

REPRODUCTIVE BIOLOGY
OF THE REDBREAST SUNFISH
Lepomis auritus

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by
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ABSTRACT

The reproductive biology of the redbreast sunfish, Lepomis auritus (family Centrarchidae), was studied in the Hudson River during the summer of 1991, using laboratory experiments and field observations. Many centrarchid species build nests in shallow, calm areas off of the main channel along the Hudson River. Although the Hudson is strongly tidal, these nesting sunfish do very well in the river. In the field, I tagged nests that were similar to the nests constructed in the artificial stream. Nests varied in substrate composition (amounts of gravel, mud, sticks, clay, and vegetation present), diameter (37-133 cm), depth (1.5-15.9 cm), and the amount of eggs and/or fry present (2575-24317). Two-thirds of all nest were exposed at low tide. Of the exposed nests, 98% contained water, which fluctuated between 18-35 °C during the study period. In the laboratory, an artificial stream was used to mimic field conditions in a more controlled environment, and nest construction, courting and spawning, and aggressive behavior were observed. Male sunfish excavated round, shallow nests. During courting, the male circled above the nest at a 45° angle at a rate of one circle per second. During spawning, the male and female swam above the nests, perpendicular to each other, and touching at their venters. The male sunfish guarded eggs and fry. Fry remained in the nest 12-14 days. During this period, sacfry absorbed their yolk and left the nest. The male stopped guarding the nest when all the fry had departed. Nesting males were aggressive toward each other and used chases, feints, face-to-face encounters and occasional fin biting to advertise and protect their nest. Although most of the nests were exposed, and the parent sunfish could not guard their eggs for several hours a day, the warm water in the nests caused a faster development rate to occur.

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INTRODUCTION

Although the shallow-water fish assemblage in the Hudson River is changing, preliminary data indicate that some sunfish populations (Centrarchidae) have remained relatively stable in the River during the last 50 years (Greeley, 1937; Beebe and Savidge, 1988; Anonymous, 1989; Daniels and Lawrence, unpubl. data). Based on descriptions of sunfish nesting behavior described in Breder (1936) and Smith (1985), I hypothesized that the behavior associated with nesting in redbreast sunfish, Lepomis auritus, may account for their apparent persistence and stability in the Hudson River. However, testing this hypothesis requires information on both the long-term changes in population size and a detailed understanding of the life history of the fish. Here I report on a study that I conducted to provide a description of the reproductive ecology of the redbreast sunfish in the tidal portion of the Hudson River.

Redbreast sunfish are widely distributed throughout Atlantic slope drainages from eastern Texas to Maine (Lee, et al., 1980 et seq.). In New York, they are found in the tidal part of the Hudson River and its tributaries, the Delaware and Susquehanna River systems, the Mohawk River and its tributaries and in the upper Hudson River system, although its presence in the Adirondack lakes and streams may result from introductions (see George, 1981; Mather, 1890). Despite its extensive range and importance as a gamefish in certain areas (Manooch, 1984), little information on its general biology has been published. Breder (1936) described its spawning behavior and Davis (1972) discusses fecundity and spawning season in North Carolina. Redbreast sunfish, like many other species of sunfish, is a nesting species that spawns in late spring or early summer. In a note, Richmond (1940) described spawning of redbreast sunfish in the tidal portion of the Chickahominy River in Virginia. The most interesting aspect of Richmond's observations was that many nests were exposed along the shore at low tide. I am not aware of similar observations reported for other redbreast sunfish populations.

This study was designed to provide information on redbreast sunfish reproductive biology by observing fishes in both the laboratory and field. I present data on nest site selection, nest construction,

spawning behavior, nesting behavior and growth in sac fry and fry from fishes observed in Cocksackie Cove, Greene County, New York and from observations made in an artificial stream.

METHODS

FIELD

I collected redbreast sunfish in the Hudson River at Cocksackie Cove, Stockport Flats, and Tivoli North Bay (Figure 1). Ultimately, I focused attention on the fishes in Cocksackie Cove. Cocksackie Cove is a tidal area opposite of the main channel. This site is composed separately of gravel and rubble on one side of the cove and mud on the other side. This site was convenient, readily accessible, not subjected to heavy human activity, and had a large redbreast sunfish population. In my initial surveys, I used 25- and 50-foot seines, snorkeled along transects, and made observations from a canoe.

The nests were tagged with eight-inch nails and fluorescent flagging. Color codes were used to differentiate nests based on the guard and growth stage of eggs and fry. Each nest was numbered so that changes on successive observation periods could be noted. Particular attention was given to maturation of the eggs and sac fry and to identifying the position of the nest in relation to other nests, potential cover, and the low-water mark.

The substrate composition of each nest site was determined by estimating the percentages of gravel/rubble, mud, sticks, vegetation, and clay. Water temperature was measured with a YSI salinity conductivity meter. I measured the physical dimensions of the nests (diameter and depth) using a meter stick and graduated wading rod. The diameter of the nest was determined by placing the meter stick from the nest rim to the other rim, and by moving the stick back and forth, the longest diameter from several measurements was taken. The depth was determined by placing the wading rod along the meter stick (along the nest diameter), and the largest depth was recorded after several measurements.

I could easily identify sunfish to species in one meter of water. At greater depths, the water was too turbid. To determine the sunfish species present in a particular nest, an electroshocker (Smith-Root Model 12 Electrofisher) was used. Standing stationary for several minutes, I placed the probe of the shocker in the nest middle to stun the fish as they entered. This was done eight times at various nests with different sizes and substrates, until it could be determined which species was collected from each type of nest.

