

# DISTRIBUTION OF THE MOSQUITOFISH, *GAMBUSIA AFFINIS* (BAIRD & GIRARD), IN INDIANA, WITH COMMENTS ON RESOURCE COMPETITION

Phillip D. Clem  
Department of Natural Sciences  
and Mathematics  
University of Charleston  
2300 MacCorkle Avenue SE  
Charleston, West Virginia 25304-1099

and

John O. Whitaker, Jr.  
Department of Life Sciences  
Indiana State University  
Terre Haute, Indiana 47809

**ABSTRACT:** The mosquitofish, *Gambusia affinis*, was collected in 14 counties in southern and western Indiana: Daviess\*, Dubois\*, Gibson, Greene\*, Knox, Owen\*, Perry, Pike, Posey, Spencer\*, Sullivan\*, Vanderburgh, Vigo\*, and Warrick. Counties marked with an asterisk plus records for Clark and Lake Counties constitute new county records. The species has expanded its range to the north and east in Indiana, reaching southern Vigo County by about 1990. Stomach analysis of 403 individuals indicated that midge adults were the most common food item. Other important foods included algae, *Plumatella* (Bryozoa), Diptera, Corixidae, chironomid larvae, and chironomid pupae. Only 1 mosquito, an adult, was found during the study. The food of the blackstripe topminnow, *Fundulus notatus*, was compared to that of *Gambusia*. The two have similar food habits — their major food is the adult midge.

**KEYWORDS:** Distribution, food habits, *Gambusia affinis*.

## INTRODUCTION

The mosquitofish, *Gambusia affinis*, is a small, surface dwelling fish of the family Poeciliidae and is the only species of livebearer native to Indiana. *Gambusia affinis* is found throughout the southern United States. The mosquitofish occurs in the lower third of the Ohio River Basin (Pearson and Krumholz, 1984), where it is native to Kentucky (Clay, 1975; Burr and Warren, 1987) and southern Illinois (Smith, 1979; Burr and Warren, 1987). The first 3 collections from Indiana were from Posey County in extreme southwestern Indiana (Jordan, 1890). Hubbs and Lagler (1942) found the mosquitofish to be "rare" in Foothills Pond, Gibson County. Gerking (1945) collected it in Gibson, Knox, and Perry Counties. *Gambusia affinis* was collected from the White River in Pike County (Proffitt and Benda, 1971), at several locations in the White River between Pike and Knox Counties (T.P. Simon, pers. comm.), and at other sites in and near Posey County (Grannan

and Lodato, 1986; Kozel, *et al.*, 1981). Thomas Cervone (pers. comm.) has recently taken the mosquitofish in the tributaries of the White River and Pigeon Creek drainage in Daviess and Gibson Counties as well as in Clark County in 1985. In addition, mosquitofish were taken in 1989 in northwestern Indiana in the Kankakee River in Lake County (T.P. Simon, pers. comm.). The Lake County population may indicate an invasion from Illinois (T.P. Simon, pers. comm.), as Krumholz had previously (1944) documented the existence of the mosquitofish as far north as the Chicago area as a result of both natural and human introductions.

Much interest was generated during the early part of this century on the use of *Gambusia* in mosquito control. To this end, experimental transplants of *Gambusia* were made to the Hawaiian Islands (Jordan, 1926), Utah (Rees, 1934), Illinois (Krumholz, 1944), and Michigan (Hubbs and Lagler, 1958). No record of any transplants in Indiana is known.

Two specimens of *Gambusia* were collected in 1927 by T.R. Becker, supposedly from Vigo County, Indiana, in a flood puddle near the Wabash River (T.P. Simon, pers. comm.). The specimens are in the museum at the University of Michigan, but the record has not been published. Since no mosquitofish were found after considerable sampling during a survey of the fish of Vigo County (Whitaker and Wallace, 1972), the collecting locality of the 1927 specimens may be in error.

