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TWO NEW SPECIES OF *SARCOPHAGA* (DIPTERA: SARCOPHAGIDAE) AMONG POLLINATORS OF NEWLY DISCOVERED *SAPRIA RAM* (RAFFLESIACEAE)

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ABSTRACT. - *Sarcophaga saprianovae* Pape & Bänziger, new species, and *Sarcophaga krathonmai* Pape & Bänziger, new species, are described from Thailand. Breeding of these and other *Sarcophaga* spp. allowed novel and correct male-female associations. Females of several species of *Sarcophaga* are involved in the pollination of newly described *Sapria ram* Bänziger & Hansen (Rafflesiaceae).

KEY WORDS. - Flesh flies, *Sarcophaga,* new species, pollination, Rafflesiaceae, *Sapria.*

INTRODUCTION

During field work carried out by the second author (HB) in a research programme on the pollination biology of various Rafflesiaceae (Bänziger, 1991, 1996), a number of Sarcophagidae were caught on or near *Sapria ram* Bänziger & Hansen, a newly discovered species of 'small rafflesia' (s.l.) (Bänziger & Hansen, 1997). Two of the sarcophagids turned out to be undescribed. Because of the significance of pollination studies for the survival of rare and threatened plants such as the Rafflesiaceae, and due to the general interest in the biology of flesh flies as elements of carrion communities, it is important to have valid names for the taxa involved. We therefore consider that the present descriptions and formal naming outside a more comprehensive revision are justified.

MATERIALS AND METHODS

Specimens of the present species were caught by HB during flower-watching sessions to study the pollination syndrome of *Sapria ram* in southern and western Thailand (1996-1999). The sites in the south were in relatively open and species-poor, evergreen forest as typically found along edges of rocky and steep cataracts, with much pandanus, few large trees but thick moss growth on generally very shallow soil. The site in western Thailand was in disturbed monsoon forest not far from a stream.

Flies were caught from the flowers or their vicinity, or from baits (rotting liver, fresh human faeces) by placing a plastic box or a sweep net over them.

In order to obtain male progeny to ensure identification of their mothers (only females are pollinators, often not identifiable) and to elucidate their feeding and larviposition habits (indispensable for the understanding of myophilic pollination mechanisms) broods from 105 wild-caught females were reared by HB (part of a more comprehensive study where more details on the trials will be given, Bänziger & Pape, in prep.). Holotypes were chosen from wild caught (i.e., not bred) males.

Male terminalia were prepared (by HB) by gentle, partial extraction (i.e., leaving terminalia attached to the abdomen) with forceps from freshly killed or post *rigor mortis* individuals killed by ethyl acetate vapours. Specimens which were not treated as above, or where more exact study required complete genitalic detachment, were dissected (by TP) after keeping specimens in a moist container for about 24 hours and carefully extracting and breaking off the terminalia from the remaining abdomen. Terminalia were soaked

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in 10 % NaOH overnight, whereafter phallus and gonopods/parameres were isolated with fine insect pins. Terminalia were then washed in tap water, dehydrated in alcohol, and transferred to glycerine for observation and illustration. Illustrations were done with a Wild M5 stereomicroscope equipped with a drawing tube, whereafter terminalia were either stored in glycerine in a microvial or washed in tap water, dehydrated in alcohol, allowed to dry, and glued to a piece of cardboard; in either case pinned with the source specimen.

When citing text from specimen labels, the text, if any, handwritten on the underside has been given in citation marks between square brackets.

Specimens have been (or are destined to be) deposited in the following institutions: The Natural History Museum, London (BMNH); Department of Entomology, Faculty of Agriculture, Chiang Mai University (DEFACU); Insect Collection, Royal Forest Department, Bangkok (ICFB); Muséum d'Histoire naturelle, Geneva (MHNG); Swedish Museum of Natural History, Stockholm (SMNH).

