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A CONTRIBUTION TO DISTINGUISHING THE EUROPEAN SPECIES OF THE SUBGENUS SYRPHUS FABRICIUS (SYRPHIDAE, DIPTERA) ACCORDING TO MALE GENITALIA AND LARVAE

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Příspěvek k odlišení evropských druhů podrodu *Syrphus* Fabricius *(Diptera, Syrphidae)* podle samčích genitálií a larev

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V práci jsou popsány samčí pohlavní orgány a larvy tří evropských druhů podrodu *Syrphus* Fabricius s. str.: *Syrphus torvus* Osten-Sacken, 1875, *S. ribesii* (Linnaeus, 1758), *S. vitripennis* Meigen, 1822. Na základě morfologie genitálií a larev jsou stanoveny další rozlišovací znaky uvedených tří druhů. Podle genitálií — i když jsou poměrně variabilní — je možné určení všech druhů, a to i jedinců méně charakteristických z hlediska dosud používaných znaků vnější morfologie. Nejobtížnější je určování těchto druhů podle larev, kde např. rozlišení druhů *S. torvus* a *S. ribesii* není v mnoha případech vůbec možné. Práce je doprovázena tabulkou konfrontující terminologické pojmy používané jednotlivými autory zabývajícími se studiem genitalií čeledi *Syrphidae,* tabulkami s rozměry dýchocích trubiček a vyobrazeními samčích pohlavních orgánů a dýchacích trubiček a diferenciální diagnostickou tabulkou, v které jsou uvedeny zjištěné rozlišovací znaky v utváření samčích genitálií, larev 3. instaru a puparií všech tří druhů.

Three European species belong to the subgenus *Syrphus* Fabricius sensu stricto (Fluke, 1950): *Syrphus torvus* Osten-Sacken, 1875, *S. ribesii* (Linnaeus, 1758) and *S. vitripennis* Meigen, 1822. These species are very similar. Their distinguishing may cause certain difficulties because it sometimes depends practically on only one known distinguishing character, which furthermore is not always quite constant. Studies of male genitalia have not, up to now, yielded any new identification characters, on the contrary, they may create certain doubts about these species. From the economic point of view these are very numerous and, consequently, very important predators of aphides. For applied studies it is important to distinguish adults and larvae, puparia and their exuvia as well. There are differences in ecology between the species (Láska, 1959). It is necessary to try to find a greater number of identification characters. The possibilities of external morphology of adults are on the whole exhausted and we have, consequently, concentrated, on the one hand, on the male genitalia and, on the other hand, on the morphological characters of the third instar larvae and puparia.

The present distinguishing characters

Sack (1932) and the keys based on his studies do not make a reliable identification of these species possible. Verral (1901), Lundbeck (1916) and recently Coe (1953) have already mentioned the morphological distinguishing characters. For the sake of completion, we describe the most important of these characters, verified and somewhat modified on the basis of our material.

The most typical subgeneric characters are hairs on the lobe of the squama. There are almost always entire yellow bands on the third and fourth abdominal tergites. The bands may be interrupted in exceptional cases only (Szilady, 1940, describes a similar aberration in *S. torvus;* see also discussion on *S. vitripennis).*

Syrphus torvus Ost.-Sack.

Male. Eyes distinctly and notably on the top vertex, dense hairy. The basal two thirds to four fifths of hind femora dark, the apical third anteriorly covered with black or mostly black hairs, only in exceptional cases with mostly yellow hairs.

Female. Eyes hairy but often in a rather sporadic, indistinct way. One half to three quarts of hind femora dark, hairs as in the male.

Syrphus ribesii (L.)

Male. Eyes bare or only sporadically covered with far minuter hairs than in the male *S. torvus,* spread rather on the sides. About one half to two thirds of hind femora dark, the apical third anteriorly covered with black or mostly black hairs.

Female. Eyes bare. Hind femora, except for the base, light; the apical half anteriorly covered with black or almost black hairs.

Syrphus vitripennis Meig.

Male. Eyes bare, or with a few microscopical hairs. About two thirds to four fifths of hind femora dark. Hind femora covered anteriorly with yellow or with mostly yellow hairs.

Female. Eyes bare. Hind femora are dark from one half to three fourths, with hairs as in the male.

MATERIAL AND METHODS

Male genitalia were studied on abundant material of the above mentioned three species, coming from various localities in Czechoslovakia. Besides, there was available one specimen of each species from Armenia (USSR), England and Poland respectively. The larvae described came also from various localities in Czechoslovakia and were collected from various species of aphids at different periods of time.

