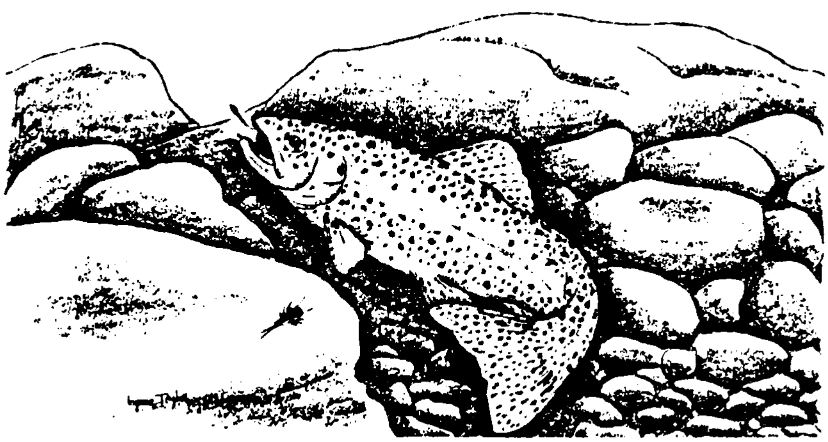
THERMAL RELATIONSHIPS IN NATIVE AQUARIUM FISH

--William R. Kenney

Fish are ectothermic vertebrates and as such the temperature of their bodies is closely related to that of the surrounding water. Lagler, et.al.(1962) note that such large, active species as tuna and marlin may demonstarte temperatures several degrees higher than that of the surrounding water, but this is becauseheat produced by muscular activity is not dissipated as rapidly as it is generated. This phenomenon is not to be construed as the ability of the fish to control his temperature, as no means of retaining heat exists after the activity ends. It can be considered the exception rather than the rule.



We as aquarists are accustomed to worrying about the possibility of a sudden drop in temperature killing our fish. Native fish hobbyists have an additional worry: Will our tank's temperature become too warm? The large variety of fish under my care are tolerant of a wide variety of temperatures, but, limits do exist. We shall examine, in this essay, the mechanisms that establish temperature limits for any species of fish.A mass of scientific information on the subject is available, but most of it deals with species of economic or recreational (sport fishing) species. However, from the study of this data it will be possible for us to understand the thermal limits of our aquarium fish, although it is beyond the scope of this essay to catalog the known limitations of those species which have been studied.

Water is necessary to vertebrate life. Therefore, a theoretical maximum temperature may be set for all fish at the boiling and freezing points of intracellular fluids. However, these limits are of no practical importance to the aquarist because other problems are encountered long before they are reached: For example, well below the the boiling point of water serious dissolved oxygen limitations will be encountered. The higher the temperature, the lower the solubility of oxygen. However, because a fish's maetabolic rate, and hence its demand for oxygen, increases with temperature, at some point water will be unable to hold enough oxygen to meet a fish's needs. Indeed, for certain active species this factor may establish the species upper lethal limit. In order to minimize temperature's effect in the aquarium, the aquarist should keep dissolved oxygen levels at or near saturation.

Lower temperature limitations (above the freezing point) may be imposed by the cessation of feeding and consequent starvation. In a monumental study by Shuter, et. al. (1980) on Smallmouth Bass, the northern limits of this species' range were accurately predicted by factors influencing the survival of juveniles through their first winter. It was demonstrated that juveniles would survive temperatures close to freezing, in spite of the fact that they ceased to feed and grow at some temperature above this, (10C). Whether or not they survived the winter depended upon the extent of their energy reserves; this in turn depended upon the length of the growing season during the first summer of their lives.

Stress induced by starvation, such as was encountered in Shuter's study, together with the direct stress of low temperature and other stress factors involved in keeping a specimen in captivity, may increase the specimen's sussceptibility to disease. This in turn may establish a practical lower limit to the temperature at which we may keep our aquarium specimens.

However, direct thermal limitations are usually iposed by the physiological history of the individual fish or fish species. The normal physiological functions of any organism are carried out by enzymes, which catalize all the chemical reactions within the cells. Individuals which have not been exposed to a wide temperature range during their recent history usually possess only those enzymes which they require for the specific temperature to which they are acclimated. Such fish are called stenothermal. Other individuals, which have been subjected to temperature change in their recent past may possess additional sets of enzymes to cope with a broader temperature range.