TAXONOMY

Sarcophaga (Lioproctia) saprianovae, new species

(Figs 1-3)

Type material. - Holotype male: THAILAND, Ranong Province, Phya Nak Falls, Khlong Naka Wildlife Sanctuary, 460 m, 14 Jan. 1996, H. Bänziger ["1055 hours on lobe + diaphragma of *Sapria ram*; Fuji Provia Ftos. 3-8"] (SMNH). Holotype in good condition with terminalia dissected and mounted on a cardboard pinned with the specimen.

Paratypes: THAILAND: 5 males 4 females with locality and collector as holotype - 1 male: 9 Jan.1996 ["1400 hours near *Sapria ram*"]; 1 female: 2 Jan.1998, 1 male: 3 Jan.1998, both with ["PNF 32 brood of 8 Dec.97 on liver (not faeces)"]; 1 female: 2 Feb.1999, 1 female: 4 Feb.1999, 1 male: 5 Feb.1999, all with ["PNF 68"]; 1 male: 2 Feb.1999, 1 male 1 female: 6 Feb.1999, all with ["PNF 65 brood"] (1 male 1 female: BMNH, 1 male 1 female: ICFB, 1 male 1 female: MHNG, 2 males 1 female: SMNH); Phangnga Province, Sri Phangnga Nat. Park, above Suan Mai Falls, 380 m, 1 male: 10 Jan.1999, H. Bänziger ["1430 h on mesh over liver box"] (MHNG); Tak Province, Umphang Distrinct, Ban Thi Pho Ji, path to Büng La Ü Ö, 810 m, 1 female: 14 Jan.1999, ["mother of brood TPJ 22 caught 1250 hours"] (MHNG); 1 male 1 female: 7 Feb.1999, both with ["ex TPJ 22 brood squeezed from wild mother of 1250 hours 14 Jan.99"] (SMNH); 1 male 1 female: 13 Feb.1999, both with ["ex TPJ 23 brood squeezed from wild mother of 1305 hours 14 Jan.99"], H. Bänziger (SMNH).

An additional number of bred specimens not included in the type series will be deposited as voucher specimens in DEFACU. Specimens to be deposited at MHNG will temporarily remain with the second author for ongoing ecological studies.

Description. - Male - Head: Frons semi-narrow, at narrowest point 0.19 x as broad as maximum head width. Frontal bristles strongest at lunule, continuing as a row of gradually weaker bristles towards vertex and ending short of the ocellar triangle; weakest frontal about at narrowest part of frons. Reclinate orbital bristle at level of anterior ocellus and about as strong as strongest frontal. Ocellar triangle setose, ocellar setae latero-proclinate and as strong as weakest frontal. Area behind posterior ocelli with 3 pairs of setae in a row followed by a pair of strong postocellars. Inner vertical well developed, stronger than strongest frontal; outer vertical not differentiated from postocular setae. Posterior to the reclinate orbitals and at level of the postocellars is a pair of medioclinate, bristly setae. Occiput dorsally (excepting the median occipital sclerite) with 3 slightly irregular rows of black setae below the postoculars, other postcranial setae white. Fronto-orbital plate and uppermost part of parafacial plate with broadly scattered setae, continuing into a row of parafacial setae near eye-margin, increasing in size ventrally and stopping short of lower eye-margin. Gena with black setae in about anterior half, with the demarcation between black and white genal setae running obliquely from lower eye-margin anteriorly and ventrally. Genal bristles black. Fronto-orbital plate with a yellow or golden tinge, parafacial plate and genal groove more distinctly golden. Gena, postgena and occiput greyish; gena of some specimens anteriorly with a faint olive or yellowish tinge at certain incidences of light.

Thorax: Depressed part of proepisternum with several blackish hair-like setae. Chaetotaxy: *acr* = 4-6 + 1, *dc* = 4-6 + 4, *ia* = 2 [strong inner posthumeral, weak presutural] + 2, *pa* = 2 + 3. Scutellum with 2 laterals, 1 discal, crossed apicals 0.6-0.7 x as long as posterior lateral.

