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ENERGY ASSIMILATION IN *EUPTERYX ATROPUNCTATA* (GOEZE) AND *EMPOASCA PTERIDIS* (DHLB.) (*HOMOPTERA, TYPHLOCYBIDAE*)*

(Ekol. Pol. 19: 325–332). **Energy assimilation during the period of larval development per individual of *Eupteryx atropunctata* (Goeze) is 1.64 calories; respiration losses 0.80 calories, biomass production 0.84 calories. For *Empoasca pteridis* (Dhlb.) these values are respectively: $A = 1.78$, $R = 0.81$ and $P = 0.97$ calories.**

The purpose of these studies was to define the values of energy assimilation by two species of leafhoppers dominating in potato crops in Poland, i.e. *Eupteryx artopunctata* (Goeze) and *Empoasca pteridis* (Dhlb.).

It is difficult to determine all the parameters of the energy budget of leafhoppers on account of their small body dimensions, the weight of imagines for the majority of the species occurring in Poland being about 1mg. In particular it is extremely difficult to determine food consumption value on account of the fact that leafhoppers feed on juice sucked from plant tissues.

Estimates of the energy budget of two species of leafhoppers with relatively large body measurements, occurring in grass associations, were made by

*This study was carried out under the International Biological Programme.

Wiegert (1964) and Andrzejewska (1967). Other species of leafhoppers have not been studied from this angle.

METHODS AND MATERIAL

Assimilation (A) was calculated from the sum total of production defined by increase in biomass (ΔG) and maintenance expenditure measured respirometrically (R) and expressed in calories (Petrusewicz 1967).

$$A = R + G$$

Respiration was measured by means of manometric respirometers after Klekowski (Żadin, Klekowski 1966) at a temperature of 20°C, with 70% RH. Measurements of the respiration of larvae of *E. atropunctata* and *E. pteridis* were made with 8 or 9 repeats, using from 4–7 larvae of different age for each repeat. Measurements of the respiration of the imagines of both species were made with 20 repeats, using 3–5 individuals for each repeat. Readings of the amount of oxygen used were made twice at 30-minute intervals; the period of 15–20 minutes before the first reading was accepted as a compensatory period. The results obtained were converted to standard conditions of temperature, pressure and humidity. After their removal from the respirometers the insects were weighed with accuracy to 0.01 mg. Respiratory energy losses were calculated on the basis of converting 5.0 cal/1 cm^3 O_2 (Kleiber 1968), assuming that RQ = 1. Leafhoppers were not kept without food before measuring respiration, therefore on account of the food they ingest from the sieve tubes of plants it can be taken that catabolism of carbohydrates dominates.

Increase in biomass was measured from the first to the last day of life for larvae cultured in Petri dishes on single potato leaves, at a temperature of 20°C. The leafhoppers were weighed daily on a microanalytical "Sartorious" scale with accuracy to 0.001 mg. Biomass production of 17 larvae of *E. atropunctata* and 25 larvae of *E. pteridis* was traced. The caloric value of the dry body mass of larvae and imagines of both species was defined in a Phillipson micro-calorimeter (Phillipson 1964).

RESPIRATION

Intensiveness of respiration of the two species is very similar (Tab. I), except that the respiration losses of imagines are greater than those of larvae. Daily energy losses connected with the respiration of an *E. atropunctata* imago are 0.18 cal/day, and for *E. pteridis* 0.17 cal/day, whereas for larvae, depending on their age, these values fluctuate from 0.007 to 0.103 cal/day. Length of

Respiratory losses during development of *Eupteryx atropunctata* and *Empoasca pteridis*