The preparation of male genitalia was carried out in the ordinary way by boiling in KOH, and enclosing in Canada balsam. To get a clearer view of individual characters, the hypopygia were divided into two parts, epandrium with paralobi and cerci, and hypandrium with aedeagus and parameres. The drawings of epandria were made from the dorsal, ventral and lateral view. In order to understand the whole arrangement, a whole hypopygium of one species is drawn from the lateral view.

The described larvae were alive so that their colour might be observed, and so that they might be further bred in order to identify the adults. The posterior respiratory process was described and measured according to the exuvia of puparia from which we determined the adults. Unhealthy or parasited specimens, which did not complete their evolution for one or another reason, were not included in the measurements.

Table I. Comparative table of the terminology used by various authors for the male genitalia of Syrphids

Dušek & Láska	Carrera, Lopes & Lane, 1947	Delucchi & Pschorn—Walcher, 1955	Fluke, 1950	Gaunitz, 1958	Glumac, 1958	Zumpt & Heinz, 1949
epandrium	9th tergit	9th tergit	10th tergite	epandrium	10th tergit	epandrium
paralobi	styli	forceps extrenes	styli	paralobi	forcepsi	paralobi
cerci	cerci	forceps internes ou cerques	cerci	cerci	lamelae	analcerci
hypandrium	9th sternit	—	penis sheath	hypandrium	—	9th tergo-sternum
lingula	—	—	lingula	—	—	—
paramere	pinça fálica	paramère	superior lobes	lobi serae (Schlussloben)	—	paramere

Male genitalia

Male genitalia of all the three species are very similar, as shown in Fluke's works (1950, 1954). After a more careful study on the basis of material from geographically distant localities, when possible individual variations can be excluded, and after a more detailed drawing of male genitalia, it is possible to state constant species characteristics, especially for the species *S. vitripennis* as compared with the species *S. torvus* and *S. ribesii* which are more difficult to distinguish. Epandrium is short and broad, carrying apically thick and short paralobi, covered with hairs and spinules. In the middle of epandrium, there are dense haired, crescent-like cerci. Hypandrium is especially conspicuous by a slightly bent and projecting lingula. The lower part of hypandrium is bluntly rounded. Parameres are more sclerotized. When viewed laterally, a sclerotized bridge appears between parameres in the form of sharp hooks pointing to lingula. A survey of the terminology of the different authors dealing with male genitalia of Syrphidae is given in Tab. I.

Syrphus torvus Ost.-Sack.

Epandrium with paralobi and cerci is roughly of same breadth and height. Cerci are crescent-like, strongly varying in breadth and form. Paralobi more or less triangle-shaped, joining epandrium by their narrower base. Hypandrium is of smaller size than in the species *S. ribesii* but larger than in *S. vitripennis*, and when viewed ventrally, slimmer in both these species. Its whole breadth is approximately the same. The ventral bridge between parameres protrudes, when viewed laterally, into very long and slim hooklets. From a ventral view it