Six individuals of *Gambusia affinis* were collected in September 1990 in Negro Ditch in southern Vigo County by the vertebrate zoology class at Indiana State University. This site has been sampled almost yearly since 1964, but no mosquitofish had been taken prior to 1990. Since the species had not previously been taken north of Knox County, this collection stimulated further sampling to determine the present distribution of the fish in Indiana. The present study was also undertaken to examine *Gambusia*'s food habits and to compare its food habits to those of the blackstripe topminnow. The mosquitofish resembles a topminnow in appearance and feeding habits, and Cervone, *et al.* (1989) referred to the topminnow as an ecological equivalent of *Gambusia*. While the mosquitofish has been taken only from southwestern Indiana, the blackstripe topminnow, *Fundulus notatus*, is distributed throughout the State. Do the two species eat similar foods and is there any evidence of food partitioning where they occur together?

## MATERIALS AND METHODS

Mosquitofish were previously known only from Posey, Gibson, Knox, Vanderburgh, Pike, Warrick, and Perry Counties in southwestern Indiana. Those counties as well as sites in other counties to the north and east that contained likely habitat (small streams or intermittent ponds with little or no current) were sampled to determine the present distribution of the species.

Most collections were taken using either a 12- and 18-foot, 1/8"-mesh seine, but a hand-held dip net was used at locations where the ditches or streams were very small and mosquitofish were visible near the surface. A total of 71 sites were sampled in 25 counties between 28 September 1991 and 13 July 1992 (Figure 1). One collection in 1991 and all the earlier collections were made using 30-foot, 1/4"-mesh seines.

