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EXTERNAL SEX DIFFERENCES IN STORED-PRODUCTS COLEOPTERA.

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External sexual dimorphism is common in Coleoptera and, if not apparent in the adult, is usually to be found in the pupa in the form of the genital appendages. Size and weight of newly emerged adults may give an indication of their sex but is not reliable as some degree of overlap usually occurs.

The aim of this paper is to bring together the known characters for sexing the adults of stored-products beetles, and for sexing the pupae where adult secondary sexual characters are apparently absent.

Sexual differences in the pupal stage.

The apex of the pupal abdomen may bear two pairs of processes (fig. 14), one, arising dorsally, representing the larval urogomphi, and the other, arising ventrally, associated with the external genitalia. The former pair is not always present but the latter pair, the genital appendages, is usually present and indicates the sex of the pupa.

In the male, the genital appendages are sometimes represented by only slight protuberances, as in *Ahasverus advena* (Waltl), but generally they take the form of distinct but short papilliform appendages, either two-segmented or without apparent segmentation. The papillae are often convergent: they are never as protuberant as those of the female.

In the female, with the exception of some Tenebrionids (fig. 17), the genital appendages are always distinct and papilliform. The papillae are always strongly protuberant and often three-segmented. Generally they are divergent but in some species they are parallel.

As a rule, therefore, the female pupa may be readily distinguished from the male by its strongly protuberant and diverging genital appendages.

Sexual differences in stored-products Coleoptera.

The sexual differences found in species attacking stored products are tabulated by families (Table I).

Where figures have been redrawn from published works, reference to the source is given in the legend to the figure.

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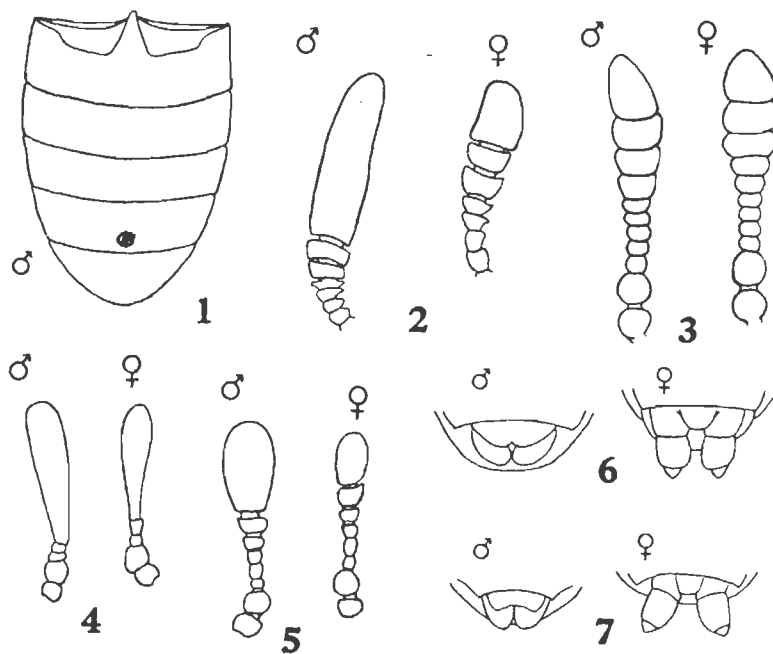
TABLE I.
 Characters for the recognition of sex in stored-products Coleoptera.