Tab. I

Developmental stage	$mm^3 O_2$/mg/hr	$mm^3 O_2$/indiv./day	cal/indiv./day	$mm^3 O_2$/indiv./stage	cal/indiv./stage
E. atropunctata					
L_1		1.536	0.0076	4.608	0.0230
L_2		3.809	0.0190	11.428	0.0571
L_3	1.28	6.605	0.0330	19.815	0.0991
L_4		9.492	0.0474	37.970	0.1898
L_5		17.449	0.0872	87.245	0.6362
Total		–	–	161.006	0.8050
Imago	2.01	37.145	0.1857	–	–
E. pteridis					
L_1		1.576	0.0079	4.727	0.0236
L_2		2.991	0.0149	8.973	0.0449
L_3	1.34	6.464	0.0323	19.392	0.0970
L_4		12.092	0.0605	48.368	0.2418
L_5		20.550	0.1027	82.201	0.4110
Total		–	–	163.661	0.8183
Imago	2.10	33.768	0.1688	–	–

development of the larvae of both species is similar; at a temperature of 20°C the larval development of *E. atropunctata* lasts 18 days, and of *E. pteridis* 17 days (Gromadzka 1970). One larva of *E. atropunctata* during its development uses 161 mm^3 of oxygen, which corresponds to 0.80 cal, and one larva of *E. pteridis* uses 164 mm^3 of oxygen, which corresponds to 0.82 cal.

BIOMASS PRODUCTION

1 g of dry body mass of *E. atropunctata* larvae corresponds to a value of 5061.0 cal/g, 1 g of dry body mass of imagines to an average figure of 6302.4 cal/g (females 6554.1 cal/g, males 6051.7 cal/g); for *E. pteridis* these values are 4943.3 cal/g and 6272.7 cal/g (females 6375.7 cal/g, males 6169.8 cal/g).

Production of body mass of *Eupteryx atropunctata* and *Empoasca pteridis*

Tab. II

Developmental stage	Average biomass of individual			Biomass increase					
				individual/day			individual/stage		
	weight			weight			weight		
	wet mg	dry mg	cal	wet mg	dry mg	cal	wet mg	dry mg	cal
E. atropunctata									
L_1	0.046	0.0120	0.0605	0.012	0.0031	0.0158	0.037	0.0096	0.0487
L_2	0.112	0.0202	0.1474	0.022	0.0057	0.0289	0.066	0.0172	0.0869
L_3	0.179	0.0465	0.2355	0.029	0.0075	0.0382	0.086	0.0224	0.1132
L_4	0.342	0.0889	0.4500	0.046	0.0120	0.0605	0.186	0.0484	0.2447
L_5	0.628	0.1633	0.8264	0.053	0.0138	0.0697	0.267	0.0694	0.3513
Total	–	–		–	–	–	0.642	0.1670	0.8448
Imago	0.770	0.2002	1.2617	–	–	–	–	–	–
E. pteridis									
L_1	0.052	0.0156	0.0771	0.013	0.0039	0.0193	0.038	0.0114	0.0563
L_2	0.114	0.0342	0.1690	0.024	0.0072	0.0356	0.073	0.0219	0.1082
L_3	0.185	0.0555	0.2743	0.035	0.0105	0.0519	0.104	0.0312	0.1542
L_4	0.333	0.0999	0.4938	0.043	0.0129	0.0638	0.174	0.0522	0.2580
L_5	0.611	0.1833	0.9060	0.066	0.0198	0.0979	0.263	0.0789	0.3900
Total	–	–	–	–	–	–	0.652	0.1956	0.9668
Imago	0.629	0.2076	1.3022	–	–	–	–	–	–

The average mass of an *E. atropunctata* larva a few hours after hatching is 0.030 mg and of *E. pteridis* 0.038 mg. Towards the end of larval development an *E. atropunctata* larva attains a mass of 0.676 mg, and that of *E. pteridis*

0.684 mg. Biomass production in the different stages increases together with the age of the larvae (Tab. II). The average daily increase in larvae of *E. atropunctata* varies from 0.012 mg to 0.053 mg, the increase of *E. pteridis* larvae from 0.013 mg to 0.066 mg. Total biomass production of an *E. atropunctata* larva is 0.642 mg, which corresponds to 0.84 cal, and of an *E. pteridis* larva 0.652 mg, which corresponds to 0.97 cal.