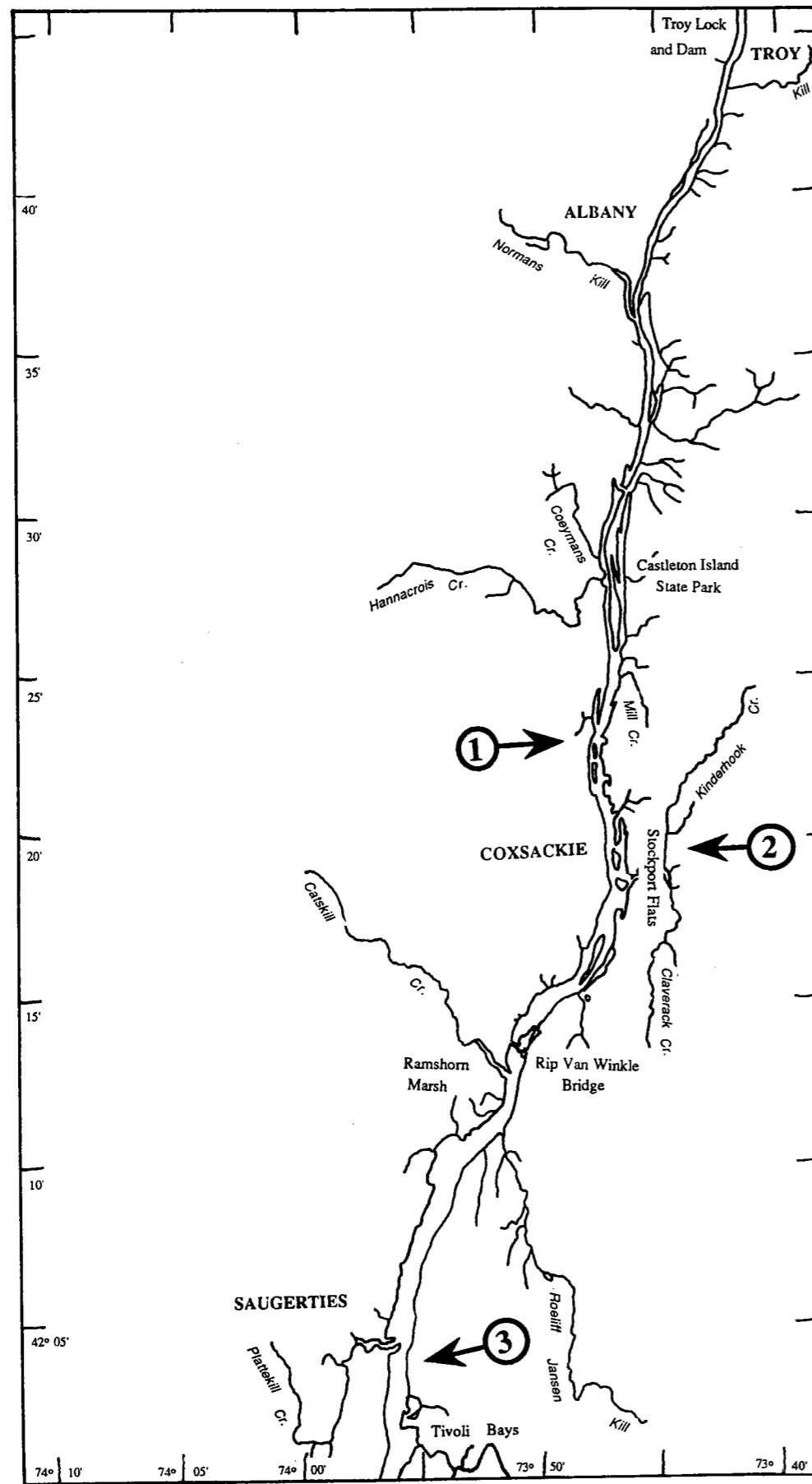


Figure 1. Upper portion of tidal Hudson River showing study sites, redbreast sunfish reproductive study, 1991. 1: Cocksackie Cove, 2: Stockport Flats, 3: Tivoli Bays.

Table 1. Measurements and estimates of redbreast and pumpkinseed nests, Cocksackie Cove, Hudson River, summer 1991. Abbreviations: G/R = gravel/rubble, M = mud, S = sticks, C = clay, V = vegetation, EXP = nest exposed, UNEXP = nest unexposed (still under water).

