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Size correlation between larvae and adults in *Aphodius* (Coleoptera, Scarabaeidae)

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Summary

Correlation between simple averages of 4 measurements of adults (separately for males and females) and 2 measurements of third-instar larvae was studied in 19 Palearctic species of dung beetle genus *Aphodius* ILLIGER. The greatest correlation (r=0.973) is found between head width of larvae (HWL) and elytra width of male beetles (EWM). The equation (HWL = 0.26 + 0.54 EWM) can be used as an additional tool for rapid larval identification.

Key words: *Aphodius*, adults, larvae, size, correlation, morphometry.

Introduction

Aphodius ILLIGER is a large genus of scarab beetles with more than 1500 species distributed world-wide (DELLACASA, 1988). Members of the genus dominate dung beetles communities in Palearctic and Nearctic regions and are important to control dung and dung-breeding flies. The species are well studied taxonomically in Europe but the preimaginal stages are much less known than the adults. Larvae of less then 1/4 of the European species of *Aphodius* were described so far (GHILAROV, 1964, KRELL, 1997).

The study of beetle larvae is considerably complicated by the fact that there is almost no correlation between morphological characters of imago and larva in Holometabola. For the great majority of Coleoptera species, the size of body is probably the only correlated character (EMDEN, 1942). The average lengths of Palearctic *Aphodius* species vary from 2.5 mm to 20.0 mm (MEDVEDEV, 1964, DELLACASA, 1983) and in many biotopes sympatric species differ considerably in size. One can suppose *a priori* that the correlation between size of larvae and beetles of different species is high. However there were no quantitative data available in the literature.

Material and methods

Examined material includes the adults and third-instar larvae of 19 *Aphodius* species collected in 1993-2001 in the following localities: 1) Kamenyuki, Brest Province, Belarus (**A. borealis* GYLLENHAL, 1827, *A. erraticus* (LINNAEUS, 1758), *A. haemorrhoidalis* (LINNAEUS, 1758), **A. corvinus* ERICHSON, 1848, *A. uliginosus* HARDY, 1847), 2) Minsk suburbs, Belarus (*A. depressus* KUGELANN, 1792, **A. granarius* (LINNAEUS, 1767)), 3) Rovnopol'e, Minsk Province, Belarus (*A. fimetarius* (LINNAEUS, 1758), *A. fossor* (LINNAEUS, 1758), **A. luridus* (FABRICIUS, 1775), **A. merdarius* (FABRICIUS, 1775), **A. pusillus* HERBST, 1789, **A. sticticus* (PANZER, 1798), **A. bimaculatus* (LAXMANN, 1770) 4) Domzheritsy, Vitebsk Province, Belarus (**A. ictericus* (LAICHARTING, 1781)), 5) Ush-Aral, South Kazakhstan (*A. immundus* CREUTZER, 1799, *A. sturmi* HAROLD, 1870), 7) Korfovskyi, Khabarovsk Territory, Russia (*A. rectus* MOTSCHULSKY, 1866), and 8) Kolochava, Carpathian Mountains, Ukraine (*A. rufipes* (LINNAEUS, 1758)). The larvae of 9 species marked with an asterisk (*) were reared *ex ovo*. Adults of the remaining 10 species were reared from field collected larvae. A sample of the larvae belonging to each of the 10 species were preserved prior to the rearing of the adults thus enabling subsequent identification.

Collected or reared larvae were killed with ethylacetate, fixed with Bouen liquid, rinsed with 80% ethyl alcohol, and preserved in 70% ethyl alcohol. Treatment with ethylacetate prevents to some degree the larvae shrinkage in the fixative liquid. Measurements were taken with a stereoscopic microscope MBS-10 equipped with an ocular-micrometre at magnifications of 16–56X. Statistica 6.0 software was used for correlation and regression calculations.

To evaluate the greatest correlation, averages of four different measurements of adults (width and length of pronotum, width and length of elytra) and two different measurements of larvae (width of head and length of head excluding labrum) were used. Males and females in many scarab genera including *Aphodius* differ in proportions of pronotum and elytra. Therefore average values of measurements of adults were calculated for each sex separately. Because the cuticle of the thorax and abdomen in scarab larvae is feebly sclerotized and very flexible, the volume of these tagmae heavily depends on physiological state of an individual and the time elapsed since moulting. It seems to be unsuitable to measure the overall length

Table 1 — Statistical characterization of the examined material. Measurements are given as mean values.

