SPAWNING BEHAVIOR OF THE CHANNEL CATFISH *ICTALURUS PUNCTATUS*

SPECIAL SCIENTIFIC REPORT–FISHERIES No. 219

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service

THE SPAWNING BEHAVIOR OF THE CHANNEL CATFISH ICTALURUS PUNCTATUS

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Special Scientific Report--Fisheries No. 219.

Washington, D.C.

June 1957

This investigation was conducted under the Saltonstall-Kennedy Act for commercial fishery research, University of Oklahoma Research Institute Projects 120 and 132, Contract Nos. 14-19-008-2382 and 14-19-008-2488. Dr. Carl D. Riggs, Project Leader, direct the work.

ABSTRACT

Channel catfish were induced to spawn in glass aquaria by the injection of fish pituitaries. The normal spawning pattern and behavior probably was not modified by the injections. During the pre-spawning period the male hazed the female and both were belligerent toward other fish. Pairing was accomplished when the female was subdued and assumed a given position on the bottom of the aquarium. The emission of sex products was preceded by a spawning reflex in which the male wrapped his tail around the head of the female and quivered, while the female responded in like manner. The spawning act required about 6 hours and eggs were released about 9 times each hour. Bright lights, visitors, or handling the spawners did not materially interfere with or delay the spawning act. The males cared for the eggs after the spawning was completed. Males were used to spawn with more than one female, but the females usually deposited all their eggs during one spawning.

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INTRODUCTION

Channel catfish play an important role as game and food fish in North America. The demand for channel-catfish fingerlings to stock waters for sport fishing has increased steadily during the past few years. Recent information has shown that the species is adaptable to a large variety of habitats and water conditions, that it is compatible with other species such as bass, bluegill, and crappie, and that it will do well when stocked alone without other forage species. Brown (1951) has demonstrated that the channel catfish will produce more pounds of edible fish per acre of water than any other species normally stocked in Texas ponds.

From the commercial standpoint, the rise of fish farming in the rice fields of Arkansas, Louisiana, and Texas has indicated that the channel catfish is one of the most desirable species to grow as food for human consumption. At the present time, the demand for catfish as food cannot be satisfied by commercial fishing in natural waters, which makes the market for domestically reared catfish particularly attractive to private fish farmers. Most hatcheries have reported difficulty in spawning channel catfish and some have failed completely because of fragmentary information and lack of understanding of the various aspects involved.

To meet this increased demand for channel-catfish fingerlings in Federal and State hatcheries and by private growers, it has become necessary to learn more of the reproduction of this species and improve techniques involved in its propagation. The problem in basic outline involves spawning, disease control, and nutrition. Primarily important is the spawning. Therefore, in order to ensure more successful spawning and to give the fish-culturist greater control of time and method of handling, we have investigated the pituitary injection method to induce spawning. The present paper reports the behavior of channel catfish induced to spawn in glass aquariums after fish-pituitary injections.

Details of the spawning behavior of the channel catfish, Ictalurus punctatus, are fragmentary. The only descriptions of the actual spawning of channel catfish are those of Murphree (1940) and Lenz (1947). Fontaine (1944) described the spawning of the flathead catfish, Pilodictis olivaris, in the Dallas Aquarium and mentioned that some aspects of their behavior were similar to those of channel catfish and the brown bullhead, Ameiurus nebulosus, which also had spawned in the Dallas Aquarium. Other papers which have contributed to an understanding of the conditions conducive to successful spawning of this species in captivity are those of Shira (1917 a, 1917 b), Clapp (1929), Doze (1925 a, 1925 b), Mobley (1931), Morris (1939), Rennick (1942), Toole (1951), and Canfield (1947). Davis(1953) summarized the generally accepted methods of artificial propagation of the channel catfish.

Spawning activities have been recorded for Ameiurus nebulosus by Breder (1935), Fowler (1917), and Smith and Harron (1904); for A.catus by Fowler (1917); for A. albidus by Ryder (1883); for Schilbeodes insignis by Fowler (1917); for Pilodictis olivaris by Fontaine (1944); and for A. natalis by Fowler (1917).