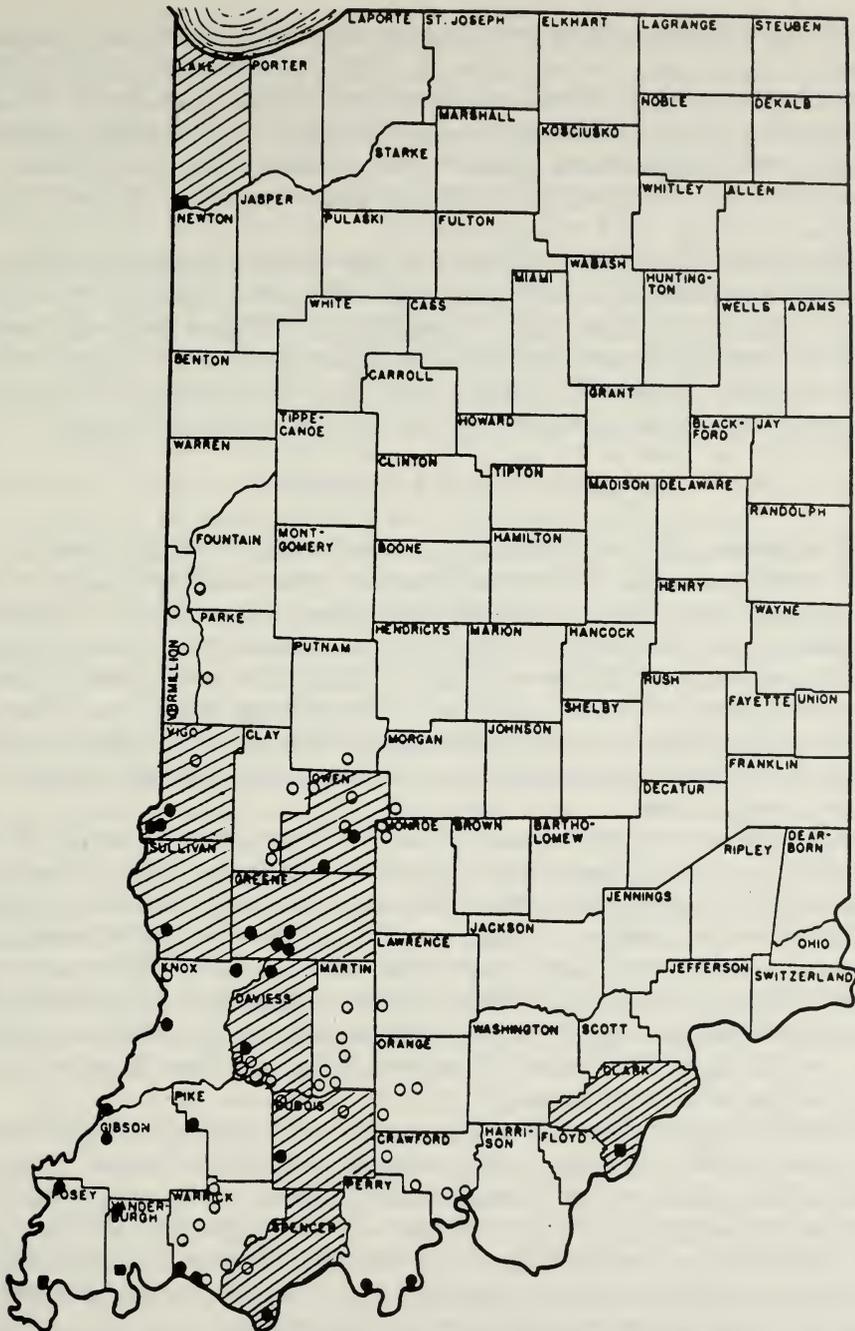


Figure 1. The distribution of the mosquitofish, *Gambusia affinis*, in Indiana. Sampling sites where mosquitofish were collected are indicated by solid (●) circles; sites sampled where no mosquitofish were collected are indicated by hollow (○) circles. Solid squares (■) indicate that populations were present but not sampled by the authors. New county records are indicated by hash marks (///). The Lake County information was provided courtesy of Thomas P. Simon; the Clark County information, courtesy of Thomas H. Cervone.

The fish were preserved in 10% formalin; their stomachs were removed and the contents were placed in petri dishes; then the contents were examined using a dissecting microscope to identify as many food items as possible. Visual estimates were made of the volume of each food item in each stomach, and the data were then summarized as percent volume ( $[\text{sum of individual volumes of food}/\text{total volume of all stomachs}] \times 100$ ) and percent frequency (the percentage of stomachs in which the food item occurred).

Nine collections of *Gambusia*, taken in 1967 in Posey County, Indiana, and 4 collections of *Fundulus notatus* from Vigo County were examined by similar methods. These data, taken before *Gambusia* had advanced northward, were compared with the current data from the areas where the two species now occur together. Statistical analyses were done by running ANOVA and Student-Newman-Keuls multiple range tests on arcsine transformed data.

## RESULTS AND DISCUSSION

**Distribution.** *Gambusia affinis* was collected from 25 of 71 sites in 14 of the 25 counties sampled in Indiana (Figure 1). Over 1,000 individuals were collected in October 1991 from Negro Ditch, Vigo County, where the first six individuals from the County had been taken the previous year. The species is currently present in Clark\*, Daviess\*, Dubois\*, Gibson, Greene\*, Knox, Owen\*, Perry, Pike, Posey, Spencer\*, Sullivan\*, Vanderburgh, Vigo\*, and Warrick Counties in the drainages of the Ohio, Patoka, Wabash, and White Rivers as well as in the Kankakee River in Lake\* County. (Those counties marked with asterisks are new county records.)

Mosquitofish were taken from streams with bottom features ranging from solid rock, to gravel, sand and sand-gravel, and mud. The presence of mosquitofish in Clark, Daviess, Dubois, Greene, Lake, Owen, Spencer, Sullivan, and Vigo Counties indicates a range extension of the species northward and eastward from its historical range in the State (Gerking, 1945). The presence of mosquitofish in Lake County probably indicates an extension of the species into Indiana from fish introduced into northern Illinois, because the species was absent from samples taken in the counties (Fountain, Parke, and Vermillion Counties) between Vigo and Lake Counties.

When the mosquitofish reached the counties north and east of its historical range is not certain. *Gambusia* was probably absent from Daviess, Dubois, Greene, Owen, Spencer, and Warrick Counties before 1945, as Gerking did extensive sampling in those counties at that time. The progression of the species up the West Fork of the White River and into the headwaters of the Patoka in recent years could be due to agricultural practices that have changed the profile of the rivers and made more suitable habitat for *Gambusia*.

The time when *Gambusia* arrived in Negro Ditch in southern Vigo County is easier to pinpoint. Seine samples have been taken in Oxendine Bayou, Negro Ditch, and the Wabash River in southern Vigo County almost yearly from 1964 to the present by vertebrate zoology classes at Indiana State University. No *Gambusia* was ever found in these collections until September 1990, when 6 individuals were taken in Negro Ditch. During September 1991, large numbers (1000) were collected from Negro Ditch, Oxendine Bayou, and Prairie Creek in

southern Vigo County. These data indicate a range extension of the species into southern Vigo County around 1990.