NEST #	DIAMETER (cm)	DEPTH (cm)	SUBSTRATE (%) (G/R, M, S, C, V)	TEMP IN C;	EXP/UNEXP @ LOW TIDE
				FRY, EGGS, OR FISH PRESENT	
1	38	3.6	80 M, 20 G/R	22, FRY	EX W/ WAT
2	57	1.5	75 G/R, 25 M	-	EX W/ WAT
3	80	5.5	85 G/R, 15 M	23, FRY	EX W/ WAT
4	122	7.0	65 M, 35 G/R	-	EX W/ WAT
5	50	4.4	85 M, 15 G/R	-	EX W/ WAT
6	80.8	3.9	85 M, 15 G/R	-	EX W/ WAT
7	84	2.0	60 M, 40 G/R	-	EX W/ WAT
8	72	3.1	55 M, 45 G/R	-	UNEXPOSED
9	61	5.7	55 M, 45 G/R	-	EX W/ WAT
10	72	4.4	50 M, 50 G/R	-	EX W/ WAT
11	96	6.3	50 M, 50 G/R	25, FRY	EX W/ WAT
12	69.5	5.5	50 M, 50 G/R	FRY/EGGS	EX, NO WAT
13	119	7.6	50 M, 50 G/R	24, EGGS	EX W/ WAT
14	100	8.9	75 M, 25 G/R	-	UNEXPOSED
15	88	7.6	80 M, 20 G/R	-	UNEXPOSED
16	83	6.4	90 M, 10 G/R	-	UNEXPOSED
17	70	6.4	85 M, 15 G/R	-	UNEXPOSED
18	105	8.9	75 M, 25 G/R	20, -	UNEXPOSED
19	45	5.1	95 M, 5 G/R	-	UNEXPOSED
20	72	7.0	80 M, 20 G/R	-	UNEXPOSED
21	85	8.3	90 M, 10 G/R	-	UNEXPOSED
22	68	5.1	60 M, 40 G/R	26, -	EX W/ WAT
23	65	6.4	65 M, 35 G/R	-	UNEXPOSED
24	87	6.4	70 M, 20 G/R, 10 V	-	UNEXPOSED
25	105	10.1	80 M, 20 G/R	-	UNEXPOSED
26	100	15.9	70 M, 20 G/R, 10 S	28, FRY	EX W/ WAT
27	38	5.7	60 M, 40 G/R	-	EX W/ WAT
28	107	11.4	75 C, 25 G/R	-	UNEXPOSED
29	71	8.9	75 M, 25 G/R	22, FRY/FISH	UNEXPOSED
30	100	7.0	70 C, 15 M, 15 G/R	23, FRY/FISH	UNEXPOSED
31	82	7.6	50 C, 30 G/R, 20 M	-	UNEXPOSED
32	107	8.9	75 M, 25 G/R	EGGS/FISH	UNEXPOSED
33	110	6.4	55 C, 35 M, 10 G/R	-	UNEXPOSED
34	85	8.9	60 C, 30 M, 10 G/R	24, FISH	UNEXPOSED
35	88	3.2	60 M, 40 G/R	-	UNEXPOSED
36	90	10.2	50 M, 40 G/R, 10 S	-	EX W/ WAT
37	80	5.7	60 C, 30 M, 10 G/R	-	UNEXPOSED
38	80	7.6	50 M, 50 G/R	-	EX W/ WAT
39	90	7.6	60 M, 40 G/R	-	EX W/ WAT
40	81	4.4	50 M, 50 G/R	-	UNEXPOSED

(Continued on next page)

41	105	7.6	55 M, 45 G/R	-	UNEXPOSED
42	84	5.7	60 C, 30 M, 10 G/R	-	EX W/ WAT
43	100	7.0	70 C, 20 M, 10 G/R	19, -	UNEXPOSED
44	93	7.0	65 C, 25 M, 10 G/R	18, -	UNEXPOSED
45	97	8.3	60 C, 30 M, 10 G/R	-	UNEXPOSED
46	78	6.4	50 M, 50 G/R	-	EX W/ WAT
47	62	4.4	50 M, 50 G/R	-	EX W/ WAT
48	78	5.7	70 M, 30 G/R	-	EX W/ WAT
49	67	5.7	60 M, 30 G/R, 10 V	30, FRY	EX W/ WAT
50	100	5.1	40M, 40G/R, 10V, 10S	-	EX W/ WAT
51	133	8.9	50 M, 50 G/R	29, FRY	EX W/ WAT
52	72	6.4	60 M, 30 G/R, 10 V	-	EX W/ WAT
53	85	8.3	50 M, 50 G/R	31, FRY	EX W/ WAT
54	95	5.7	40M, 30G/R, 20V, 10S	-	EX W/ WAT
55	88	5.7	80 G/R, 20 M	-	EX W/ WAT
56	91	10.8	70 G/R, 30 M	-	EX W/ WAT
57	79	8.3	60M, 30V, 5S, 5 G/R	-	EX W/ WAT
58	88	10.2	90 G/R, 10 M	-	EX W/ WAT
59	93	10.8	90 G/R, 10 M	-	EX W/ WAT
60	72	9.5	80 G/R, 10 M, 10 V	-	EX W/ WAT
61	37	4.4	90 G/R, 10 M	-	EX W/ WAT
62	95	11.4	90 G/R, 10 M	31, FRY	EX W/ WAT
63	113	11.4	70 G/R, 20 M, 10 S	-	EX W/ WAT
64	86	10.2	90 G/R, 10 M	-	EX W/ WAT
65	87	10.2	60 M, 40 G/R	-	EX W/ WAT
66	103	11.4	60 M, 40 G/R	-	EX W/ WAT
67	105	8.3	60 G/R, 30 M, 10 S	29, FRY	EX W/ WAT
68	55	5.7	80 G/R, 20 M	-	EX W/ WAT
69	88	8.9	90 G/R, 10 M	-	EX W/ WAT
70	80	8.3	90 G/R, 10 M	-	EX W/ WAT
71	97	10.2	75 G/R, 25 M	-	EX W/ WAT
72	85	7.0	90 G/R, 5 M, 5 S	-	EX W/ WAT
73	39	6.4	70 G/R, 20 M, 10 S	EGGS	EX W/ WAT
74	57	7.6	50 G/R, 40 S, 10 M	-	EX W/ WAT
75	60	7.6	50 G/R, 40 S, 10 M	-	EX W/ WAT
76	39	7.0	80 G/R, 20 M	-	EX W/ WAT
77	51	8.3	80 G/R, 20 M	-	EX W/ WAT
78	42.6	7.9	70 S, 20 M, 10 G/R	29, EGGS	EX W/ WAT
79	107	7.0	90 G/R, 10 M	27, FRY	EX W/ WAT

Table 2. Summary of the redbreast sunfish nest data listed in Table 1. Abbreviations: G/R = gravel/rubble, M = mud, S = sticks, C = clay, V = vegetation.

