Opusc. Zool. Budapest, XIX – XX, 1985

Examination of the Growth of Blaberus craniifer Burm. (Blattidea)

By

G. GERE*

Abstract. About 80% of the *Blaberus* cockroaches molted nine times in laboratories and at room temperature. On an average, the males attained adult age on the 474th, the females on the 481st day. Their full duration of life was 605 and 754 days, respectively. The length of the successive larval stages show an increasing tendency.

Up to the 7th larval stage the water content of the animals decreased from the initial 74.7% to 65.2%, then it remained on a nearly identical level till they attained adult age. From the 7th larval stage on the body mass of the females became gradually greater than the one of the males. The body mass of the young adult males reached an average of 3300, that of the females one of 4400 mg. Their body mass is growing with time in the character of a cubic progression. Other examinations and data in the literature make probable that this basic form of growth is general among the epimorphous insects. The knowledge of the characteristics of growth of the various animals permits biomass calculations indispensable when surveying the material- and energy exchange of the communities' productivity.

In production biological respect, the role of the animals in the communities can be characterized relying on their material- and energy exchange. In this regard in the first place the interrelated proportions of the material- and energy pathways (incorporation, discarding, respiration) formed on the basis of the vital functions of the organism, as well as the quality conditions of the produced materials are generally taken into consideration. However, when judging the part played, the absolute quantity of the transferred substance depending on time is just as decisive a factor, which is in part identical with the conception of the intensity of the food consumption. The intensity of the animals' food consumption depends on many interior (specific, individual) and exterior (temperature, humidity, quality of food, etc.) circumstances. Most important in this regard is the character of growth and naturally also its duration.

It is a generally known fact that in case of a relative state of equilibrium, out of the offspring of each animal couple within the community on a statistical average two will similarly propagate. The other remaining – and as a rule numerous – so-called marginal individuals (BALOGH, 1953) will become the food of the other members of the community (of the next trophic level built on the semaphoronts of the species in question). These marginal individuals come to be consumed in most cases continuously within the limits set by the duration of life of the species. The question, however, when and how much biomass the spe-

* *Dr. Géza Gere*, ELTE Állatrendszertani és Ökológiai Tanszék (Zoosystematical and Ecological Institute of the Eötvös Loránd University), Budapest, Puskin u. 3, H – 1088.

cies in question will produce and can offer to its consumers is again in a great part decided by the character of growth. Consequently, the rules of growth are of equally determining character in the system of connections of the network of nutrition directed down- and upwards. For this reason, the question constitutes an important part of the knowledge of production biology.

The aim of the author's present work was to make acquanited with the duration of the postembryonal development and with the rules of the changes in body mass under definite conditions of an epimorphous insect, the American giant cockroach (*Blaberus craniifer* BURM.). In the examined respect the author considers this species a model animal, since in the sense of production biological type theory (GERE, 1979) one may assume that the basic character of its growth is similar to that of other epimorphous insects.

Method

The author kept the breeding stock essentially according to WYNINGER's method (1974). He placed the test animals in unglazed earthenware dishes covered with glass plates (GERE, 1958). The dishes he sank into wet sand. Through the porous walls of the vessel an adequate quantity of water was absorbed, from the sand which increased internal humidity. 1—5 cockroaches came into each dish of 8—14 cm in diameter, depending on the size of the animals. In the bottom of the dishes there was litter consisting of wood shavings, where the animals could withdraw.

The food of the animals was the dogs' food "Protecan". The air-dried material of Protecan contains approx. 38% of protein, about half of which is of animal-, half of plant origin. Its primary material is bran. (Verbal information obtained in the producing "Phylaxia" company.) So Protecan can beconsidered a mixed food, that suits best the animal's food demand (LAFON, 1951; BEIER, 1961).

The animals could drink from the water drops on the 20×20 or 30×30 mm glass-plates placed into the dishes. Experimental temperature fluctuated between 20—23 °C.

The water content of the cockroaches was determined by way of drying control animals kept in an identical way with the test animals till weight-balance, at 104 °C.

Examination results

Nearly 80% of the about 600 cockroaches under observation in the experiment molted nine times. With the others ten molts could be observed. WILLNIS et al. (1958) found 10—11 larval stages in the males and 10 ones in the females. The animals of different sex could be differentiated morphologically from the 6th larval stage on.

Table 1 presents the average duration of the larval stages of the cockroaches molting nine times. It can be seen that the duration of the larval stages is, mainly in the second half of the development — in conformity with BEIER's (1961) data — of growing tendency.

Blaberus cockroaches are long-lived insects. Although the average duration of the larval ages of the individuals of the two sexes was nearly identical (with

the males 474, with the females 481 days), the life of the latter was particularly protracted in consequence of the almost 9 months long adult life. Among the given experimental conditions, the males lived 605±49, the females 754±78 days.

