by Dr. Peters which Mr. Knobel has subsequently revised and amended.

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FIVE YEARS OF STARVATION OF LARVÆ

THE specimens concerned are the larvæ of *Trogoderma tarsale*, a small beetle well known as a museum pest. The last of a large number of specimens lived, without a particle to eat, for the suprisingly long period of five years, one month and twenty-nine days or, to be more specific, from October 28, 1911, to December 25, 1916, a period of 1,884 days. The case is decidedly outstanding, as to my knowledge, nothing similar has ever been recorded as a result of starvation experiments with other animals. It is very probable that under otherwise non-disturbing conditions the starving larvæ would have lived for even a longer period. The specimens concerned in this article had undergone considerable disturbance after the first two years of starvation, since many of the larvæ made the trip between Idaho and Wisconsin with me three or four times, and several of them covered the distance five times. The trips one way varied in duration from four to seven days. There is no doubt but that the jarring of the train had accelerated the metabolism of the larvæ. This fact was evinced by the moulting of practically every individual toward the end of the trip or within a few days after it, and by the decided decrease in the dimensions of the larvæ immediately following such a moult. Larvæ placed under starvation shortly after my arrival in Idaho in the summer of 1913, which have not been so disturbed, show indications of even greater tenacity than is here recorded.

It will not be out of place here to mention how the starvation experiments with this particular species which proved to be of such unusual interest came about. While a graduate student at the University of Wisconsin the writer got into a dispute concerning the classification of the larvæ. To prove his point he decided to grow some of the specimens to maturity and thus obliterate the uncertainty of identification. A number of the largest larvæ available were placed in glass dishes together with some food material. Not having plenty of the favorite food material at hand at the time, several specimens were placed in other dishes without food and set aside in a separate drawer with the intention of providing for them later. However, these were neglected until the opening of school the following September when the writer accidently discovered them in their secluded place. Much to his surprise all of the specimens were alive, in spite of the fact that they had remained there for five months without a thing to eat. It was also noticed that the larvæ had decreased in size. This observation was further substantiated by the gradual decrease in size of the various cast-off skins, which this species is not known to attack. This interesting information later led to experimental work on the longevity of the larvæ, without food, on a large scale.

A number of specimens varying in size from newly hatched to practically full-grown larvæ were placed in individual sterilized vials for the purpose of ascertaining the period of time that they could live without food. Even the newly hatched specimens showed an amazing tenacity by living over four months without ever having eaten at all. Some of the one fourth grown specimens lived for fourteen months; those about one half grown lived almost three years; those three fourths grown lived four years; and most of the largest specimens lived over four years, several of them over four and a half years, and one five years and seven days; while the last one died after five years, one month and twenty-nine days of starvation.

One of the most interesting phases of these experiments is the gradual decrease in size of the individual specimens. Many of the largest larvæ which were about 8 mm. in length dwindled down to practically the hatching length of 1 mm. before dying, and practically all of the specimens which were below 7 mm. at the beginning of the experiment dwindled down to the same dimensions. Many of the larvæ of 2 and 3 mm. were reduced to somewhat below the hatching length, and practically all of the newly hatched specimens fell down to about three fourths of their original length. Speaking in terms of reduction in size, it is astonishing to note that some of the largest larvæ have been reduced to about 1/600 of their maximum larval mass.

Another, and even more interesting phenomenon, is the fact that when the starved specimens almost reach the smallest size possible and are then given plenty of food, they will again begin growing in size. A number of the larvæ which were half grown when placed under starvation for the first time, have through alternating periods of "feasting and fasting" attained that size three times and are now on the way to their fourth "childhood"; and even some of the large specimens have started dwindling down to their third "childhood" after having twice attained the practically maximum larval size.

Occasionally these larvæ are found in large numbers in insect, seed and drug collections, and naturally destroyed as soon as discovered. The writer would appreciate any amount of this living material that the reader may happen to find if he has no use for it himself. The larvæ, pupæ or living adults of other dermestids are equally desirable for the purpose of comparative studies. In response to a recent circular letter many men have already sent me some valuable material. The names of the donators will appear in the forthcoming detailed publication of this extensive and of necessity prolonged investigation.

The problem has now attained enormous proportions and involves the use of thousands of specimens. Many normal larvæ of different sizes, as well as many specimens in the different periods of starvation have been sectioned during the past few years, and comparative cytological studies of the various structures of the organisms are being made. Physiological studies with special reference to metabolic water and excretion have also been started.

J. E. WODSEDALEK

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SPECIAL ARTICLES

THE RÔLE OF THE NUCLEUS IN OXIDATION[1]

IN 1897 Spitzer[2] reported that nucleoproteins extracted from certain animal tissues have the same oxidizing power as the tissues themselves. The idea that the nucleus is a center of oxidation was advocated by Loeb,[3] who pointed out that this would explain why cells deprived of nuclei live but a short time and are unable to regenerate missing parts. R. Lillie[4] sought to obtain direct experimental evidence by applying reagents which become colored on oxidation. He found the greatest amount of color in the neighborhood of the nucleus, indicating that it is a center of oxidation. Subsequent workers,[5] using stains which change color on oxidation, failed to agree as to the results.

Mathews[6] has stated that the nucleus is directly concerned in oxidation.

Warburg[7] found that NaOH increased oxidation in the sea urchin egg, but did not penetrate sufficiently to cause a change of color in the interior of eggs stained with neutral red. This is regarded by some as indicating that oxidation is largely confined to the surface of the cell.[8] R. Lillie[9] has recently found that the formation of indophenol in leuco-

[1] Preliminary communication.

[2] *Pflüger's Archiv*, 67: 615, 1897.

[3] *Archiv für Entwickelungsmechanik der Organismen*, 8: 689, 1899.

[4] *Am. Jour. Physiol.*, 7: 412, 1902.

[5] *Cf.* Wherry, E. T., SCIENCE, N. S., 37: 908, 1913; Schultze, W. H., *Verh. deutsch path. Ges.*, 16: 161, 1913; Reed, G. B., *Jour. Biol. Chemistry*, 22: 99, 1915. Unna, P. G. und Godoletz, L., Oppenheimer's *Handb. d. Biochem. Erganzungsband*, *S.* 327, 1913.

[6] Mathews, A. P., "Physiological Chemistry," 1915, p. 180.

[7] Warburg, O., *Zeit. f. physiol. Chemie*, 66: 305, 1910; *Biochem. Zeit.*, 29: 414, 1910.

[8] This conclusion does not seem to be necessary. *Cf.* Loeb and Wasteneys, *Jour. of Biochemistry*, 14: 459, 1913; also Osterhout; *Ibid.*, 19: 335, 1914. Owing to the buffer action of the protoplasm and to the presence of pigment the penetration of a small amount of alkali is not easily detected.

[9] *Jour. of Biol. Chemistry*, 15: 237, 1913.