Family and species	Character and its sexual expression	Fig.	Reference
DERMESTIDAE			
<i>Dermestes frischii</i> Kug. <i>D. peruvianus</i> Cast. <i>D. haemorrhoidalis</i> Kust. <i>D. maculatus</i> Deg.	A large puncture and brush of hairs on the 4th abdominal sternite : ♂ present ♀ absent	1	Hinton, 1945
<i>D. lardarius</i> L. <i>D. ater</i> Deg.	A large puncture and brush of hairs on the 3rd and 4th abdominal sternites : ♂ present ♀ absent	-	Hinton, 1945
<i>Attagenus pellio</i> (L.)	Apical segment of antennal club : ♂ 4 or 5 × as long as combined length of the two basal segments ♀ slightly longer than the combined length of the two basal segments	2	Hinton, 1945
<i>A. megatoma</i> (F.) (= <i>piceus</i> (Ol.))	Apical segment of antennal club : ♂ 3 or 4 × as long as combined length of the two basal segments ♀ about equal in length to combined length of the two basal segments	-	Hinton, 1945 (includes figure)
<i>Anthrenus verbasci</i> (L.)	Pupal genital papillae : ♂ globular, convergent ♀ 3-segmented, strongly protuberant and nearly parallel	6	—
<i>A. flavipes</i> Lec. (= <i>vorax</i> Waterh.)	Pupal genital papillae : ♂ globular, slightly convergent ♀ 3-segmented, protuberant, divergent	7	—
<i>A. fuscus</i> (Ol.)	Apical antennal segment : ♂ not petiolate ♀ somewhat petiolate	4	Hinton, 1945
<i>A. museorum</i> (L.)	The 8th (apical) antennal segment : ♂ about 6 × as long as the 7th antennal segment ♀ about twice as long as the 7th antennal segment	5	Hinton, 1945

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TABLE I—cont.

Family and species	Character and its sexual expression	Fig.	Reference
DERMESTIDAE—cont. <i>Phradonoma tricolor</i> (Arrow)	Antennal club : ♂ indistinctly 6-segmented	♀ 3-segmented	- Hinton, 1945 (includes figure)
<i>Trogoderma granarium</i> Everts	Apical segment of antennal club : ♂ elongate	♀ not elongate	3 Beal, 1956
	Fusion of antennal segments is common in both sexes but the above differences can always be appreciated as the places of fusion are apparent to some degree		
<i>T. versicolor</i> (Creutz.)	Antennal club : ♂ 6-8-segmented	♀ 4-segmented	- Hinton, 1945 (includes figure)



Figs. 1-7.— 1, *Dermestes frischii* Kug., abdomen (♂); 2, *Attagenus pellicio* (L.), antenna (♂, ♀) (Hinton, 1945 p. 307); 3, *Trogoderma granarium* Everts, antenna (♂, ♀) (Beal, 1956 p. 561); 4, *Anthrenus fuscus* (Ol.), apical segments of antenna (♂, ♀) (Hinton, 1945 p. 358); 5, *Anthrenus museorum* (L.), antenna (♂, ♀) (Hinton, 1945 p. 361); 6, *Anthrenus verbasci* (L.), terminal segments of pupal abdomen, ventral view (♂, ♀); 7, *Anthrenus flavipes* Lec., the same.

TABLE I—cont.