The trend of the water content of the animals of various ages can be seen in Table 2. The author performed the measurements at all times in the animals being at the beginning of the actual larval stage. Each of the data shows the average result of 5 parallel measurings. In the single measurings 3 to 5 animals were comprised. The water content in the bodies of the cockroaches definitely decreased up to the 7th larval stage, subsequently to this it remained on a nearly identical level.

Table 1. The average duration of the larval stages and of the imago stage of Blaberus craniifer

Stage	1	2	3	4	5
Duration (days)	36	48	48	49	43
Stage (♂)	6	7	8	9	imago
Duration (days)	47	63	66	74	131
Stage (♀)	6	7	8	9	imago
Duration (days)	48	62	70	76	273

Table 3 informs on the trend of formation of the body mass of the animals. Also in this case the data indicate the conditions prevailing at the beginning of the single stages, and refer to the cockroaches molting nine times. From the Table appears that from the 7th larval stage on the females are of greater body mass than the males. Up to the time they have reached adult age, the difference between the two markedly increases. In dry body mass the relative difference is even somewhat greater than in live weight, because at that age the decrease in water content per cent is greater with the females than with the males. This is caused probably by the accumulation of protein and fatty substance necessary for the formation of the eggs. In adult state the cockroaches still grow on for a time. However, the study does not deal with this question.

Remarkably, there are quite significant differences in size between the animals on identical levels of development. The author observes that at the beginning of the 9th larval stage the body mass of female cockroaches used in other experiments fluctuated between 2400 ans 4780 mg. At this age the smallest animals were those of the grou molting ten times, on the other hand, in their adult age these became larger than the average.

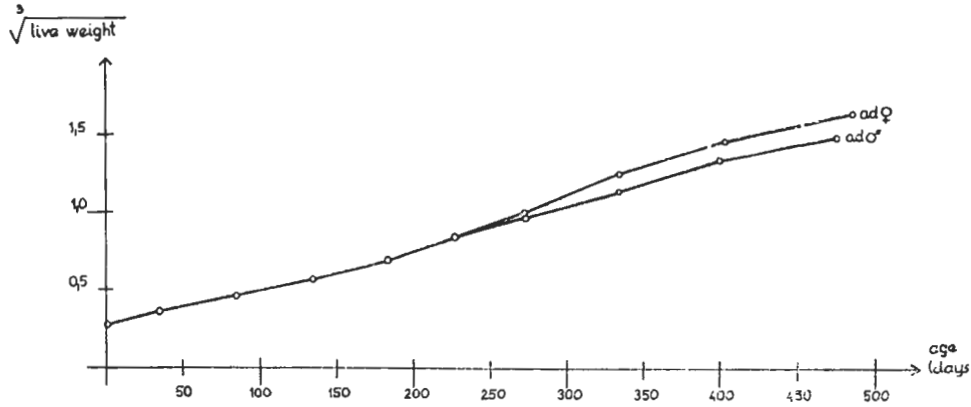

Fig. 1. The curve of increase in weight of *Blaberus craniifer* transformed according to the cubic-root values of the live-weight data

It can also be found out from Table 3, to how much times their original size the animals grew in the single larval stages. This relative rate of growth gradually decreased with advancing age. The first larval stage seems an exception because here, on account of the substantial decrease in water content, it is not the live- but the dry body mass that is of significance.

Valuation

If one represents the 1/3 power of the values of live body mass in the function of time graphically, one obtains an approximately direct line (Figure 1). Consequently, the examined animals grow in a cubic character. The slight S curve to be observed in the Figure reflects the general feature of the animals' growth,

Table 2. The water content of Blaberus craniifer at the beginning of the single larval stages and of the imago stage

Stage	1	2	3	4	5
Water content (%)	74.7 ± 0.7	69.2 ± 0.8	69.7 ± 1.1	67.4 ± 0.4	67.0 ± 0.5
Stage (♂)	6	7	8	9	imago
Water content (%)	66.7 ± 1.2	65.2 ± 0.2	66.1 ± 0.7	65.2 ± 0.6	65.3 ± 1.0
Stage (♀)	6	7	8	9	imago
Water content (%)	66.7 ± 0.3	64.9 ± 0.2	65.1 ± 0.9	65.5 ± 1.0	64.7 ± 0.4

insofar as in the initial and concluding stages the intensity of growth is somewhat slighter as compared with the character of growth. Incidentally, begun from embryonal growth the initial stage may include a shorter or longer part of postembryonal life.

GIER (1947) got a most similar curve of growth when measuring another cockroach, *Periplaneta americana*. It is known from FEWKES's examinations (1960) that also *Stalia major* (Hemiptera, Nabididae) distant from the cockroaches as to relationship, yet similarly epimorphous and also several other species of the family grow like this. The same can be said about the stick-insect *Carausius morosus* (EIDMANN and KÜHLHORN, 1970), as well as about the cricket *Gryllus bimaculatus* (GERE and HUBER, unpublished data).