METHODS AND FACILITIES

Glass aquariums with capacities of 6, 10, and 35 gallons were used for spawning containers. These squariums were placed on a bench 30 inches high in the holding house of the U. S. Fish Cultural Station, Tishomingo, Oklahoma, where workers frequently passed. Each aquarium was supplied with flowing water. A tar-paper mat was placed on the bottom of each aquarium so that the eggs could be easily removed if necessary.

Fish ranging in total length from 14 to 22 inches were used, a male usually being paired with a slightly smaller female. The females were injected with fish pituitaries to induce spawning. Usually several injections of fresh or acetone-dried pituitaries were necessary to precipitate spawning, and even then only a few of the injected fish spawned successfully. The time of day when spawning occurred may have been influenced by the time of the last injection, and may not have been indicative of the normal spawning hour. The duration of the spawning act, the frequency of egg emission, and the intensity of spawning activity might have been dependent upon the dosage and schedule of injections. Since our data concur with the indirect description of the spawning of a noninjected pair of channel catfish (Fontaine 1944) and since we have observed the behavior of several other species which were induced to spawn by the pituitary method, we do not believe that the basic spawning pattern was modified by the pituitary injections. Rather, any visual, physical, or chemical stimuli which normally cause the fish's own pituitary to secrete the gonadotropins necessary to precipitate the spawning act were bypassed, so to speak, by the exogenous gonadotropins.

SELECTION OF FISH FOR SPAWNING

Fish for spawning were selected during the breeding season, from the middle of April to the last week in July when water temperatures ranged from 70° to 85° F. According to oral reports from the Federal fish-culturists of the southwestern United States, the largest or oldest fish spawn first, while the smallest fish are usually the last to spawn.

Each selected female was placed with a male in an aquarium. The condition of the females for spawning was rated excellent, although it was always difficult to evaluate the exact physiological condition. Each female was well-rounded, and the roundness of the abdomen extended past the pelvics to the genital orifice. The belly was flaccid, and the genitals were raised and reddish. The females ranged from 14 to 17 inches in length. They received pituitary injections to induce spawning.

On the basis of external characters, the males also were judged to be in excellent spawning condition. They were from 15 to 21 inches long and each possessed good secondary sexual characteristics--a head slightly wider than the body, pigmented jaw and belly, and distinct, well-formed genital papilla, with the opening of the urogenital duct somewhat dilated. The papilla was resilient and recovered its original shape after being rubbed in a posterior to anterior direction, a test which we frequently used. Both gross and microscopic examination of the testes have verified the value of this test for the papilla, since males with small, soft genitals had underdeveloped testes, whereas a fish with a relatively firm papilla possessed correspondingly better developed testes.

The males were not injected with pituitary materials. Two males received androgens (testosterone) several days before they were spawned, but no information was obtained to indicate whether the injections influenced spawning. One male had spawned previously outside in the regular hatchery spawning pens. Another male spawned with two females in the aquarium experiments and tended the eggs of a third spawning.

PRESPAWNING BEHAVIOR

When males and females (either injected or noninjected) were placed together in an aquarium there were various reactions and responses on the part of the male, which may be generally classified as aggressive or passive. If he was aggressive, he bit and drove the female; and this behavior usually continued for 20 or 30 minutes, or occasionally until the female was near the point of death. This aggressiveness usually stopped if the female remained in a given location near the bottom of the aquarium. If she assumed this position and the two stayed beside one another and/or frequently swam in circles, we considered the participants paired. If the female swam off too far the male hazed her again until she returned to her original position. If the female persistently swam up from the bottom, the aggressive male pursued her with such vigor that it was not long before she was exhausted or injured, and swam along the sides of the aquarium at the top of the water. This action was taken to mean the female was not ready for pairing, and she was removed.