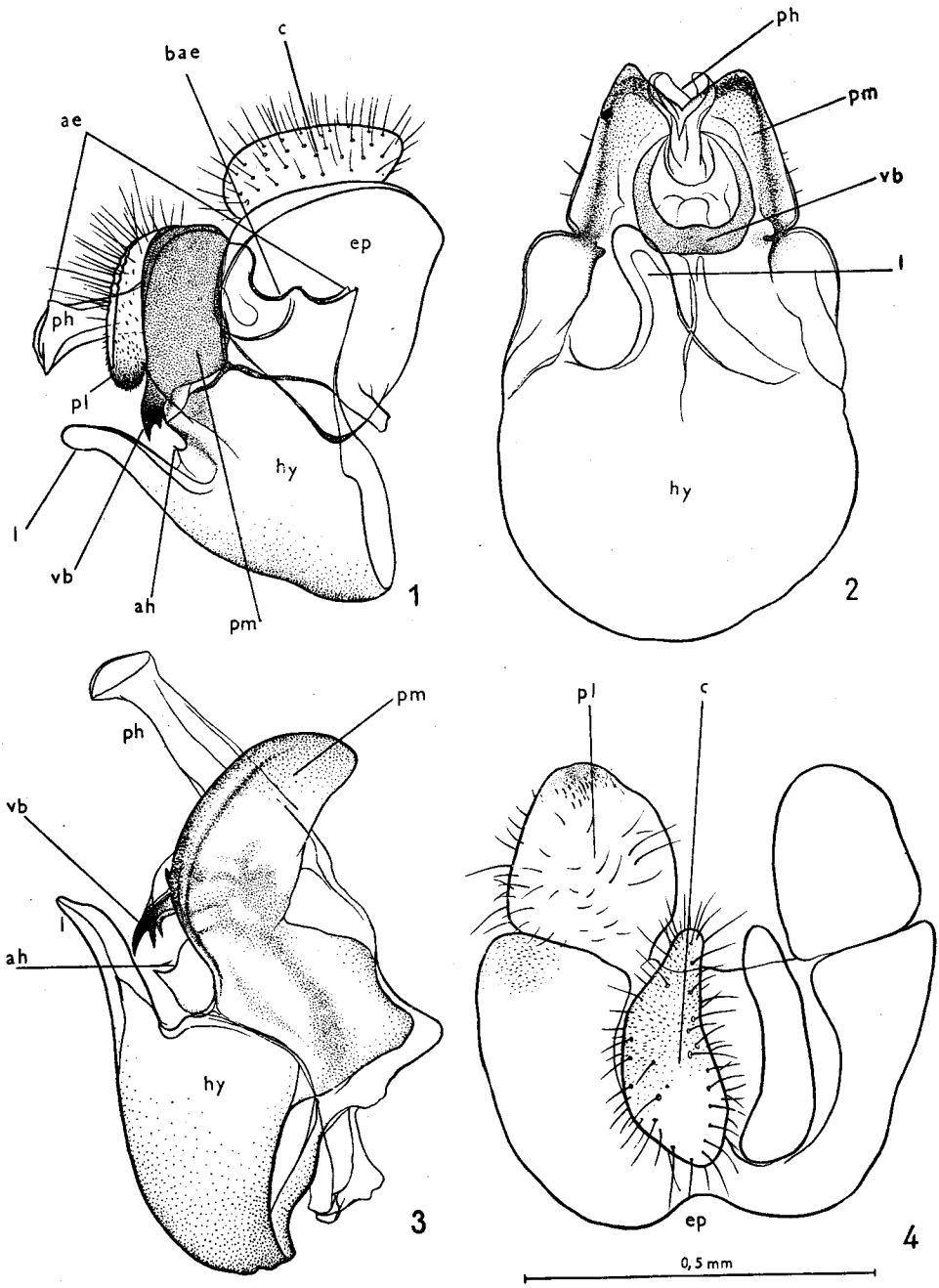

Plate 1: Fig. 1. *Syrphus vitripennis* Meig., hypopygium from lateral view. Figs. 2—4. *Syrphus ribesii* (L.): 2. Hypandrium from ventral view. 3. Hypandrium from lateral view. 4. Epandrium from dorsal view (left and right cerci and paralobi belonging to different specimens so that the variability in form is visible).