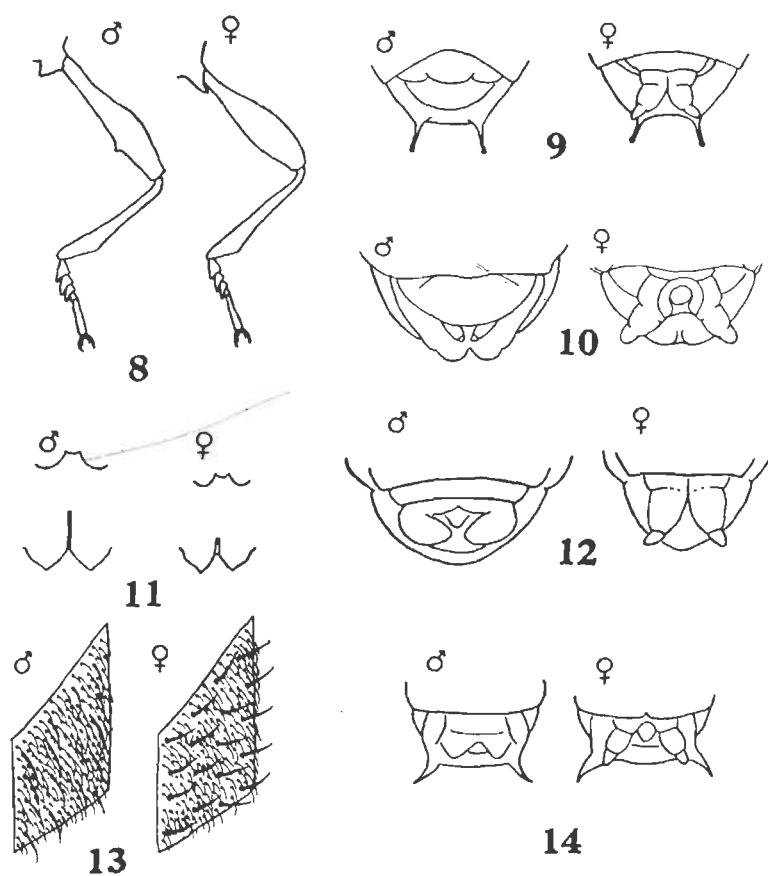
Family and species	Character and its sexual expression	Fig.	Reference
BOSTRYCHIDAE <i>Rhyzopertha dominica</i> (F.)	Pupal genital papillae : ♂ convergent, 2-segmented not protuberant ♀ divergent, 3-segmented and protuberant	10	Potter, 1935
ANOBIIDAE <i>Stegobium paniceum</i> (L.) <i>Lasioderma serricorne</i> (F.)	} Pupal genital papillae : ♂ globular, not protuberant ♀ protuberant, 3-seg- mented and dis- tinctly divergent	—	—
PTINIDAE <i>Mezium affine</i> Boield.	Pupal genital papillae : ♂ slightly protuber- ant and divergent but adpressed to the 9th sternite for the greater part of their length, not dis- tinctly segmented, rounded apically ♀ strongly protuber- ant, divergent, 3- segmented with the apical seg- ment pointed	—	—
<i>Gibbium psylloides</i> (Czenp.) <i>G. boieldieui</i> Levrat	} A large round puncture bearing an erect brush of compact hairs on the middle of the metasternal disc : ♂ present ♀ absent	—	Hinton, 1941
<i>Trigonogenius globulus</i> Sol.	A median setiferous puncture on the pos- terior 1/5 of the metasternal disc : ♂ present ♀ absent	—	Hinton, 1941
<i>Pseudeurostus hilleri</i> (Rtrr.)	A brush of long erect hairs arising from a large, oval, shallow depression on each side of the middle apical region of 5th abdominal sternite : ♂ absent ♀ present	—	Hinton, 1941

TABLE I—cont.

Family and species	Character and its sexual expression	Fig.	Reference
PTINIDAE—cont. <i>Niptus hololeucus</i> (Fald.)	Pupal genital papillae : ♂ small and globular, parallel to convergent, not distinctly segmented or protuberant ♀ distinctly protuberant and divergent, apically pointed, segmentation indistinct	—	—
<i>Stethomezium squamosum</i> Hinton	Pupal genital papillae : ♂ protuberant, parallel to convergent, 2-segmented and rounded apically ♀ strongly protuberant, divergent, 3-segmented and pointed apically	—	—
<i>Tipnus unicolor</i> (Pill. & Mitt.)	Pupal genital papillae : ♂ convergent, small and appearing globular (much as <i>P. tectus</i> , fig. 12) ♀ protuberant, divergent, large 3-segmented and pointed apically	—	—
<i>Ptinus sexpunctatus</i> Panz.	Metasternum : ♂ broader, with the median longitudinal line narrow and extending from the base to the middle of the metasternum ♀ narrower, with the median longitudinal line broad and confined to basal fifth	11	Hinton, 1941
<i>P. tectus</i> Boield.	No secondary sexual characters occur in the adult but adult sexing can be achieved, without injury, by squeezing out the genitalia on the day of emergence Pupal genital papillae : ♂ globular ♀ 3-segmented, protuberant, divergent	12	—
<i>P. fur</i> (L.)	♂ (i) Body elongate, subparallel sided (ii) Pronotum with a median hump (iii) Antennae long ♀ (i) Body obovate (ii) Pronotum without a median hump (iii) Antennae relatively short	—	Hinton, 1941

TABLE I—cont.

