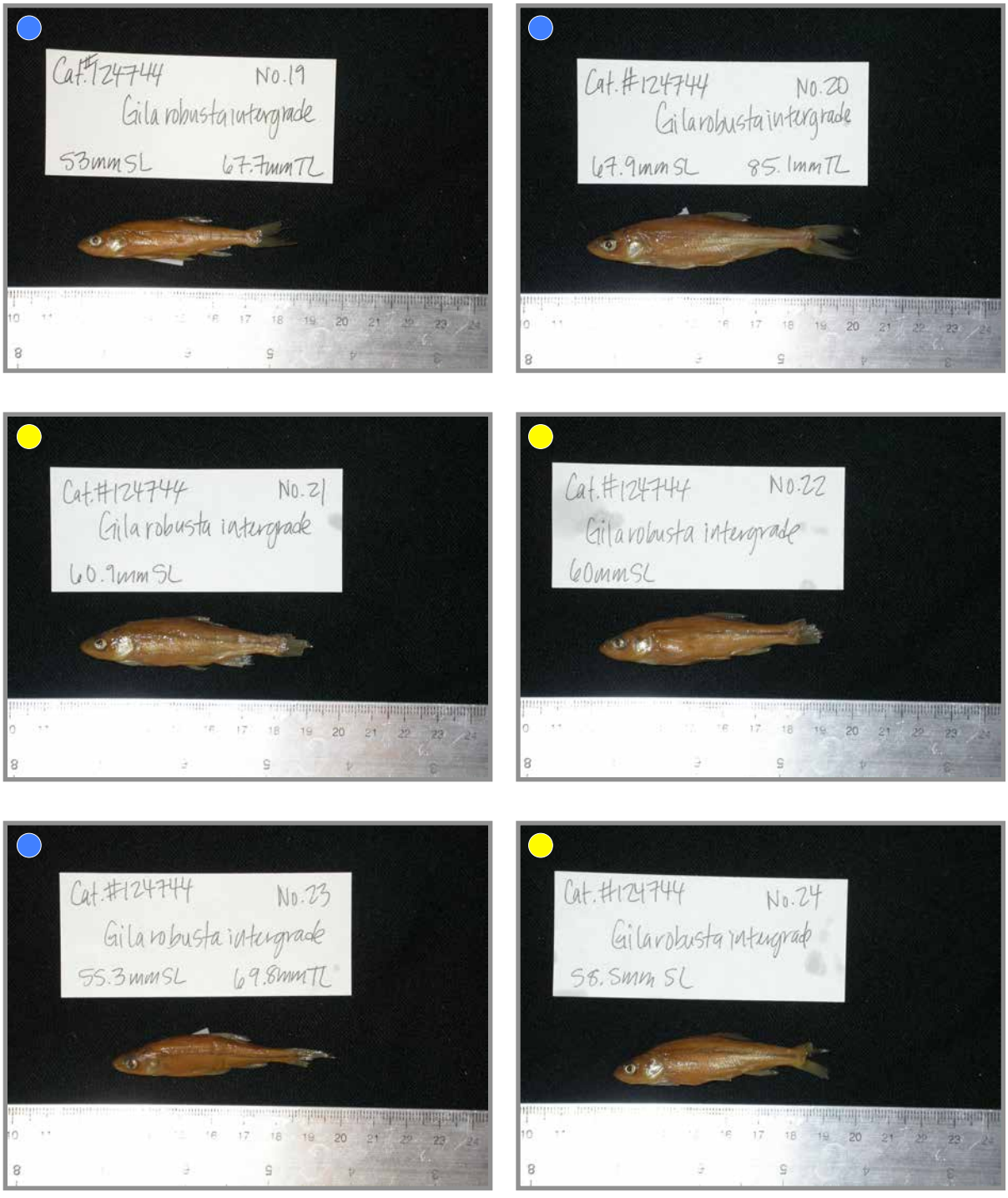
● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 124744. New Mexico, Grant County, Gila River, on US 260, at Cliff. Hubbs family. 30 June 1938. n = 27.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 124744. New Mexico, Grant County, Gila River, on US 260, at Cliff. Hubbs family. 30 June 1938. n = 27.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

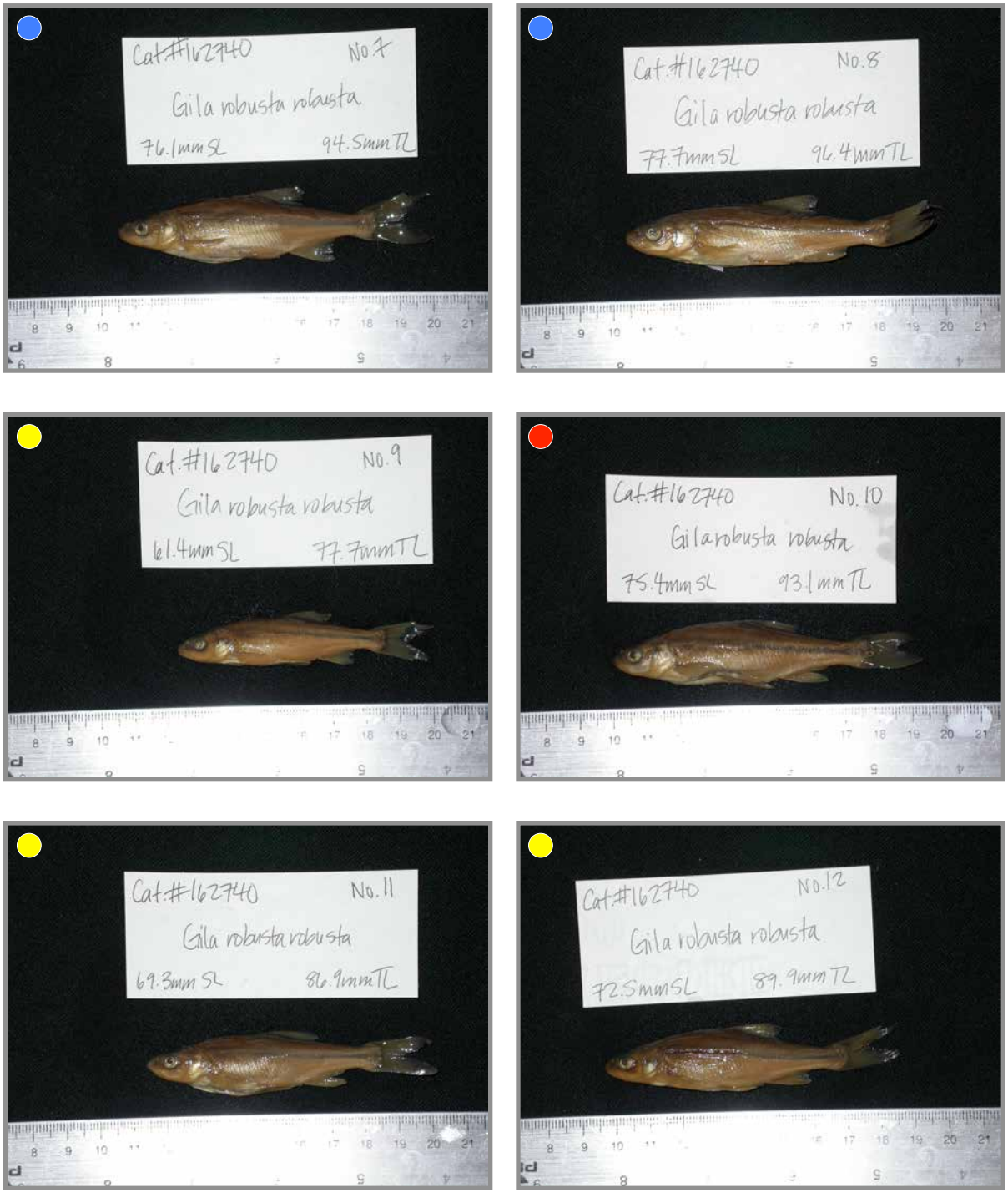
UMMZ 124744. New Mexico, Grant County, Gila River, on US 260, at Cliff. Hubbs family. 30 June 1938. n = 27.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 124744. New Mexico, Grant County, Gila River, on US 260, at Cliff. Hubbs family. 30 June 1938. n = 27.

● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
⊗ = specimen <50 mm SL; species not determined

UMMZ 162740. New Mexico, Grant County, Gila River, ca. 6 miles above Redrock, at mouth of box canyon; flood tributary Colorado River drainage. R.R. Miller and H.E. Winn. 6 May 1950. n = 39.



● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
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UMMZ 162740. New Mexico, Grant County, Gila River, ca. 6 miles above Redrock, at mouth of box canyon; flood tributary Colorado River drainage. R.R. Miller and H.E. Winn. 6 May 1950. n = 39.

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● = *G. intermedia*, Gila Chub ● = *G. nigra*, Headwater Chub ● = *G. robusta*, Roundtail Chub
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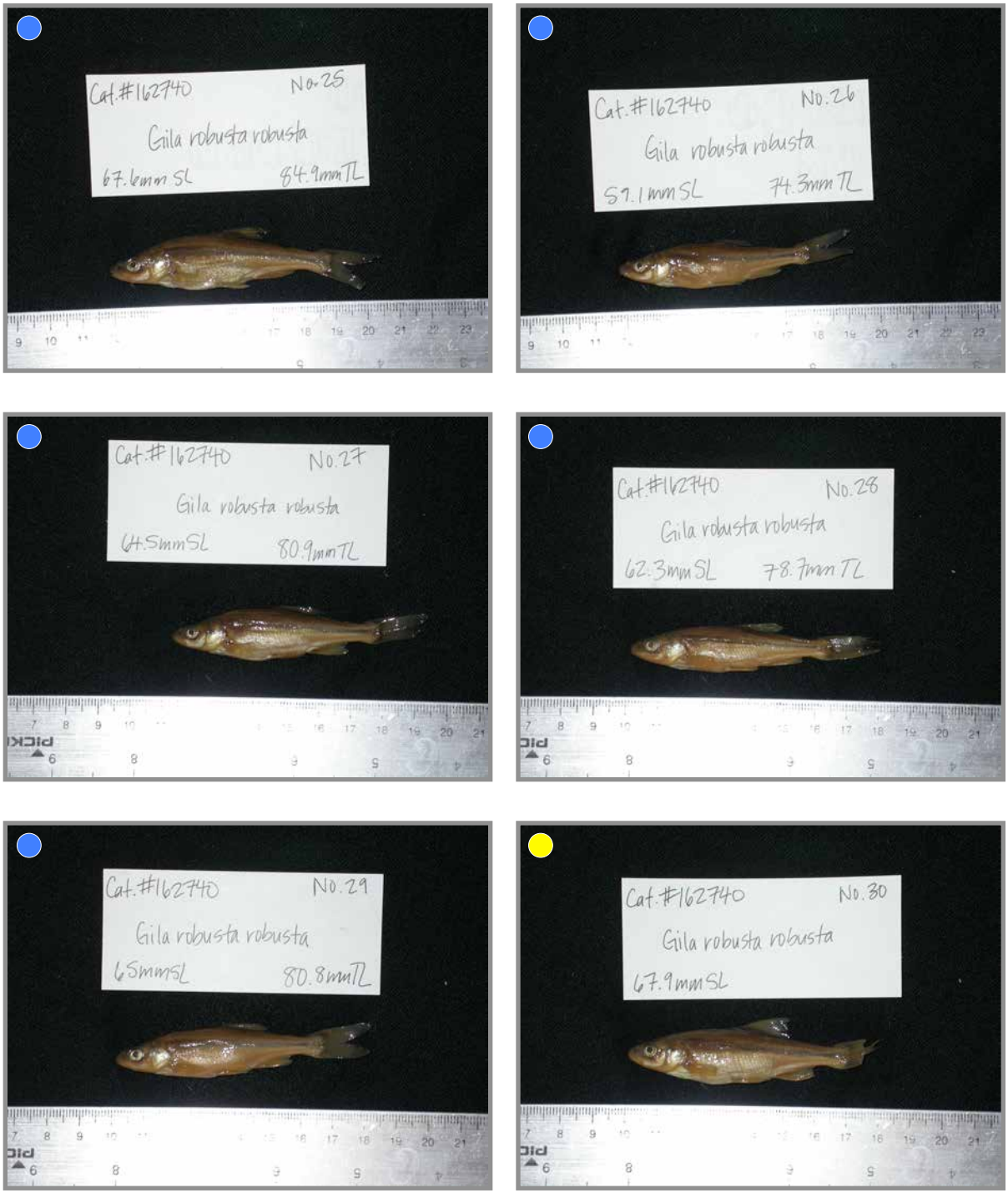
UMMZ 162740. New Mexico, Grant County, Gila River, ca. 6 miles above Redrock, at mouth of box canyon; flood tributary Colorado River drainage. R.R. Miller and H.E. Winn. 6 May 1950. n = 39.



= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
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= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
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= *G. intermedia*, Gila Chub = *G. nigra*, Headwater Chub = *G. robusta*, Roundtail Chub
= specimen <50 mm SL; species not determined

UMMZ 162740. New Mexico, Grant County, Gila River, ca. 6 miles above Redrock, at mouth of box canyon; flood tributary Colorado River drainage. R.R. Miller and H.E. Winn. 6 May 1950. n = 39.