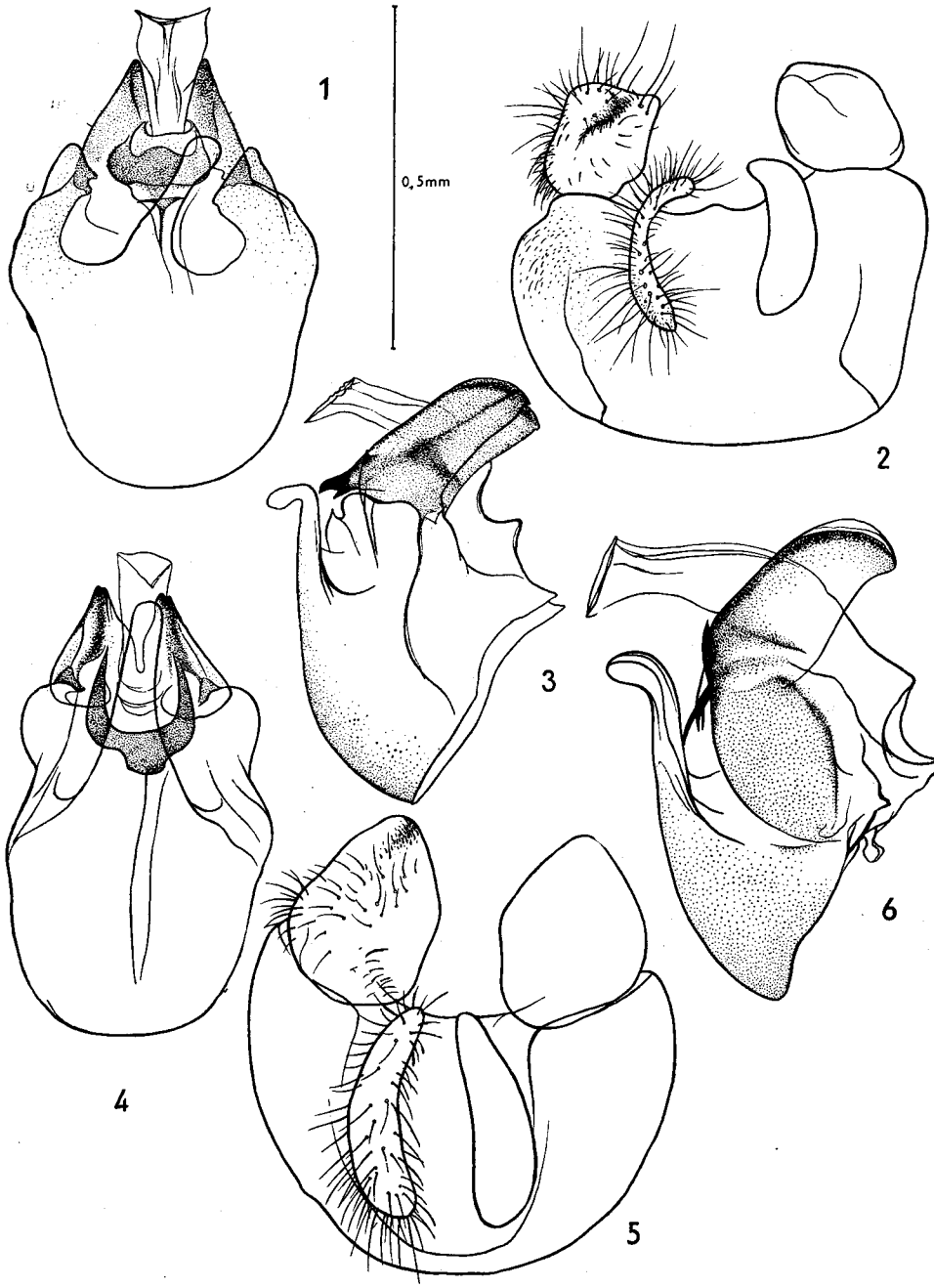

Plate 2: Figs. 1—3. *Syrphus vitripennis* Meig.: 1. Hypandrium from ventral view. — 2. Epandrium from dorsal view (left and right cerci and paralobi belonging to different specimens). 3. Hypandrium from lateral view. Figs. 4—6. *Syrphus torvus* Ost.-Sack.: 4. Hypandrium from ventral view. 5. Epandrium from dorsal view. 6. Hypandrium from lateral view.

is not terminated flatly and ovally in the basal part, but it forms an angular prominence. This character is not too conspicuous in individuals with a less sclerotized hypopygium. The apical fold is not distinct. The dorsal side of the basal part of aedeagus is almost straight.

Syrphus ribesii (L.)

Epandrium is similar to that of *S. torvus,* from which it is indistinguishable. In the form of cerci, it varies to a great extent, while the shape of paralobi is relatively constant. Of all the three species the hypandrium is the longest, the broadest and, in general, the most robust. The breadth reaches its highest degree in the basal third. From a ventral view, the ventral bridge is horseshoe-shaped, with an oval lower part. The apical fold of hypandrium is relatively little hollowed. The dorsal side of the basal part of aedeagus is slightly undulated.

Syrphus vitripennis Meig.

The length of epandrium is smaller than its breadth, paralobi relatively short and not distinctly triangular as in the foregoing species, but rather oblong. Cerci are rather strongly crescent-like. Their shape and especially breadth considerably vary. Hypandrium is the smallest of all the three species. From the ventral view it widens suddenly in the middle. The ventral bridge between parameres projects, when laterally viewed, into relatively thick hooklets. The apical fold of hypandrium is deeply hollowed. The dorsal side of the basal part of aedeagus is strongly S-shaped.

Variability

There is a striking variability in the form of male genitalia, especially in epandrium and cerci. Hypandrium varies very strongly in the shape, termination and length of lingula. In one specimen of *S. torvus,* which is otherwise a normal one, lingula is almost entirely reduced. Much variable is also the arrangement of the dorsal part of parameres, which is sometimes terminated by a notch, otherwise however it is smoothly rounded.

Third instar larvae and puparia

Larvae and puparia of all the three species are very similar and, up to now, have not, as a matter of fact, been distinguished, even though all of them were described several times. In the following descriptions, we are giving all, even if only partial characteristics, which we could ascertain. Some of these distinguishing characters had been preliminarily used in our previous paper (Dušek and Láska, 1961). We are not giving the characteristics common, to all the three species as they are given in the above mentioned paper. The dimensions of the posterior respiratory processes, measured in a great number of specimens, are arranged in tables and are not usually given in the text.

Syrphus torvus Ost.-Sack.