Family and species	Character and its sexual expression		Fig.	Reference
PTINIDAE—cont. <i>Ptinus clavipes</i> Panz. (= <i>hirtellus</i> Sturm)	♂ (i) Body elongate, subparallel sided (ii) Eyes large and prominent (iii) Antennae long	♀ (i) Body obovate (ii) Eyes smaller (iii) Antennae shorter	—	Hinton, 1941
<i>P. pusillus</i> Sturm	♂ (i) Body slightly elongate (ii) Middle and hind tibial spurs long and curved	♀ (i) Body ovate (ii) Middle and hind tibial spurs short and straight	—	Hinton, 1941
CLERIDAE <i>Necrobia rufipes</i> (Deg.)	Each of the elytral striae punctures : ♂ with a stiff black seta subrecumbent and leaning backwards like the elytral pubescence ♀ with a stiff black seta leaning forwards		13	Simmons & Ellington, 1925
TROGOSITIDAE <i>Tenebroides mauritanicus</i> (L.)	Pupal genital papillae : ♂ two slight protuberances ♀ protuberant, 3-segmented, divergent		14	—
CUCUJIDAE <i>Cryptolestes</i> species <i>C. turcicus</i> (Grouv.) <i>C. pusilloides</i> (Steel & Howe) <i>C. pusillus</i> (Schönh.) <i>C. ugandae</i> Steel & Howe <i>C. ferrugineus</i> (Steph.) <i>C. capensis</i> (Waltl)	Hind tarsi : ♂ 4-segmented ♀ 5-segmented In addition to the basic separation on tarsi, the antennae and mandibles are useful in the separation of the sexes Antennae : ♂ nearly as long as the body ♀ about 2/3 the length of the body External mandibular tooth : ♂ present ♀ absent		—	— Lefkovitch, 1959 Lefkovitch, 1959



Figs. 8-14.— 8. *Oryzaephilus surinamensis* (L.), hind leg (♂, ♀); 9. *Ahasverus advena* (Waltl), terminal segments of pupal abdomen, ventral view (♂, ♀); 10. *Rhyzopertha dominica* (F.), the same (Potter, 1935 p. 463); 11. *Ptinus sexpunctatus* Panz., median area of metasternum (♂, ♀); 12. *Ptinus tectus* Boield., terminal segments of pupal abdomen, ventral view (♂, ♀); 13. *Necrobia rufipes* (Deg.), median third of elytron (♂, ♀); 14. *Tenebroides mauritanicus* (L.), terminal segments of pupal abdomen, ventral view (♂, ♀).

TABLE I—cont.

