Pimephales: More Than Just Bait

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Pimephales species are an over-looked and under-respected group of fishes. They are found just about anywhere, don't develop vibrant colors, and are commonly raised for bait; therefore, they don't have that "shock" value when collecting them (it's more of a "ho-hum" value). However, I enjoy raising them and feel they make great aquarium fishes. They are hardy, will eat about anything (both plant and animal matter), develop interesting breeding morphological features, are fairly easy to spawn, and, being schooling pacifists, make nice tank-mates for my madtoms, sunfishes and darters.

Pimephales can occur in the same geographic areas without interbreeding. They can share the same habitats but often separate by slight niche differences. There are four species of *Pimephales* (accounts from Cross, 1967; Miller and Robison, 1973; Robison and Buchanan, 1988; Page and Burr, 1991; and Pflieger, 1997):

1) Bluntnose Minnow, *P. notatus* (Rafinesque) (front cover photo), occurs in the Great Lakes, Hudson Bay, and Mississippi River basins. Found in a variety of habitats, it most commonly is found in the midwater or near the bottom of quiet backwaters of streams that have clear, warm water and permanent flow.

2) Fathead Minnow, *P. promelas* Rafinesque (Fig. 1), occurs throughout North America except mountainous areas and portions of the Atlantic Slope; because of its frequent use as fishing bait, it has been introduced into many areas outside of its natural range. Found in a variety of habitats, it most commonly is found in the muddy pools of small streams and in impoundments. "Rosy red," a genetic strain of *P. promelas*, commonly can be found in pet stores.

3) Slim Minnow, *P. tenellus* (Girard), occurs in the Ozarks and adjacent regions in the Red and Arkansas river drainages and other tributaries of the Mississippi River. It predominantly lives in the midwater or near the streambed of runs of mid-sized streams that have clean sand/gravel bottoms and moderate flowing water.

4) Bullhead Minnow, *P. vigilax* (Baird & Girard), occurs in the Mississippi River basin and Gulf Slope drainages. It predominately lives in sluggish pools of larger streams that have silty/sandy bottoms, continuous flow, low gradients, and spare vegetation.

The Fish Room

I have been collecting and breeding *Pimephales* species since 2000. I collect both *P. notatus* and *P. promelas* throughout Kansas and Illinois, *P. tenellus* in the Neosho River, Kansas, and *P. vigilax* throughout Illinois. I segregate fishes into 10 aquaria: six 40 L, one 60 L, one 130 L, one 150 L, and one 210 L. *Pimephales* growth and fecundity are influenced by population density, food supply, water chemistry, and habitat (McCarraher and Thomas, 1968). Low population densities (0.09 to 0.26 fish per liter in aquaria) and high feeding rates increase growth, gamete development, and egg size (Smith et al., 1978). Therefore, I stock *Pimephales* between 0.1 to 1.2 fish per liter, and feed them just about everything, including flake foods, pellets, live invertebrates, and frozen insect larvae. I place most substrates known for North American minnows (Page and Johnston, 1990) in each aquaria: sand, gravel, pebble, cobble arranged to created narrow crevices, logs with crevices and exposed undersurfaces, and paired valves of freshwater mussel species known to occur in the fishes'