Larva or puparium were desribed several times, especially by American authors (see Hennig, 1952), recently by Brown and Clark (1960).

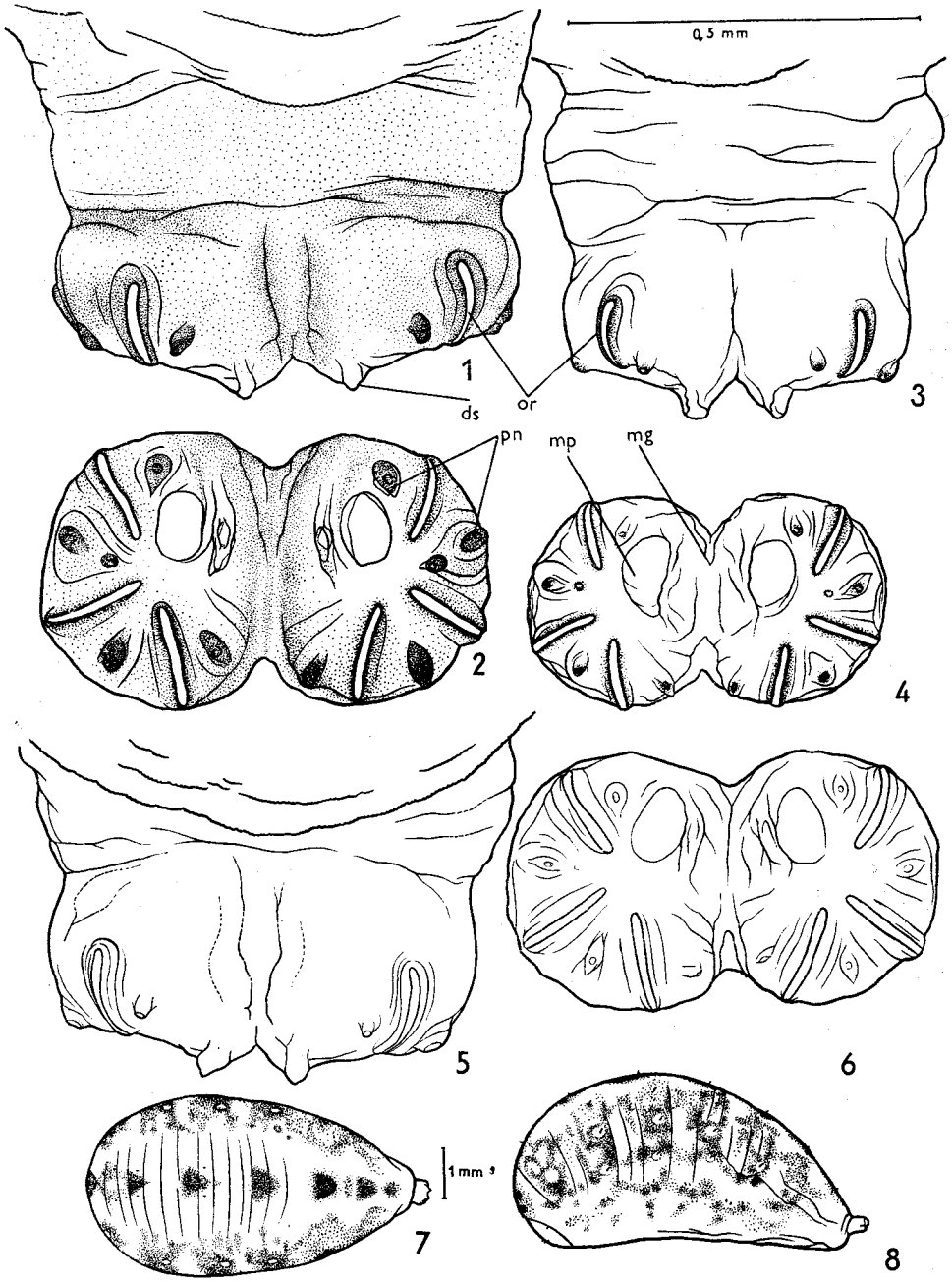

Plate 3: Figs. 1—2. *Syrphus torvus* Ost.-Sack.: 1. Posterior respiratory process. — 2. Spiracular plates. Figs. 3, 4, 7, 8, *Syrphus vitripennis* Meig.: 3. Posterior respiratory process. 4. Spiracular plates. 7. Puparium from dorsal view. 8. Puparium from lateral view. Figs. 5—6. *Syrphus ribesii* (L.): 5. Posterior respiratory process. 6. Spiracular plates.

