the family level. Because developmental state changes dramatically as fish grow and to better facilitate use of character dependencies (e.g., if yolk is absent, characters such as length of yolk are removed from consideration), it was necessary in the catostomid and cyprinid keys to treat each developmental phase and size interval for a species as separate taxa (e.g., *Catostomus insignis* protolarva, 13 mm SL). Rich-text files of background information, beginning instructions, and other information to be accessed when using *Intkey* were prepared or modified with a word processor. Character lists and natural-language, taxon descriptions were also generated as rich-text files for reference when using the key.

The computer-interactive key to families of Gila River Basin fish larvae is based on characters and character states utilized in previously published family keys by Drewry (1979), Auer (1982), Holland-Bartels, et al. (1990), and Wallus et al. (1990; also Kay et al. 1994 and Simon and Wallus 2004). Those data were then modified or supplemented as necessary with descriptive data and observations from other publications, particularly for the family Cichlidae (Mironova 1969, Fryer and Iles 1972, Trewavas 1983, McGowan 1988, Morrison et al. 2003; also FishBase at http://www.fishbase.org/home.htm). Mostly to illustrate representative larvae for use with the key, but also as an alternative to it, a pictorial guide to the families of Gila River Basin fish larvae was prepared as an appendix. It consists of pertinent portions of the pictorial family guide with brief lists of distinguishing characteristics published by Wallus et al. (1990) for the Ohio River drainage, but is supplemented with an original section on Cichlidae with drawings of larvae from Fryer and Iles (1972) and McGowan (1988).

Although *Intkey* can make extensive use of taxon and character-state-selection images, preparation and inclusion of such were neither critical for operation of the key nor logistically and budgetarily feasible for this guide (if there is enough interest and support, they could be prepared and incorporated in future versions of the key). Also, such images can require a considerable amount of storage memory and at times a strictly text key may be preferable, especially for the experienced user or when using a slower computer with limited memory. Instead, the user is expected to extensively reference the illustrations and descriptive information provided in the species accounts. However, as examples of how character-state-selection images function, such illustrations were prepared and included in the key for developmental phase and phases of gut development. Images used by *Intkey* were created or modified from scanned files using computer drawing and presentation programs.

Interim and near-final versions of the three keys were subjected to in-house testing. However, based on reviews and feedback from use in routine collection processing, future refinements of the key will likely be implemented and made available for download over the Internet.

RESULTS AND DISCUSSION

Results are divided into three complementary sections–Species Accounts, Comparative Summary Tables, and Computer-Interactive Keys. For identification purposes, users should become familiar with and use all three taxonomic tools. Although all descriptive data in the species accounts and comparative summary tables (except those replicated in terms of total length in the species accounts) comprise the data sets for the keys, results from the keys can be confirmed using the well-illustrated species accounts and comparative summary tables.

Whenever possible, specimen identification should be based on multiple characters.

More than 1,480 specimens (539 for this investigation and 842 for prior studies) were analyzed in detail for morphometrics, meristics, and morphological developmental state relative to size, and several hundred of these and additional specimens for pigmentation and special morphological characters. Still, there are undoubtedly rare specimens with character extremes beyond the ranges recorded herein. Data for fathead minnow are particularly weak (just 15 specimens analyzed for a partial set of counts and measures–Snyder et al., 1977).

Because of the similarity among larvae of some Gila River Basin catostomids and cyprinids, the specific identity of some larvae will remain inconclusive or questionable after application of the key and diagnostic criteria provided herein. The identity of such specimens must be considered tentative and should be designated as such by appending a question mark ("?") to the most probable taxon name (e.g., "*Gila robusta* ?", preferably with a footnote on other possibilities), or by leaving the identity at family level (e.g., "unidentified Cyprinidae"), or genus (i.e., *Gila* sp.) if other genera can be eliminated. Some inconclusive specimens may be hybrids.