If the male was passive to the female, then a number of possibilities existed: the male and female were not ready for spawning, and therefore did not mutually stimulate each other to sexual display; both were ready and pairing was spontaneous without benefit of courtship; or the male was ready and willing to accept any female; the female was ready and the male possessed no sexual urge. Close observation frequently made easier a decision on the above possibilities. If the female assumed a dominant role and attempted to bite the male, without invoking a belligerent response from him, we considered the male to be sexually incompetent or in some other way to be incompatible. However, a male thus rejected by the female or by the experimenters could not be classed as a male not ready for spawning, for one such male spawned with a female 4 days later. Any biting on the part of the female, directed either towards other females or towards males, was accepted as a sign of readiness to spawn, since paired catfish (both male and female) usually drove other fish away. If the male was not aggressive towards a female, some aggressiveness usually could be evoked by the addition of another male; then we chose the more aggressive fish to participate in the subsequent spawning of an injected female. In this situation, however, it was felt that the resident fish had the advantage, but this premise did not always hold true. In one experiment a 21-inch male, which had previously spawned, was placed with a 17-inch female. This male exhibited little aggressiveness. He responded by a slight pushing with his body when other males his size and smaller were added; he assumed what we called an "alert position," that is, he usually swam or rested slightly off the bottom of the aquarium with some movement expressed in the caudal and pelvic fins, whereas males which did not spawn rested on the bottom with fins drooped. Since this male had previously spawned, he was left with the female, and they later spawned.

An instance of aggressiveness possibly due only to a disparity in size was also noted. A 16.1-inch female, which spawned in an aquarium, was placed with a 22-inch male whose secondary sexual characteristics were not well developed, that is, he possessed a narrow head for his body length, slight gray color on the sides of the jaw, and a papilla that was small, soft, and flabby. A postmortem revealed that the testicular development was poor, and although motile sperm could be obtained by maceration, the testes were no larger than well-developed testes in 16-inch males. This male was overly aggressive towards the female. When the female came to the bottom, the male bit her viciously along the top of the caudal peduncle or just behind the pectorals (a favorite target when two males engaged in combat). Such an attack forced her to swim quickly up and away. Further attacks by the male sometimes brought her to the bottom, but the male bit her severely at that time, forcing her away again.

In pairing acts in which aggressiveness occurred, it was observed that if the fish were going to pair, the bites of the male became progressively less severe until they were more like a nudge in the region of the vent, an action that may have led some observers to presume that the male bites a gelatinous plug from the genital orifice (see table 1). In the above-cited case the male was replaced. The male may have been capable of spawning and might have spawned with a larger female. He may have been too rough for the small female, although some other similarly matched combinations resulted in successful spawnings.

No particular behavior which absolutely presaged imminent spawning was noted on the day before spawning. Both fish were active, frequently circling in the aquarium and coming back to rest in the same position, on the bottom of the aquarium, where the eggs were later deposited (see also Fontaine, 1944).

A few hours before the event, there were some rather positive signs that spawning was to take place. The female occasionally would make what we called "runs" along the bottom. In this type of behavior the female moved over the spot where the eggs were to be deposited in a wiggling motion, the pelvic and pectoral fins alternately beating against the bottom. These runs were short, about 4 to 6 inches. This same behavior was later a part of the spawning act and was repeated many times. As far as our observations indicated, it played two or possibly three roles. These runs of the female, later in the spawning act, aerated the eggs just as the male aerated the eggs after spawning was complete. This motion cleaned the area where the eggs were to be laid. Also it might stimulate the male, for, a male would usually attempt to spawn with a female engaged in such behavior.

The spawning reflex refers to a definite behavior on the part of the participants. When

Table 1.--Points of difference in previous reports of spawning behavior.

Activity	According to Murphree (1940), and Lenz (1947)	According to Clemens and Sneed (1957)
Preparation of nest	By the male.	Both participate; female more active over place where eggs are to be deposited.
Activity of female just before spawning	Female inhales air to exert pressure during passage of eggs.	Watched for, but no such observation made, although female sometimes gives off bubbles of gases without having gone to the top to "inhale" air.
Activity of male prior to passage of eggs	Male uses his teeth to break gelatinous plug in the reproductive vent.	Watched for, but no such observation made; "plug" believed not present.
Egg laying and fertilization	Female lays eggs; male pushes her aside, then fertilizes.	Egg laying and probably the emission of sperm occur within a matter of 15 seconds in mating position; i.e., at the climax of the spawning embrace.