Legs: Hind trochanter ventromedially with several short, bristly setae.

Abdomen: No marginals on T1+2-T3, with a pair of median marginals on T4, with a complete row of median marginals on T5. Microtomentum forming the usual tessellated, sarcophagine pattern changing with the incidence of light. Colour of microtomentum olive-grey on T1+2 and gradually changing posteriorly to a

golden yellow on T5. ST5 more or less flat, i.e., without marked ventral projection when seen in situ, specimen in lateral view. Strong bristles along inner margin.

Terminalia: Dark reddish to brownish black. Protandrial segment sparsely greyish microtomentose and without marginal bristles. Cercus at level of surstylar tip with a few bristly setae on ventral (anterior) margin amongst the normal setae; dorsally just before the strong curvature of the apex some short setae perpendicularly to the surface form an ill-defined tuft. Ventral margin of cercus even and without any major concavity. Phallus with juxta desclerotised medially and distally, sclerotised parts in posterior view giving the appearance of two scales (reminiscent of beetle elytra). Distal to the juxta 3 pointed lateral projections; the most proximal projection rather short and indistinct, all projections indistinct when phallus is seen in lateral view.

Length: 11.5-12.0 mm.

Female - As male except for usual sex-related differences. Margin of T5 and terminalia with light brown or orangish ground colour. Median marginal bristles of T5 situated at a distance of at least 2.0x one socket diameter from the margin proper. Extreme posterior margin of T5, i.e., posterior to row of marginal bristles, with several setae (more than twice the number of marginal bristles). T6-7 with a full row of marginal bristles and entire margin densely beset with hair-like setae; hairs and bristles intergrading in size. ST7 flat, with gently concave posterior margin and marginal row of setae.

Length: 10.0-12.0 mm.

Etymology - A composite word formed from the genus *Sapria* (Rafflesiaceae) and the Latin word *nova* [= new]. The epithet alludes to the triple novelty of a newly described flower, a new fly, and a new association - Sarcophagidae were hitherto unknown as pollinators of Rafflesiaceae.

Distribution. - Oriental Region - S and W Thailand.

Biology. - See 'Biological Notes' below.

Taxonomic remarks. - *Sarcophaga saprianovae* is here placed in subgenus *Lioproctia* Enderlein (see Pape [1996] for included species). No explicit subgeneric diagnosis is currently available for *Lioproctia,* but the subgenera *Boettcherisca* Rohdendorf + *Lioproctia* + *Sarcorohdendorfia* Baranov may constitute a monophyletic group argued from the shared presence of a setose proepisternal depression and from similarities in male and female terminalia (Pape *et al.,* 2000). Due to marked similarities in male terminalia between *S. saprianovae* and *S. pattoni* Senior-White, the nominal taxon *Sarcophaga pilipleuris* Salem, 1946, described from Java and synonymised with *S. pattoni* by Sugiyama *et al.* (1987), was given special attention when evaluating the identity of *S. saprianovae.* As *S. pattoni* otherwise is known from Nepal to Vietnam and southern China, with Taiwan being the only other non-continental record so far (Pape, 1996), such attention seemed a sound precaution. An attempt to trace the two syntypic specimens of *S. pilipleuris*, however, were unsuccessful. According to Salem's (1946) original paper, he borrowed specimens from a number of major museums and [at that time] private collections, and from the label data provided for *S. pilipleuris* [both types collected by Jacobson] the two types may be suspected to have been on loan to Salem from the Zoological Museum Amsterdam, in which museum the major part of the Indonesian material collected by Jacobson was deposited. No Salem types, however, are currently known to exist in the Amsterdam collection (B. Brugge, pers. comm.) and the *S. pilipleuris* syntypes are not present in The Natural History Museum either - nor are any other types from taxa described in the same paper as *pilipleuris* (N.L. Wyatt, pers. comm.). An extensive quest at relevant Egyptian institutions (by Dr T.I. Tantawi, University of Alexandria) has likewise proven negative (H.H. Salem was based at the Parasitology Department, Faculty of Medicine, University of Alexandria). No specimens from the Salem collection were present at the University of Alexandria nor at the University of Cairo, and no information seems to exist in these institutions as to the fate of the Salem collection. An inquiry about the Salem collection to Prof. M. Hafez (by T.I. Tantawi through the University of Cairo) provided no clues (T.I. Tantawi, pers. comm.). Apparently, no specimens from Salem's 1946-paper were ever returned, and with no indication that Salem's collection could still be in existence the types are considered lost.