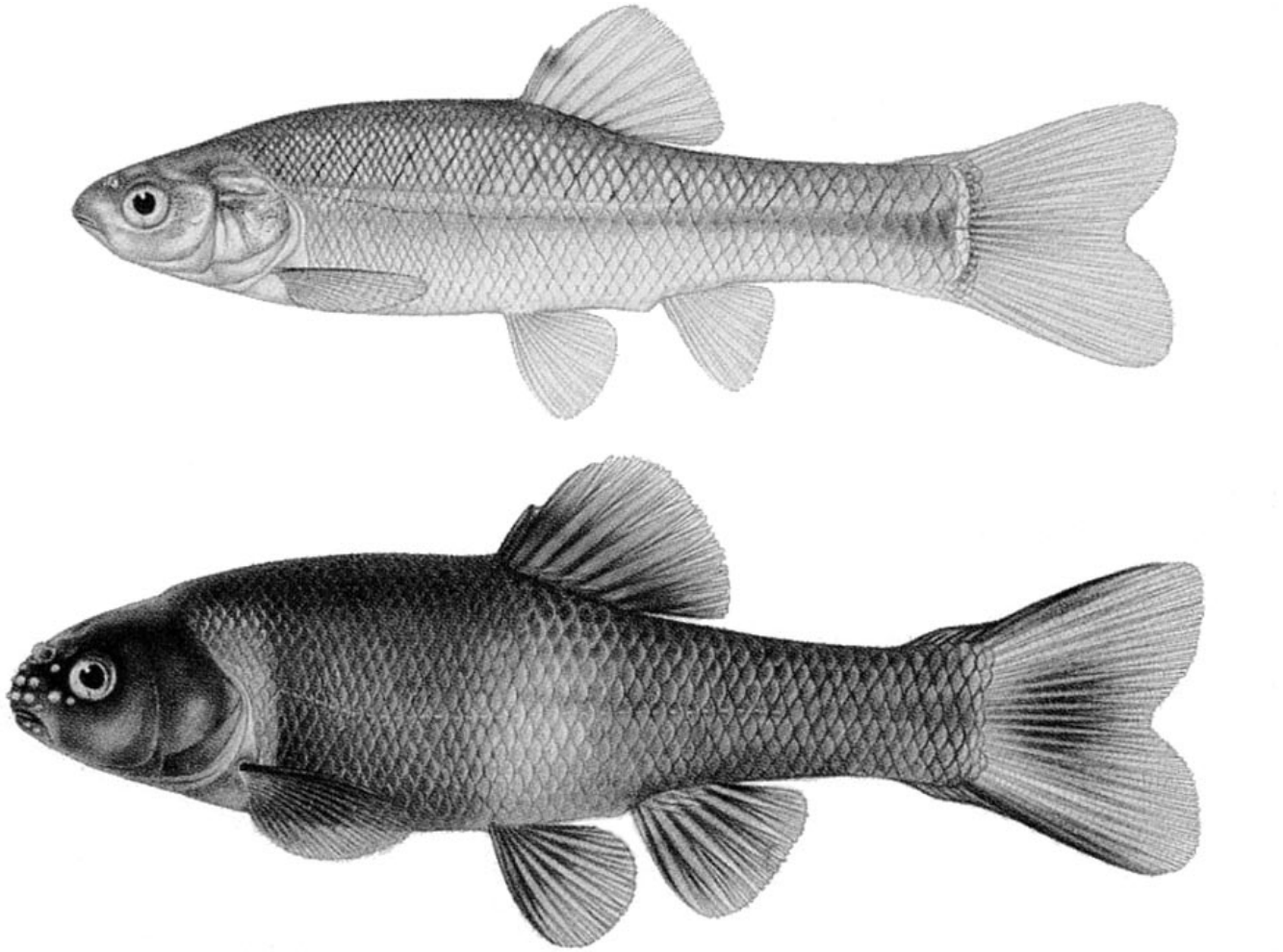

Fig. 1.
Fathead Minnow, *Pimephales promelas*, female above, nuptial male below.
Illustrations © Joseph R. Tomelleri.

ranges. I make sure proportions of substrates and densities of freshwater mussels and logs are similar to that found at the point of collection. I keep aquaria at ambient light (10L-14D to 16L-8D) and temperature conditions (to 26°C), except I do not allow temperature to fall below 10°C. (I don't want to freeze out my family.) Because *P. tennellus* are believed to spawn among rocks in fast water (Cross, 1967), I provide approximately 0.25 m/s of flow at the substrate's surface in their aquaria, but I do not provide flow in the other aquaria.

Pimephales Breeding

Pimephales species have evolved similar breeding morphological features and similar breeding behaviors (e.g., the egg-clustering breeding strategy; Page and Ceas, 1989). Gonad weight is determined by water chemistry, but typically gonosomatic index scores for both male and female are low throughout winter and increase as the spawning season nears (Smith, 1978). Once conditions are favorable, the breeding female develops an enlarged urogenital structure and continues schooling behavior. The breeding male, which typically becomes larger than females, shifts from schooling behavior to territoriality; he develops a swollen black head, breeding tubercles on snout, a thickened first dorsal ray fin, and dorsal pad on nape and spine. He then establishes a territory within a crevice of submerged object and prepares his nest by using various visual and contact displays (Table 1); he seldom leaves his nest throughout this process. Once his nest is prepared, the male continues using various visual and contact displays (Table 1) and can use sound (Johnston and Johnson, 2000) and water-borne chemicals (Cole and Smith, 1992) to entice a female to

Table 1. Observed male *Pimephales* spp. behaviors performed (EN = establishing a nest, C = courtship, and ND = nest defense). Terms taken from McMillan and Smith (1974) and Cole and Smith (1987a).