a male attempted to spawn with the female, the fish were headed in opposite directions. Then he wrapped his tail around her head so that his caudal fin covered her eyes, the end of the tail at times reaching as far as the posterior tip of her operculum. Then the male's body quivered, during which time his pectoral fins beat, but his pelvics remained rather motionless and pointed backwards, and in some cases slightly to the side. The duration of this reflex depended on the female. If she did not react to it, the reflex of the male was very brief. If the female did not pull away from him immediately or if her avoidance was slow, it lasted about five seconds. Occasionally some prolonged spawning reflexes were observed in which the female was rather passive, and the male discontinued the attempts in about 8 or 10 seconds. When the female responded and participated, the reflex required about 12 to 20 seconds.

SPAWNING BEHAVIOR

If the female responded, she usually did so within 5 seconds. When she participated she wrapped her tail around the head of the male and quivered in unison with him. Both her pelvic and pectoral fins were motionless during this act. With each reflex a contraction of the abdominal muscles of the female moved the eggs posteriorly and progressively produced a flattened area behind the pectoral fins. She then lunged forward about 3 to 5 inches as the eggs spurted out. A current of water, produced by the lunge, caused the eggs to swirl up before they settled to the bottom.

It was believed that the male released milt at the end of the reflex at the same moment that the female released eggs. However, the reproductive vents in the two fish were not opposite each other at that time. Since the fish faced in opposite directions, the vents were separated by a distance equal to the distance between the pectoral and pelvic fins. The vents were not brought together as in goldfish, carp, and sunfish, and hence they were further separated by half the width of each fish. The question arose, how efficient fertilization was effected under these conditions. Since the male's pectoral fins beat slowly during the reflex, the slight current of water which must pass backwards along the male, would carry the sperms away from the eggs. However, if the milt was released just before the female lunged forward, her movement would create currents of water that would carry the sperms in the direction of the recently released eggs. That such currents of water did occur was evidenced by the fact that the eggs swirled up at the time of release as the female lunged forward. After the lunge, the female remained motionless for a few seconds, her head on the bottom, her body tipped slightly up and over the egg mass, her caudal peduncle and tail drooped to give her a humpbacked appearance. The male might remain more or less motionless at this time, but he usually became active before the female. When the female began to move again, she usually backed up over the eggs and remained above them with her pelvic fins beating for several minutes. This series of events was then repeated until spawning was completed.

DURATION OF SPAWNING

Of the four spawnings that occurred in the aquariums, we witnessed only one from beginning to end. It lasted 6 hours. Another spawning was estimated to have lasted 6 hours; our calculations were based on the amount of eggs already deposited when the pair was found spawning. A 1-pound female discharged about three-fourths of her eggs in 3 hours, at which time she was removed and hand stripped. The fourth occurred between 12:30 a.m. and 7:30 a.m.

The duration of spawning under natural conditions probably depends on several factors: the size of the female, the intensity of environmental stimuli such as light, temperature, or disturbance, and the inherent sexual drive of the participants. In the case of the pituitary-injected fish, the duration probably depended to a large extent upon the degree of hormonal stimulation by the exogenous gonadotropins. However, the fact that all the spawnings required 4 to 6 hours (despite variables in pituitary injections) suggested an inherent rhythm.

NUMBER OF EGGS AND FREQUENCY OF RELEASES

From 3:30 p.m. to 5:33 p.m., in the case of one spawning, there were 18 depositions of eggs, averaging about 9 each hour. If this rate continued for the full 6 hours that the fish were observed to spawn, the female would lay about 150 eggs each time, in order to lay 8,000 eggs. The rate and number, of course, may vary with the size of the female, her readiness to spawn, and the sexual vigor of either male or female. Generally, females which weighed from 1 to 4 pounds produced about 4, 000 eggs per pound of body weight. Fish of larger size usually spawned about 3, 000 per pound of body weight.