Abbreviations used in figures: Plates 1—2: ae — aedeagus, ah — apical fold of hypandrium, bae — basal part of aedeagus — dorsal side, c — cerci, ep — epandrium, hy — hypandrium, l — lingula, pl — paralobus, pm — paramere, ph — phallus, vb — ventral bridge.

Plate 3: ds — dorsal spur, mp — median plate, mg — median groove, or — orificium, pn — periorificial nodules.

Dixon's (1960) description is based on the descriptions of the American authors. In normally coloured larvae, a median brick-red line of adipose tissue starts dorsally on the anterior segments; it is frequently interrupted and approximately between the fourth and fifth segments passes into a pair of lines. These lines are often interrupted, especially on the fifth and sixth segments, and may be rather irregular. They are broadest on the first and second folds of the segments, and narrowest or interrupted between the third and fourth folds. The lines can be joined transversally on the second fold of the segments. Irregular projections often project in this place from median lines postero-laterally, sometimes they are even separated from these lines.

Table II. Measurements of posterior respiratory processes in mm (30 specimens measured in each species)

Syrphus species	*S. torvus*			*S. ribesii*			*S. vitripennis*		
	min.	max.	aver.	min.	max.	aver.	min.	max.	aver.
length	0,38	0,55	0,47	0,38	0,57	0,48	0,38	0,49	0,42
apical width	0,50	0,68	0,61	0,53	0,65	0,60	0,43	0,52	0,48
width in the narrowest place	0,46	0,63	0,58	0,49	0,65	0,57	0,41	0,52	0,45
basal width	0,57	0,74	0,6	0,57	0,76	0,67	0,46	0,57	0,52
apical height	0,32	0,40	0,37	0,30	0,38	0,36	0,27	0,33	0,31
ratio of apical width to length	1,18	1,44	1,32	1,05	1,64	1,26	0,94	1,36	1,16

More laterally on each side is a wider, backwards widening stripe of adipose tissue, undulated in shape, sometimes rather irregular, cream to yellow in colour, starting between the fourth and fifth segments. The black gut-content is clearly visible, being translucent on each side between the brick-red line and the cream stripe, as an irregular and interrupted black line. The median lines, usually of brick-red colour, may be also light orange to ochreous. Even in the last case, the colour of the median lines is almost always deeper than that one of the more lateral stripes. After last defecation and especially in cases of the larvae falling into the diapause, the colour pattern becomes progresively diffused and the dorsal lines become paler. In the colour plates of our previous paper (Dušek and Láska, 1959) is illustrated the larva of *S. ribesii,* which does not differ in colour from *S. torvus.* The posterior respiratory process of *S. torvus* does not differ significantly in measurements from that of *S. ribesii,* but it differs from that of *S. vitripennis* (see tab. II and III). The apical width of posterior respiratory process of *S. torvus* is in 93 per cent of cases larger than 0.55 mm; the apical width of one of *S. vitripennis* reached maximally 0.54 mm. The colour of posterior respiratory process varies from brownish through dark brown to black. The apical part is frequently darker; on the other hand, the basal part is rarely darker. Orificia in most cases are lined with dark, frequently almost or quite black colour. The spiracular plate may be all dark often including the dorsal spur, median plate and median groove. Periorificial nodules in most cases are almost or quite black. From all puparia, which we hawe seen, none had a dark pattern.

Syrphus ribesii (L.)

Larva or puparium were described several times — Lundbeck (1916), Vimmer (1925, 1931), Krüger (1926), Fluke (1929), Bhatia (1939), Scott (1939), Dixon (1960). For earlier descriptions see Brauer (1883). The coloration of larva is the same as described in larva of *S. torvus* (see also colour plates of Dušek and Láska, 1959). Posterior respiratory process does not significantly differ in shape or measurements from that of *S. torvus* Apical

Table III. Apical width of posterior respiratory processes measured in a greater number of specimens (Including specimens given in Tab. II)

Number of specimens measured in each species		Apical width in mm			Percentage of specimens with apical width greater than:			
		min.	max.	aver.	0,51 mm	0,53 mm	0,55 mm	0,57 mm
S. torvus	72	0,50	0,68	0,61	98,6 %	97,2 %	93,1 %	88,9 %
S. ribesii	79	0,51	0,67	0,59	100 %	97,5 %	88,9 %	83,5 %
S. vitripennis	112	0,37	0,54	0,48	17,0 %	2,7 %	0,0 %	0,0 %

width of posterior respiratory process is almost in ninety per cent of cases larger than 0.55 mm. The colour of posterior respiratory process is generally lighter than that in *S. torvus*. It is light brown to red-brown. Orificia are lined in a somewhat darker shade, brown to dark brown; or exceptionally it may be almost black. Periorificial nodules do not differ in colour from the basic colour of spiracular plates, or they are brown or rarely also nearly black. From all puparia which we had seen none had a dark pattern.