N=79 NESTS

	DIAMETER (cm)	DEPTH (cm)	SUBSTRATE (%)				
			G/R	M	S	C	V
Mean	83.2	7.5	43.4	44.3	2.9	7.9	1.1
Range	37-133	1.5-15.9	5-90	5-95	5-70	50-75	10-30
# of nests and percentage containing specific substrate	-----	-----	79 100%	78 98.7%	11 13.9%	10 12.7%	6 7.6%

To count the eggs in the nest, I used a 7-cm diameter plastic cylinder with an area of 38.48 cm². Along the nest diameter, 6-8 scoops of the eggs or fry were placed into jars. The jar was filled with 70% ethanol for preservation and the eggs and fry were brought back to the lab and counted. This method damaged the nest so a second method was used to estimate the egg/fry count. The cylinder was also placed at 10 cm intervals along the nest diameter, and all the eggs encompassed by the cylinder were counted. The total number of eggs in the nest was computed by multiplying the mean count/cylinder by the area of the nest. Certain nests were examined repeatedly over the study period to monitor egg development, fry dispersal, and repeat nesting.

I mapped all nests in a part of Cocksackie Cove using a level, stadia rod, and surveyors chain. The position of each nest, shoreline and low water mark were noted to provide information on the proximity of neighboring nests and exposure at low tide.

After the field study was completed, a seine was used to determine which fish species were present around the nesting area at Cocksackie Cove.

LABORATORY

Male and gravid female redbreast sunfishes were introduced into an artificial stream system located in the Biological Survey Laboratory New York State Museum. This system is described in Daniels (1989). In brief, this system consisted of two separate stream chambers and a large holding tank. The streams had a working area of 3.5 x 0.6 m. Water velocity was regulated in each stream by valves; depth was regulated by stand pipes. The substrate consisted of sand, gravel, and rubble. The day-night cycle corresponded to nature. Temperature was maintained between 19-24 °C.

Redbreast sunfish were collected from Stockport Flats and Tivoli North Bay off Magdalen Island (Figure 1) and introduced at different times into the stream. For trials #1 and #3, two males and four females were introduced into the stream. In trial #2, three males and four females were introduced. I observed the redbreast sunfish behavior for 20-25 minutes at 1.5-2 hour intervals. During this time, nesting, courting, spawning and aggressive behaviors were noted.

The diameter of the eggs and the lengths of fry were measured, along with the yolksac spherical volume until the fry absorbed their yolksac and left the nest. This yolksac volume was determined by estimating the radius of the yolksac (using the microscope ocular units), and plugging this into the formula for volume of a sphere. Fish were sacrificed at the conclusion of the trials to determine their gonadal condition.