Variations in the biomass of imagines from the time of metamorphosis from the final larval stage to the time of attaining maturity were not traced. The average mass of imagines of *E. atropunctata* and *E. pteridis* is 0.77 mg and 0.63 mg which corresponds to about 1.3 cal.

ASSIMILATION

The daily amount of energy assimilated by an *E. atropunctata* larva increases with age on an average from 0.02 cal to 0.16 cal (Tab. III); for *E. pteridis* these values are from 0.03 cal to 0.20 cal. Energy assimilated during the whole of larval development by an individual corresponds to a value of 1.6 cal for *E. atropunctata* and 1.8 cal for *E. pteridis*.

Energy assimilation (cal) in larvae of *Eupteryx atropunctata* and *Empoasca pteridis*

Tab. III

Developmental stage	Individual/day	Individual/stage
E. atropunctata		
L_1	0.0235	0.0717
L_2	0.0479	0.1440
L_3	0.0712	0.2123
L_4	0.1080	0.4345
L_5	0.1569	0.9875
Total	–	1.6498
E. pteridis		
L_1	0.0272	0.0799
L_2	0.0505	0.1531
L_3	0.0842	0.2512
L_4	0.1243	0.4998
L_5	0.2006	0.8010
Total	–	1.7851

DISCUSSION OF RESULTS

E. atropunctata and *E. pteridis* are species with similar food requirements, a similar period of development and similar weight; the values of the above mentioned parameters of the energy budget of these species are also similar.

Analysis of biomass production of the larvae of *E. atropunctata* and *E. pteridis* confirms the principle put forward by Kuznecov (1948) and confirmed in recent years by Chłodny (1967) in studies on the Colorado beetle. According to this principle production per unit of body mass decreases with growth of the body. Increase in biomass of leafhoppers per mg of body, calculated by dividing the value corresponding to increase in body mass in the given stage by the final weight of this stage, exhibits a tendency to decrease in successive stages (Tab. IV). In the case of *E. atropunctata* larvae the value of this coefficient decreases from 0.61 to 0.39 and for *E. pteridis* from 0.55 to 0.38.

Biomass production in mg of body weight for successive developmental stages of the larvae of *Eupteryx atropunctata* and *Empoasca pteridis*

Tab. IV

Developmental stage	Weight at end stage (mg)	Biomass production per stage (mg)	Increase in biomass/mg of body weight
E. atropunctata			
L_1	0.061	0.037	0.606
L_2	0.133	0.066	0.496
L_3	0.209	0.086	0.411
L_4	0.484	0.186	0.384
L_5	0.676	0.267	0.394
E. pteridis			
L_1	0.069	0.038	0.551
L_2	0.151	0.073	0.483
L_3	0.229	0.104	0.454
L_4	0.396	0.174	0.439
L_5	0.684	0.263	0.383

The values of respiration and production described above differ fairly considerably from the values of these parameters for another species of leafhopper – *Philaenus spumarius* L. (Wiegert 1964). Daily respiration losses of the larvae of *P. spumarius* are about 10 times greater in relation to larvae of *E. atropunctata* and *E. pteridis* when calculated for the same mass, while biomass production is about 4 times greater; biomass production and respiration of *P. spumarius* were measured at a slightly higher temperature (23°C) in relation to measurements made for *E. atropunctata* and *E. pteridis* (20°C).