The lack of mosquitofish in northern Vigo County (Figure 1) as well as in Fountain, Parke, and Vermillion Counties in the upper Wabash drainage and Crawford, Martin, and Orange Counties in the Patoka and White River drainages indicates that this fish does not presently occur in these streams, where relatively little appropriate habitat exists.

**Foods of *Gambusia*.** The foods eaten by 320 individuals of *Gambusia affinis* from Posey County in and around Hovey Lake during the summer of 1967 are indicated in Table 1. The most common food item, in both percent volume and percent frequency, was the adult midge (Chironomidae), which formed 17.0% of the diet by volume and 14.6% by frequency, followed by algae (15.8% by volume and 13.0% by frequency) and the bryozoan, *Plumatella* (12.8% by volume and 10.7% by frequency). Chironomids in all 3 life forms made up 21.1% of the volume and occurred at a frequency of 18.7% in the mosquitofish from Hovey Lake. Only one mosquito, an adult, was found in the 320 stomachs.

At Reelfoot Lake in western Tennessee, Barnickol (1941) found that chironomid larvae made up 3.0% and culicid larvae less than 1.0% of the total food volume from the 318 mosquitofish stomachs he examined. Plant material comprised a higher volume (24.7%) than in this study (16.9%). Rice (1941), also at Reelfoot Lake, found that chironomid larvae and pupae made up 2.0% and culicid larvae 13.0% of the total food volume in the stomachs of the 465 mosquitofish he examined. Rice also noted differences in both the total volume and frequency of food items in fish captured in open water as opposed to those taken in water with heavy vegetation. In the stomachs of *Gambusia* from open water, Chironomidae formed 12.0% of the food items by total volume and 13.2% by frequency. No Culicidae were found. For those mosquitofish taken from water with heavy vegetation, 25.0% of the total volume of food items eaten and over 28.0% of the food items by frequency were culicids. In this case, no chironomids were found.

Mosquitofish collected in our study were all taken in open water with the dominant vegetation being larger trees and shrubs. The effectiveness of *Gambusia affinis* in controlling mosquitoes, at least in relatively open water, is questionable at best. Perhaps a better common name for this fish would be "midgefish."

The foods in the stomachs of 36 blackstripe topminnows, *Fundulus notatus*, taken from central Indiana prior to the presence of *Gambusia affinis* are listed in Table 1. The main food items were chironomid adults (35.6% by volume and 20.8% by frequency) followed by Formicidae (8.8% by volume and 6.9% by frequency) and damselfly (6.1% by volume and 4.1% by frequency). Chironomids in all 3 life forms comprised 39.9% of the stomach contents by total volume and 27.5% by frequency. Of the 27 food items identified from *Fundulus notatus*, 15 were food items and 3 were major food items (i.e., they formed at least 5% of the total food volume) used by *Gambusia affinis*.

Comparison of the foods in the stomachs of 56 topminnows from Vigo, Sullivan, Knox, and Pike Counties with foods in the stomachs of 47 mosquitofish taken in those same areas at the same time yielded twelve identifiable food items common to both species (Table 2). For each species, the food consumed in greatest quantity was the adult midge (12.8% by volume and 8.0% by frequency for mosquitofish; 14.3% by volume and 9.3% by frequency for topminnows).

Table 1. The principle food items found in the stomachs of 320 mosquitofish, *Gambusia affinis*, from Posey County, Indiana (listed in order of importance); and the food items found in the stomachs of 36 topminnows, *Fundulus notatus*, from central Indiana taken prior to the occurrence of mosquitofish there (not listed in order of importance).