Syrphus vitripennis Meig.

The larva or puparium was described by Vimmer (1925), Scott (1939), Dunn (1949), Brauns (1953, 1954), Dixon (1960). These descriptions are very brief or erroneous (see discussion). The larva is somewhat smaller in comparison to both species described above. But above all it differs from both in coloration. The colour of both pairs of stripes of adipose tissue is the same, mostly cream-yellow, rarely also ochreous and only exceptionally also orange. Even in the last case the gradation of colour of both pairs of stripes is the same. Medial and more lateral stripes approximately from seventh segment on are placed closely to one another and somewhat deeper under the skin they are really connected so that the gut contents may not appear between these. Black gut contents appear only between both stripes of the medial pair, forming a typical regularly interrupted median line. After last defecation a progressive diffusion of colour pattern takes place especially if the larvae fall into the diapause. Then these specimens may not be distinguished any longer from the diapausing ones of the previous species. In the colour plates of our previous papers (Dušek and Láska, 1960, 1961) all in all three specimens of larvae of *S. vitripennis* are illustrated. Posterior respiratory process is relatively somewhat longer in shape as compared with the previous species, as follows from the ratio of apical width and total length (see Table II). Howe-

Table IV. Diagnostic table of differences of the distinguishing characters based on the form of male genitalia, third instar-larvae, and puparia

S. torvus	*S. ribesii*	*S. vitripennis*
Epandrium with paralobi and cerci rounded	Epandrium with paralobi and cerci rounded	Epandrium with paralobi and cerci a little quadrate
Paralobi ± triangular	Paralobi ± triangular	Paralobi ± rectangleformed
Hypandrium slender, all its parts nearly of same breadth	Hypandrium robust, broader in its lower third part	Hypandrium rather small, in the middle evidently broadened
Ventral bridge of hypandrium from ventral view forms in its basal part an angled protuberance, from lateral view it protrudes into long and slender little hooks	Ventral bridge of hypandrium from ventral view horseshoe-like, from lateral view it protrudes into rather strong little hooks	Ventral bridge of hypandrium from ventral view not too apparent, its basal part un even, in lateral view it protrudes into short strong little hooks
Single stripes of adipose tissue separated from one another, so that the inner content of larva is visible	Single stripes of adipose tissue separated from one another, so that the inner content of larva is visible	Both pairs of stripes are confused, so that the inner content of larva is visible only in the middle
First dorsal pair of stripes of the adipose tissue brick - -reddish, the second pair yellowish	First dorsal pair of stripes of adipose tissue mostly brick-reddish, the second pair yellowish	First and second dorsal pairs of stripes of the same colour, mostly yellowish
Respiratory process mostly dark brown with its orificia mostly black to brownish marginated	Respiratory process mostly brown to bright brown with its orificia only a little darker marginated	Respiratory process bright brown with its orificia mostly black-brownish marginated
Apical width of respiratory process mostly larger than 0,55 mm	Apical width of respiratory process mostly larger than 0,55 mm	Apical width of respiratory process mostly smaller than 0,55 mm
Puparium without the dark pattern (populations of Czechoslovakia)	Puparium constantly without any dark pattern	Puparium with or without dark pattern

ver, from the size and the ratio of posterior respiratory process the most constant appears to be its apical width in normal specimens. The width is 0.37 mm to 0.54 mm according to measurements of 112 specimens. Approximately ninety per cent of specimens of the previous species exceed the greatest apical width measured by more than 0.01 mm. Posterior respiratory process is mostly light brown coloured. In most cases the orificia are lined in dark brown to black, rarely in light brown only. If the orificia are broadly lined in black, the spiracular plates may be in general darker. Even in the last case, however, the dorsal spurs, median plates and median groove remain in most cases lighter. Periorificial nodules are mostly dark brown to black, rarely being not distinguished in colour from the ground colour. The puparium may have a dark pattern. Out of 112 specimens, a dark pattern was observed in

55.4 per cent. The pattern consists of a median dorsal row of dark spots, placed always on the anterior part of segments. On lateral sides of puparium is a row of spots, often of a complex shape and in most cases fusing together For darker puparia the typical feature are light circular islands about segmental hairs mainly in their third and fourth pairs. The puparia with little developed patterns only have the dorsal row of spots.