Term	Definition	Type
Hovering	remaining virtually stationary below the ceiling of the cobble crevice; usually coincides with other EN behaviors	EN
Circling	swimming in a spherical path below the ceiling of the cobble crevice; usually coincides with other EN behaviors	EN
Rubbing	stroking his head and/or dorsal pad on the ceiling of the cobble crevice; usually coincides with other EN behaviors	EN
Nibbling	contacting the ceiling of the cobble crevice with his tubercles, nostrils and mouth; usually coincides with other EN behaviors	EN
Approaching	swimming rapidly toward the female, only to suddenly stop < 5 cm of her; usually combined with other C behaviors	C
Lateral displaying	positioning himself either in front of and at right-angles to, or beside and parallel to, the female, simultaneously extending all fins; usually combined with other C behaviors	C
Tapping	touching the nest site and/or female with head; usually combined with other C behaviors	C
Leading	escorting the female to the nest site; usually combined with other C behaviors	C
Biting	contacting intruder with open mouth and closing it upon contact; usually intersperses with other ND behaviors	ND
Head-butting	swimming toward intruder and pushes it with the anterior end of his snout; usually intersperses with other ND behaviors	ND
Chasing	swimming rapidly after fleeing intruder; usually intersperses with other ND behaviors	ND
Tail-beating	positioning himself alongside intruder and laterally undulates his caudal fin and posterior part of his body; usually intersperses with other nest defense behaviors	ND
Carouselling	orienting head-to-tail with intruder and swims after other fish in a circular path; usually intersperses with other ND behaviors	ND
Charging	swimming rapidly and directly toward intruder; usually intersperses with other ND behaviors	ND
Fin erection	elevating dorsal fin to its full height; usually intersperses with other ND behaviors	ND

spawn. Similarly, females can release chemical stimuli to increase the male's courtship behavior (Cole and Smith, 1987b).

The act of spawning seems to be consistent among the four species of *Pimephales* (McMillan and Smith, 1974; Page and Ceas, 1989; Tiemann, 2007). When ready to spawn, the female enters and examines the male's nest. She then turns on her side and allows him to juxtapose himself below her. The pair remains pressed together on their sides and simultaneously swims in circles while undulating. During this process, the female releases an egg from her genital papilla, rolls it along the upward side of her body, and presses it in a single-layer cluster to the underside of the submerged object while the male simultaneously releases sperm to fertilize the egg.

Females of all four species of *Pimephales* experience fractional spawning (release of eggs at intervals). Fractional spawning not only allows the female to increase her fecundity by producing more eggs in a breeding season than she could possibly hold, but also decreases the chance that an entire generation will be eliminated by short-term environmental events (Gale and Buynak, 1982). Multiple clutches of eggs also will allow individuals that hatched early in a season to have as long of a growing season as those that hatched at the end of the season of the previous year (Van Cleave and Markus, 1929). Typically fewer days are taken in between spawnings at the beginning of the spawning season compared to the end of the spawning season. The number of eggs per spawning session is variable but generally there is a tapering off in clutch size at the end of the spawning season.

After spawning, the female leaves and the male spends the majority of his time near the nest and usually does not leave to court new females, eat, or guard fry. The male vigorously defends his nest against intruders by using various visual and contact displays (Table 1). A male can continuously spawn while caring for his eggs (see below), and often has a nest with eggs in various stages of development. The number of eggs in a male's nest appears to be limited by nest size, which suggests that spawning substrates might limit male reproductive success (Markus, 1934).

Table 2. Comparative spawning behaviors and statistics for *Pimephales* spp. Data were taken from the following: [1]Wynne-Edwards (1932), [2]Markus (1934), [3]Westman (1938), [4]Parker (1964), [5]Flickinger (1969), [6]McMillan and Smith (1974), [7]Gale and Buynak (1982), [8]Gale (1983), [9]Unger (1983), [10]Ming and Noakes (1984), [11]Unger and Sargent (1988), [12]Sargent (1988), [13]Page and Ceas (1989), [14]Tiemann (2007), and [15]Tiemann (unpublished data).