EFFECTS OF DISTURBANCES ON SPAWNING

One might suppose that the females in our experiments were rendered somewhat insensitive to external stimuli because of the intense internal or hormonal stimuli created by the introduction of the pituitaries. However, this reasoning would not apply to the males which were not injected with hormones, unless the males were secondarily affected and stimulated to a high degree of sexual awareness by the injected females by reason of her actions or because of secreted hormones.

The following observations suggest, at least, that when the female is under the influence of exogenous gonadotropins, disturbance does not interfere with the successful completion of the spawning act:

1. The aquariums in which spawning occurred were placed on tables in an area where workers and visitors frequently passed.

2. A pair of catfish began spawning at 8:50 p.m. after they had been moved several times the previous day to try out various pairing combinations with other fish.

3. Two pairs spawned under bright lights which were being used in connection with a movie camera.

4. The male of a spawning pair being photographed under bright light ate the first eggs deposited. However, after he was fed liver, the pair successfully spawned, but the photography was discontinued. Since other pairs spawned under bright lights, hunger rather than excitement was probably the cause of the egg eating.

5. Moving either a spawning male or female to another aquarium with other fish and then back to their resident aquarium and mate failed to delay spawning in any instance.

STAGES OF DEVELOPMENT AND PERIOD OF INCUBATION

We are in accord with the sequence of embryonic development as given by Murphree (1940), see table 2. The actual day when the respective developmental stages occur vary according to the temperature. Inasmuch as channel catfish spawn between 70° and 85° F., with the optimum temperature around 80° F., the period of incubation within this temperature range is from 5 to 10 days (Toole 1951). We witnessed hatching in 5 days; but at mean temperatures of about 80° F., the time from the first deposition of eggs to the time when the first egg hatched ranged from 6 to 7 days. One lot of eggs (referred to as "a spawn") began hatching in 5 days and 19 hours, and all eggs were hatched 6-1/2 hours later. Eye spots may be observed by close examination late on the third day at temperatures of 82° F., but may be inconspicuous up to 5 days at temperatures of 79° F. These results concur with reports in the literature, see table 3.

Eggs that were laid first were the last to hatch. A gradient of oxygen tension between the top and bottom eggs probably accounted for the difference in hatching time. Minute differences in temperature between the top and bottom appeared rather unlikely especially in the aquarium experiments.

CARE OF EGGS

It is a well-established fact that the male channel catfish cares for the eggs after the spawning is finished. However, we observed that the female cared for the eggs from the standpoint of aeration during the period of spawning; at least her activities at the time might serve that purpose. The paddling of the male when he lay next to the female did accomplish some aeration, but the male did not assume the responsibility until spawning was over. At the end of the spawning period the male for the first time began paddling on the top of the eggs, while the female rested quietly to one side. In one instance, after

Table 2.--Stages of development at 78° F., observed with unaided eye (After Murphree 1940)

Stage	Age
If the egg has no pulsation	Less than 24 hours
If it has pulsation	2 days
If it has bloody streak	3 days
If it has blood all over	4 days
If it has eyes	5 days
If it has eyes and turns over in shell	6 days
If it has a complete fish, no bloody streak	7 days
If the fish is beginning to burst out of egg	8 days

Table 3.--Period of incubation

Temperature	Time	Authority	Remarks
78° F.	8 days	Murphree, 1940	
75° F.	8-10 days	Canfield, 1947	Eye spots, 4-5 days
April-August	5-10 days	Toole, 1951	
80° F.	7-9 days	Lenz, 1947	Eye spots, 5th day
80° F.	7 days 6-25-56 to 7-2-56	Clemens and Sneed (present work)	
82° F.	6 days 7-16-56 to 7-22-56	"	
80° F.	7 days 7-3-56 to 7-10-56	"	
80° F.	6 days 6-28-56 to 7-4-56	"	
80° F.	3 a.m. 5 p.m. 7-20-56 to 7-26-56 Close to 7 days	"	
75° F.	5-12-56 to 5-19-56 Close to 7 days	"	

he had thus assumed the care of the eggs, one more attempt to spawn was observed; but there was no further deposition of eggs. The female remained quietly to one side, occasionally circling, but the male hovered over the eggs and promptly began the activities necessary for their care. From then on, the female was permitted less and less to be near the eggs. The male drove her away as he did any other intruder. The biting of a hand or some object inserted in a keg or can containing a brooding male is familiar to fish-culturists.