DISCUSSION

The three species belong to the subgenus *Syrphus* Fabr. s. str. and there can be no doubt about their close relationship. Enderlein (1937) mechanically and incorrectly classified *S. torvus* as a part of the genus *Dasysyrphus,* which was created by him, although as early as 1916 Lundbeck demonstrated convincingly the relatedness of all three species.

Duda (1940) describes *Syrphus strandi* as a new species or variety of *S. vitripennis.* According to his description the latter is distinguished from *S. vitripennis* mainly by its yellow abdominal bands interrupted in the third and fourth tergite. We have compared male genitalia in two similar specimens with genitalia typical for *S. vitripennis* and have not found any difference between them. We assume that also *S. strandi* Duda, though it is not available, belongs to *S. vitripennis,* being only an extremely coloured specimen.

Male genitalia of all three species were drawn by Fluke (1950, 1954) and Glumac (1958). The former author's drawing are careful enough but rather schematic and tiny but important characteristics are not indicated. Fluke states that differences in genitalia of these species are small and thus species characterization by genitalia in this group is generally difficult. When describing the genitalia of the species *S. ribesii,* Fluke (1954) mainly pays attention to the width and shape of the lingula and arrives at distinguishing two types in a series of studied specimens. One type consists of specimens from Holland and Colorado, the other of those from Finland, Scotland, France, Spain and Italy. According to our experience, however, the shape of the lingula is greatly variable in the studied species, as compared with the other parts of hypopygium (Cf. variability in descriptions of genitalia and drawings of two specimens of *S. vitripennis).* In addition to this, Fluke investigated individual European specimens only. These are the reasons why we do not attach much importance to his statement. In his papers, Glumac (1958, 1960), deals with male genitalia of the family *Syrphidae* and following his investigation makes conclusions as to rearranging the taxonomic conception of this family. From his text and, above all, from his illustrations can be however seen, that genitalia have been dealt with rather cursorily, without due attention being paid to the homologisation of individual organs, and that insufficient care was given to preparations and that the drawing itself was not accurate enough. This decreases the value of his numerous illustrations for comparative studies and makes impossible to check up the author's conclusions. Glumac's descriptions and illustrations of male genitalia of the three species studied by us have not made our study easier.

Larva *S. torvus* is distinguished by Heiss (1938) from related species by its periorificial nodules located close in to center of spiracular plate. Our specimens did not differ in this respect from the other species. North American authors, e. g. Heiss (l. c.), Brown and Clark (1960) state that puparia can have a dark pattern, which could not be seen in our numerous material of

puparia. These discrepancies may be caused by differences resulting from the geographical distance between European and American populations. The dark pattern is also mentioned by Gäbler (1938). In this case it is not clear whether it is a mistake of his, or whether this dark pattern really occurs in some European populations, too. The character by which Scott (1939) distinguishes the puparium of *S. torvus* from *S. ribesii,* the arrangement of transverse markings on the puparium, is quite accidental.

The larva or puparium of *S. vitripennis* was not differentiated by Scott (l. c.) and practically not by Vimmer (1925) either, who states that *S. ribesii* is more olive-coloured than *S. vitripennis.* Dunn (1949) mentions as the only distinguishing character the smaller size of *S. vitripennis.* Only Dixon's statement that the posterior respiratory process in *S. vitripennis* is darker, is partly a distinguishing character from *S. ribesii,* (the colouring of the spiracular plates). The most detailed description of the larva *S. vitripennis* is published by Brauns (1953), which in his next work (Brauns, 1954) is accompanied by two colour illustrations. Greatest attention is paid to the description of the colouration, which in this species is the most important distinguishing character. From descriptions and illustrations it follows, however, that Brauns described as *S. vitripennis* also the typically coloured larvae of *S. torvus* or *S. ribesii.*

CONCLUSION

1. The adults of the species *S. torvus, S. ribesii* and *S. vitripennis* can be reliably distinguished on the basis of a complex of characters of outer morphology and the characters of male genitalia.
2. In male genitalia a considerable variability was found, but in spite of large variants the species character can be established; they are especially the proportions of epandrium, hypandrium, the shape of ventral bridge and the dorsal side of the lower part of aedeagus.
3. Distinguishing the larvae of *S. torvus* and *S. ribesii* is unreliable and it can be done in certain cases only, on the base of the darker colouring of the posterior respiratory process. There are no additional characters on puparia either.
4. Larvae *S. vitripennis* can be well distinguished from the above mentioned species because of their colouring and partly also by the size of the respiratory process. Puparia are partly distinguishable by the dark pattern.
5. All three species form a unified, closely related group. Species *S. torvus* and *S. ribesii* are more related to each other than to *S. vitripennis.*

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