Proceedings of the Iowa Academy of Science

Volume 67 | Annual Issue Article 74

1960

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Abstract. Of five species reared under different conditions of temperature and light, only *Hypogastrura matura* exhibited a phenotypic difference. This difference was in the relative lengths of the furcula and the head and appeared to be a matter of selective survival rather than a direct response of the phenotype to the environment.

Cassagnau (1955) described striking changes which occurred in the anal horns of a winter form of *Hypogastrura purpurascens,* causing them to resemble the anal horns of *Ancistracanthella,* when the specimens were reared for 30 to 60 days at abnormally high temperatures. These changes appeared in a small percentage of the specimens when they had been subjected to such temperatures for 30 days, but at 60 days 70 percent of them showed these modifications in the anal horns. Some change in the anal horn and papilla was first noted at temperatures well below the thermal death point and was accompanied by modification of the mouth parts, furcula, and genital aperture.

In order to determine whether this phenomenon was widespread and to show what effect light had on the phenotype, several species of Collembola, *Hypogastrura matura* (Hypogastruridae), *Sinella caeca, S. curviseta, Entomobryoides purpurascens* (Entomobryidae), and *Sminthurinus quadrimaculatus* (Sminthuridae) were reared under different conditions of temperature and light. Each species was subjected to the following conditions:

	Usual temperature range (degrees C.)	Extremes (degrees C.)
Oven-light	27-30	26-33
Oven-dark	27-30	26-33
Refrigerator-light	4.5-10	1-16
Refrigerator-dark	4.5-10	1-16
Room temperature-light	24-27	21-29
Room temperature-dark	24-27	21-29

The refrigerator temperature in the light at any given time was generally 1.5°-2°C higher than that in the dark. Dark conditions were maintained in light-tight microscope cases. The insides of the boxes were painted black and the openings sealed to prevent the

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admittance of light. The darkness of each box was tested with photographic paper. In some cases the original adults failed to reproduce and were replaced. The animals were grown from 30 to 143 days under the different conditions with periodic harvests of the excess full-grown adults.

The cultures were reared in covered jars on about an inch of substrate composed of plaster of Paris and activated charcoal in a ratio of 9:1. When contained in the jars, the substrate mixture acted as a humidifier, maintaining the relative humidity above 95 percent (Huber, 1958). The cultures were watered at five-to-six-day intervals to ensure saturation of the substrate.

Transfer of live specimens from jar to jar was accomplished by anesthetizing them with a small (10-15 second) dose of CO_2 and lifting them from a damp slip of filter paper or a water-color brush. The CO_2 was administered from the cylinder through a funnel which was slightly smaller than the mouth of the jar. This eliminated waste of gas and kept the specimens from blowing away. The animals were exposed to CO_2 only for 2-4 seconds after they ceased moving, in order to prevent injury and death.

Hypogastrura matura and *Sinella curviseta* thrived when fed on yeast. The other three species fed on the alga *Protococcus* found on tree bark. All forms were sensitive to drying, but *Sminthurinus quadrimaculatus* appeared to be especially so.

The approximate lethal temperature of each species was determined by raising the oven temperature daily until less than six of the specimens remained alive. These temperatures are as follows: *Hypogastrura matura,* 33.5° C; *Sinella caeca,* 34.5° C; *S. curviseta,* 38.5° C; *Entomobryoides purpurascens,* 45° C; and *Sminthurinus quadrimaculatus,* 54.5° C. *Sinella curivseta* and *Hypogastrura matura* were submitted to sublethal (1-2° C below lethal) temperatures for a period of several weeks.

The refrigerator temperatures fluctuated greatly, but none of the cultures except *Hypogastrura matura* reproduced at all these temperatures. Only a few specimens of *Sminthurinus quadrimaculatus, Sinella caeca, S. curviseta,* and *Entomobryoides purpurascens* survived for any length of time, and these were in the light. Table 1 summarizes the survival of the various species in cold conditions.