Miscellaneous unidentified Oriental and Australasian Sarcophagidae deposited in the Zoological Museum Amsterdam, including several specimens collected by Jacobson himself, some even from the type locality of *S. pilipleuris*, were sorted and identified without finding any specimen of *S. pattoni.* Still, the detailed illustrations of the copulatory apparatus provided by Salem (1946: fig. 3) combined with his concise

description definitely supports treating *S. pilipleuris* as a synonym of *S. pattoni.*

To assure a reliable separation of *S. pattoni* and *S. saprianovae*, even in cases of greased or otherwise discoloured specimens, the following couplet may be used.

Key to separate *Sarcophaga pattoni* and *S. saprianovae*

1. **Both sexes:** Abdominal microtomentum entirely greyish-silvery-blackish [i.e., the 'typical' colour of the sarcophagine abdominal microtomentum]. **Male:** Cercus with an S-shaped anterior (or ventral) margin, showing a convex bulge with stronger bristles about at level of surstylar tip. Phallic juxta with 1-2 sclerotized, unequal spines on each side; with dorsal surface transversely corrugated; and with lateral margins diverging (strict dorsal, or posterior view). ..... *Sarcophaga pattoni* Senior-White
- **Both sexes:** Abdominal microtomentum greyish-silvery at base; extensively yellowish or golden yellow on T4-T5. **Male:** Cercus with anterior margin almost straight at level of surstylar tip, gradually curving apically. Cercus just proximal to level of surstylar tip with a few bristly setae on ventral (anterior) margin amongst the normal setae. Phallic juxta subapically with 3 sclerotized, unequal spines on each side (Fig. 3); with dorsal surface practically smooth; and with lateral margins parallel or slightly converging (strict dorsal, or posterior view)..... ..... *Sarcophaga saprianovae* Pape & Bänziger

Sarcophaga (Boettcherisca) krathonmai, new species

(Figs 4, 5)

Type material. - Holotype male: THAILAND, Ranong Province, Khlong Naka Wildlife Sanctuary, Phya Nak Falls, 460 m, 7 Jan.1999, H. Bänziger ["on/near foul liver"] (SMNH).

Paratypes. THAILAND: 1 male, data as holotype (BMNH); 7 males 10 females, locality and collector as holotype: 1 female: 11 Jan.1996 ["has orchid pollinarium on back, caught 1440 hours near *Sapria ram*"], 1 female: 28 Dec.1997, 1 male: 1 Jan.1998, both with ["PNF 19a brood of 7 Dec.97 on liver (not faeces) bred on liver"], 1 female: 29 Dec.1997, 1 male: 30 Dec.1997, both with ["PNF 31 mixed brood of 8 Dec.97 on liver (not faeces)"], 1 female: 31 Dec.1997 ["PNF 6 mixed brood of 5 Dec.1997 reared on liver"], 1 female: 1 Jan.1998 ["PNF 30"], 1 male: 1 Jan.1998 ["PNF 42 of 8 Dec.97 liver (not faeces)"], 1 male: 3 Jan.1998 ["PNF 30"], 1 female: 8 Jan.1999 ["mother of PNF 69 of 1345 hours, larviposited on liver"]; 1 female: 30 Jan.1999 ["PNF 69"], 1 male: 31 Jan.1999 ["PNF 69"]; 2 males 3 females: 31 Jan.1999 ["PNF 50"] (1 male 2 females: BMNH, 3 males 4 females: SMNH, 2 males 3 females: MHNG, 1 male 1 female: ICFB). MALAYSIA: Perak State, 5 km E Chenderiang, 1 female, 23 Jan.1994, H. Bänziger ["around + on perigone of *Rafflesia cantleyi*"] (MHNG).

