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TEMPERATURE AND FISHES

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Harmful or even lethal temperatures cannot be defined for fishes as a group with accuracy, for the reactions of fishes to changes in temperature are influenced regularly by several variables. The gross limits of temperature between which fishes in general survive lie roughly between 0° and 35° Centigrade (32° - 95° Fahrenheit). However, fishes of many species are injured or die at temperatures below 95° F., some tolerate temperatures a degree or more above 95° F., and others survive exposures to temperatures below the freezing point of water. Therefore, in evaluating the hazards of any particular temperature or temperature change, the factors discussed below must be considered.

SPECIES DIFFERENCES

Fish can be divided roughly into cold water species and warm water species according to their temperature preferences. However, three groups must be recognized if the responses to temperature changes are considered. The cold water fishes which normally live in water between 32° and 50° F. usually do not tolerate temperatures above 81° F. Trout and salmon are examples of this group.

The second group includes the common warm water fishes of the temperate zone such as the minnows, carp, catfish, perch, sunfish and bass. These species are subjected to a seasonal gamut of temperature from near 32° to 86° or even 91° F., although during the summer months they move into water below 86° F. if possible.

The third group is composed of tropical and subtropical species usually found in waters at temperatures between 68° to 86° F. Many of the freshwater forms of this group can tolerate temperatures of 93° F. and higher. The fishes of this group, both marine and freshwater, however, are injured or die if the water temperature is reduced to near 63°F., a temperature quite satisfactory for fishes of the first two groups. Storey and Gudger

(1936), writing of marine fishes of this warm-water group found near Florida state that the reduction of the water temperature to 60°F., "might cause trouble to all but the hardiest," of these subtropical marine fishes. In the freshwater fauna of the United States, the characin, Astyanax mexicanus and the chiclid, Heros cyano-guttatus, are representatives of this group and many marine forms are found in our gulf and southern coastal waters.

The destruction of enormous numbers of these subtropical marine fishes has been charged from time to time to the sudden lowering of water temperatures, notably the tilefish, Lopholatilus chamaeleonticeps, at the edge of the Gulf Stream (Jordan and Evermann, 1908), various gulf fishes (Wilcox, 1887) and 47 species of Caribbean fishes near the Florida coast (Storey and Gudger, 1936).

ACCLIMATION

Regardless of the group or species, acclimation is an important factor in determining the temperatures harmful or lethal for any individual fish. Acclimation of a fish varies with the species, some being more capable of adjustment to temperature changes than others, with the temperature at which the fish is living and with the length of exposure to the acclimating temperatures. Under field conditions as the seasonal cycle of water tempertures progresses, the maximal and minimal temperatures lethal for the individual fish change because the fish makes physiological acclimating adjustments which are synchronized with these gradual changes in water temperature. In general, during the summer months when the water is warm, the maximal temperature at which a fish can survive is higher than in the winter when the water is cold.

For example Brett (1944) found the lethal temperature for the catfish, Ameiurus nebulosus, living in a Canadian lake to be 83° F. in early May when these catfish were acclimated to water temperatures of 46° F. or lower. However, the lethal temperature for catfish from this same lake was 96° F. in August when these fish had become acclimated to the water temperature of 78.3° F. during the summer rise in the temperature of the lake water.

The writer has acclimated both Loch Leven trout, Salmo trutta levenensis, and the chiclid, Heros cyanoguttatus, to temperatures unusual for these species. Loch Leven trout by gradual elevation of the water temperature over a period of days adjusted so that they could tolerate approximately 86° F. if the water were constantly and vigorously aerated, although fish from the same lot living in water at 59° F. died when transferred to water at 77° F. The chiclids, by progressive reduction of the water temperature, were acclimated so that they survived for several months at 62.6° F. in spite of the fact that fish of this same species taken from Texas waters where the temperature for the greater part of the day was near 90° F. died when transferred to water at 68° F.

PHYSICAL AND CHEMICAL FACTORS

Many of the reports on the lethality of various temperatures to fish are complicated by the fact that as the temperature of the water rises, the oxygen-carrying power of the water decreases. Therefore, warming the water of a stream already low in dissolved oxygen may reduce the oxygen to a point critically low for fish life. Consequently death of fishes not infrequently has been ascribed to a sudden elevation of water temperature when actually death was caused by low oxygen as the lethal temperature had not been attained. The reduction of dissolved oxygen by rising water temperature rapidly becomes a severe hazard for the fish for as the body temperature of a fish is raised that individual uses more oxygen due to an attendant rise in metabolism.

The writer has observed that the harmful actions of many acids and heavy metals on fishes are potentiated by elevating the temperature of the water in which the fish is held. These acids and heavy metals form coagulation films on the gills of fish, thereby reducing the efficiency of the gill and consequently the absorption of dissolved oxygen from the water. The formation of the films on the gills proceeds more rapidly as the water temperature rises and as the fish requires more oxygen at the higher temperatures, the detrimental action of the coagulation film is correspondingly greater when the body temperature is elevated.

The toxic actions of many substances on the fish are increased as the body temperature of the fish rises. Accordingly, for the most part, many water pollutants become more dangerous to fishes if the water temperature is elevated. Therefore, even sublethal rises in water temperatures may be the cause of death if various pollutants are present.

PHYSIOLOGICAL CONDITION

As the body temperature passes the normal range and approaches the maximal lethal value, there is a tendency for the products of metabolism and incomplete metabolism to accumulate in the cells and tissues. The toxic actions of these substances apparently play major roles in killing the cells and thereby the animal although many other factors enter into this very complex reaction. Experimental work has also shown that the various tissues are not equally disturbed by rising body temperature and that those containing fatty substances are usually the more susceptible to thermal injury. It is not surprising, therefore, that the reactions of animals and fish in particular to rising body temperature depend somewhat at least on the physiological condition of the individual, nor that in view of the complicated factors involved, conflicting findings have been reported.

Among the correlations that have been noted between the physiological condition and the reaction to elevation of body temperature, a few may be mentioned. In general fish in very poor nutritional state or fish which have been subjected to long periods of absolute starvation die at lower maximal lethal temperatures than well-nourished individuals. Gravid females seem less resistant than males to the effects of body temperature. The sex glands and especially the ovaries are more sensitive to the higher temperatures than the body as a whole so that elevation of body temperature can at times alter the quality of the eggs. This is the background for the statement, often made by fish culturists, that warming gravid fish will impair the quality of the spawn. However, all of the correlations listed are subject to much variation and numerous exceptions because so many factors contribute to the reactions of fish to heat.

Reduction of body temperature to near lethal levels also causes an accumulation of the products of metabolism. These in turn can contribute extensively to conditions resulting in the death of the fish. Actual freezing produces mechanical and physical changes in the cells which also must be considered as contributing causes to death at temperatures below that at which water freezes.

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