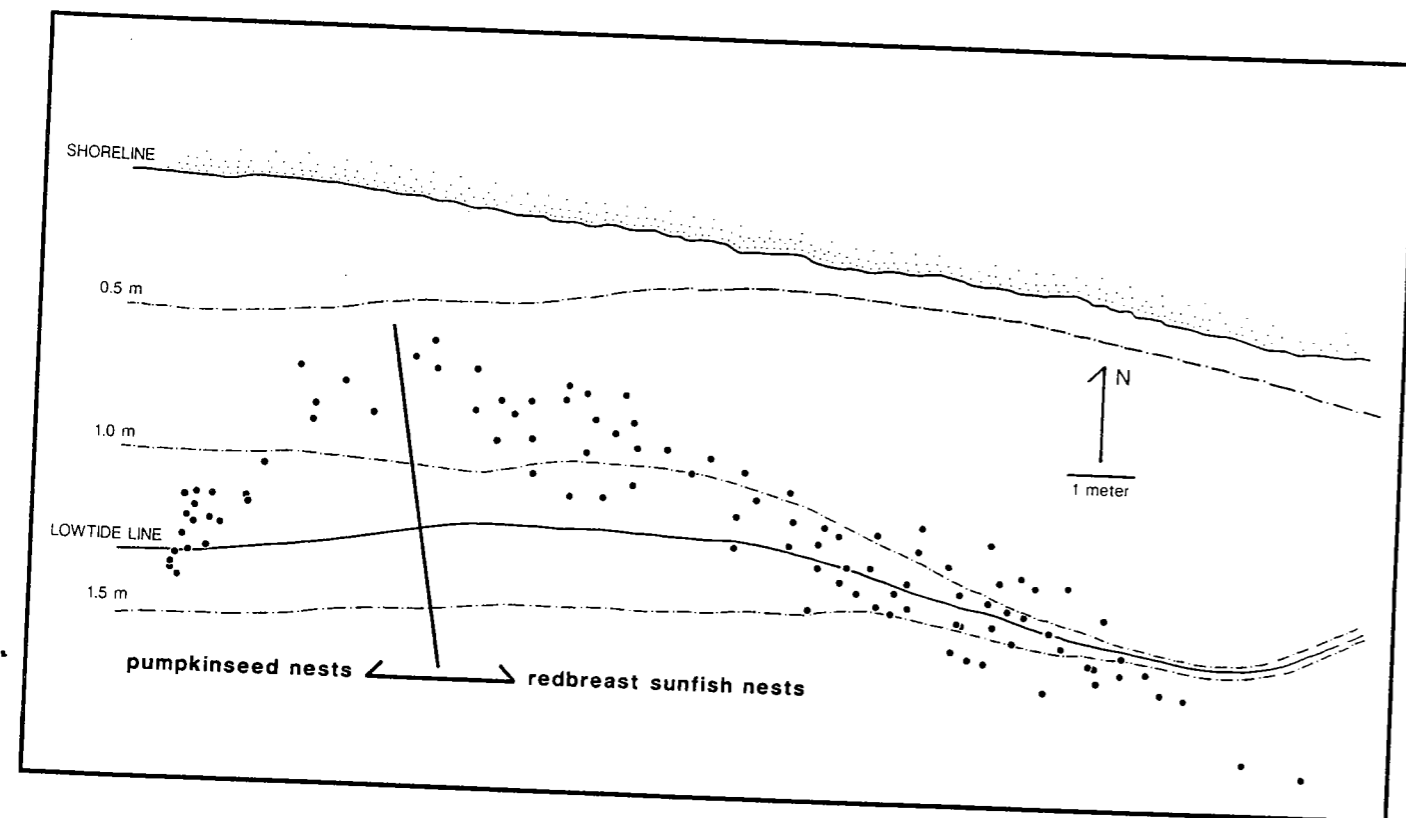


Figure 2. Cocksackie Cove map showing the distribution of redbreast sunfish nests, with respect to shoreline and lowtide line, Hudson River, during the summer of 1991. Pumpkinseed sunfish are also present, as shown on the map.

RESULTS

FIELD

During May 1991, I counted 79 nests in Cocksackie Cove. I continued to find newly excavated nests throughout the study. At the conclusion of the study, in August, 1991, 227 nests (both redbreast and pumpkinseed nests) remained; of these 16 were abandoned. The abandoned nests lost their shape and became covered with vegetation and mud. Most of the nests (67% of the initial 79 nests) remained exposed during low tide (see Tables 1 and 2). Ninety-eight percent of the exposed nests contained water. The eggs and fry discovered in exposed nests without water did not survive.

I grouped nests by substrate type. The different substrates found were rubble/gravel, mud, sticks, vegetation, and clay (see Tables 1 and 2), and of these the nests contained either gravel or mud in the highest percentages. Both nest types (either gravel or mud nests) were found in adjacent, but distinctly separate areas of the cove, since part of the cove contained only gravel and part contained only mud. Vegetation and sticks were found in 7.6% and 13.9% of the nests, respectively.

The diameter of nests ranged from 37 to 133 cm and the nest depth ranged from 1.5 to 15.9 cm. The water temperature in the exposed nests always had higher readings than the water temperature in the cove. River water temperatures averaged 21° C whereas the average maximum water temperature in exposed nests was 29.6° C.

Based on the capture of nest guards with the electrofisher, redbreast sunfish occupied nests composed of gravel, whereas pumpkinseed were found on the nests composed of mud and clay. Since the western part of Cocksackie Cove consisted of mud and the eastern side of gravel, redbreast sunfish and pumpkinseed were separated from one another. I found no redbreast sunfish on mud nests, but a few pumpkinseed were observed in the redbreast sunfish nesting area. The other three common centrarchids that have been found in Cocksackie Cove -- bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and largemouth bass (*Micropterus salmoides*) -- were not observed during the study.

The distribution of the sunfish nests in the northern portion of Cocksackie Cove is shown in Figure 2.

Table 3. Egg/fry counts from redbreast sunfish nests, Cocksackie Cove, Hudson River, summer 1991.

Nest#	Stages	Nest Area(cm ²)	Mean Egg/Fry Count	Total Count	Nest Temp(°C)
1	fry	5808.8	134	20285	28
2	eggs	8332.3	112	24317	26
3	eggs	3653.0	33	3209	26
4	eggs	4231.4	36	3992	27
5	eggs	7389.8	31	6017	31
6	eggs	7854.0	47	9622	31
7	eggs	7088.2	44	8105	28
8	eggs	993.1	104	2701	35
9	eggs	6361.7	30	4980	34
10	eggs	5026.5	20	2575	34
11	eggs	6503.9	36	6064	29
12	eggs	6082.1	47	7468	29
13	fry	5674.5	36	5260	28
14	eggs	4901.7	51	6442	29

Summary:				
mean:	5707.2	54	7931	29.6
range:	993.1-8332.2	20-134	2575-24317	26-35
standard deviation:	1905.2	35.2	6464.6	3.0
standard error:	509.2	9.4	1727.7	0.8

Figure 3. Distribution of eggs along the diameter of 14 redbreast sunfish nests, Cocksackie Cove, Hudson River, summer 1991.

