

## RELATIONSHIP OF FINE SEDIMENT AND TWO NATIVE SOUTHWESTERN FISH SPECIES

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In the southwestern United States, the native fish fauna is low in diversity and is composed primarily (95%) of cypriniform (minnow and sucker) species (Minckley 1973; Rinne and Minckley 1991). All native species have declined in range and numbers in the past half century (Miller 1961; Rinne 1994, 1996). As a result, most of the native fauna is either federally or state listed (Williams et al. 1989; Minckley and Deacon 1991; Rinne and Minckley 1991). Spikedace (*Meda fulgida*) and loach minnow (*Rhinichthys [Tiaroga] cobitis*) are two such natives. These two federally threatened species are restricted to the Gila River basin in Arizona and New Mexico, and have declined dramatically in range and numbers (Minckley 1973; Rinne and Minckley 1991; U.S. Fish and Wildlife Service 1990a, 1990b).

Fine sediment (< 2 mm) is a natural component of bed load in streams (Hynes 1972:23–24). Fines can affect aquatic environments and their inhabitants in both suspended and depositional form. Considerable literature has addressed the effects of fines on salmonids and their habitats (e.g. Meehan 1991), but most information is on the depositional, substrate, or bedload state of fines. By contrast, there is a complete lack of information on the effects of the fine component of stream substrates on non-salmonid species.

Anthropogenic activities across the southwestern landscape are thought to indirectly impact native fishes and their habitats (Rinne et al. 1998, 2001). In the Southwest, livestock grazing has generally been implicated as the major, extrinsic contributor to native fish decline in general, and specifically to the decline of these two threatened species. However, there is no information on the mechanisms of the impact from grazing on native fishes (Rinne 1999a, 1999b, 2000; Medina and Rinne 1999).

The fine sediment produced by livestock grazing and its effect on spawning habitat (substrate) is

frequently offered as the primary mechanism of impact on these two species. However, a paradox exists. Spikedace have declined and have remained absent in one southwestern desert river for a few years despite livestock grazing removal (Rinne 1999a; Medina and Rinne 1999). By contrast, both spikedace and loach minnow are sustaining themselves in another reach of desert river where livestock grazing is present (Rinne et al. 2001). Biological consultation is ongoing for many grazing allotments with streams and rivers in U.S. Forest Service Region 3 that have historically sustained or currently contain the species.

Because of (1) the status of these two native fish species and (2) the suggestion that grazing indirectly and negatively impacts both species through fine sediment production, it is timely to examine trends in distribution and abundance data for both, relative to sediment fine composition of stream substrates. Conceptually, such an approach should commence to define the relationships and the probable impact of fine sediment on spikedace and loach minnow.

The major objectives of this paper are to examine and define (1) the substrate composition of spikedace and loach minnow habitat, (2) the fine component of these substrates where spikedace and loach minnow are present and absent, and (3) the probability that sediment fines have been a primary causative factor in the decline of these two species.

### Methods and Study Areas

Spikedace were collected with both seines and backpack DC electrofishing techniques depending upon habitats sampled (Stefferd and Rinne 1995; Rinne et al. 2001). Loach minnow were collected primarily by electrofishing into block seines positioned 2–4 m downstream of initial points of sampling. Individuals were immobilized and washed downstream into the net. All fish were removed, enumerated, measured, and returned alive to the stream.

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Substrates were characterized by pebble count methodology (Bevenger and King 1995). Water velocity was measured with a direct readout flow meter and depths with a meter rule. The study areas included the upper Verde River (Stefferd and Rinne 1995) in west-central Arizona and the upper Gila River (Rinne et al. 2001) in southwestern New Mexico.

## Fines and Fishes

### Substrates Utilized

Substrates are a reflection, in part, of gradients and velocities of aquatic habitats (Hynes 1972: 11). Spikedace were found over sand (< 2 mm, 21%) to gravel (3–64 mm, 55%) substrates in the glide-run and low-gradient riffle habitats in both the upper Verde (Rinne and Stefferud 1996) and the upper Gila (Rinne and Deason 2000). Loach minnow occupied only high-gradient riffle habitat composed of gravel (38%) and pebble (65–127 mm; 32%) substrate. Rinne (1991) reported on substrates occupied by spikedace in several southwestern rivers and streams, however numeric indexes of 1 to 5 (sand-gravel-pebble-cobble-boulder) were utilized to define substrate habitats occupied. Spikedace was found over quite variable substrates depending on stream size. Rinne (1989) reported loach minnow also occupying a wide range of substrates from gravel to cobble in the same suite of streams in Arizona and New Mexico.

### Fine Component of Occupied Habitats

Rinne and Stefferud (1996) specifically did not report fine content of substrate for spikedace. However, glide habitats were reported to be composed of a mean of about 30 percent sand (fine) substrate and run habitats were characterized by a mean of about 25 percent sand or fines. Although not defined at that time, a re-calculated average fine content of "glide-run" habitats from Rinne and Stefferud (1996) is about 29 percent. Neary et al. (1996) documented that spikedace numbers increased almost three-fold (18 to 52 individuals) when the fine component of the substrate decreased from about 27 percent to 7 percent.

In the upper Gila River, Rinne and Deason (2000) reported that spikedace were most commonly found over sand-gravel substrates. Sand content or fine levels averaged 12 percent where spikedace were present to 5 percent where absent. Further, the sand content in all glide-run habitats sampled in the Verde and Gila Rivers in 2000 was 18 and 20 percent, respectively. Sand substrate in

glide-run habitats in the upper Verde River declined from 50 percent (range = 50–53,  $n = 7$ ) in 1996 to 38 percent (range 10–77,  $n = 7$ ) in 2000 (Rinne, unpublished data). Rinne (1991) reported spikedace located over sand substrates, but use of these habitats varied by stream.

