ICHTHYOLOGICAL NOTES

DIFFERENTIAL RESPONSES TO DROUGHT IN TWO SPECIES OF FUNDULUS.—The fresh-water marshes of southern Florida are characterized by seasonal rainfall. Typically a six month rainy season from May through October is followed by a six month period of drought. In some locations the rainy season accounts for over 80% of the annual rainfall. During the dry season low rainfall results in the gradual drying of the shallow marshes, a process accelerated in the spring by increasing evaporation and transpiration. During periods of lowering water level, fish move from the shallow marshes and become concentrated in ponds and other areas of deeper water.

During the study of a small pond in the southeastern Big Cypress Swamp (Kushlan, 1972) distinctive behavioral responses to drying conditions were discovered in the golden topminnow (*Fundulus chrysotus*) and the marsh killifish (*Fundulus confluentus*). The density of fish in the pond was determined using four drop traps described in detail elsewhere (Kushlan, 1972; 1974).

F. chrysotus ranges throughout the fresh-water wetlands of southern Florida. It is particularly abundant in ponds and along canal banks but uncommon in open marshes of the Everglades. *F. confluentus* has been considered to be a preferentially brackish water species entering fresh water only in areas adjacent to brackish water and for short periods of time (Bailey, Winn and Smith, 1954; Carr and Goin, 1955; Miller, 1955; Brown, 1956; Harrington and Haeger, 1958; Harrington, 1959a, b). However some workers have briefly noted its presence in fresh-water areas of Florida (Kilby, 1955; Tabb and Manning, 1961). In actuality *F. confluentus* is a common resident in the fresh waters of the Big Cypress Swamp and Everglades although varying in abundance in different years.

At the study pond in the Big Cypress Swamp, *F. chrysotus* is a member of the resident fauna occurring there throughout the year and becomes increasingly abundant during periods of lowering water level. For example during the spring dry period of 1970, its density increased from 3 fish/m^2 on 17 April to 41 fish/m^2 on 15 May. *F. confluentus,* on the other hand, is seldom found in the pond but occurs during high water in the marsh prairies and dwarf cypress swamps nearby. During the dry period of spring 1970, only a single *F. confluentus* was caught in the pond. However localized masses of from 15 to 40 fish of this species were found stranded by the falling water level on the drying mud of nearby cypress and willow swamps 5 to 20 m from the edge of the pond. These fish survived on the damp mud for at least 24 hours after they were first noted on 15 May 1970. No other species of small fish were found trapped on the gently sloping mud.

Thus the two species of *Fundulus* apparently differed in their behavioral responses to lowering water levels during the spring dry period of 1970, *F. chrysotus* becoming concentrated in the remaining pool of water while *F. confluentus* massed along its periphery. The function of this behavior is not clear, but the massing of *F. confluentus* may be reproductive in nature and the distinct responses of the two species may relate to differences in reproductive strategy. This suggestion is supported by the finding that the eggs of *F. confluentus* can survive out of water in a humid microclimate during dry periods (Harrington, 1959a; Harrington and Harrington, 1972) and that the locations of the masses of fish in the Big Cypress Swamp are similar to the oviposition locations found by Harrington and Haeger (1958) in a drying salt marsh. In addition the known placement of eggs on the ground (Harrington 1959a) and the reproductive behavior of related species, for example *F. majalis* (Newman, 1909), are consistent with this possibility. Observations made during an unseasonable winter dry period in 1970 are also instructive. The peak abundance of fish in the pond occurred in December when *F. chrysotus* showed the expected increase in density. However unlike the previous spring *F. confluentus* also increased in the pond, and no masses were found along its periphery. Thus massing did not occur during the December low point in the nearly year-round reproductive period of *F. confluentus* which Harrington (pers. comm.) found in southern Florida salt marshes.

Certainly too little is known about the reproduction and ecology of these species for any conclusive statement regarding the cause of this differential behavior to be made at this time. The phenomenon reported here was however a distinct and obvious one which is undoubtedly of biological significance. It is hoped that future, more systematic studies on the ecology of these species may provide an explanation for the observations.

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APPARATUS FOR DEVELOPMENT OF AQUATIC EMBRYOS IN CONTROLLED ENVIRONMENTS UNDER CONTINUOUS OBSERVATION.

—This apparatus permits continuous observation of numerous embryos housed individually under controlled environmental conditions that can be changed as often as desired with ease and rapidity. To our knowledge no comparable apparatus has been reported in the literature.

The apparatus, referred to hereafter as an incubation rack, has two components (Figs. 1 and 2). The lower part is a set of individual vials containing the solution in which the embryo develops. The upper part is a set of mesh-bottomed baskets that fit into the vials of the lower part of the incubation rack. An upper part, with one developing embryo in each basket, can be easily transferred from one to another of the lower parts, thereby changing the environment (media, temperature, etc.) of the embryo.

We have utilized vials, baskets and mesh appropriate for eggs of the killifish, *Oryzias latipes*. These eggs are about 1.2 mm in diameter and are spawned in batches of 5–20 per day by each female.

An incubation rack is prepared as follows:

1) The lower part is made of three layers of plexiglass, each 11.5 × 14.5 cm, and fastened one above the other with plexiglass rods. The top two layers contain 20 holes, 2 cm in diameter, arranged as 5 holes in each of 4 rows. Each hole is for a vial 6.5 cm tall, 1.9 cm in diameter, which holds 11 ml (#3-330, Fisher Scientific Company, Springfield, N. J.). The bottom layer of

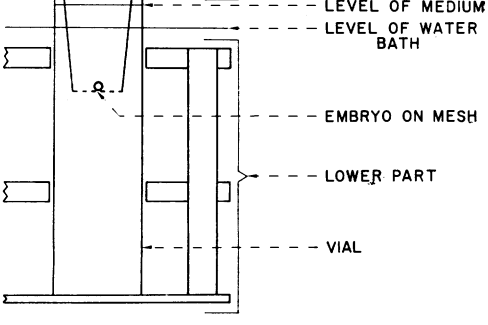

Fig. 1. Diagrammatic profile of incubation rack showing components of upper and lower parts.