		adults										larvae		
		number of specimens		pronotum width, mm		elytra width, mm		pronotum length, mm		elytra length,mm		number of specimens	head width, mm	head length, mm
	Species	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀			
1	A.sticticus (Panzer)	9	13	2,30	2,15	2,51	2,48	1,69	1,59	2,92	3,00	20	1,51	1,12
2	A.haemorrhoidalis (L.)	10	10	2,09	2,15	2,26	2,40	1,55	1,63	2,45	2,53	16	1,47	1,08
3	A. fimetarius(L.)	5	4	3,53	3,13	3,85	3,65	2,48	2,21	4,01	3,90	20	2,30	1,64
4	A.pusillus Herbst	4	11	1,81	1,70	1,91	1,90	1,32	1,24	2,21	2,15	18	1,29	0,85
5	A. sturmi Harold	14	10	1,39	1,39	1,50	1,50	1,09	1,09	2,00	2,00	20	1,00	0,72
6	A. merdarius (F.)	6	4	1,77	1,73	1,93	1,95	1,31	1,26	2,29	2,41	7	1,18	0,82
7	A.immundus Creutzer	7	11	2,36	2,32	2,63	2,63	1,64	1,59	3,34	3,15	7	1,74	1,19
8	A. ictericus (Laicharting)	6	2	2,28	2,23	2,47	2,58	1,67	1,63	3,23	3,05	6	1,55	1,13
9	A. depressus Kugelann	9	9	3,74	3,91	4,03	4,40	2,58	2,67	4,25	4,84	15	2,31	1,74
10	A. rectus Motshulsky	14	16	2,52	2,47	2,66	2,77	1,83	1,87	3,01	3,13	9	1,87	1,26
11	A. erraticus (L.)	9	9	3,29	3,39	3,44	3,57	2,41	2,46	3,35	3,49	7	2,35	1,87
12	A. fossor (L.)	9	10	6,02	5,53	6,37	5,95	4,46	4,02	6,30	6,24	15	3,47	2,43
13	A. uliginosus Hardy	12	4	1,94	1,91	2,20	2,28	1,39	1,35	2,65	2,60	10	1,63	1,20
14	A. borealis Gyllenhal	5	8	1,71	1,67	1,90	1,98	1,24	1,20	2,45	2,62	18	1,21	0,90
15	A. bimaculatus (L.)	7	7	4,19	4,06	4,56	4,80	2,61	2,53	5,21	5,66	12	3,10	2,24
16	A. granarius (L.)	9	9	2,15	2,05	2,22	2,23	1,55	1,49	2,68	2,65	19	1,67	1,18
17	A. luridus (F.)	9	4	3,62	3,79	3,83	4,17	2,33	2,35	4,54	5,22	5	2,10	1,48
18	A. rufipes (L.)	10	10	4,80	4,41	5,26	5,07	2,95	2,63	7,25	7,16	22	3,24	2,38
19	A. corvinus Erichson	6	8	1,71	1,65	2,03	1,94	1,14	1,06	2,54	2,45	20	1,19	0,82

or width of larvae. Only head capsule and, partly, mandibles are considerably sclerotized, therefore only measurements of these are reliable enough.

Results

The statistical characterisation of the examined material is given in Table 1 and the Pearson correlation coefficients for adult and larval measurements are given in Table 2. The correlation of every adult measurement and every larval measurement is high and all correlation coefficients are higher than 0.9. The greatest correlation is found between the head width of larvae and the three measurements of adults: elytra and pronotum width of males and elytra width of females ($r \sim 0.97$). The smallest correlation is found between the head length of larvae and pronotum length of adults of both sexes ($r = 0.922$). One can see that correlation of lengths is greater than that of widths.

Scatter diagram and regression line of average head width of larvae (HWL) and average elytra width of males (EWM) are shown on Figure 1. The equation of the regression line is as follows:

$$HWL = 0.26 + 0.54 \times EWM$$

Table 2 — Pearson correlation coefficients of means of 4 measurements of beetles and 2 measurements of larvae of 19 *Aphodius* species.