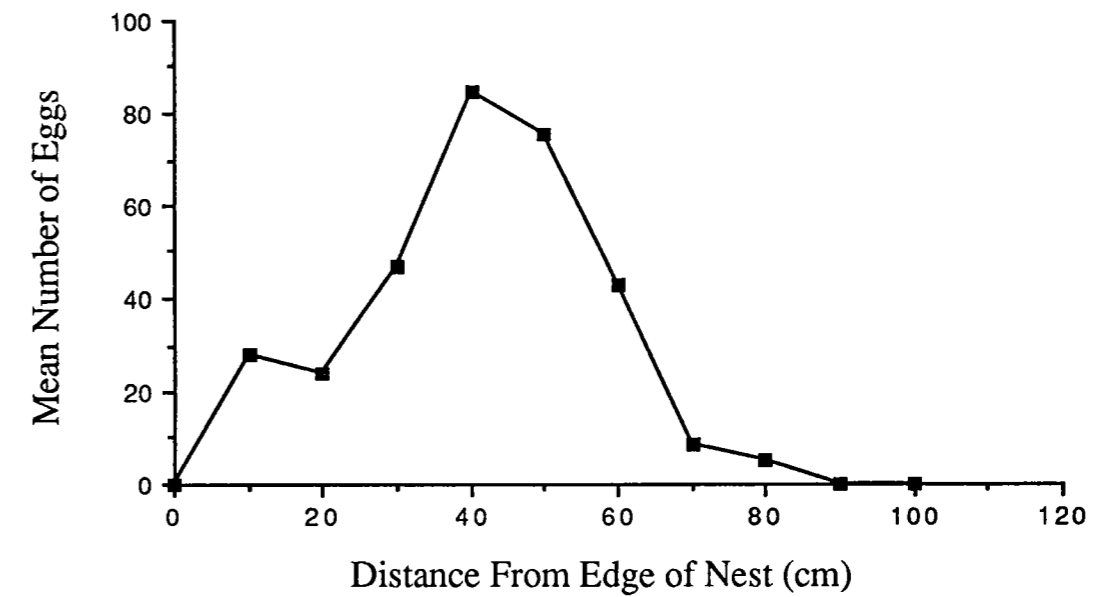


Table 4. Redbreast sunfish nesting behavior observed in an artificial stream system as percentage of total observation period, Biological Survey Laboratory, New York State Museum, summer 1991. Percentages taken from the behaviors in 5 minutes time. Male 1 was successful, male 2 was unsuccessful (ate his eggs).

Behaviors (Males)	Male 1 (%)	Male 2 (%)	mean
Nest Building			
-fanning with caudal fin	15.7	7.0	11.4
-picking up rocks with mouth	10.3	10.7	10.5
Courting			
-male chasing female	13.0	27.3	20.2
-male circling rapidly above nest	4.0	8.3	6.2
Guarding			
-aggressive behavior			
-M1 and M2 face off	16.3	19.3	17.8
-fin biting	2.0	1.7	1.85
-swimming on top of nest (still)	38.7	25.7	32.2
Behaviors (Females)	Fem 1	Fem 2	
-swimming (still) in stream corner	85.7	95.0	90.4
-chased by male	10.7	3.3	7.0
-circled with male above nest	1.7	---	1.7
-female chases female	2.0	1.7	1.85

Table 5. Growth and fry characteristics of redbreast sunfish hatched in artificial stream, Biological Survey Laboratory, New York State Museum, summer 1991. Abbreviations: E = eggs, S = sac fry, F = fry.

DAY	E,S,OR F	MEAN LENGTH(mm)	MEAN YOLKSAC VOLUME(mm ³)	SUMMARY OF ACTIVITY
1	E	2.27	---	---
2	E	2.27	---	---
3	E	2.27	---	---
4	E	2.27	---	---
5	E	2.27	---	---
6	S	4.95	5.08	large yolksac, no movement, all larvae on nest bottom
7	S	6.08	4.06	fry movement on nest bottom
8	S	6.92	4.62	more movement on nest bottom
9	S	8.18	4.31	movement still on nest bottom, pectoral fin movement
10	S	7.92	2.84	yolksac much smaller, movement out of nest
11	S	8.36	---	slight yolksac seen but cannot be measured, much movement throughout stream
12	F	8.45	---	large amount of fry dispersed throughout stream, yolksac absorbed, some still present in nest
13	F	9.25	---	all fry out of nest and widely dispersed
14	F	9.52	---	same as above
15	F	10.08	---	same as above
16	F	9.46	---	a smaller number of fry seen
17	F	9.72	---	very small amount of fry seen, rest disappeared
18	F	9.90	---	few fry present in stream

Figure 4. Artificial stream redbreast sunfish mean fry growth, day 1 to day 18, Biological Survey Laboratory, New York State Museum, summer 1991.