An additional number of bred specimens not included in the type series will be deposited as voucher specimens in DEFACU. Specimens to be deposited at MHNG will temporarily remain with the second author for ongoing ecological studies.

Description. - Male - Head: Frons semi-narrow, at narrowest point 0.18 x as broad as maximum head width. Frontal bristles strongest at lunule, continuing as a row of gradually weaker bristles towards vertex and ending short of the ocellar triangle; weakest frontal about at narrowest part of frons. Reclinate orbital bristle at level of anterior ocellus and about as strong as strongest frontal. Ocellar triangle setose, ocellar setae latero-proclinate and at most as strong as weakest frontal. Area behind posterior ocelli with 3-5 pairs of setae in an irregular row followed by a pair of strong postocellars. Inner vertical well developed, stronger than strongest frontal; outer vertical not differentiated from postocular setae. Posterior to the reclinate orbitals and at level of the postocellars is a pair of medioclinate, bristly setae. Occiput dorsally (excepting the median occipital sclerite) with 2 slightly irregular rows of black setae below the postoculars, other postcranial setae white. Fronto-orbital plate with row of setae near eye-margin, row continuing onto parafacial plate increasing in size ventrally and stopping short of lower eye-margin. Gena entirely with black setae or at most with 1-2 white setae posteriorly close to genal suture. Fronto-orbital plat, parafacial plate and genal grove silvery grey, at most with a faint tinge of olive or yellow. Gena, postgena and occiput greyish.

Thorax: Depressed part of proepimeron with several blackish hair-like setae. Chaetotaxy: *acr* = 4-5 + 1, *dc* = 5-6 + 4, *ia* = 2 [strong inner posthumeral, weak presutural] + 2, *pa* = 2 + 3. Scutellum with 2 laterals, 1 discal, crossed apicals 0.6-0.7 x as long as posterior lateral.

Legs: Hind trochanter ventromedially with several short, bristly setae.

Abdomen: No marginals on T1+2-T3, with a pair of median marginals on T4 (or a widely spaced row), with a complete row of median marginals on T5. Microtomentum forming the usual tessellated, sarcophagine pattern changing with the incidence of light. Colour of microtomentum olive-grey on T1+2 and gradually changing posteriorly to a golden yellow on T5. ST5 more or less flat, i.e., without marked ventral projection when seen in situ, specimen in lateral view. Strong bristles along inner margin.

Terminalia: Reddish-orangish to brownish. Protandrial segment sparsely greyish microtomentose and without marginal bristles. Cercus distally with distinct subapical ventral hump and short claw-like tip. Posterior (dorsal) surface of cercal prong with a shallow, trough-like concavity extending for most of its length, sometimes extending onto the cercal base. Distal part of cercal prong laterally with some bristly setae (number variable).

Length: 10.0-11.5 mm.

Female - As male except for usual sex-related differences. Margin of T5 and terminalia with light brown ground colour. Median marginal bristles of T5 situated at a distance of at most 2.0x one socket diameter from the margin proper. Extreme posterior margin of T5, i.e., posterior to row of marginal bristles, with few setae (about equal to the number of marginal bristles). T6-7 with a full row of marginal bristles, with an equal number of additional setae. ST7 almost flat, with a shallow median groove anteriorly and a large median V-shaped incision on posterior margin, setae restricted to postero-lateral corners.