When the male assumed a position over the eggs, his pelvic fins alternately beat continuously. He generally faced the same direction. Occasionally he circled away from the eggs and then returned. The most striking activity was exhibited by the male when he vigorously wiggled his body and pressed and packed the eggs with the flat side of his pelvic fins in a manner that shook the entire egg mass. As he "worked the eggs" he moved forward from one end of the egg pile to the other, which gave the impression that he was walking on his fins. This action was similar to the "run" of the female during the spawning act.

Obviously such an act served to aerate the developing eggs, especially those deep in the mass, but it might also serve to move the embryo in the shell. This idea is supported by the fact that good incubation and hatching is obtained at some hatcheries by the paddle-wheel method, which stimulates to some degree the agitation of the eggs by the male. Also, eggs removed from under a brooding male or hand stripped and fertilized with sperm macerated from the testes did not hatch as well as those attended by the male, although ample aeration and fresh water were provided.

Vigorous males worked the eggs every 5 to 10 minutes the first day or two, but later in the incubation period the workings were less frequent. Less vigorous males worked the eggs every 20 to 30 minutes. After several workings, the edges of the egg mass sometimes pulled loose from the tar-paper mat. The eggs were loosened more when the male pulled at the eggs with his mouth. Murphree (1940) apparently observed this activity and claimed that dead eggs were removed at this time. We never observed any males removing dead eggs in any manner and further have observed dead eggs on the top of the mass throughout the incubation period. According to Smith and Harron (1904) the male bullhead, A. nebulosus, picked up the eggs in his mouth and spit them out again. This procedure was also practiced with the young fry, sometimes with fatal results. We never observed channel catfish taking the eggs completely in their mouths. One male was seen trying to move a loose egg mass that had shifted from the center of the aquarium by placing his snout under the edge of the mass and carrying it a little forward as he swam.

We have seen spawn in kegs in hatchery spawning pens which became free and some which stuck quite fast. When a mass became loose from the tarpaper in an aquarium, no eggs were left behind.

The type of nest surface and the amount of silt in the nest or water may determine whether or not the eggs remain attached. The fact that the eggs may be loosened suggested to us that kegs with a lip or a depression might aid the male in keeping a loose egg mass in the keg, and indeed this is the type of container found most satisfactory by practically all channel catfish culturists.

Breder (1935) reported that a pair of Ameiurus nebulosus continued to fan for 10 days the site from which eggs were taken, and that this activity ceased the same day the eggs hatched in the laboratory. He suggested that the spawning act "wound up" some mechanism that simply ran down. Male channel catfish separated from their spawn did not exhibit such behavior, either when the eggs were removed or when the fish was removed from the eggs. The eggs probably stimulate the paternal behavior of the male. This hypothesis was checked when both the eggs and male were transferred from one aquarium to another. The male continued to attend and care for the eggs.

One 15-inch male was used to incubate three spawn, two of his own and an additional one. This male received a severe injury to his right eye during his second courtship. He was injected interperitoneally on alternate days with approximately 75,000 units of penicillin in sesame oil.

This second spawn was tended with considerably less vigor than the first, and there were relatively few attempts at working the eggs. Only about 10 percent of the eggs of this spawn successfully hatched, many of them dying shortly before or during hatching. He attended a third spawn which also hatched poorly for the same reasons.

In poor hatching, the eggs in the center of the mass were the ones most affected. A normal, uninjured male is capable of successfully spawning with at least three females, a fact reported to us by experienced fish-culturists, and also indicated by our experiments.

POST HATCHING ACTIVITY

When the eggs hatched the males were removed and the newly-hatched fry accumulated in a mass on the bottom and usually in the corner of the aquarium. They remained in this position for about two days; then they began to come to the surface. At this time the yolk was greatly reduced and the skin pigment was visible. By the third day they started to feed and move about the aquarium, at which time they were transferred to feeding troughs.