Appendix V. Morphologic measures, meristic values, and species determinations of specimens >50 mm SL (INT = *Gila intermedia*, NIG = *Gila nigra*, ROB = *Gila robusta*) examined for this study. (Header Codes: SL = Standard Length, TL = Total Length, CPL = Caudal Peduncle Length, HL = Head Length, CPD = Caudal Peduncle Depth, HL/CPD = Head Length divided by Caudal Peduncle Depth, CPL/CPD = Caudal Peduncle Length divided by Caudal Peduncle Depth, LLS = Lateral Line Scale count, A = Anal Fin ray count, D = Dorsal Fin ray count).

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
INT	1729	1	112.4	129.6	25.5	27.7	10.8	2.56	2.36	77	8	8
NIG	1729	2	126.2		28.7	34.4	11.1	3.10	2.59	80	8	8
NIG	1729	3	79.0		15.7	23.4	7.5	3.12	2.10	79	8	8
INT	1729	4	123.3		26.8	30.9	11.5	2.69	2.33	79	8	9
INT	1729	5	98.7		22.4	27.1	9.3	2.91	2.41	77	9	8
INT	1729	6	102.5	119.7	19.8	26.9	9.3	2.89	2.13	80	8	9
INT	1729	7	103.3	118.7	22.4	27.7	9.8	2.83	2.29	81	9	8
NIG	1729	8	93.2		20.3	26.7	8.8	3.03	2.31	79	8	8
INT	1729	11	112.8		25.8	29.3	10.0	2.93	2.58	83	8	8
NIG	1729	17	58.5		12.1	16.2	5.0	3.24	2.42	77	8	8
ROB	1731	1	182.8	227.0	39.9	44.9	15.1	3.00	2.60	83	9	9
ROB	1731	2	161.7	201.5	35.4	42.3	13.0	3.30	2.70	80	9	9
ROB	1731	3	166.4	204.8	37.6	41.7	13.2	3.20	2.80	83	9	9
ROB	1731	13	51.6	64.2	10.7	14.5	4.5	3.20	2.40	84	9	9
ROB	1731	14	51.7	66.6	10.6	15.0	4.4	3.80	2.40	83	9	9
ROB	1731	15	55.5	66.5	12.0	16.3	4.8	3.40	2.50	88	9	9
ROB	1731	16	55.7	71.9	11.9	16.0	4.9	3.30	2.40	92	9	9
ROB	1731	17	56.9	72.0	12.7	16.4	4.0	3.40	2.60	80	9	9
ROB	1731	18	59.2	77.7	12.3	16.6	5.0	3.30	2.50	82	9	9
INT	1731	19	64.4	81.5	13.8	17.2	5.8	2.90	2.40	81	9	9
ROB	1732	1	294.7	333.0	60.1	74.4	21.1	3.50	2.80	79	9	9
ROB	1732	2	268.1	301.0	57.5	69.0	20.3	3.40	2.80	84	9	9
ROB	1732	3	222.6	273.0	52.0	60.2	17.0	3.50	3.10	81	9	9
ROB	1732	4	130.8	162.3	29.6	35.3	11.1	3.20	2.70	80	9	8
NIG	1732	5	115.9	142.8	24.0	32.4	10.9	2.97	2.20	80	9	9
ROB	1732	6	98.4	121.2	21.7	26.3	8.8	3.00	2.50	78	9	8
ROB	1743	1	195.1	299.0	43.1	54.6	15.1	3.62	2.85	80	8	8
ROB	1743	2	132.5	152.8	29.4	33.3	11.1	3.00	2.65	81	9	9
NIG	1743	3	147.0	181.5	29.7	37.5	12.5	3.00	2.38	81	8	9
ROB	1743	4	183.0		39.3	55.0	16.7	3.29	2.35	88	9	9
ROB	1743	5	219.0	244.0	36.3	48.2	13.7	3.52	2.65	81	8	8
NIG	1743	6	119.8	135.1	24.0	30.0	9.7	3.09	2.47	76	9	9

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
ROB	1743	7	153.6	180.8	33.9	38.5	11.5	3.35	2.95	80	9	9
INT	1743	8	123.6	140.0	25.0	31.3	11.8	2.65	2.12	80	9	9
ROB	1745	1	231.2	278.0	50.9	64.1	18.8	3.40	2.70	82	9	9
ROB	1745	2	224.3	275.0	50.1	60.6	18.2	3.30	2.80	83	9	9
ROB	1745	3	213.8	265.0	48.1	58.0	17.4	3.30	2.80	82	9	9
ROB	1745	4	183.6	231.0	38.2	50.0	15.5	3.20	2.50	85	9	9
ROB	1745	5	156.6	192.0	35.1	42.9	13.3	3.20	2.60	82	8	9
ROB	1745	6	248.0	304.0	53.8	64.9	20.3	3.20	2.65	94	8	9
ROB	1745	7	231.0	282.0	50.2	58.8	19.4	3.03	2.59	92	9	9
NIG	1745	8	223.0	267.0	46.0	56.4	18.5	3.05	2.49	84	8	8
NIG	1745	9	213.0	264.0	44.1	55.2	18.2	3.03	2.42	84	8	8
NIG	1745	10	190.0	235.0	34.6	52.1	16.8	3.10	2.06	83	9	8
ROB	1745	11	152.7	183.8	32.4	39.1	13.4	2.92	2.42	89	9	8
ROB	1745	12	153.7	188.3	31.8	40.4	13.6	2.97	2.34	89	8	9
NIG	1745	13	131.9	164.0	23.2	36.2	11.5	3.15	2.02	85	8	9
ROB	1745	14	136.4	167.2	29.1	39.6	12.3	3.22	2.37	84	8	9
ROB	1747	1	85.9	101.0	16.6	23.0	7.1	3.24	2.34	85	9	9
ROB	1748	1	109.8	133.6	25.3	29.7	8.6	3.50	2.90	82	9	9
ROB	1752	1	111.6	139.0	24.3	31.6	9.0	3.50	2.70	82	9	9
ROB	1752	2	95.8	122.0	21.3	27.1	8.3	3.20	2.60	81	9	9
ROB	1752	3	102.4	121.6	23.6	28.7	8.6	3.30	2.70	81	9	9
ROB	1752	4	240.4	264.0	53.5	62.2	17.4	3.60	3.10	83	9	9
ROB	1752	5	237.0	291.0	45.8	64.0	18.9	3.39	2.42	83	8	8
ROB	1752	6	221.0	263.0	45.0	56.2	16.1	3.49	2.80	85	9	9
INT	1752	7	96.1	117.8	21.3	25.8	8.9	2.90	2.39	79	8	8
ROB	1752	35	107.7	131.0	20.5	28.7	8.7	3.30	2.36	86	9	9
ROB	1752	36	98.2	122.2	18.9	26.8	7.9	3.39	2.39	81	9	9
ROB	1752	38	54.6	65.7	10.5	15.5	4.3	3.60	2.44	87	9	9
ROB	1752	44	52.6	62.6	11.4	14.2	4.3	3.30	2.65	83	9	9
NIG	2007	1	101.2		23.5	28.9	9.7	3.00	2.40	78	9	9
INT	2007	2	97.3		21.1	26.7	9.4	2.80	2.20	80	8	8
INT	2007	3	89.4		20.7	26.0	8.9	2.90	2.30	78	8	8