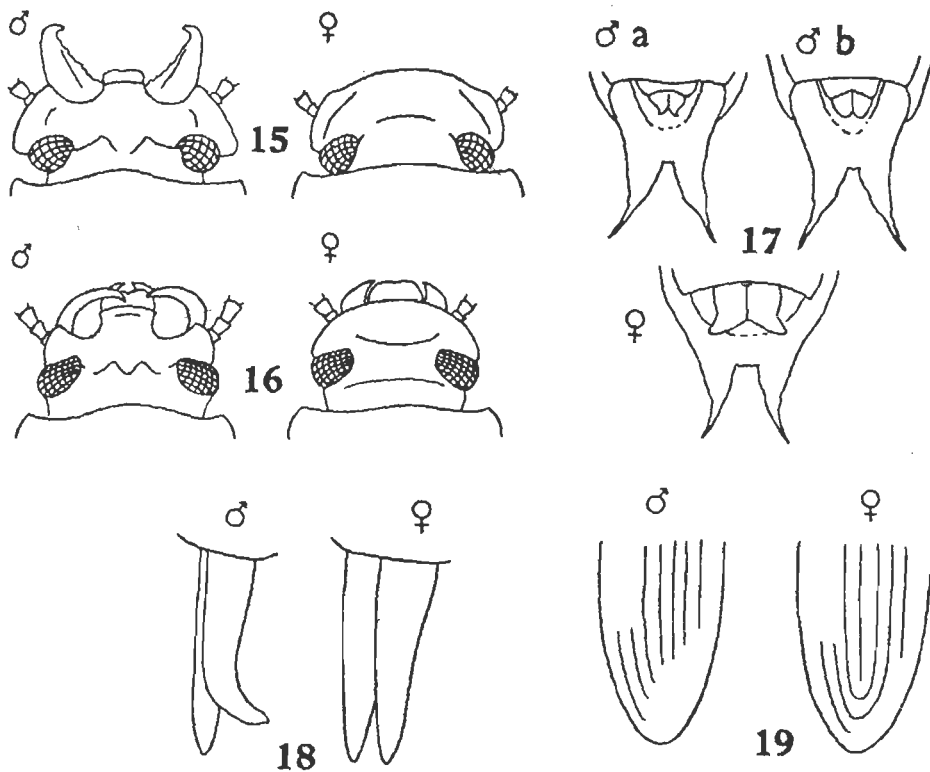
Family and species	Character and its sexual expression		Fig.	Reference
SILVANIDAE				
<i>Ahasverus advena</i> (Waltl)	Pupal genital papillae : ♂ very small, hardly visible		9	—
	♀ protuberant, 3-segmented, divergent			
<i>Cathartus quadricollis</i> (Guér.)	♂ (i) Pronotum elongate (ii) Hind tibiae with a tooth at the apex	♀ (i) Pronotum quadrate (ii) Hind tibiae without a tooth at the apex	—	—
<i>Oryzaephilus surinamensis</i> (L.) <i>O. mercator</i> (Fauv.)	♂ Hind coxal process conical and hind femora with a tooth	♀ Hind coxal process not conical and hind femora without a tooth	8	—
MYCETOPHAGIDAE				
<i>Mycetophagus quadriguttatus</i> (Müll.) <i>Typhaea stercorea</i> (L.)	Front tarsi : ♂ 3-segmented		—	Hinton, 1945
	♀ 4-segmented			
LATHRIDIIDAE				
<i>Coninomus nodifer</i> (Westw.)	Hind tibiae : ♂ with a tooth		—	Hinton, 1945
	♀ without a tooth			
<i>Enicmus minutus</i> (L.)	Pupal genital papillae : ♂ apparently without papillae		—	—
	♀ oval, apically pointed			
NITIDULIDAE				
<i>Carpophilus obsoletus</i> Erichs. <i>C. ligneus</i> Murr. <i>C. dimidiatus</i> (F.) <i>C. hemipterus</i> (L.) <i>C. maculatus</i> Murr.	6th abdominal sternite : ♂ entirely ventral and visible, 5th sternite with a very deep round emargination to accommodate 6th		—	Dobson, 1954
	♀ not visible, 5th sternite rounded apically			

TABLE I—cont.

Family and species	Character and its sexual expression		Fig.	Reference
CRYPTOPHAGIDAE <i>Cryptophagus</i> species	Hind tarsi : ♂ 4-segmented ♀ 5-segmented		—	Coombs & Woodroffe, 1955
TENEBRIONIDAE <i>Tenebrio obscurus</i> F.	Pupal genital papillae : ♂ slightly divergent at apices, small and inconspicuous ♀ divergent and conspicuous, flattened, somewhat chitinised, not papillate		17	—
<i>T. molitor</i> L.	Fowler (1891) separates the sexes on the degree of curvature of the front tibia, but the author found this too variable to be useful Pupal genital papillae : ♂ parallel, fused at base, small and inconspicuous ♀ identical with those of <i>T. obscurus</i>		17	—
<i>Tribolium confusum</i> Duv.	♂ (i) All elytral striae abbreviated before apex (ii) Anterior femora with a sub-basal setiferous puncture on the ventral side	♀ (i) Elytral striae 4 & 6 and 7 & 3 meeting at apices and entire (ii) Anterior femora without a setiferous puncture	19	Hope, 1953 Hinton, 1942
<i>T. castaneum</i> (Hbst.)	The elytral striae used in the separation of the sexes in <i>T. confusum</i> can also be used here but the difference is not so apparent and considerable practice is necessary. The setiferous puncture is, however, more easily seen in this species Sub-basal setiferous puncture on anterior femur : ♂ present ♀ absent		—	Hinton, 1942 (includes figure)

TABLE I—cont.