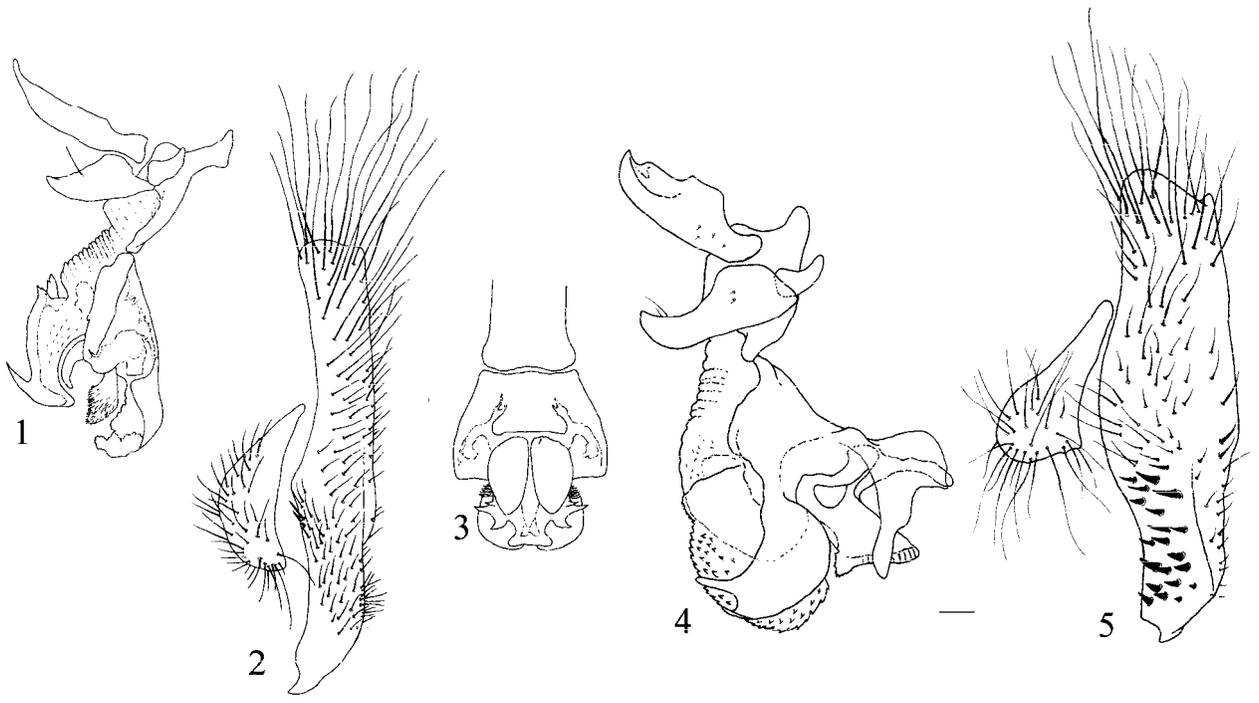
Length: 11.0 mm.

Etymology. - Composed from the Thai: *krathon* = spittoon, the vernacular name for *Sapria* spp. alluding to the shape of the flowers, and *mai* = new. The epithet, which should be treated as a noun in apposition, is the Thai version of *saprianovae* and as such has the same meaning.

Distribution. - Oriental Region - Malaysia, Thailand.

Biology. - See 'Biological Notes' below.

Taxonomic remarks. - *Sarcophaga krathonmai* belongs to subgenus *Boettcherisca* Rohdendorf (*peregrina* group of Hardy [1932] and Sugiyama &



Figs. 1-5. *Sarcophaga* spp., male terminalia. Figs. 1-3. *Sarcophaga saprianovae* Pape & Bänziger. 1. Phallus, gonopod and paramere [left lateral view]. 2. Cercus and surstylus [left lateral view]. 3. Distal part of phallus [dorsal view]. Figs. 4, 5. *Sarcophaga krathonmai* Pape & Bänziger. 4. Phallus, gonopod and paramere [left lateral view]. 5. Cercus and surstylus [left lateral view]. Scale bar 0.1 mm.