The manufacture of enzymes is thus controlled by environmental factors, but the ability to manufacture them is genetically controlled. Marine species, particularly in the tropics, have been exposed for millenia to an environment where temperature changes are small and gradual. They may have lost the ability to manufacture additional sets of enzymes.

From the above discussion of enzymes we realize that when we subject a fish to a change in temperature of more than a few degrees we require it to do one of two things: either it must bring a new set of enzymes into play or, if it does not have them, it must manufacture them. This latter mechanism takes time; failure to accoplish it before the vital processes are interrupted will result in the specimen's death. THUS,BOTH THE MAGNITUDE AND THE SPEED OF THE TEMPERATURE CHANGE WILL EFFECT OUR SPECIMEN's CHANCES FOR SURVIVAL. A typical graph of the thermal tolerance range for many species, when plotted against acclimation temperature, forms a parallelogram, as shown in Figure 1:

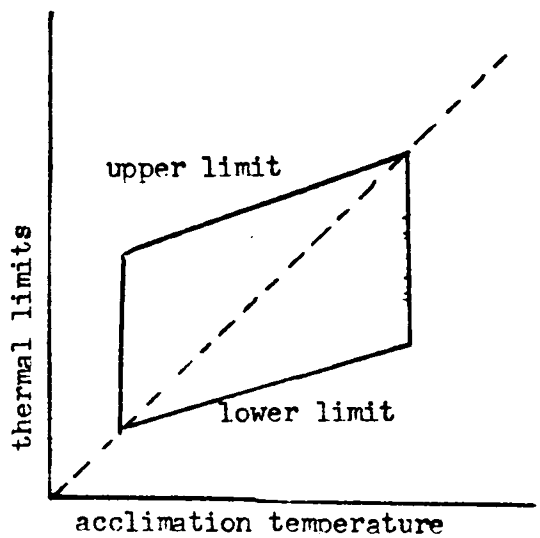


Fig. One: Thermal Limitations of aquarium fish plotted against acclimation temperature.

To interpret Figure 1, imagine that a specimen, acclimated to any temperature on the dashed line, is subjected to a temperature change. If we go up or down from the dashed line but remain within the parallelogram, the specimen will be able to adjust. If we go above or below the indicated area, the fish will die. Naturally, the exact values with which we label the coordinates will depend on the species under consideration.

Many authors of popular aquarium literature have reported a rather narrow temperature range for many of the species they discuss. More detailed studies reveal that these popular reports were based on a single acclimation temperature. Thus the ultimate temperature limits for many species will prove to be considerably broader. Many comments of this kind are flagrantly prejudicial to native fishes.

Centrarchids, such as the Longear Sunfish shown above, are frequently referred to as "cold water fishes"-- something they most certainly are not. The Bluegill has been shown by Hickman and Dewey (1973) to have an upper thermal limit of 35.5 C, much warmer than the average tropical fish aquarium. To those who state that Bluegills do better in cool water, I cite Beitinger and Maguson (1979) who demonstrated that Bluegills which were allowed to select from among alternative water temperatures chose ranging from 30-31 C; also, this is the temperature range at which Bluegills exhibit optimum growth. Thus it is inaccurate to refer to native fish as a group as "cold water fish". While it is not within the scope of this essay to list the upper thermal limit of native fish suitable for the home aquarium, the aquarist planning to establish a native fish community will often be pleasantly surprised at the wide range of temperatures most of our natives will tolerate. Indeed, only certain only certain gropus, such as trout, sculpins and minnows from the northern part of the continent require refrigeration or location in an air-conditioned room. To obtain an idea in advance if such measures are required, the aquarist should try to ascertain the maximum summer water temperature of the body of water from which his specimens are taken. This should provide a good guideline.

For those interested in a tabulation of studies which have been performed on various native species to determine their thermal limits, the reader is referred to Carlander's Handbook of Freshwater Fishery Biology. To this the aquarist can offer his own observations, since most of the species in Carlander are gamefish species, not normally found in the home aquarium.