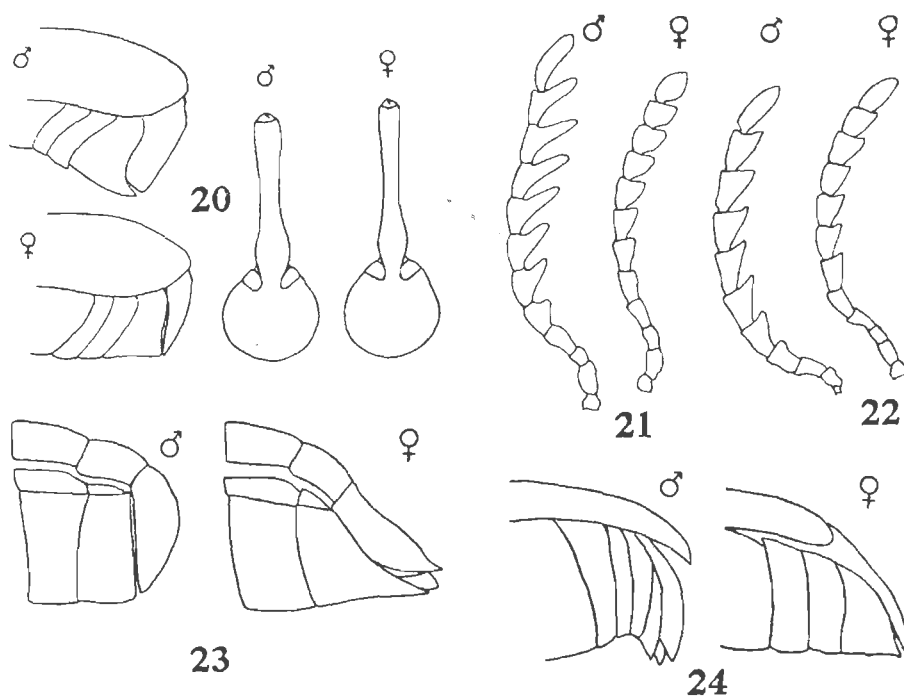
Family and species	Character and its sexual expression	Fig.	Reference				
TENEBRIONIDAE—cont. <i>Palorus ratzeburgi</i> (Wissm.) <i>P. subdepressus</i> (Woll.)	<table border="0"> <tr> <td colspan="2">} Pupal genital papillae :</td> </tr> <tr> <td>♂ small, globular and inconspicuous</td> <td>♀ conspicuous, protuberant and divergent apically</td> </tr> </table>	} Pupal genital papillae :		♂ small, globular and inconspicuous	♀ conspicuous, protuberant and divergent apically	—	—
} Pupal genital papillae :							
♂ small, globular and inconspicuous	♀ conspicuous, protuberant and divergent apically						
<i>Gnathocerus maxillosus</i> (F.)	<table border="0"> <tr> <td colspan="2">A 'tusk-like' dorsal tooth on each mandible, and head with two median prominences :</td> </tr> <tr> <td>♂ present</td> <td>♀ absent</td> </tr> </table>	A 'tusk-like' dorsal tooth on each mandible, and head with two median prominences :		♂ present	♀ absent	16	—
A 'tusk-like' dorsal tooth on each mandible, and head with two median prominences :							
♂ present	♀ absent						
<i>G. cornutus</i> (F.)	<table border="0"> <tr> <td colspan="2">A large, tapering dorsal tooth on each mandible, and head with two prominences :</td> </tr> <tr> <td>♂ present</td> <td>♀ absent</td> </tr> </table>	A large, tapering dorsal tooth on each mandible, and head with two prominences :		♂ present	♀ absent	15	—
A large, tapering dorsal tooth on each mandible, and head with two prominences :							
♂ present	♀ absent						
<i>Sitophagus hololeptoides</i> (Cast.)	<table border="0"> <tr> <td colspan="2">Anterior lateral regions of head produced into a pair of horns in front of the eyes :</td> </tr> <tr> <td>♂ present</td> <td>♀ absent</td> </tr> </table>	Anterior lateral regions of head produced into a pair of horns in front of the eyes :		♂ present	♀ absent	—	—
Anterior lateral regions of head produced into a pair of horns in front of the eyes :							
♂ present	♀ absent						
<i>Alphitophagus bifasciatus</i> (Say)	<table border="0"> <tr> <td colspan="2">Anterior region of head thickened and excavated. Top of head with two black, shining ridges :</td> </tr> <tr> <td>♂ present</td> <td>♀ absent</td> </tr> </table>	Anterior region of head thickened and excavated. Top of head with two black, shining ridges :		♂ present	♀ absent	25	Surtees, 1961
Anterior region of head thickened and excavated. Top of head with two black, shining ridges :							
♂ present	♀ absent						
<i>Latheticus oryzae</i> Waterh.	<table border="0"> <tr> <td colspan="2">A brush of hairs at the centre of the labium:</td> </tr> <tr> <td>♂ present</td> <td>♀ absent</td> </tr> </table>	A brush of hairs at the centre of the labium:		♂ present	♀ absent	—	Hafeez, M. A., & Chapman, G. (personal communication)
A brush of hairs at the centre of the labium:							
♂ present	♀ absent						
<i>Alphitobius laevigatus</i> (F.) <i>A. diaperinus</i> (Panz.)	<table border="0"> <tr> <td colspan="2">} Mid-tibiae :</td> </tr> <tr> <td>♂ with one spur of apical pair turned inwards</td> <td>♀ with both apical spurs straight</td> </tr> </table>	} Mid-tibiae :		♂ with one spur of apical pair turned inwards	♀ with both apical spurs straight	18	Hewlett, 1958
} Mid-tibiae :							
♂ with one spur of apical pair turned inwards	♀ with both apical spurs straight						