Relying on the data at the author's disposal, as yet few in number referring, however to epimorphous insects distant from one another as to relationship, it

Table 3. The live- and absolutely dry body mass of Blaberus craniifer at the beginning of the larval stages and of the imago stage, further the relative growth rate during the stages

Stage	Number of the measured animals (pieces)	Live weight	Absolutely dry weight	To how many times its size does the animal grow during the stage
		at the beginning of the stage (mg)		
1	65	24.1 ± 1.9	6.1	1.9
2	50	45.5 ± 3.1	14.0	2.1
3	55	96.0 ± 12.4	29.1	2.0
4	55	195.0 ± 27.3	63.5	1.8
5	50	360.0 ± 52.0	118.9	1.8
6 (♂)	40	643.0 ± 108.2	214.2	1.6
7 (♂)	40	1050 ± 202	364.9	1.5
8 (♂)	40	1600 ± 236	542.2	1.5
9 (♂)	35	2420 ± 394	841.9	1.4
Imago (♂)	35	3300 ± 272	1144.4	–
6 (♀)	45	643.0 ± 108.2	214.2	1.7
7 (♀)	45	1110 ± 176	389.4	1.9
8 (♀)	42	2080 ± 254	726.5	1.6
9 (♀)	42	3260 ± 509	1125.7	1.3
Imago (♀)	42	4400 ± 485	1554.5	–

seems probable that this growth of cubic character is a general feature of the epimorphous insects. Naturally, besides this growth is at all times specific to the species, which – as is known – is modified by a wide variety of environmental factors. Also a period of rest may be inserted into the course of growth. One should also know that at ecdysis growth is interrupted, moreover, at such times a temporary regression in body mass appears (GERE, 1978).

According to our knowledge, at variance with what was said before, the body mass of the holometamorphous insects grows – apart from the initial and ultimate stages – on the whole exponentially, while the weight curve of the birds and mammals comes near to the simple linear function (GERE, 1956, 1978).

At the middle of the duration of its larval life, the *Blaberus* cockroach reaches about 22 and 17% respectively, of the body mass it had at the beginning of its imago age (data referring to males and females). On the other hand, the body mass of the holometamorphous caterpillar *Hyphantria cunea* is, at the half-time of the positive stage of its growth, only 4,2% of the one acquired by it till the end of the said stage (GERE, 1956). Again, the nestling of the song bird *Lonchura striata*,h aving attained the half time of its life within the nest, acquires already 68% of the body mass characteristic of the species (GERE, 1978).

So different are the quotients of the potential biomass produced till the half time of their stages of growth by the various animals. This is the sense in which their part in the food system of the living communities has to be judged. From this it can also be seen how misleading conclusions one could rach if one characterized the lessening in number of the marginal individuals not by registering the decrease of the biomass but merely by indicating the diminution of the number of individuals. In such and similar regards can the information material about the growth of the animals serve with a fundamental basis of forming one's production-biological attitude.

REFERENCES

1. BALOGH, J. (1953): Grundzüge der Zoozönologie. – Akadémiai Kiadó, Budapest: 1–247.
2. BEIER, M. (1961): Blattopteroidea, Blattodea. – In: Bronns, H. G.: Klassen und Ordnungen des Tierreichs. Akad. Verlagsges. Geest und Portig K.–G., Leipzig, V. III.: 587–848.
3. EIDMANN, H. & KÜHLHORN, F. (1970): Lehrbuch der Entomologie. – Verl. Paul Parey, Hamburg, Berlin: 1–633.
4. FEWKES, D. W. (1960): The food requirements by weight of some British Nabidae (Heteroptera). – Ent. Exp. Appl., 3: 231–237.
5. GERE, G. (1956): Investigations into the laws governing the growth of Hyphantria cunea Drury caterpillars. – Acta Biol. Acad. Sci. Hung., 7: 43–72.
6. GERE, G. (1958): Methode zur Lebendhaltung und Zucht von Arthropoden der Waldböden. – Acta Zool. Acad. Sci. Hung., 3: 225–231.
7. GERE, G. (1978): Szárazföldi ízeltlábúak és gerincesek produktivitásának alaptípusai. – Doktori disszertáció, Budapest: 1–212.
8. GERE, G. (1979): Ökologisch-produktionsbiologische Typen in der Tierwelt. – Opusc. Zool. Budapest. 16: 77–85.
9. GIER, H. T. (1947): Growth rate in the cockroach Periplaneta americana (Linn.). – Ann. Ent. Soc. Amer., 409: 303–317.
10. LAFON, M. (1951): Essais sur l'alimentation d'un insecte: Blatta orientalis L. I. Données quantitatives sur la nutrition azotée. – Physiol. Comp. Oecol. den Haag, 2: 224–240.
11. WILLNIS, E. R., RISER, G. R. & ROTH, L. M. (1958): Observations on reproduction and development in cockroaches. – Ann. Ent. Soc. Amer., 51: 53–69.
12. WYNIGER, R. (1974): Insektenzucht. (Methoden der Zucht und Haltung von Insekten und Milben im Laboratorium). – Verl. Eugen Ulmer, Stuttgart: 1–368.