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
NIG	2007	4	87.7		18.9	25.1	8.4	3.00	2.30	80	8	8
ROB	2007	5	85.3		20.1	23.9	7.7	3.10	2.60	81	9	9
NIG	2007	6	73.8		16.1	21.2	7.1	3.00	2.30	81	8	8
NIG	2007	7	61.7		14.5	17.4	5.8	3.00	2.50	81	9	9
NIG	2007	8	54.6		11.2	16.5	5.3	3.10	2.10	79	8	8
NIG	2007	9	53.8		12.9	15.2	5.1	3.00	2.50	80	8	9
INT	2007	10	52.3		12.3	14.7	5.3	2.80	2.30	80	8	8
NIG	2007	11	51.6		11.1	15.3	4.9	3.10	2.30	80	9	9
ROB	2624	1	199.8	242.0	43.0	54.9	17.0	3.20	2.50	84	9	9
ROB	49890	1	75.6	90.8	14.5	20.3	6.2	3.28	2.34	83	9	9
ROB	49890	2	102.5	123.5	21.8	27.1	9.3	2.90	2.33	82	9	9
NIG	49890	3	106.9	128.6	21.5	28.6	9.5	2.99	2.25	81	9	8
NIG	49890	4	121.1	147.4	25.0	34.0	10.9	3.12	2.29	82	9	9
NIG	49890	5	171.0	195.5	36.4	45.3	14.7	3.08	2.48	82	9	9
NIG	62754	1	93.1	119.5	18.2	24.0	7.7	3.12	2.36	84	9	9
NIG	62754	2	115.8	148.3	22.7	30.9	10.0	3.09	2.27	81	9	8
ROB	62754	3	113.1	143.3	24.4	30.6	10.0	3.06	2.44	84	9	9
INT	62754	4	108.9	138.0	23.0	31.0	11.3	2.74	2.04	82	9	8
INT	62754	5	98.1	123.5	20.0	25.9	9.4	2.76	2.13	81	9	9
ROB	62754	6	80.5	103.3	14.7	21.3	6.3	3.38	2.33	83	9	8
INT	62754	7	114.3	145.1	26.6	28.7	11.7	2.46	2.28	82	9	9
NIG	62754	8	96.1	119.8	20.2	25.4	8.0	3.18	2.53	81	8	8
NIG	62754	9	78.1	100.6	14.8	20.1	6.4	3.14	2.31	83	9	9
ROB	62754	10	53.6	70.3	10.3	15.9	4.4	3.65	2.36	82	9	9
NIG	62958	177-1	74.1	88.2	14.4	20.5	6.8	3.03	2.13	83	9	9
ROB	62958	177-2	65.8	81.2	14.3	17.4	5.8	3.00	2.46	81	9	8
ROB	62958	177-3	63.9	79.3	14.1	17.2	4.8	3.56	2.91	82	8	8
ROB	62958	177-4	68.9	87.7	12.8	19.2	5.9	3.24	2.16	81	9	9
ROB	62958	177-5	52.5	69.3	10.8	15.6	4.7	3.34	2.31	81	9	9
ROB	62958	177-6	56.5	70.4	11.5	15.8	4.4	3.58	2.62	76	9	8
NIG	62958	177-8	58.5	73.8	11.5	16.7	5.6	3.00	2.06	81	9	9

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
ROB	63002	1	57.8	73.2	12.3	15.4	4.7	3.28	2.62	80	9	8
ROB	63002	2	58.3	73.3	11.0	16.9	4.3	3.95	2.57	80	9	9
ROB	63002	3	64.7	79.2	12.8	17.7	4.6	3.89	2.80	80	9	9
NIG	63002	4	53.7	67.9	10.0	15.4	4.5	3.42	2.23	82	8	8
ROB	63002	5	70.0	85.7	14.4	20.3	5.2	3.92	2.78	78	9	9
NIG	63002	6	63.6	79.1	12.9	17.2	5.6	3.04	2.28	79	9	9
ROB	63002	7	71.8	87.2	15.1	20.2	5.5	3.68	2.74	80	9	9
ROB	63002	8	61.3	76.4	13.5	16.7	4.7	3.54	2.86	81	9	9
ROB	63002	9	64.3	80.0	11.4	17.9	4.7	3.79	2.41	80	9	9
ROB	63002	191-2	99.7	123.7	22.4	27.6	8.0	3.43	2.79	82	9	9
ROB	63002	191-3	94.6	115.7	18.3	26.1	8.1	3.23	2.26	79	9	9
NIG	63189	1	106.1	128.8	21.3	30.9	9.7	3.17	2.19	79	9	9
ROB	63189	2	86.2	105.5	19.4	22.4	6.9	3.24	2.80	80	9	9
ROB	63189	3	85.1	102.7	17.9	22.8	6.2	3.68	2.89	82	9	9
ROB	63189	4	77.0	95.4	14.2	22.3	5.7	3.89	2.47	83	9	9
ROB	63189	5	77.6	97.5	15.8	21.9	6.5	3.40	2.45	83	9	9
ROB	63189	6	79.5	94.5	16.4	21.9	6.2	3.53	3.15	81	9	9
ROB	63189	7	76.6	92.7	16.1	20.9	6.1	3.42	2.64	80	9	9
ROB	63189	8	57.3	72.8	12.2	17.5	4.9	3.57	3.02	79	9	9
ROB	63189	9	67.9	84.6	13.4	18.2	5.1	3.59	2.65	80	9	9
NIG	63189	10	64.4	78.9	12.0	18.1	5.6	3.21	2.13	79	9	9
ROB	77046	178-01	116.0	142.4	23.7	31.7	9.3	3.40	2.54	85	9	9
INT	77046	178-02	83.6	102.7	18.4	23.0	8.6	2.67	2.14	80	9	9
NIG	77046	178-03	69.6	86.4	13.7	20.1	6.4	3.12	2.12	80	9	8
INT	77046	178-04	64.7	82.1	13.5	17.3	5.9	2.95	2.30	81	9	8
INT	77046	178-05	71.9	90.3	13.8	20.4	7.1	2.85	1.93	81	9	9
INT	77046	178-06	65.6	81.7	11.9	18.9	7.0	2.71	1.70	82	9	8
INT	77046	178-07	64.9	81.1	12.9	18.3	6.7	2.74	1.93	79	8	8
NIG	77046	178-08	55.5	70.8	12.0	15.7	5.7	2.77	2.12	82	9	9
NIG	77046	178-09	54.3	67.4	10.3	14.9	5.0	3.00	2.06	79	8	8
NIG	77046	178-10	70.6	89.6	15.0	20.5	6.7	3.07	2.25	81	8	8
ROB	77046	178-11	57.4	70.9	12.8	15.8	5.7	2.75	2.24	84	9	9