Kurahashi [1988]) and is morphologically very similar to *S. nathani* (Lopes) to which it keys out in the key provided by Kano & Sugiyama (1983). The most marked difference between these species is the golden abdominal microtomentum of *S. krathonmai* versus the entirely greyish colour of *S. nathani.* Such colour differences, however, may be considered inconclusive indicators of specific separation within the genus *Sarcophaga.* Some infraspecific variation occurs in Oriental populations of widespread species, e.g., *S. albiceps* Meigen, yet never to a degree comparable to *S. krathonmai* versus *S. nathani.* Moreover, small but consistent differences in the shape of the male cercus (see key below) provide further morphological evidence for treating *S. krathonmai* as a valid species. No differences, however, have been found in phallic morphology. It should be noted that *S. krathonmai* and *S. nathani* are fully sympatric (material of the latter in SMNH, MHNG and DEFACU) with no apparent intergrading of the diagnostic features. *Sarcophaga krathonmai* may thus be separated from *S. nathani* as follows:

Key to separate *Sarcophaga nathani* and *S. krathoumai*

1. **Both sexes:** Abdominal microtomentum entirely greyish-silvery-blackish [i.e., the 'typical' colour of the sarcophagine abdominal microtomentum]. **Male:** Cercus with posterior (dorsal) surface evenly curved and without any demarcated depression. .... *Sarcophaga nathani* (Lopes)
- **Both sexes:** Abdominal microtomentum extensively yellowish or golden yellow, especially on T4-T5. Almost greyish-silvery at base of abdomen. **Male:** Cercus with posterior (dorsal) surface showing a shallow trough-like depression extending for most of its length and sometimes extending onto the cercal base. .....*Sarcophaga krathonmai* Pape & Bänziger

Biological Notes. - Females, and less frequently males, of *S. krathonmai* and *S. saprianovae* fed from rotting liver and fresh human faeces. Females larviposited on liver but never on faeces, even if gravid, though larvae could be readily reared also on faeces to healthy adults of the same size.

Besides the two new species described above, eleven further *Sarcophaga* species were found on or near *Sapria ram* at the three study sites (Table 1). While all 13 species are potential pollinators, only 6 species have so far been seen acquiring pollen from *Sapria ram*, viz. *S. albiceps* Meigen, *S. nathani* (Lopes), *S. notabilis* (Kano & Lopes) [not previously recorded from Thailand], *S. yunnanensis* Fan, and two not yet identifiable species in the female sex. *Sarcophaga krathonmai, S. saprianovae,* and *S. multivillosa* Shinonaga & Tumrasvin are, to conclude from their behavioural patterns, virtually certain pollinators but definitive proof has to wait for the conclusion of the ongoing ecological study of the complex pollination syndrome (Bänziger, in prep.).

Table 1. Species of *Sarcophaga* captured on or near *Sapria ram* in Thailand. Species marked with an asterisk represent first records for Thailand. [Voucher specimens provisionally in the research collection of HB.]

Sarcophaga albiceps Meigen, 1826
Sarcophaga antilope Böttcher, 1913 or *S. inextricata* Walker, 1859 [females only]
Sarcophaga krathonmai Pape & Bänziger *
Sarcophaga multivillosa (Shinonaga & Tumrasvin, 1979)
Sarcophaga nathani (Lopes, 1961)
Sarcophaga notabilis (Kano & Lopes, 1969) *
Sarcophaga pattoni Senior-White, 1924
Sarcophaga saprianovae Pape & Bänziger *
Sarcophaga seniorwhitei Ho, 1938
Sarcophaga serrata Ho, 1938
Sarcophaga yunnanensis (Fan, 1964)
Sarcophaga sp. "4" & *Sarcophaga* sp. "43" [unidentified females, probably different from the species above]

Both sexes were obviously attracted to *Sapria ram* by the flower's odour reminiscent of rotten meat. However, males never pollinated the flower and only very occasionally flew onto it but used its vicinity as a *rendez-vous* site for mating. Females generally settled on the flower and entered, or attempted to enter, the flower's recess where the sexual organs are concealed.