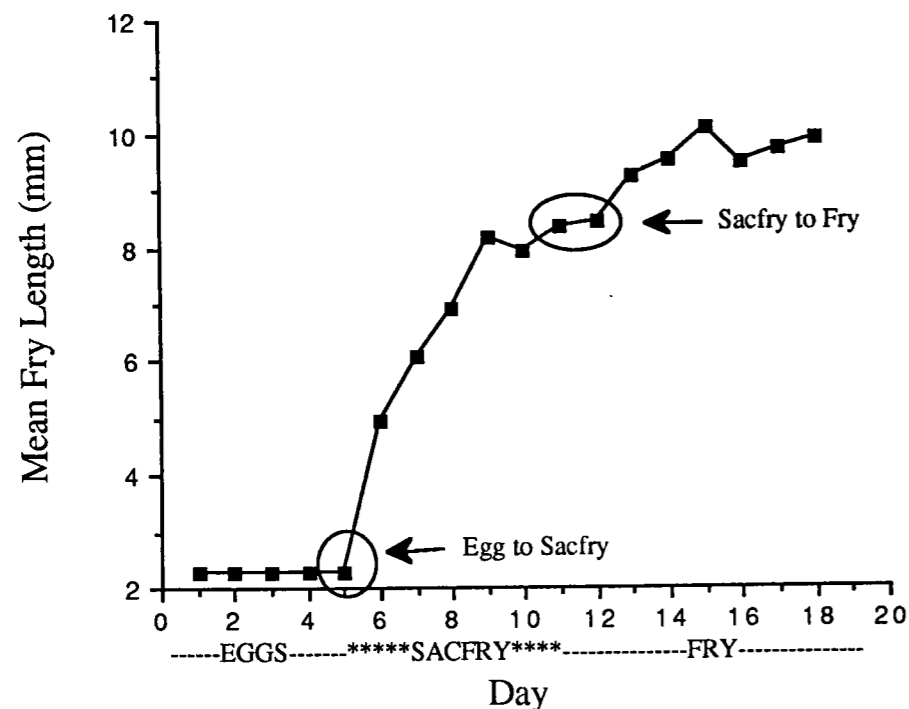
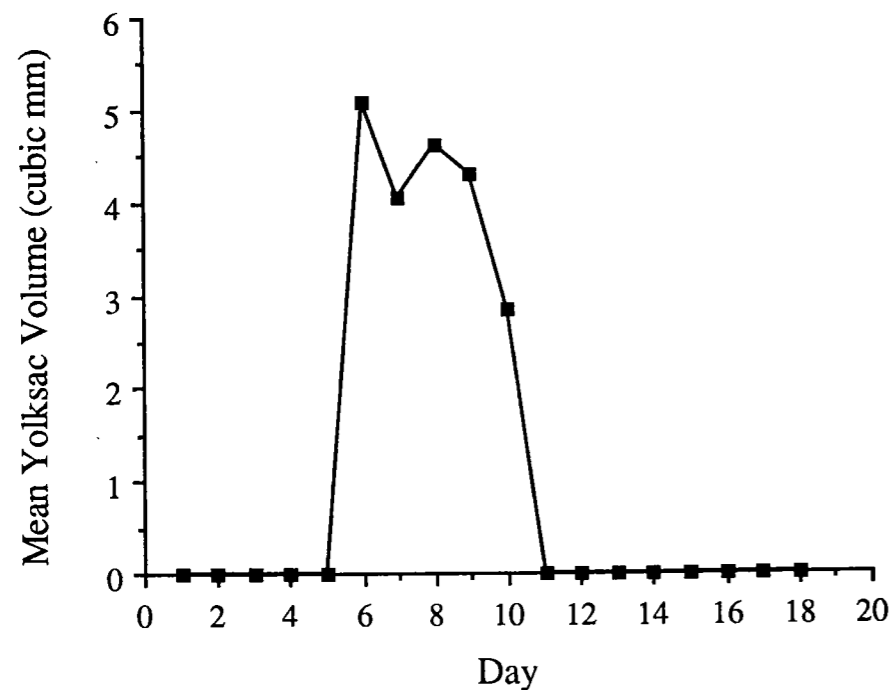


Figure 5. Yolksac absorption by day in mean volume of redbreast sunfish sacfry, Biological Survey Laboratory, New York State Museum, summer 1991.



This figure also shows the maximum low water line and the number of nests exposed. At maximum low tide, 67% of the nests were out of the river. Redbreast sunfish nests averaged 35.7 cm from their nearest neighbor, whereas pumpkinseed nests averaged 25.9 cm from neighboring nests.

In 14 nests, the total egg or fry count ranged from 2575 to 24317 (Table 3). The eggs and fry were scattered throughout the nest, but most were concentrated in the center (Figure 3). The adhesive eggs stuck to stones, sticks, vegetation, and even some broken glass found in the nests. Eggs varied in color - ranging from an opaque cream to yellow.

Based on observations from 11 nests, hatching occurred in 3-4 days, yolk absorption required 4-5 days, and fry departed the nest two days later.

LABORATORY

Male redbreast sunfish built nests, courted females, spawned, and showed aggression towards the other male in two of three trials in the laboratory. Males constructed shallow, circular nests on sand or gravel substrate using a combination of behaviors that included fanning and sweeping away of sand or pebbles with their caudal fin, picking up larger pebbles with their mouths and moving them to the periphery of the nest, and pushing larger rocks (diameter > 2 cm) to the periphery with their snouts. During nest construction, neighboring males acknowledged each other 17.8% (Table 4) of the total time by facing each other and fanning their pectoral fin vigorously.

To court females, the male swam at a 45° angle in a circle over the nest touching the water surface. The female swam next to the male. A complete circle took an average of 1 second. The male and female circled parallel to the bottom of the nest. Both faced the same direction, the male swam upright and the female swam at a 90° angle to the male. The fish touched each other at their venters. Courting activity lasted for an average of 35 seconds and resulted in a failure to spawn in nine attempts often observed. After eggs were laid, the males continued to fan their nests, picked up pebbles, faced neighboring males, and chased females.

In trial 1, one of the two males ate the eggs in his nest. The second male continued circling his nest

with occasional fanning and rock moving. Five days after the eggs were laid, sacfry hatched (Table 5, Figure 4). Sacfry did not begin swimming for 24 hours. The sacfry's initial attempts at movement consisted of short hops off the substrate, but by the time the yolk sac was fully absorbed in 3-4 days, the fry were capable of maintaining their position in the water column indefinitely (Table 5, Figures 4 and 5). When all the fry departed the nest and were dispersed throughout the stream, the male left the nest. This occurred 8 days after hatching.

The fish did not spawn in trial 2 or 3. Males did construct nests, and attempted to court females, but were unsuccessful.

DISCUSSION

Surveys throughout the study established that the centrarchid assemblage in Cocksackie Cove consisted of five species: redbreast sunfish, pumpkinseed, bluegill, largemouth bass, and black crappie. Nests of at least three of the species, redbreast sunfish, pumpkinseed and largemouth bass, were observed during this study. These results confirm Breder's (1936) observation that it was not unusual to find several species of centrarchids spawning in the same area. Largemouth bass spawned earlier than the sunfish in deeper water since fry were taken in seine hauls in early June. Redbreast sunfish and pumpkinseed nests were abundant and visible in late May when this study began.