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
NIG	77046	178-12	52.4	65.1	9.9	15.3	5.0	3.03	1.96	81	9	9
NIG	77046	178-14	56.2	72.0	9.6	16.2	5.2	3.14	1.87	77	9	8
NIG	77046	178-15	52.0	64.4	10.3	15.2	4.7	3.23	2.19	75	9	8
ROB	77050	1	69.3	88.4	14.1	19.0	5.5	3.43	2.54	84	8	8
NIG	77050	2	65.0	82.9	13.4	16.8	5.7	2.97	2.36	80	9	9
ROB	77050	3	56.1	71.5	11.5	15.3	4.4	3.48	2.61	82	8	8
NIG	77050	4	57.3	72.3	10.4	15.3	5.1	3.03	2.05	82	9	8
ROB	77050	5	80.8	102.1	15.8	22.3	6.8	3.29	2.33	83	9	9
ROB	77050	6	52.9	67.2	10.1	13.9	4.2	3.30	2.40	79	9	8
NIG	77050	7	80.6	99.7	16.2	22.3	7.3	3.04	2.20	84	8	8
NIG	77050	8	78.7	98.6	16.9	21.8	7.2	3.01	2.34	83	9	9
ROB	77050	9	53.3	67.6	11.2	14.0	3.8	3.65	2.94	81	8	8
ROB	77050	10	70.9	87.2	14.2	19.5	5.9	3.32	2.42	81	9	9
ROB	77050	252-01	136.6	165.5	27.9	37.5	10.6	3.54	2.63	82	8	8
ROB	77050	252-02	96.2	116.2	21.7	24.8	8.7	2.85	2.49	87	9	8
INT	77050	252-03	96.7	115.1	20.7	24.2	8.8	2.76	2.36	80	9	8
INT	77050	252-04	92.6	116.8	17.7	26.0	8.8	2.97	2.01	76	8	8
ROB	77050	252-05	83.6	105.3	16.7	23.3	7.2	3.24	2.32	79	9	9
NIG	77050	252-06	80.6	101.2	16.6	21.6	7.1	3.02	2.32	84	9	9
ROB	77050	252-08	81.4	101.5	17.3	21.9	6.5	3.37	2.67	86	9	9
ROB	77050	252-10	76.5	94.8	15.6	19.3	6.4	3.03	2.46	83	9	9
INT	77050	252-11	76.3	95.0	16.1	20.0	7.6	2.64	2.12	84	8	8
NIG	77050	252-13	80.4	100.9	16.4	21.1	6.7	3.15	2.45	82	8	8
NIG	77050	252-14	74.5	93.5	15.0	20.6	6.6	3.14	2.27	82	9	8
NIG	77050	252-15	75.5	95.0	14.6	19.8	6.8	2.90	2.15	84	8	9
NIG	77050	252-16	76.7	96.8	16.4	21.4	7.0	3.07	2.36	81	8	8
INT	77050	252-19	73.3	88.1	15.4	20.2	7.1	2.83	2.16	79	9	8
NIG	77050	252-20	69.7	88.0	13.7	18.5	5.9	3.14	2.33	80	9	9
ROB	77050	252-21	67.2	85.2	14.0	17.8	5.5	3.24	2.55	83	9	9
ROB	77050	252-22	65.1	80.6	13.2	17.6	5.3	3.35	2.50	79	9	8
ROB	77050	252-23	58.1	72.2	12.5	15.1	4.8	3.13	2.60	83	9	9
NIG	77050	252-24	62.6	79.3	9.9	16.8	5.3	3.19	1.87	82	8	8

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
INT	77050	252-27	55.4	68.4	12.8	14.2	4.8	2.94	2.65	81	9	9
ROB	77050	252-28	55.4	69.7	11.8	14.5	4.5	3.22	2.61	83	8	8
ROB	77050	252-30	53.8	69.0	11.6	14.6	4.1	3.57	2.85	85	9	8
ROB	77050	252-31	50.2	64.8	9.7	13.9	4.0	3.51	2.44	82	9	9
NIG	77050	252-32	50.2	63.3	9.3	14.1	4.3	3.28	2.17	80	8	8
ROB	77050	252-33	52.2	65.5	10.7	14.3	3.6	3.97	2.96	79	9	9
ROB	77050	252-41	51.8	63.8	11.3	13.3	3.9	3.44	2.91	84	9	9
ROB	77050	252-46	53.1	66.0	9.7	14.4	4.4	3.26	2.20	80	9	9
ROB	77050	252-48	51.6	63.5	11.0	13.0	3.8	3.39	2.87	81	9	8
ROB	110434	1	159.8	202.0	36.5	42.4	12.4	3.42	2.94	80	8	8
ROB	110434	2	176.1		37.1	47.8	13.9	3.44	2.67	86	9	9
NIG	110434	3	166.6	204.0	36.0	44.0	14.7	2.99	2.45	81	8	8
INT	110434	4	111.4	137.0	25.5	27.9	11.4	2.45	2.24	82	9	8
INT	110434	5	111.8	138.0	23.5	30.6	10.8	2.83	2.18	79	9	9
INT	110434	6	116.9	145.0	27.7	31.4	10.8	2.91	2.56	81	8	8
ROB	110434	7	92.2	113.0	20.5	25.5	8.0	3.19	2.56	79	8	8
ROB	113528	1	112.2	139.0	22.0	30.5	9.3	3.28	2.37	77	8	9
ROB	113528	2	56.1		12.9	15.6	4.9	3.18	2.63	82	8	8
INT	118180	1	140.6	173.9	27.3	36.9	14.1	2.62	1.94	83	9	8
ROB	118180	2	135.4	171.2	30.0	35.8	11.2	3.20	2.68	82	9	8
ROB	118180	3	131.9	165.6	30.7	34.7	11.3	3.07	2.72	87	9	9
ROB	118180	4	122.6	152.7	25.2	34.4	10.9	3.16	2.31	84	9	9
INT	118180	5	122.4	150.0	25.5	31.0	12.1	2.56	2.11	80	8	8
INT	118180	6	119.3	144.7	26.2	31.9	11.3	2.82	2.32	86	8	9
INT	118180	7	114.7	139.0	27.6	30.0	10.6	2.83	2.60	75	8	8
ROB	118180	8	120.2	149.3	28.1	32.1	10.2	3.15	2.75	82	9	8
ROB	118180	9	106.8	135.1	24.4	30.9	9.7	3.19	2.52	83	9	9
ROB	118180	10	118.2	150.2	25.5	32.1	9.2	3.49	2.77	79	9	9
ROB	118180	11	103.1	128.0	21.5	29.1	8.7	3.34	2.47	85	9	9
INT	118180	12	77.9	98.9	16.1	21.2	7.4	2.86	2.18	82	8	8
NIG	118182	1	133.6	164.8	30.2	36.2	11.7	3.09	2.58	79	8	8
ROB	118182	2	129.0	161.0	28.9	34.9	10.9	3.20	2.65	88	9	9