Figs. 15-19.— 15, *Gnathocerus cornutus* (F.), head (♂, ♀); 16, *Gnathocerus maxillosus* (F.), head (♂, ♀); 17, *Tenebrio obscurus* F., terminal segments of pupal abdomen, ventral view (♂ a, ♀), *T. molitor* L., the same (♂ b); 18, *Alphitobius laevigatus* (F.), apical tibial spur (♂, ♀) (Hewlett, 1958 p. 144); 19, *Tribolium confusum* Duv., apex of elytron (♂, ♀) (Hope, 1953 p. 265).

TABLE I—cont.

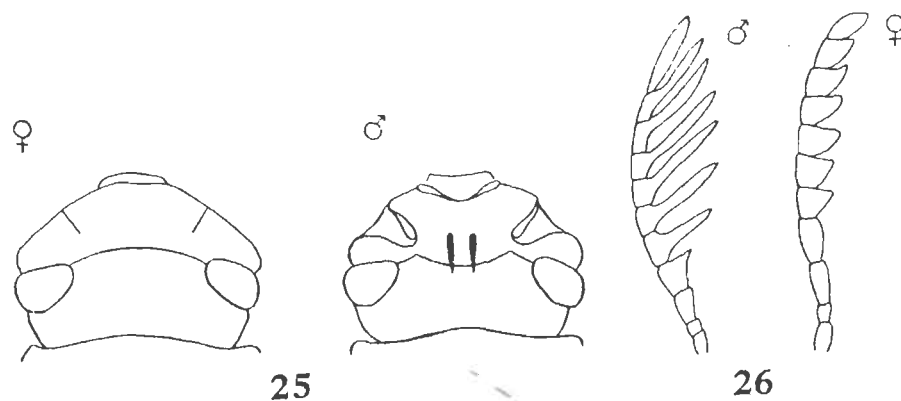
Family and species	Character and its sexual expression		Fig.	Reference
CURCULIONIDAE <i>Sitophilus granarius</i> (L.)	♂ (i) Rostrum comparatively rough ; shorter and wider than that of the ♀ (ii) Abdominal sternites 5 & 6 projecting downwards	♀ (i) Rostrum smooth and shining ; somewhat longer and thinner than that of the ♂ (ii) Abdominal sternites 5 & 6 not bent downwards	20	—
<i>S. oryzae</i> (L.) <i>S. zeamais</i> Motsch.	} Rostrum : ♂ distinctly shorter and wider than that of the ♀ ; rough	♀ distinctly longer and narrower than that of the ♂ ; smooth and shining	—	—
ANTHRIBIDAE <i>Araecerus fasciculatus</i> (Deg.)	Pygidium : ♂ vertical, not distinctly visible dorsally	♀ inclined, distinctly visible dorsally	23	Mohamed Taher el Sayed, 1940
BRUCHIDAE <i>Callosobruchus chinensis</i> (L.)	♂ Antennae pectinate	♀ Antennae serrate	21	Southgate, 1958
<i>C. rhodesianus</i> (Pic)	♂ Antennae strongly serrate	♀ Antennae weakly serrate	22	Southgate, 1958
<i>C. phaseoli</i> (Gylh.)	♂ (i) Antennae strongly serrate (ii) Pygidium without dark patches (Elytra usually brown with white scales)	♀ (i) Antennae weakly serrate (ii) Pygidium with two dark patches, one on each side of the mid-line (Elytra usually black with patches of brown that are covered with white scales forming a distinct pattern)	—	—