The nests observed were constructed in mud; some nests were lined with gravel and almost all nests included small amounts of vegetation and/or sticks (Tables 1 and 2). Redbreast sunfish were found only on those nests lined with gravel, whereas pumpkinseed were observed on the nests excavated in mud. These results are similar to those reported by Rose (1936), Richmond (1940) and Davis (1972). Richmond and Davis emphasized that redbreast sunfish constructed nests on sand or gravel and individuals that built nests in mud did not spawn successfully. Breder commented that redbreast sunfish were absent from ponds with very soft bottoms that lacked sand or gravel bars or shores. All three authors noted the

importance of nearby cover, in the form of logs, stumps, rocks or docks, to successful nest construction and spawning in redbreast sunfish. Cocksackie Cove is primarily a mud-bottom inlet with distinct sand or gravel areas. The substratum is composed of a mud-gravel mix in the northeastern corner of the cove, the area where all redbreast sunfish nests were observed. Male redbreast sunfish cleared the gravel by fanning which placed the loose mud into the water column. This must have been a constant activity by the guarding male since abandoned nests were rapidly silted over. In the laboratory, males constructed nests in both sand and gravel (mud was not an option).

Richmond (1940) was the only author to document the reproductive biology of redbreast sunfish in a tidal river. The Hudson River is tidal to the Troy Dam (Cooper, et al., 1988) so Richmond's study offers the best comparative information. My results corroborate Richmond's observation that redbreast sunfish often construct their nests in shallows that become dry at low tide. As was the case reported by Richmond, the nests in Cocksackie Cove are all below the level of the lowest high tide, so that each nest was inundated at least twice a day. But the exposure time for each nest varied depending on the height of the tide and its elevation. This variable exposure subjected the nests and the eggs and sacfry in the nests to highly unstable environmental conditions. For example, water temperature in the exposed nest rose in relation to that of the river water, often by as much as 40 %. Richmond does not speculate on the advantages and risks of constructing a nest in an area where it will be exposed and I did not test any hypotheses that may explain this behavior. Several explanations may account for this behavior, however. Rate of development of the eggs and fry may increase in the warmer temperatures of the exposed nests, providing these individuals with a size advantage over unexposed fish when they leave the nest affording them greater protection against predators (Moyle and Cech, 1982). Risk from predation may be less in the exposed nests; terrestrial predators may not exist in the area whereas aquatic nest raiders may be abundant. The position of the nests may be the result of exploitation competition for space. It remains to be demonstrated whether or not the winners of any competition are the fish that constructed their nests at the high or low elevations. These hypotheses are testable; but require additional observations and manipulations before any definitive answers can be drawn. One of the new discoveries of this work is that

a second species of sunfish, pumpkinseed, was demonstrated to construct its nests in areas that are exposed at low tide.

As reported by Breder (1936), redbreast sunfish excavate shallow nests in shallow water. The size of the nests and their position in Cocksackie Cove are similar to the nests described by Breder, Richmond and Davis. Redbreast sunfish nests in Cocksackie Cove differed in size, construction material and position in the Cove from those of pumpkinseed (Table 1 and 2, Figure 2). Redbreast sunfish nests were also more numerous and more densely packed the Cove than those of their conspecific.

Embryo counts varied among nests in Cocksackie Cove (Table 3, Figure 3) but fall within the range reported by Davis (1972). Fecundity in redbreast sunfish from the Hudson River range from 1130 to 5900 oocytes (Daniels, Tyler, and Lawrence, unpubl. data) with a mean of about 3500 oocytes. Counts varied with size of female, but the relationship was not significant. Since embryo counts in nests were as high as 24,300, it is likely that several females spawn with an individual nesting male. Since the embryos in a single nest often vary in color, it is likely that the males mate with different females over a period of days. The embryos and sacfry were scattered throughout the nest, but over 80 % of the embryos were within 20 cm of the center of the nest. These embryos are in the deepest part of the nest and in the part directly under the nest guard (when he is present) and therefore are afforded the greatest amount of protection from both desiccation and potential predators. As described by Breder (1936), the embryos of the redbreast sunfish are adhesive and stick to the stones, sticks and debris in the nests in Cocksackie Cove.

The early life history of the redbreast sunfish has not been described. Based on the development of fry in the laboratory, I found that embryos hatch in five days and sacfry remain in the nest an additional five to six days. After about twelve days the yolk sac is absorbed and the fry abandoned the nest and scattered throughout the tank. The nest guard abandoned the nest on the thirteenth day. Mortality of fry in the laboratory was complete by day twenty. Prior to this day, fry were active, but since there was no suitable food supply, it became impossible to keep them longer. Figure 6 is a photograph taken under a microscope of the redbreast sunfish from the artificial stream. The eggs averaged 2.27 mm in diameter, the sacfry larva (taken on Day 7) averaged 6.08 mm in length, and the fry (taken on Day 14) with all of the



Figure 6. Microscope photograph of redbreast sunfish eggs, sacfry, and fry (from artificial stream, Biological Survey Laboratory, New York State Museum, summer 1991). Size represents average length on that day.
Top-Day 7, sacfry: mean size = 6.08 mm
Middle-Day 13, fry: mean size = 9.25 mm
Bottom-Day 3, eggs: mean size = 2.27 mm (in diameter)

yolksac absorbed averaged 9.52 mm in length.

This study was designed to provide a description of the nesting behavior and early life history of the redbreast sunfish. Future studies should consider both the aspects of the behavior of this species that remain unexplained and the role that this species serves in the fish assemblages of the Hudson River as a system.

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