Neyman, J., T. Park, and **Elizabeth L. Scott.** 1956. Struggle for Existence—the Tribolium Model: Biological and Statistical Aspects, in J. Neyman, ed., Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability. vol. IV, pp. 41-79. Berkeley, University of California.

Park, T. 1934. Observations on the General Biology of the Flour Beetle, *Tribolium confusum*. Quart. Rev. Biol. **9**: 36-54.

———. 1937. The Culture of *Tribolium confusum*. in J. G. Needham, ed., Culture Methods for Invertebrate Animals. Comstock.

———, **B. Ginsburg,** and **Shirley Horwitz.** 1945. Ebony: a Gene Affecting the Body Color and Fecundity of *Tribolium confusum*. Physiol. Zool. **18**: 35-52.

———, and **Nancy Woollcott.** 1937. Studies in Population Physiology VII: The Relation of Environmental Conditioning to the Decline of *Tribolium confusum* Populations. Physiol. Zool. **10**: 197-211.

Rich, E. R. 1956. Egg Cannibalism and Fecundity in *Tribolium*. Ecology **37**: 109-120.

Roth, L. M. 1943. Studies on the Gaseous Secretion of *Tribolium confusum* II. The Odoriferous Glands. Ann. Ent. Soc. Amer. **36**: 397-424.

Salt, G. 1937. The Sense Used by *Trichogramma* to Distinguish between Parasitized and Unparasitized Hosts. Proc. Roy. Soc. B **122**: 57-75.

———, and **F. S. Hollick.** 1946. Studies of Wireworm Populations II. Spatial Distribution. J. Exp. Biol. **23**: 1-46.

FLOW, TEMPERATURE, SOLAR RADIATION, AND ICE IN RELATION TO ACTIVITIES OF FISHES IN SAGEHEN CREEK, CALIFORNIA

PAUL R. NEEDHAM AND ALBERT C. JONES
Department of Zoology, University of California, Berkeley, California

As pointed out by Hubbs and Trautman (1935), Maciolek and Needham (1952), and Benson (1953), a study of winter conditions in streams is a badly neglected phase of freshwater ecology. Most stream surveys and studies are conducted in summer when weather is hospitable. However, a fundamental characteristic of high mountain trout waters is the possession of a relatively short, pleasant summer season while, over the rest of the year, generally severe conditions prevail with low temperatures, floods, ice, and snow.

It is well known that severe winter conditions cause extremely high mortalities of trout, as indicated by the work of Needham and Slater (1945), Needham, Moffett and Slater (1945), Maciolek and Needham (1952), Nielson *et al.* (1957), and Miller (1958). Tack (1938) reports that ice crystals plugged the mouths and gills of trout in ponds and killed them by suffocation. Reimer's (1957) work indicates that such heavy winter mortalities are due more to adverse and exhaustive physical conditions than to food conditions at this season. Despite these observations, the factors that actually cause heavy mortalities of stream-dwelling animals remain to be clearly defined and measured. It is the purpose of this paper to present the effects of certain of these physical factors on stream conditions and on the activities and well-being of fishes during winter periods. These studies were conducted at the Sagehen Creek Project operated under the University of California. This project is located at an elevation of 6,337 feet on the east slope of the Sierra Nevadas in the Tahoe National Forest, 12.8 miles north of Truckee, California.

Sagehen Creek is a tributary of the Little Truckee River which flows into the main Truckee River near the California-Nevada state line. Averaging around 15 feet in width, it is fed by springs and melting snow and fluctuates from around 50 cubic feet per second during spring run-off to about 2.0 c.f.s. in September. It rises at an elevation of around 7,000 feet and after passing over its 10 mile course, enters the Little Truckee at an elevation of 5,000 feet. The winter studies described here were all conducted within a half mile of the station headquarters. The facilities provided there have been described by Needham (1956).

Sagehen Creek basin is entirely forested except for scattered meadows along the stream. The dominant trees consist of Jeffrey pine (*Pinus Jeffreyi*), white fir (*Abies concolor*), red fir (*Abies magnifica*), and lodgepole pine (*Pinus contorta*) which dominates the wetter areas. The average winter snow pack is roughly 44 inches. Severe winter conditions usually prevail from mid-December to the end of March with intermittent periods of clear weather occurring for short intervals.

The only native salmonid fish in Sagehen Creek was the Lahontan cutthroat trout, *Salmo clarki henshawi,* but these have long since been replaced by introduced forms: eastern brook trout, *Salvelinus fontinalis;* rainbow trout, *Salmo gairdneri;* and brown trout, *Salmo trutta.* These 3 species all occur in the area of the station and the only

ECOLOGY

ALL FORMS OF LIFE IN RELATION TO ENVIRONMENT

OFFICIAL PUBLICATION OF THE
ECOLOGICAL SOCIETY OF AMERICA

Vol. 40, No. 3 July, 1959

CONTENTS

NOTES AND COMMENT

T DURHAM, N. C.

Y OF AMERICA

TY PRESS