Figs. 20-24.— 20, *Sitophilus granarius* (L.), posterior region of abdomen (side view), head and rostrum (♂, ♀); 21, *Callosobruchus chinensis* (L.), antenna (♂, ♀) (Southgate, 1958 p. 593); 22, *Callosobruchus rhodesianus* (Pic), antenna (♂, ♀) (Southgate, 1958 p. 593); 23, *Araecerus fasciculatus* (Deg.), posterior region of abdomen, side view (♂, ♀) (Mohamed Taher el Sayed, 1940 p. 136); 24, *Caryedon gonagra* (F.), posterior region of abdomen, side view (♂, ♀) (Davey, 1958 p. 401).

TABLE I—cont.

Family and species	Character and its sexual expression	Fig.	Reference
BRUCHIDAE—cont. <i>Callosobruchus analis</i> (F.)	Separation is possible only by using the cuticular colour of the pygidium : ♂ pygidium with a wide median testaceous (i.e., brownish-yellow) strip or 'V'-shaped area	♀ pygidium with a narrow median testaceous strip	— Southgate, Howe & Brett, 1957
<i>C. maculatus</i> (F.)	In freshly emerged specimens the ♀ usually has a distinct large spot on each elytron whilst the ♂ is without distinct large spots but there is a wide range of intermediate forms	—	Southgate, Howe & Brett, 1957
<i>Caryedon gonagra</i> (F.) <i>C. cassiae</i> (Gylh.)	Pygidium : ♂ not visible from above	♀ distinctly visible from above	24 Davey, 1958 (gonagra)
<i>Bruchidius atrolineatus</i> (Pic)	♂ Antennae flabellate	♀ Antennae serrate	26 —
<i>Acanthoscelides obtectus</i> (Say)	Pygidium : ♂ vertical, only partly seen from above (as in fig. 23♂)	♀ oblique, in full view from above (as in fig. 24♀)	— —
<i>Zabrotes subfasciatus</i> (Boh.)	♂ Elytra variegated with patches of grey and fawn pubescence	♀ General elytral pubescence black but with a distinct small area of white pubescence surrounded by a very narrow circle of fawn pubescence	— —



Figs. 25-26.— 25, *Alphitophagus bifasciatus* (Say), dorsal view of head (♂, ♀) (Surtees, 1961 p. 112); 26, *Bruchidius atrolineatus* (Pic), antenna (♂, ♀).

Summary.

The known external characters, and some new ones, for separating the sexes of pupae and adults of stored-products Coleoptera are described and in many cases figured.

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