Food	<i>Gambusia</i>		<i>Fundulus</i>	
	% Vol	% Freq	% Vol	% Freq
Chironomidae (adult)	17.0	14.6	35.6	20.8
Algae	15.8	13.0	0.4	1.4
Bryozoa (mostly <i>Plumatella</i> )	12.8	10.7		
Diptera (unidentified)	5.9	7.0	4.7	5.6
Cecidomyiidae	4.4	5.8	0.1	1.4
Cicadellidae	4.3	3.9	2.4	4.1
Formicidae	3.7	4.3	8.8	6.9
Cladocera	3.4	2.9		
Chironomidae (pupae)	3.1	3.1	3.9	5.6
Cynipoidea	2.0	2.9		
Corixidae	1.9	1.9	2.8	1.4
Invertebrate (unidentified)	1.7	1.7		
Tipulidae (adult)	1.6	1.2		
Trichoptera (larvae)	1.6	1.7	2.2	2.8
Staphylinidae	1.6	1.4		
Araneae	1.4	1.4	2.2	2.8
Insect (unidentified)	1.3	2.3	2.8	1.4
Aphididae	1.1	1.4	2.5	4.2
Chironomidae (larvae)	1.0	1.0	0.4	1.4
Homoptera	1.0	0.8		
<i>Gambusia</i> (embryo)	1.0	0.8		
Sciomyzidae	0.9	0.6		
Plant (unidentified)	0.9	0.6		
Crustacea	0.9	0.8		
Ephemeroptera (naiad)	0.8	0.6		
Coleoptera (unidentified)	0.7	1.0	1.7	4.2
Saldidae	0.6	0.2		
Hemiptera	0.6	0.6		
Cercopidae	0.5	0.4		
Diptera (larvae)	0.5	0.8		
Syrphidae	0.4	0.4		
Lepidoptera (adult)	0.4	0.4		
Sciaridae	0.4	1.2		
Chrysochloridae	0.3	0.8		
Hymenoptera	0.3	0.8		
Gerridae	0.3	0.2		
Phoridae	0.3	0.2		
Geometridae	0.3	0.2		
Mycetophilidae	0.3	0.2		

Food	<i>Gambusia</i>		<i>Fundulus</i>	
	% Vol	% Freq	% Vol	% Freq
Simuliidae	0.3	0.2		
Acarina	0.3	1.0		
Lygaeidae	0.3	0.2		
Eriosomatidae	0.3	0.6		
Otitidae	0.3	0.4		
Carabidae (larvae)	0.3	0.2		
<i>Carex</i> (seed)	0.2	0.2		
Collembola	0.2	0.4	0.7	2.8
Culcidae (adult)	0.2	0.4		
Zygotera			6.1	4.1
Grass seeds			3.8	5.6
Small fish			3.1	2.8
Ceratopogonidae			2.8	1.4
Hemerobiidae			2.8	1.4
Chermidae			2.8	1.4
Thysanoptera			2.2	6.9
Corrodentia			1.3	4.2
<i>Daphnia</i>			1.4	1.4
Ephemeroptera			1.4	1.4
Reduviidae			1.1	1.4
Coccidae			0.3	1.4
Totals	99.2*		100.0	

\* Seven additional food items account for remaining 0.8% of *Gambusia*'s total food volume.

Chironomid adults, Corixidae, chironomid pupae, Cicadellidae, Diptera, Aphididae, Cecidomyidae, *Daphnia*, chironomid larvae, snails, Cynipoidea, and Coleoptera made up 85.5% of the total volume in mosquitofish and 70.5% in topminnows. The percent frequency of these food items was 53.4% in mosquitofish and 45.8% in topminnows. The foods consumed by the 2 species are quite similar. No mosquitoes (adult, pupae, or larvae) were found in the stomachs of either species.

Eleven food items that occurred at rates of at least 5% by volume in any of the groups of fish (*Gambusia* in Posey County, *Fundulus* from central Indiana before the arrival of *Gambusia*, and *Gambusia* and *Fundulus* when the two occurred together in central Indiana) were examined for statistical differences in food preference between fish groups (Table 3). Five of the food items (chironomid pupae, Cicadellidae, Diptera, Cecidomyidae, and Formicidae) showed no significant differences between any of the fish groups. Significant differences in rates of consumption occurred for the other six foods.

Two of the six, algae and bryozoans, were most heavily eaten by *Gambusia* in Posey County. These two foods may have been readily available in Posey County. Two other food items, chironomid adults and zygopterans, were most abundant in the stomachs of *Fundulus*, when that species occurred in the absence of *Gambusia* in central Indiana. Many of these specimens were from Vermillion

Table 2. A comparison of the food items taken from the stomachs of 47 individuals of *Gambusia affinis* and 56 individuals of *Fundulus notatus* in the area where their ranges overlap.