Hybridization among Colorado River System catostomids is particularly well documented (e.g., Hubbs et al. 1943, Hubbs and Hubbs 1947, Hubbs and Miller 1953, Smith 1966, Holden and Stalnaker 1975, McAda 1977, Prewitt 1977, McAda and Wydoski 1980, and Clarkson and Minckley 1988). Based on the key or diagnostic criteria summarized herein, some hybrid metalarvae and early juveniles may be at least tentatively identified as such by more experienced users, but because of fewer characters, hybrid protolarvae and mesolarvae, will likely be identified as the parental species they most closely resemble or remain questionable.

Although skeletal characters were not studied as part of this investigation (except for vertebra counts), Snyder and Muth (2004) found that certain osteological features can be diagnostic for late metalarvae and juveniles of razorback sucker, subgenus ***Pantosteus***, and subgenus *Catostomus*. Those data (size and shape of the frontoparietal fontanelle, first interneural bone, and anterior-dorsal maxillary projection; angle at which the postcleithrum extends from the cleithrum; and position of the mandibles relative to the maxillae) are included in the catostomid key for flannelmouth sucker and razorback sucker, but unlike Snyder and Muth (2004), have not been included in the species accounts for those species. The subgeneric differences probably extend to desert sucker and Sonora sucker but such have not been verified except for frontoparietal fontanelle dimensions in Sonora sucker based on data from an earlier unpublished investigation. The fontanelle narrows somewhat later in Sonora sucker than in flannelmouth sucker, after which its width becomes diagnostic for distinguishing Sonora sucker from razorback sucker (Table 64 and catostomid key). Unfortunately these skeletal characters, as well as vertebra counts, require that specimens be cleared and preferably stained for bone (or that the structures of interest be otherwise exposed). They are therefore best used to confirm or refine identities based on characters for which special preparation is not required.

Although prepared for use by Gila River Basin biologists, the species accounts, comparative summary tables, and keys that follow, as well as introductory information at the beginning of this guide, may also be useful to early life history investigators working elsewhere. Allowing for potential population differences in developmental morphology, these descriptions and the keys can be used for identification of covered species wherever they may occur. For example, roundtail chub, speckled dace, red shiner, fathead minnow, and carp are common in many reaches of the Colorado River Basin, and the latter four species in many other North American river systems. Where two or more of these species occur together and any other closely related sympatric species can be eliminated otherwise as possibilities, the computer-interactive key has the flexibility of being limited to just those species and effectively becoming a

key for that region, site, or circumstance. The family key might be particularly useful elsewhere, although several families of freshwater-spawning fishes in North America are not included.

Species Accounts

The following accounts serve as concise, but detailed and well-illustrated descriptions of the larvae and early juveniles of the subject species. Together with the comparative summary tables, they are provided to help confirm identities determined through the keys or for use as an alternative to the keys.

Species accounts herein for desert sucker, Sonora sucker, longfin dace, spikedace, and loach minnow comprise the only descriptive information published for the larvae of those species since Winn and Miller (1954) described their mesolarvae. The remaining accounts are either slight modifications of existing accounts in Snyder and Muth (1990, 2004–flannelmouth sucker and razorback sucker) or reformatted accounts from Snyder et al. (1977), Snyder (1981), and Muth (1990), supplemented with new or recalculated data and, for roundtail chub and speckled dace, new illustrations of protolarvae.

Each 6-page account begins with an illustration of the adult fish; map of its distribution in the Colorado River Basin; brief summaries of adult descriptions, reproduction (including reproductive guides as defined by Balon 1975b and 1981), and early life history; and a table of adult meristics. Much of this information was extracted from literature cited at the bottom of the first page. Each account continues with description of the larvae and early juveniles. Page one concludes with a table of size at apparent onset of selected developmental events. Page two consists of a table of size at developmental-interval and gut-phase transitions and a table of morphometrics and meristics summarized by developmental phase. The next four pages illustrate five to eight stages of development from just hatched protolarvae through early juveniles up to about 30 mm SL.