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The Effects of Temperature and Food Quality on the Larval Development of *Gryllus bimaculatus* (Orthoptera, Gryllidae)*

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Summary. Newly hatched larvae of *Gryllus bimaculatus* were kept on five synthetic diets of different protein contents (5%, 15%, 30%, 40%, and 50% of dry weight) and at three temperature ranges until imaginal molting. Each temperature range encompassed a daily alternating temperature and the corresponding constant mean temperature (29/11° C–23° C, 33/15° C–27° C, 37/19° C–31° C, LD 16:8 h). The course of development of the larvae depends on both the temperature and the diet. The penultimate larval instar period served for estimation of development under all rearing conditions. According to weight gain, duration of development, mortality, and food conversion efficiency a dietary protein content of 30% was optimal under a constant temperature-regime; at alternating temperatures protein contents of 15%–50% were satisfactory for optimal development. The energy requirement for a gain of one gram of dry weight is greatest at *P*-5%-diet and lowest at *P*-30%-diet. The results are discussed in terms of their ecological and physiological importance for field crickets.

Introduction

Development of insects has been studied previously mainly with respect to optimal conditions. These optimal conditions, however, will almost never exist in the field. For ecologically relevant problems it is important to know the minimal as well as the optimal temperature and food requirements of an animal. Another essential fact is that neither the effect of temperature nor that of food should be considered in isolation because of their natural interdependence (Schramm, 1972; Harlow et al., 1976). Temperature has a pronounced effect on digestive efficiency of poikilothermic animals and there are strong changes

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in the course of the year in the quality and quantity of the food available. The mediterranean field cricket *Gryllus bimaculatus*, which is exposed to great temperature changes during the day within its natural habitat, seems to be very suitable for studies of effects on its larval development by temperature, both daily alternating and constant, in combination with different diets. The aim of the present paper is to quantify these combined effects in an ecologically realistic way.

Materials and Methods

1. Rearing Conditions

Larvae of *G. bimaculatus* de Geer (Orthoptera) were reared from hatching to the fourth larval instar (ca. 10 mg body weight), with 89–230 animals held together in a plastic box ($20 \times 20 \times 10$ cm). Subsequently, each individual was kept in a separate small plastic beaker (Hoffmann, 1973); 13–34 animals were available for each series. Young larvae were fed daily and older larvae every 2nd or 3rd day ad lib. with a synthetic diet. Every 2nd or 3rd day weight and larval instar of the animals were examined.

Three temperature ranges were chosen for these studies, each with a daily alternating temperature (16 h high, 8 h low temperature) and the corresponding constant mean temperature, LD-change 16:8 h. Alternating temperatures had a day/night amplitude of 18 degrees (Hoffmann, 1974), and the mean values of the temperature ranges differed from each other by about 4 degrees. In the figures, results of alternating temperatures are indicated with o---o; those of constant temperatures with △——△ symbols.

Temperature range:	1	2	3
Alternating temperature:	29/11° C	33/15° C	37/19° C
Constant temperature:	23° C	27° C	31° C

The animals were fed five different synthetic diets. The compositions of all diets is explained in Tables 1–3. The diets contained different amounts of protein (casein, vitamin-free from Serva, Heidel-

Table 1. Composition of the diets. Left column: constituents of dry weight in percent; right column: net weight in grams per 200 ml distilled water

	P-5%		*P*-15%		*P*-30%		*P*-40%		*P*-50%	
Protein (casein)	5.2	1.3	14.9	4.2	29.6	10.2	39.5	16.0	50.0	25.2
Wheat-germ oil	5.2	1.3	5.3	1.5	4.9	1.7	4.9	2.0	5.0	2.5
Cholesterol	1.0	0.25	1.1	0.3	1.0	0.35	1.0	0.4	1.0	0.5
Glucose	44.0	11.0	39.0	11.0	32.0	11.0	27.1	11.0	21.8	11.0
Stock constituent[a]	44.6	11.2	39.7	11.0	32.5	11.2	27.5	11.2	22.2	11.2

[a] See Tables 2 and 3

Table 2. Composition of 1 g stock constituent. Dr. Boness, Fa. Bayer Leverkusen, kindly placed the vitamin mixture to our disposal

Agar	537.0 mg
Vitamin mixture[a]	223.7 mg
Salt mixture (see Table 3)	89.5 mg
Ascorbic acid	78.3 mg
Sorbic acid	44.7 mg
Potassium hydroxyde 22%	26.8 mg

[a] See Hoffmann and Stockmeier (1975)