ADDITIONAL SPAWNINGS DURING THE SAME SEASON

We believe that male catfish can be used for propagation a second time two or three days after spawning, provided that the fish are in good condition and that the eggs of the first spawning are artificially incubated, or each 2 weeks if the male is allowed to attend each spawn. Therefore, the number of males in the brood-stock may be reduced to half the number of females.

Second spawnings of females as well as males within a single season were reported for bullheads by Breder (1935). This may occur in the female channel catfish as an irregular event. A spawning keg was raised to pick up the newly-hatched fish on the seventh day after a spawn had been found, but eggs early in development were there instead. The eggs in the bottom of this mass were dead and it was believed that these had been deposited 7 days previously. The second deposition of eggs had beenmade 3 days later, as evidenced by their stage of development, and the male was attending the eggs. It is possible that the fish were disturbed during the spawning act and did not return until three days later; or the female had deposited eggs without the male in attendance, a possibility which we believe to happen seldom if ever; or the physiological level of gonadotropic hormones was such that spawning was delayed or intermittent.

Four females which were induced to spawn with injected pituitary materials and two that spawned without injections were handled after spawning and no eggs could be stripped. Another uninjected female which had spawned 9 days previously was stripped of about a thousand eggs. This female might have spawned a second time, but there is no practical significance to a second spawning when it represents only the left-over eggs of a previously incomplete spawn. In our experience, when female catfish spawn they usually void all their eggs.

SUMMARY

Channel catfish, Ictalurus punctatus, were injected with fish pituitaries and spawned in glass aquariums. Although the fish were thus induced to spawn, the basic spawning pattern and behavior reflexes probably were not modified by the injections. Rather, any visual, physical, and chemical stimuli which normally cause the fish's own pituitary to secrete the gonadotropins necessary to precipitate the spawning act were bypassed by the exogenous gonadotropins, thus causing the fish to spawn.

During the prespawning period the male drove or hazed the female and often bit her on the flank or caudal peduncle. This activity continued until the female assumed a position on the bottom of the aquarium. They were then considered "paired."

Both the male and female were belligerent toward other fish, either male or female, when these were added to the aquarium. The degree of aggressiveness seemed to be correlated with gonadal development, but established residency also played a part.

No particular behavior which absolutely

presaged an imminent spawning was noted on the day prior to spawning. Both fish were active, frequently circling in the aquarium and coming to rest in a previously assumed position. The place on the bottom of the aquarium where the female was located was the place where the eggs were later deposited.

A few hours before spawning, the female moved over the spot where the eggs were to be deposited with a wiggling motion, the pelvic fins alternately beating with the respective pectoral. These "runs" were later a part of the spawning act and appeared to serve to aerate and clean the eggs. Also, it probably stimulated the male as he would try to embrace the female when she was engaged in such behavior.

The spawning reflex preceded each emission of sex products. When a male spawned with the female he swam beside her so that the fish were headed in opposite directions. Then he wrapped his tail around her head while his body quivered and the female bent her tail around the snout of the male. It was at the end of this reflex that the eggs and milt were released.

The actual spawning act required about 6 hours, despite variables in pituitary injections, which suggested an inherent rhythm. Eggs were released about 9 times each hour.

Disturbances such as bright lights, visitors, workers, movement, and examination of the spawners did not inhibit spawning.

Observations on the incubation period and embryology were in keeping with those already reported in the literature.

The female aerated the eggs during the spawning; at least her activities served that purpose. The male assumed the care of the eggs when spawning was complete. He assumed a position over the eggs where his pelvic fins alternately beat continuously. Occasionally he circled away from the eggs and then returned. Often he wiggled his body and pressed and packed the eggs with his pelvic fins in a manner which shook the egg mass. As he "worked" the eggs he moved forward from one end of the pile to the other, as though walking on his fins. No males attempted to remove dead eggs or take the eggs into their mouths although some males massaged the eggs with their mouth. Another tried to move a loosened egg mass back to its original position.

One male was used to incubate three spawns, two of his own and an additional one. The females, however, usually deposited all their eggs in one spawning period, but one was found that retained some ripe eggs.

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