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
NIG	118182	3	123.9	150.7	26.5	34.7	11.5	3.02	2.30	78	8	9
NIG	118182	4	113.2	138.1	26.3	30.7	10.4	2.95	2.53	82	8	8
NIG	118182	5	102.2	131.2	20.9	28.6	9.3	3.08	2.25	76	9	9
INT	118182	6	94.3	117.8	20.7	25.5	9.1	2.80	2.27	68	8	8
INT	118182	7	89.8	112.7	22.6	25.3	9.4	2.69	2.40	72	8	8
INT	118182	8	85.5	107.5	19.5	23.5	8.6	2.73	2.27	76	8	8
INT	118182	9	76.0	95.1	17.5	21.5	7.5	2.87	2.33	70	8	8
ROB	124744	1	106.8		22.7	29.7	9.0	3.30	2.52	86	9	8
INT	124744	2	114.5	138.0	24.1	30.6	10.4	2.94	2.32	75	9	8
ROB	124744	3	85.0	103.6	18.4	23.9	7.3	3.27	2.52	84	9	9
ROB	124744	4	84.5	104.2	18.5	24.5	7.5	3.27	2.47	87	9	9
ROB	124744	5	76.4	93.0	16.8	21.4	6.5	3.29	2.58	85	9	9
NIG	124744	6	76.1	95.4	17.5	21.2	7.2	2.94	2.43	80	9	8
ROB	124744	7	66.8	83.5	14.9	18.8	5.6	3.36	2.66	83	9	9
ROB	124744	8	53.9		11.8	16.4	4.6	3.57	2.57	80	8	8
NIG	124744	9	54.8	69.2	10.7	15.8	5.1	3.10	2.10	81	9	9
NIG	124744	10	68.1	85.0	14.4	18.6	6.3	2.95	2.29	80	9	9
ROB	124744	11	57.3		13.3	17.3	5.2	3.33	2.56	79	8	9
NIG	124744	12	57.2		12.8	16.0	5.3	3.02	2.42	78	8	8
NIG	124744	13	73.0		16.0	20.6	6.9	2.99	2.32	77	9	8
ROB	124744	14	64.4	80.2	13.9	18.9	5.9	3.20	2.36	81	9	9
ROB	124744	15	67.3		14.8	19.2	5.1	3.76	2.90	84	9	9
ROB	124744	16	69.6	83.6	15.1	19.8	6.0	3.30	2.52	87	9	9
INT	124744	17	56.6		12.3	16.7	6.1	2.74	2.02	68	8	8
INT	124744	18	55.4	71.1	12.4	16.5	5.8	2.84	2.14	71	8	8
ROB	124744	19	53.0	67.7	11.3	15.5	4.2	3.69	2.69	83	9	9
ROB	124744	20	67.9	85.1	15.6	18.9	5.5	3.44	2.84	94	9	9
NIG	124744	21	60.9		12.0	17.2	5.5	3.13	2.18	79	8	9
NIG	124744	22	60.0		12.7	17.0	5.8	2.93	2.19	78	9	8
ROB	124744	23	55.3	69.8	12.2	15.7	4.4	3.57	2.77	82	9	9
NIG	124744	24	58.5		12.9	16.2	5.3	3.06	2.43	73	8	8
NIG	124744	25	58.7		11.5	17.0	5.5	3.09	2.09	72	9	8

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
ROB	124744	118	189.3	234.0	40.6	48.1	15.5	3.10	2.62	81	9	8
ROB	162740	1	160.8	197.0	36.5	42.0	12.5	3.36	2.92	85	9	9
ROB	162740	2	86.2	107.7	17.8	23.3	7.6	3.07	2.34	89	9	9
ROB	162740	3	83.1	102.5	18.4	22.0	6.6	3.33	2.79	88	9	9
NIG	162740	4	68.1	84.7	14.6	20.0	6.5	3.08	2.25	81	9	9
ROB	162740	5	79.8	99.6	18.3	22.0	7.2	3.06	2.54	87	9	9
ROB	162740	6	67.7	83.6	15.4	18.4	6.0	3.07	2.57	85	9	9
ROB	162740	7	76.1	94.5	17.7	20.6	6.7	3.07	2.64	86	9	9
ROB	162740	8	77.7	96.4	16.6	21.1	6.9	3.05	2.41	86	9	8
NIG	162740	9	61.4	77.7	13.4	17.8	5.9	3.02	2.27	83	8	8
INT	162740	10	75.4	93.1	17.5	19.9	7.2	2.76	2.43	80	8	8
NIG	162740	11	69.3	86.9	15.1	19.9	6.8	2.93	2.22	79	9	9
NIG	162740	12	72.5	89.9	15.1	19.8	6.5	3.05	2.32	84	9	8
ROB	162740	13	74.9		15.5	20.8	6.1	3.41	2.54	81	8	9
ROB	162740	14	78.9	96.8	17.5	21.7	7.1	3.06	2.46	86	9	8
ROB	162740	15	64.6	81.2	14.6	18.1	6.1	2.99	2.41	84	9	9
ROB	162740	16	77.6	99.2	16.4	22.5	7.2	3.13	2.28	82	9	9
ROB	162740	17	74.9	92.8	17.3	20.4	6.4	3.19	2.70	81	9	9
ROB	162740	18	65.9	83.0	15.3	18.6	6.0	3.10	2.55	80	9	8
ROB	162740	19	79.2	100.0	18.3	21.8	7.3	2.99	2.51	85	9	9
ROB	162740	20	58.9	74.4	13.3	16.7	5.2	3.21	2.56	80	9	8
ROB	162740	21	67.3	84.0	14.9	19.0	5.5	3.45	2.71	84	9	9
ROB	162740	22	70.6	86.8	15.0	19.0	6.3	3.02	2.38	84	9	9
ROB	162740	23	68.2	85.2	15.4	19.2	5.6	3.43	2.75	85	9	9
ROB	162740	24	77.7	95.6	16.1	21.6	6.3	3.43	2.56	83	9	9
ROB	162740	25	67.6	84.9	15.2	19.1	6.0	3.18	2.53	85	9	8
ROB	162740	26	59.1	74.3	13.8	17.1	4.8	3.56	2.88	82	9	8
ROB	162740	27	64.5	80.9	14.8	17.8	5.8	3.07	2.55	80	9	9
ROB	162740	28	62.3	78.7	13.0	17.8	5.4	3.30	2.41	83	9	8
ROB	162740	29	65.0	80.8	15.2	18.2	5.7	3.19	2.67	86	9	9
NIG	162740	30	67.9		14.3	18.9	6.2	3.05	2.31	80	9	9
ROB	162740	31	63.5	78.3	13.2	18.3	5.6	3.27	2.36	83	9	9