Loach minnow was captured almost exclusively (90%+) in high-gradient riffle habitats in the upper Gila. In these habitats, substrates had a mean of 8.3 percent fines in 1999 and 8.8 percent in 2000. Of 49 high-gradient riffles sampled in the upper Gila in 1999 and 2000, fines averaged only 6 percent of the substrate composition. Based on substrate indexes, Rinne (1989) documented that loach minnow minimally occupied habitats over sand substrates.

Finally, if one compares the abundance of spikedace and loach minnow in respective aquatic macro-habitats where captured, there are no obvious, consistent, indirect trends of relationships between percentage fines in substrates and densities of fish (Tables 1 and 2).

## Discussion

### Spikedace

Spikedace has declined markedly between 1994 and 1999 in the upper Verde River (Rinne 1999b). By comparison, the species is yet present and locally abundant in the upper Gila River (Rinne et al. 2001; Rinne in press). Fine sediment in optimum glide-run habitats is near identical (18 and 20%) in the two rivers (Rinne and Deason 2000). Further, there is no apparent indirect trend in abundance of spikedace relative to fine sediment concentration (Table 1). Livestock grazing has been removed from the upper Verde River

Table 1. Relationship of abundance of spikedace in the upper Gila River, 1999–2000, relative to percentage fine content of substrate. Absence of spikedace is calculated only from glide-run habitat type.

	Sample size	Abundance category	Range of fine content	Mean fine content
1999				
	32	0	0–96	24
	16	< 5	0–88	28
	11	5–9	4–88	20
	18	> 10	0–46	17
2000				
	30	0	0–60	–
	13	< 5	0–41	13
	8	5–9	0–29	1
	2	> 10	15–41	28

Table 2. Relationship of abundance of loach minnow in the upper Gila River, 1999–2000, relative to percentage fine content of substrate. Absence of loach minnow is calculated only from high-gradient riffle habitat type.

	Sample size	Abundance category	Range of fine content	Mean fine content
1999	25	0	0–28	3.0
	24	< 5	0–64	9.5
	9	5–9	0–38	12.0
	5	> 10	0–18	6.0
2000	8	0	0–26	6.3
	13	< 5	0–65	4.0
	3	5–9	0	10.0
	2	> 10	0	6.3

corridor since 1997; it is present in the Gila–Cliff Valley reach of the upper Gila River. This reach of the upper Gila has been reported as the area of greatest concentration of the species for almost 2 decades (Propst et al. 1986; Rinne et al. 2001).

Limited data on the upper Verde (Neary et al. 1996) suggest that spikédace abundance increased markedly relative to marked decrease in sand substrates. Nevertheless, substantial numbers of spikédace were present and in spawning aggregations in aquatic habitats containing substrate fine levels of up to 27 percent. By comparison, in the upper Gila in 1999–2000 spikédace were collected over substrates with fines averaging 21 percent (Table 1).

#### Loach Minnow

Although historically present in the Verde River, I only have data on loach minnow presence and abundance for the upper Gila River, 1999–2000. This species almost exclusively occupied high-gradient riffles (slope > 1.0%, mean 2.2%) characterized by gravel-pebble (70%) and cobble (14%) substrates. The almost complete lack of this habitat type in the upper Verde in 1999 (Rinne et al. 2001) must certainly reduce the probability of loach persistence in the upper Verde River. It may further suggest why historically this species was not collected in the extreme upper Verde River.

In both 1999 and 2000, fines in high-gradient riffle habitats averaged less than 9 percent. A mean of only 6 percent fines was calculated for all high-gradient riffle habitats in the upper Gila. As recorded for spikédace, there was no inverse trend in loach minnow abundance and fine sediment concentration (Table 2). The flushing process

caused by higher velocities (mean 68 cm/sec) in high-gradient riffles moves fines through these habitats naturally, resulting in low substrate fines levels. Propst et al. (1988) reported that loach minnow occupied the upper erosional, less consolidated portions rather than the lower depositional, more sedimented portions of these habitats. Although not specifically recorded, I have also noted this linear distribution of abundance of loach minnow in high-gradient riffles.

Similar to spikédace, loach minnow spawning is likely the critical life history stage that is affected by fines. Resting cover and the effects of fines on food supply are likely of secondary limiting nature. Propst et al. (1988) documented that deposition of eggs in riffle habitats occurs at the downstream undersurfaces of cobble and boulder substrate components. In the event of excessive fines in the bedload these areas would conceivably become filled because of extant hydrologic function which would deposit these fine sediment materials in these areas of lower velocity. However, the fines (ca. 9%) recorded in high-gradient riffles in the upper Gila do not appear to approach an excessive level. As with spikédace, specific study is needed to substantiate this contention.

#### Conclusions

The data suggest that fines cannot be unequivocally identified as negative impacts on spikédace or loach minnow in these two desert rivers. Further, neither can grazing-generated fines be implicated as a major limiting factor, because this land use is present at moderate to high levels in the Gila–Cliff Valley where both species are present. Also, it is here that loach minnow and spikédace have persisted through time (Propst et al. 1986, 1988; Sublette et al. 1990) and are currently present and locally abundant (Rinne et al. 2001). Additional detailed, controlled studies are needed to unequivocally document the threshold of the effect of sediment fines on spikédace and loach minnow sustainability.

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