Food	<i>Gambusia</i>		<i>Fundulus</i>	
	% Vol	% Freq	% Vol	% Freq
Chironomidae (adult)	12.8	8.0	14.3	9.3
Corixidae	12.8	6.8	19.6	5.6
Chironomidae (pupae)	9.8	5.7	7.0	8.6
Invertebrate (unidentified)	8.5	4.6	0.9	1.4
Cicadellidae	8.2	4.6	7.9	2.3
Diptera (unidentified)	6.8	5.7	4.8	2.3
Aphididae	6.7	4.6	2.3	2.3
Cecidomyiidae	5.5	3.4	1.4	1.9
<i>Daphnia</i>	4.0	2.3	3.7	7.1
Insect (unidentified)	3.1	3.4	0.3	0.5
Chironomidae (larvae)	3.0	1.1	0.7	0.9
Copepoda	2.3	1.1		
Mollusca (snail)	2.1	1.1	3.2	0.9
Cynipoidea	2.1	1.1	1.8	0.9
Delphacidae	2.1	1.1		
Phalacridae	2.1	1.1		
Plant (unidentified)	2.1	1.1		
Bryozoa (mostly <i>Plumatella</i> )	1.8	1.1		
Seeds (unidentified)	1.3	1.1		
Acarina	1.2	2.3		
Phoridae	1.1	1.1		
Coleoptera (unidentified)	0.4	1.1	2.6	1.9
Crustacea	0.1	1.1		
Tipulidae			3.9	1.4
Cercopidae			3.2	1.4
Staphylinidae			3.0	1.4
Chrysomelidae			2.8	1.9
Algae			2.5	0.9
Gerridae			2.5	0.9
Ephemeroptera (naiad)			1.8	0.9
Ceratopogonidae			1.8	0.5
Ephemeroptera			1.8	0.5
Coccidae			1.8	0.5
Miridae			1.8	0.5
Trichoptera (larvae)			1.6	1.9
Thysanoptera			0.5	1.4
Formicidae			0.4	0.9
Homoptera			0.4	0.9
Totals	99.9		100.3	

Table 3. The correlation between major foods (those occurring at a rate of 5% or more by volume in at least one sample) found in the stomachs of *Fundulus* and *Gambusia*. Food items in boldface occurred at significantly higher rates than other food items.

Food	<i>Gambusia</i> alone	<i>Gambusia</i> w/ <i>Fundulus</i>	<i>Fundulus</i> w/ <i>Gambusia</i>	<i>Fundulus</i> alone	F Value
Chironomidae (adult)	17.0	12.8	14.3	<b>35.6</b>	<b>4.817</b>
Corixidae	1.9	<b>12.8</b>	<b>19.6</b>	2.8	<b>24.755</b>
Chironomidae (pupae)	3.1	9.8	7.0	3.9	2.619
Cicadellidae	4.3	8.2	7.9	2.4	1.594
Diptera (unidentified)	5.9	6.8	4.8	4.7	0.085
Aphididae	1.1	<b>6.7</b>	2.3	2.5	<b>8.611</b>
Cecidomyiidae	4.4	5.5	1.4	0.4	1.378
Formicidae	3.7	0.0	0.4	8.8	3.309
Zygoptera	0.0	0.0	0.0	<b>6.1</b>	<b>11.584</b>
Algae	<b>15.8</b>	0.0	2.5	0.4	<b>11.605</b>
Bryozoa (mostly <i>Plumatella</i> )	<b>12.8</b>	1.8	0.0	0.0	<b>1.873</b>
TOTALS	70.0	64.4	60.2	67.6	

County, north of *Gambusia*'s range and habitat. The zygopterans may have been particularly abundant there.

The most important food of both species, adult chironomids, was common in all samples but was significantly more abundant only in the sample where *Fundulus* occurred alone. Adult chironomid usage was not significantly different between any of the other three groups. Usage was second highest (17.0%) in *Gambusia* in Posey County and lowest (12.8% and 14.3%) when both fish species occurred together.

Since adult midges were the most abundant food eaten by both species, the two species of fish might compete for chironomids, if these insects were in short supply. Water boatmen (Corixidae) were taken at low rates by *Gambusia* in Posey County and by *Fundulus* before invasion by *Gambusia*. Water boatmen were eaten in significantly greater amounts where the two fish occurred together in central Indiana. The water boatmen might have been selected due to a shortage of midges. In addition, *Gambusia* fed on significantly more aphids when *Fundulus* was present.

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