Activity in rainbow trout (*Salmo gairdneri*) as a function of acclimation and thermal environment

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The activity of rainbow trout (*Salmo gairdneri*) acclimated at 12°C was compared to that of trout acclimated at 22°C over a 15-min exposure to each of four thermal environments (12°, 17°, 22°, and 27°C). Activity increased with increases in environmental temperature, and trout acclimated at 12°C were significantly more active than those acclimated at 22°C. The results suggested that increases in environmental temperature may be aversive and that subsequent activity due to thermal increases may be part of an avoidance or escape mechanism.

The water quality of most natural rivers and lakes has been altered by reservoirs, storages, releases, diversion, and other multiple water-use developments. For example, reservoirs have their primary effect on water quality by reducing turbidity and water temperature. Such changes in stream ecosystems have a major effect upon aquatic animal and plant life (Friedman, 1969). Aquatic poikilotherms, such as fish, are able to adapt to thermal increases in their environment for short periods of time through physiological changes, such as increased metabolic activity (Fry, 1947). Fish are able to extend their temperature tolerance through the process of acclimation (Brett, 1956). Fisher & Elson (1950) have demonstrated that the distance traveled in response to an electrical stimulus in *Salmo salar* and *Salvelinus fontinalis* is a function of the environmental temperature and the strength of the stimulus. This suggests that temperature has an effect upon fish activity. The present investigation was designed to assess the effects of varying environmental temperatures and levels of acclimation upon the behavioral activity of rainbow trout.

SUBJECTS

The Ss were 32 rainbow trout (*Salmo gairdneri*) obtained from a local hatchery 1 to 3 weeks prior to experimentation. Within the laboratory the Ss were maintained in groups of 2 in 19-liter aquariums at either 12°C or 22°C. The Ss ranged in weight from 2 to 3 g and were 3-4 cm long.

APPARATUS

The experimental apparatus is schematized in Fig. 1. The apparatus consisted of a gray plywood chamber, 30 cm long, 15 cm wide, and 20 cm high. A gray plywood partition divided the chamber into two equal

compartments. A series of 6-mm holes perforated the partition, permitting an easy flow of water. A 5-cm aperture extending the width of the partition, 6.25 cm from the bottom, permitted free movement of the S from one compartment to the other. Infrared photoelectric cells were mounted parallel to the aperture outside the chamber. If movement was made in either direction through the aperture, the photoelectric beam would be broken, activating an electronic counter.

A perforated rubber hose, 1.25 cm in diam, was attached to a water source and transversed the bottom of the chamber. A flow of tap water of the desired temperature could be directed through the hose into the chamber. Overflows positioned in one end of the chamber maintained a water level of 17.5 cm.

PROCEDURE AND EXPERIMENTAL DESIGN

The Ss were acclimated for 1 week at either 12°C or 22°C, with 16 trout within each condition. During testing, all Ss were exposed to each of four thermal conditions (12°, 17°, 22°, and 27°C) within the test chamber. Eight Ss, 4 from each acclimation level, were exposed to each of four orders of presentation (4 by 4 Latin square).

All Ss were tested individually. At the beginning of each session, the S was placed in the apparatus for a period of 15 min. At the end of the time interval, the S was removed from the chamber and placed in a Pyrex jar containing 250 ml of 12°C or 22°C water (same as acclimation level) for a period of 15 min. At the end of the 15-min intertrial interval (ITI), the S was again placed in the apparatus at a new temperature setting. In this manner, all Ss were exposed to each of the four temperature variations for a period of 15 min each, with a 15-min ITI between each setting. The number of movements through the aperture were recorded for each session.

RESULTS AND DISCUSSION

Figure 2 presents the mean frequencies of responses for the two groups acclimated at 12°C and 22°C over the four test temperatures. The analysis of variance (Lindquist, Type IV, 1953) yielded a significant difference between the acclimation levels ($F = 32.38$, $df = 1/24$, $p < .01$), within temperature levels ($F = 68.13$, $df = 3/72$, $p < .01$), and a Temperature by Acclimation interaction ($F = 26.38$, $df = 3/72$, $p < .01$). All other effects were nonsignificant ($p > .01$). Multiple comparisons were made using the Duncan multiple-range test. Ss

Fig. 1. A schematic of the experimental chamber.

Fig. 2. Changes in activity as a function of temperature for Ss differing in levels of acclimation.

acclimated at 12°C showed a significant difference at all levels ($p < .01$) except under the 12°C and 17°C conditions. Significant differences were also obtained between the 12°C and 22°C acclimation levels, with the exception of the 12°C and 17°C test temperatures. All other comparisons were nonsignificant ($p > .01$).

The results of the present study indicate that activity is a function of water temperature. As can be observed in Fig. 2, activity in trout acclimated at 12°C increased with increases in test temperature, whereas trout acclimated at 22°C were significantly less active at the 22°C and 27°C test temperatures. Similarly, fish acclimated at low temperatures have lower metabolic and tolerance levels than conspecifics acclimated at a higher temperature (Brett, 1956). This suggests that the more divergent the temperature from the acclimation level, the more aversive it becomes. Homeotherms, such as rats, will barpress to escape aversive thermal conditions (Epstein & Milestone, 1968). The activity functions in the present research may

be one aspect of an avoidance or escape behavior pattern.

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ERRATUM

Several errors in page numbers appear on the cover of Volume 21, Number 5. The following corrections should be made.

Was	Should be
280-296	280-292
299	293
304	300
310	306
238	258
314	310
320	316
300	296
302	298
312	308
298	294
306	302
308	304
317	313
318	314

Similar errors were made in the table of contents of Volume 21. They may be corrected by locating the beginning of a title and changing the page numbers as follows:

Under Motivation—

An expression of body weight ... 299 should be 293

Prey selection ... 304 should be 300

Sex differences ... 310 should be 306

Under Learning—

The classically conditioned ... 300 should be 296

Generalization gradients ... 302 should be 298

Reversal learning ... 312 should be 308

Under Avoidance and Punishment—

Between-groups incentive ... 298 should be 294

The buzzer ... 306 should be 302

Shock-avoidance ... 308 should be 304

Effects of a punitive ... 317 should be 313

Motivation-performance ... 318 should be 314

Under Social Behavior—

Social inhibition ... 314 should be 310

Dependence ... 320 should be 316

The same errors appeared in the author index and should be corrected as follows:

Anderson, W. H., 298; Ayres, J. J. B., 294; Booth, D. A., 293 (from 209); Campbell, H. W., 300; Crawford, M. L. J., 304; Forman, H., 316; Harris, C. J., 316 (from 320); Henderson, N. D., 314; Hogan, J., 316; Johnson, D. F., 298; Levinthal, C. F., 296; Matyniak, K. A., 308; Melvin, K. B., 313; Morrison, B. J., 316 (from 320); Nyby, J., 310; Papsdorf, J. D., 296; Quinsey, V. L., 294; Riess, D., 302 (from 306); Rollings, J. P., 313; Singh, D., 306; Stettner, L. J., 308; Thiessen, D. D., 310; Wallace, P., 310.

The person who made these errors is no longer on our staff.

Editor