Pollination by Sarcophagidae is new for rafflesias (i.e. *Rafflesia, Rhizanthes, Sapria,* tribe Rafflesiae) which otherwise were known to be pollinated only by Calliphoridae (Beaman et al., 1988; Bänziger, 1991, 1996). Some species of rafflesias may not exclusively, but only overwhelmingly be pollinated by exponents of one or the other fly family but it is intriguing that these deceptive flowers have developed seductive powers apparently capable of discriminating between Sarcophagidae and Calliphoridae.

Tropical pollination studies including carrion flies are often constrained by the current lack of reliable means for the identification of female pollinators. This is

especially pertinent to the Sarcophagidae, where females of *Sarcophaga* (s.l.) are notoriously difficult to separate. To facilitate the separation of females of what is here informally called the 'yellow-abdomen' assemblage of *Sarcophaga*, i.e., the two new species and the two very similar species *S. multivillosa* and *S. notabilis*, we have provided a list of diagnostic features combined with a matrix showing their distribution in these four species (Table 2). This presentation is considered the best interim solution and as such superior to a more traditional, and in any case very preliminary key. More species are most likely involved in the pollination of *S. ram*, and a larger material of pollinators is needed to refine the circumscriptions of features through studies of infraspecific variation.

Table 2. Character matrix and list of characters to separate females of the 'yellow-abdomen' assemblage of *Sarcophaga* captured on or near *Sapria ram* in Thailand.

characters	1	2	3	4	5	6	7	8	9	10	11
S. krathonmai	0	0	0	-	0	0	0	1	1	1	0
S. multivillosa	1	0	1	0	1	1	0	1	0	0	0
S. notabilis	1	0	1	0	0	1	0	1	1	1	1
S. saprianovae	0	1	1	1	1	1	1	1	0	1	0

CHARACTERS

1 - Head with fronto-orbital and parafacial plates silvery grey (occasionally with weak yellowish tinge in *saprianovae* but never in *krathonmai*) (0)
- Head with fronto-orbital and parafacial plates yellowish or golden (1)

2 - Fronto-orbital plate, apart from frontal bristles, with a single row of short setae close to eye-margin and continuing onto parafacial platae (0)
- Fronto-orbital plate, apart from frontal bristles, with scattered short setae (1)

3 - Genal setae all black, at most 1-3 white setae in postero-dorsal part (0)
- Several white setae in posterior part of gena, not restricted to postero-dorsal part (1)

4 - Gena with white setae in posterior third, white setae extending anteriorly to lowermost level of eye (0)
- Gena with white setae in posterior half, white setae reaching anteriorly almost to level of lowermost parafacial seta (1)

5 - Occiput with two irregular rows of black setae below (behind) the row of postocular setae (0)
- Occiput with three irregular rows of black setae below (behind) the row of postocular setae (1)

6 - Depressed part of proepimeron usually setose in a restricted, central area (0)
- Depressed part of proepimeron setose almost on entire surface (1)

7 - Median marginal bristles of T5 situated at a distance of at most 2.0x one socket diameter from the margin proper (0)
- Median marginal bristles of T5 situated at a distance of at least 2.0x one socket diameter from the margin proper (1)

8 - Microtomentum of abdominal T3-5 silvery or greyish (0)
- Microtomentum of abdominal T3-5 distinctly yellowish or golden (1)

9 - Female T5-T6 densely setose posterior to marginal row of bristles; with more than twice as many hairlike setae as marginal bristles (0)
- Female T5-T6 with only scattered hair-like setae posterior to marginal row of bristles, almost the same number of hair-like setae as marginal bristles (1)

10 - Female terminalia with black ground colour (0)
- Female terminalia with brownish or orangish ground colour (1)

11 - Female ST 7 anteriorly with at most a shallow median furrow, and disc on either side very slightly domed (0)
- Female ST 7 with a pair of almost knob- or button-like convexities, raised medially so as to form a distinct median groove (1)

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