	Adults							
	Males				Females			
Larvae	Pronotum width	Elytra width	Pronotum length	Elytra length	Pronotum width	Elytra width	Pronotum length	Elytra length
Head width	0, 971	0, 973	0, 936	0, 941	0, 961	0, 970	0,929	0,930
Head length	0, 959	0, 960	0, 922	0, 928	0, 955	0,963	0, 922	0,926

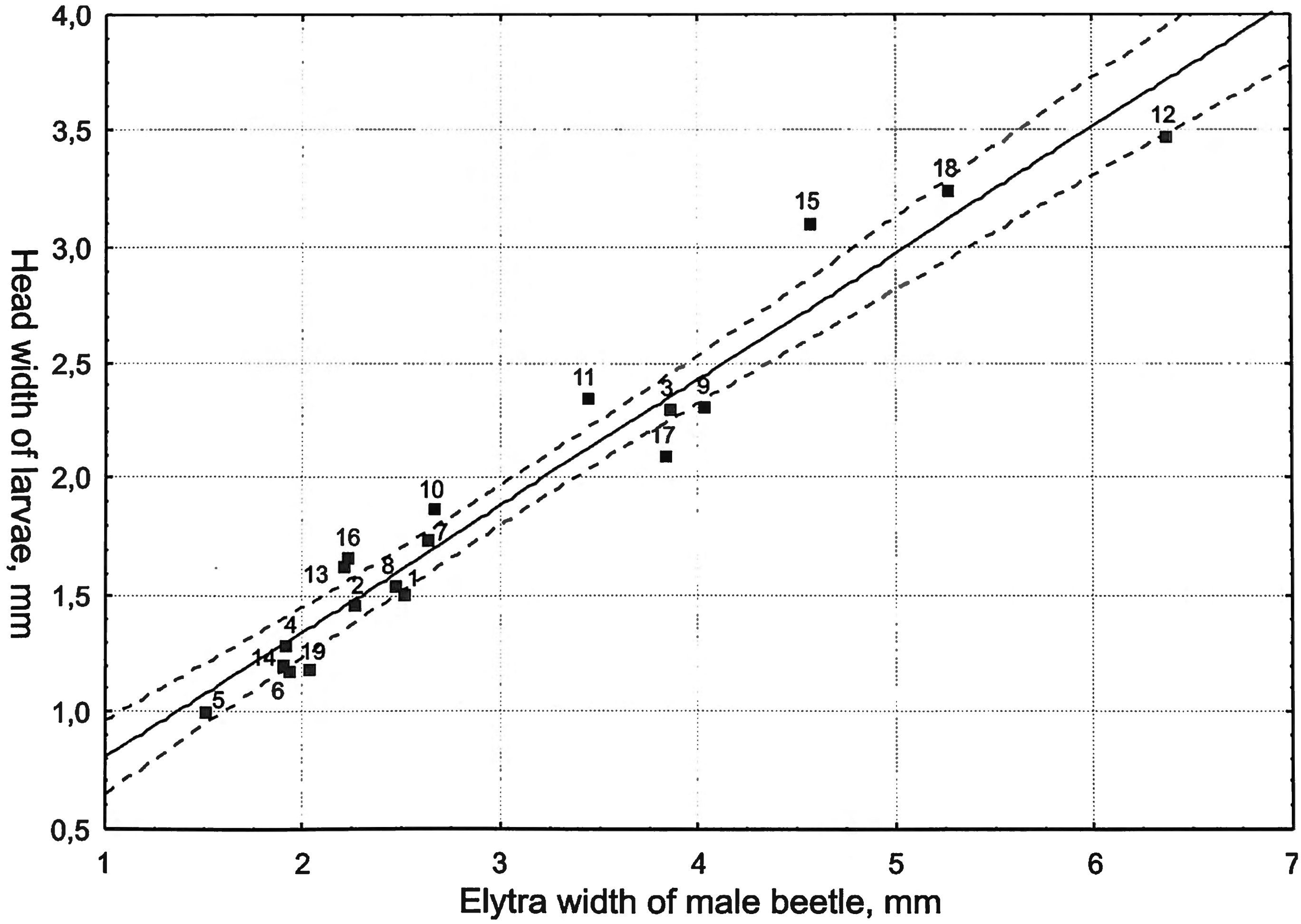

Fig. 1 — Scatter diagram and regression line of average head width of larvae and average elytra width of males of 19 *Aphodius* species. Case numbers correspond to the species numbers in Table 1. Confidence intervals are 95%.

Discussion

Two methods are commonly used for identification of the beetle larvae: 1) larvae are reared from the eggs laid in laboratory by the identified adults, and 2) adults are reared for identification from a part of the larvae collected together and indistinguishable from each other by the morphological characters. However, in a number of cases, e.g. only preserved larvae are available, these methods cannot be used. The provided approximate ratio between the size of adults and that of larvae can be used as an additional tool for rapid larval identification of the genus *Aphodius*.

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