The caloric value of larvae and imagines of *E. atropunctata* and *E. pteridis* is similar to the caloric value given by Wiegert (1964) for *P. spumarius* and by Andrzejewska (1967) for *Cicadella viridis* L. The caloric value of the dry body mass of *P. spumarius* was 5336 cal/g for larvae and 5808 cal/g for imagines, while the caloric value of dry body mass of *C. viridis* is 5800 cal/g. Imagines of *E. atropunctata* and *E. pteridis* have a relatively high caloric value, exceeding 6000 cal/g. It may be that these differences, and those described

above, are due inter alia to the different way in which the various species of leafhopper feed. *P. spumarius* and *C. viridis* belong to a group of leafhoppers which suck plant juice from the vascular part of the conducting fascicles of plants, whereas *E. atropunctata* and *E. pteridis* feed on the sieve tissue (Carter 1963, Emeljanov 1964).

It is impossible to draw conclusions from Wiegert's data (1964) as to energy assimilation by *P. spumarius* during the whole period of larval development, but it is clear from Andrzejewska's studies (1967) that one larva of *C. viridis* assimilates 21.25 cal during development, that is, over 10 times more than the larvae of *E. atropunctata* and *E. pteridis*; the average weight of a *C. viridis* larva is about 15 times greater than the average weight of the larvae of *E. atropunctata* and *E. pteridis*. Andrzejewska does not, however, give the temperature conditions under which she carried out her measurements.

The ratio of assimilation value to the amount of food consumed by the organism provides information on the degree to which food is utilized. The percentage of assimilated energy, calculated from the relation to consumption, varied for certain phytophagous insects from 26 to 45% (Chłodny, Gromadzka, Trojan 1967). For the leafhoppers *P. spumarius* and *C. viridis* these values are 26.3% and 33.5% (Wiegert 1964, Andrzejewska 1967) – average 30%. Assuming that this value is similar in other species of leafhopper also, an attempt may be made to calculate the amount of energy consumed together with food by *E. atropunctata* and *E. pteridis*. This, for the larval period of these species, varies for one individual within limits of 5 calories (4.7 cal for *E. atropunctata* and 5.1 cal for *E. pteridis*).

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ASYMILACJA ENERGII PRZEZ *EUPTERYX ATROPUNCTATA* (GOEZE) I *EMPOASCA PTERIDIS* (DHLB.) (*HOMOPTERA, TYPHLOCYBIDAE*)

Streszczenie

Asymilację obliczono z sumy wartości przyrostu biomasy i respiracji wyrażonych w kaloriach. Respirację mierzono za pomocą respirometrów manometrycznych w temperaturze 20°C. Przyrost biomasy mierzono od pierwszego do ostatniego dnia życia larw hodowanych w temperaturze 20°C. Wartość kaloryczna ciała skoczków określona została w mikrobombie kalorymetrycznej Phillipsona (1964).

Wartości badanych parametrów budżetu energetycznego są podobne u obu gatunków. Jedna larwa *Eupteryx atropunctata* (Goeze) w ciągu swojego rozwoju zużywa 161 mm^3 tlenu co odpowiada 0,80 cal, a larwa *Empoasca pteridis* (Dhlb.) 164 mm^3 tlenu co odpowiada 0,82 cal. (tab. I). Przyrost biomasy w poszczególnych stadiach larwalnych zwiększa się wraz z wiekiem larw (tab. II). Całkowity przyrost biomasy larwy *E. atropunctata* wynosi 0.64 mg co odpowiada 0,84 cal, a przyrost larwy *E. pteridis* 0,65 mg co odpowiada 0.97 cal. Energia zasymilowana w czasie całego rozwoju larwalnego przez jednego osobnika w przypadku *E. atropunctata* odpowiada wartości 1,6 cal, a w przypadku *E. pteridis* 1,8 cal (tab. III).

W oparciu o znajomość stosunku asymilacji do konsumpcji, wyznaczonego dla innych gatunków skoczków oraz znajomość asymilacji *E. atropunctata* i *E. pteridis*, obliczono prawdopodobne ilości skonsumowanej wraz z pokarmem energii przez te gatunki. W okresie larwalnym, u jednego osobnika, wynosi ona około 5 kalorii.

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