Spawning attributes	***P. notatus***	***P. promelas***	***P. tenellus***	***P. vigilax***
Photoperiod at the onset of sexual maturity	15L-9D[15]	15L-9D[15]	15L-9D[14]	15L-9D[15]
Temperature at the onset of sexual maturity	16°C[15]	16°C[15]	16°C[14]	16°C[15]
Breeding strategy	Egg-clustering[13]	Egg-clustering[6]	Egg-clustering[14]	Egg-clustering[13]
Earliest spawning age	Age-1[15]	Age-1[2]	Age-1[14]	Age-1[15]
Earliest spawning photoperiod	14L-10D[15]	12L-12D[15]	16L-8D[14]	15L-9D[15]
Earliest spawning temperature	18°C[15]	16°C[6]	24°C[14]	21°C[15]
Spawning time	All day[15]	All day[15]	Mornings[14]	All day[15]
Length of spawning time	> 6 hours[8]	> 9 hours[7]	10 min.[14]	30 min.[15]
Length of spawning season	4 months[15]	4 months[11]	1 week[14]	1 week[15]
Males exhibit polygamy (Y/N)	Y[3]	Y[5]	Y[14]	Y[4]
Males breed asynchronously (Y/N)	Y[3]	Y[9]	Y[14]	Y[4]
Males exhibit allopaternal care (Y/N)	Y[15]	Y[12]	?	?
Females exhibit fractional spawning (Y/N)	Y[8]	Y[7]	Y[14]	Y[15]
Time between spawnings for females	Up to 14 days[8]	Up to 16 days[7]	2-5 days[14]	2 days[15]
Max. number of clutches	19[8]	26[7]	3[14]	2[15]
Max. number of eggs laid per clutch	> 500[8]	> 1,000[7]	189[14]	25[15]
Max. number of eggs laid during spawning season	> 4,000[8]	> 10,000[7]	> 300[14]	41[15]
Larger females lay more eggs (Y/N)	N[8]	N[7]	Y[14]	?
Larger males with larger nests (Y/N)	N[10]	N[10]	Y[14]	?
Male post-spawning mortality (Y/N)	Y[15]	Y[2]	Y[14]	Y[15]
Female post-spawning mortality (Y/N)	N[15]	N[2]	N[14]	N[15]
Incubation period	Varies on temp.[15]	Varies on temp.[15]	6 days @ 24°C[14]	Varies on temp.[4]
Eggs adhesive (Y/N)	Y[13]	Y[6]	Y[14]	Y[13]
Egg color	Transparent[15]	Transparent[15]	Transparent[14]	Transparent[13]
Egg shape	Spherical[15]	Spherical[15]	Spherical[14]	Spherical[4]
Egg size	1.45 mm[3]	1.15[2]-1.30[1] mm	1.20 mm[14]	1.00[4]-1.50[4] mm
Egg care by parent (Y/N)	Y – male[3]	Y – male[6]	Y – male[14]	Y – male[4]
Fry color	Milky-white[15]	Milky-white[2]	Milky-white[14]	?
Fry size	5.00 mm[3]	4.75 mm[2]	4.65 mm[14]	?
Fry care by parent (Y/N)	N[15]	N[3]	N[14]	?
Time fry begin to school	8 days[3]	8 days[3]	7 days[14]	?

Allopaternal care (adoption of unguarded eggs) is part of the male's reproductive strategy. It appears that females tend to prefer to spawn with a male who has eggs in his nest (Unger and Sargent, 1988). When given a choice among unguarded nests, the male usually chooses to occupy a nest already containing eggs rather than start one of his own. Allopaternal care and egg survival increase with increasing clutch size (Sargent, 1988). However, the male discriminates between his sired and adopted eggs to increase his ability to attract a female and sire his own offspring (Sargent, 1988). The male gives less care and defends less vigorously his adopted eggs than his sired eggs, and exploits his adopted

eggs both as both a food source and a female attractant. The male reduces his adopted eggs to an adequate size to attract a female yet leave enough space for his sired eggs (Unger and Sargent, 1988).

The single-layer clustering allows the male to easily attend the nest (Page and Ceas, 1989). He rubs his dorsal pad and thickened first dorsal ray over the eggs to spread, turn, clean, and/or aerate the eggs. Throughout this contact, goblet cells in the dorsal pad secrete mucus onto the nest, apparently serving as a lubricant for the eggs against abrasion and disease and as a chemical marking of the breeding site (Smith and Murphy, 1974). The dorsal pad in the male contains taste buds, allowing chemosensory sampling of the nest (Smith and Murphy, 1974). Induced by a peak androgen production, the dorsal pad contains no alarm substance cells to prevent possible discharge of *shreckstoff* (an alarm pheromone released by specialized skin cells when damaged in certain fish) during nesting (Smith, 1973). However, the male retains the advantage of detecting and responding to the alarm substance if it is emitted from another fish (Smith, 1976).

Some post-spawning mortality occurs for the males but not the females. Reduced feeding during the spawning season combined with excess energy expenditure while both undergoing physiological changes associated with development of secondary sex characteristics and fighting intruders during nesting might decrease immunity and result in increased post-spawning mortality (Gale and Buynak, 1982).

Spawning statistics for *Pimephales* species are listed in Table 2. These data are a combination of some of my published data (permission was granted by the Southwestern Association of Naturalists), some of my unpublished data, and data collected by others.

Concluding Remarks

I have had better spawning successes of *P. notatus*, *P. promelas* and *P. tenellus* compared to *P. vigilax*. For *P. vigilax*, I was unable to record some spawning information; I am hoping that future spawning successes will rectify the paucity of data. Regardless of species, I noticed that some variables (e.g., temperature) caused inconsistencies in my results. Because my observations were in an artificial setting, there are no doubt differences in life history characteristics (e.g., *P. vigilax* fecundity numbers and spawning season length) than what occurs in the wild. Be sure to check out Bock (1997) and Muller (2000) in previous issues of *American Currents* for their experiences breeding *P. promelas*.

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Bluntnose Minnow

Pimephales notatus (Rafinesque 1820)
Family: Cyprinidae

A male Bluntose Minnow, Pimephales notatus, fanning his fry attached to the underside of the rock. Photograph © Garold W. Sneegas.