Table 1
Survival of Various Species of Collembola Under Conditions of Cold

Species	Time (days)	Number surviving
Sinella caeca	52	None
S. curviseta	52	None
Entomobryoides purpurascens	143	One
Sminthurinus quadrimaculatus	120	One
Hypogastrura matura	30	All*

*Also a few eggs and young

In the oven at room temperature, the number of individuals of *E. purpurascens* and *S. quadrimaculatus* fluctuated greatly. At the time of the last sampling, the *S. quadrimaculatus* populations had increased from 25 percent to 150 percent in 143 days. The maximum *E. purpurascens* increase was 50 percent after 143 days; however, some of the cultures had died entirely independently of the experimental conditions to which they were subjected. *S. curviseta* populations increased from 1600 percent to 3400 percent, and *S. caeca* populations from 2100 percent to 4900 percent, in 143 days, with no apparent differenc as a result of the differing conditions. No figures were available for *H. matura,* because a large number of individuals was transferred from the stock culture to insure a large reproduction in a relatively short time.

The gross morphology of the animals remained constant under all environmental conditions, including the sublethal oven temperatures. Even such generally variable structures as the mucro, unguis, postantennal organ (in *Hypogastrura*), and chaetotaxy, eyes, mouth parts, sensory setae, and female anal appendages (in *Sminthurinus*) showed no change under any conditions. The number of *S. quadrimaculatus* and *E. purpurascens* individuals was so small that no statistical data could be obtained.

There was an apparent difference in *Sinella,* but statistical analysis showed no significant change under any conditions tested. Extensive measurements of the color variation in *S. curviseta* were made, using the Munsell notation. Head and antenna lengths of both *S. curviseta* and *S. caeca* were also measured. None of these showed significant change.

No significant difference in the shape or relative lengths of the anal horn and papilla of *Hypogastrura matura* appeared. However, a striking difference appeared between the relative lengths of the furcula and head of the specimens reared in the refrigerator and under sublethal temperatures. From Figure 1 it is evident that the furcula of specimens reared in the oven was distinctly larger in relation to the head than was that of the specimens in the refrigerator culture. Yet both of these fell within the range of the furcula/head ratio of specimens taken from the stock culture. Because of this overlap with the stock culture and the lack of intermediate forms, it seems likely that the separation of the oven and refrigerator specimens is due to selection rather than phenotypic modification.

In summary, then, the different species survived variously under the different conditions. *Sinella, Sminthurinus quadrimaculatus,* and *Entomobryoides purpurascens* died at the lower temperatures. *Hypogastrura matura* survived at refrigerator temperatures but its maximum temperature tolerance was less than any of the others. *Smin-*

thurinus quadrimaculatus and *Entomobryoides purpurascens* exhibited high temperature tolerances. None of the species examined showed any clear phenotypic differences under the different conditions, with the exception of the *Hypogastrura matura* furcula. This

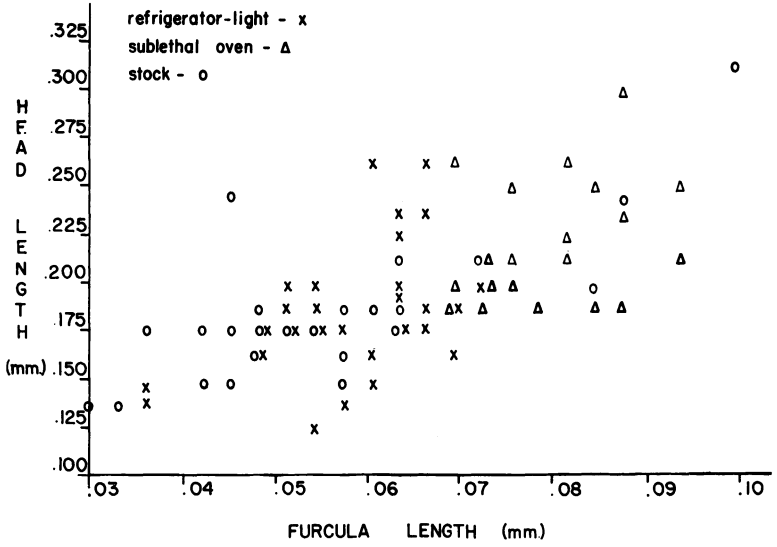

Figure 1. *Hypogastrura matura,* ratios of head/furcula lengths.

change appeared to be a matter of selective survival under the different environmental conditions rather than a direct response of the phenotype to the environment. It is clear from this study that the phenotypic plasticity noted by Cassagnau is not universal in the Collembola, and may well be limited to a very small number of species.

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