Appendix V. (continued).

Chub Species	Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
ROB	162740	32	59.0	73.9	11.4	17.1	4.8	3.56	2.38	83	9	9
ROB	162740	33	62.5	78.9	13.9	17.1	5.0	3.42	2.78	88	9	9
NIG	162740	34	59.5	74.0	12.9	16.6	5.5	3.02	2.35	82	8	8
ROB	162740	35	57.8	73.5	12.7	16.6	5.1	3.25	2.49	85	9	8
ROB	162740	36	56.0	69.8	11.9	15.8	4.8	3.29	2.48	79	9	9
ROB	162740	37	58.3	73.6	12.8	16.6	4.7	3.53	2.72	80	9	8
ROB	162740	38	54.0	68.4	11.7	16.2	4.7	3.45	2.49	81	9	8
NIG	162740	39	74.3	90.9	16.5	20.9	6.9	3.03	2.39	81	8	8

Appendix VI. Morphologic measures and meristic values of specimens <50 mm SL examined for this study. (Header Codes: SL = Standard Length, TL = Total Length, CPL = Caudal Peduncle Length, HL = Head Length, CPD = Caudal Peduncle Depth, HL/CPD = Head Length divided by Caudal Peduncle Depth, CPL/CPD = Caudal Peduncle Length divided by Caudal Peduncle Depth, LLS = Lateral Line Scale count, A = Anal Fin ray count, D = Dorsal Fin ray count).

Appendix VI. (continued).

Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
1730	1	48.1	62.9	10.6	14.0	4.0	3.50	2.65	81	9	9
1731	4	40.2	52.1	8.3	12.0	3.9	3.08	2.13		9	8
1731	5	41.7	54.4	8.5	12.8	3.6	3.56	2.36		9	8
1731	6	43.9	55.4	8.8	12.4	4.4	2.82	2.00		9	8
1731	7	44.1	56.0	9.5	13.1	4.1	3.20	2.32		8	8
1731	8	45.8	59.5	10.0	13.4	4.1	3.27	2.44		9	8
1731	9	46.9	61.1	10.3	13.8	4.4	3.14	2.34	80	9	8
1731	10	46.0	59.2	10.1	13.5	4.2	3.21	2.40		8	8
1731	11	49.7	63.7	11.0	14.5	4.2	3.45	2.62		9	9
1731	12	49.9	64.8	10.5	14.0	4.6	3.04	2.28		9	8
1732	7	41.8	49.2	9.2	12.6	4.1	3.07	2.24		9	9
1732	8	35.1	39.2	7.2	11.0	3.3	3.33	2.18		9	9
1736	1	38.7	47.6	8.0	12.2	3.8	3.21	2.11		9	9
1736	2	45.4	49.6	10.4	13.7	4.2	3.26	2.48		9	9
1736	3	37.3	45.1	7.8	11.6	3.2	3.63	2.44		9	9
1736	4	28.2	35.2	6.0	8.9	2.6	3.42	2.31		9	9
1737	1	40.0	50.8	8.2	13.3	3.6	3.69	2.28		9	8
1737	2	47.4	62.6	10.3	14.4	3.9	3.69	2.64		9	8
1737	3	42.0	51.1	8.1	12.8	3.3	3.88	2.45		9	9
1737	4	34.6	44.5	6.8	10.6	2.7	3.93	2.52		9	9
1737	5	41.0	52.6	8.1	12.3	3.4	3.62	2.38		9	8
1737	6	43.7	54.0	8.5	13.0	3.9	3.33	2.18		9	9
1737	7	38.4	49.5	8.1	11.6	3.3	3.52	2.45		9	9
1737	8	36.9	47.8	7.4	11.1	3.6	3.08	2.06		9	9
1737	9	32.1	40.3	6.2	10.5	3.1	3.39	2.00		9	8
1737	10	37.2	48.5	7.5	10.8	2.9	3.72	2.59		9	8
1737	11	32.7	42.1	7.3	10.0	3.6	2.78	2.03		8	8
1738	1	26.8	35.0	5.7	8.1	2.1	3.86	2.71	79	9	9
1739	1	36.4	45.0	7.6	10.9	3.2	3.41	2.38		9	9
1752	8	47.7	56.5	10.2	14.2	4.3	3.30	2.37		9	9
1752	9	37.9		8.2	12.1	3.3	3.67	2.48		9	9
1752	10	39.7	47.0	6.7	11.7	2.9	4.03	2.31		9	9
1752	11	33.3	38.1	5.7	10.0	2.5	4.00	2.28		9	9

Appendix VI. (continued).

Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
1752	12	44.4	52.8	8.8	13.0	4.1	3.17	2.15	81	9	9
1752	13	48.2	59.2	9.8	14.3	4.8	2.98	2.04		9	9
1752	14	37.4	45.2	7.2	11.7	3.1	3.76	2.32		9	9
1752	15	32.9	37.3	7.6	9.8	2.3	4.26	3.30		9	9
1752	16	40.9	48.0	8.0	12.0	3.7	3.24	2.16		9	9
1752	17	43.3		9.2	12.5	3.7	3.38	2.49		9	9
1752	18	46.5		9.5	14.2	4.0	3.55	2.38	84	9	9
1752	19	42.3	47.0	8.9	13.3	3.9	3.41	2.28		9	9
1752	20	45.2	54.4	8.2	13.3	3.8	3.50	2.16		9	9
1752	21	38.6	45.0	7.4	11.2	3.2	3.50	2.31		8	8
1752	22	45.2		9.6	13.1	3.7	3.54	2.59		9	9
1752	23	41.3	48.2	7.0	12.0	3.1	3.87	2.26		9	9
1752	24	34.5	40.5	7.2	10.3	2.7	3.79	2.65		9	9
1752	25	46.6	55.4	9.8	13.6	4.0	3.40	2.45	83	9	9
1752	26	43.8	53.3	8.0	13.1	3.5	3.74	2.29		9	9
1752	27	45.1	54.2	8.3	13.3	3.4	3.91	2.44		9	9
1752	28	39.3	46.5	8.2	11.6	3.3	3.52	2.48		9	8
1752	29	37.8	43.5	7.0	10.9	3.8	2.87	1.84		9	9
1752	30	46.6	56.3	8.4	13.4	3.9	3.44	2.15	84	9	8
1752	31	35.8	41.3	7.3	10.2	2.9	3.52	2.52		9	9
1752	32	42.3	49.0	8.2	12.7	3.7	3.43	2.22		9	9
1752	33	40.7		8.3	12.2	3.3	3.70	2.52		9	9
1752	34	45.9	53.9	7.9	13.4	4.0	3.35	1.98		9	9
1752	37	45.1	55.0	8.4	13.1	4.0	3.28	2.10		9	9
1752	39	45.3	54.1	8.7	13.6	4.2	3.24	2.07		9	9
1752	40	27.3	31.4	6.0	7.8	2.4	3.25	2.50		8	8
1752	41	30.9		6.9	11.0	2.5	4.40	2.76		9	9
1752	42	33.2	38.6	6.5	9.9	2.9	3.41	2.24		9	9
1752	43	35.4	40.5	7.3	9.8	2.8	3.50	2.61		9	9
1752	45	35.8	42.3	10.2	14.4	4.6	3.13	2.22		9	8
1752	46	42.9	50.0	7.4	12.5	4.1	3.05	1.80		9	9
1752	47	46.5	56.1	9.2	13.5	4.2	3.21	2.18		9	9
1752	48	41.6	49.5	8.4	12.5	3.8	3.29	2.21		9	8

Appendix VI. (continued).

Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
1752	49	39.3	47.0	7.9	11.6	3.4	3.41	2.32		9	9
1752	50	40.4	45.8	7.8	11.9	3.3	3.61	2.36		9	9
1752	51	41.8	47.9	8.5	12.5	3.2	3.91	2.66		9	9
1752	52	38.9		5.9	11.5	3.4	3.38	1.74		9	9
1752	53	36.3	43.2	5.6	10.2	3.3	3.09	1.70		9	9
1752	54	44.7	53.1	8.9	13.3	4.3	3.09	2.07		9	9
1752	55	40.9	49.0	7.3	12.4	3.6	3.44	2.03		9	9
1752	56	30.7	33.9	5.7	9.4	2.2	4.27	2.59		9	9
1752	57	39.8	46.4	6.6	11.9	3.4	3.50	1.94		9	8
1752	58	40.5	49.4	8.8	11.6	3.1	3.74	2.84		9	9
1752	59	44.6	52.2	8.4	12.8	3.2	4.00	2.63		8	9
1752	60	39.1	46.6	7.2	11.6	3.7	3.14	1.95		9	9
1752	61	36.4	43.1	7.4	11.1	3.0	3.74	2.50		9	9
1752	62	30.0		5.3	10.4	3.0	3.47	1.77		9	9
1752	63	33.6		6.3	9.8	2.4	4.08	2.63		9	9
1752	64	43.2	52.4	7.4	13.1	3.6	3.64	2.06		8	9
1752	65	43.4	51.2	7.6	12.6	3.7	3.41	2.05		9	9
1752	66	41.4		7.2	11.2	3.6	3.11	2.00		9	9
1752	67	41.8		8.3	12.4	3.7	3.35	2.24		9	9
1752	68	40.6		7.2	11.5	3.2	3.59	2.25		9	9
1752	69	31.4		5.5	9.7	2.7	3.59	2.04		9	9
1752	70	43.5	52.8	8.8	13.1	3.7	3.54	2.38		8	9
2007	12	49.5		11.4	14.6	4.6	3.17	2.48	83	8	8
2007	13	46.9		10.9	13.9	4.4	3.16	2.48	83	9	9
2007	14	45.6		9.2	13.1	4.1	3.20	2.24	85	9	9
2007	15	37.0		8.0	11.9	4.1	2.90	1.95	81	8	8
2007	16	39.8		7.8	12.3	4.1	3.00	1.90	80	8	8
2007	17	40.1		9.1	11.2	3.5	3.20	2.60	82	8	8
2007	18	31.9		6.7	10.6	3.2	3.31	2.09	83	8	8
2007	19	31.9		7.1	10.4	3.5	2.97	2.03	83	9	9
2010	1	43.3	57.2	9.2	13.8	3.9	3.54	2.36	87	7	8
2010	2	40.0	53.7	8.5	12.5	3.6	3.47	2.36	82	9	9
2010	3	29.4	37.5	6.4	9.0	2.3	3.91	2.78		9	8

Appendix VI. (continued).

Museum Number	Specimen Number	SL	TL	CPL	HL	CPD	HL / CPD	CPL / CPD	LLS	A	D
2010	4	27.3	35.2	5.5	9.0	2.6	3.46	2.12		9	9
2010	5	26.5	35.0	5.5	8.4	2.1	4.00	2.62		9	9
2010	6	21.5	27.4	3.5	7.0	1.9	3.68	1.84		9	9
2767	1	47.7	59.9	9.6	13.6	4.3	3.16	2.23		8	9
2767	2	42.1	52.1	9.2	12.3	3.6	3.42	2.56		9	8
3130	1	22.4	28.3	5.5	6.8	2.2	3.09	2.50	79	8	8
62958	177-07	48.3	57.7	9.3	15.0	4.4	3.41	2.11		8	8
62958	177-09	48.8	62.5	10.2	13.5	4.3	3.14	2.37		9	9
62958	177-10	47.6	57.1	10.3	14.4	4.2	3.43	2.45		8	8
63189	11	48.3	58.9	9.8	13.1	4.0	3.28	2.45		9	9
63189	12	48.1	62.0	9.9	13.7	4.4	3.11	2.25		9	9
77046	178-13	49.1	61.4	8.9	13.2	4.6	2.87	1.93		8	8
77046	178-16	33.5		6.3	9.1	3.4	2.68	1.85		9	8