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First record of the psyllid *Crucianus latipennis* in South America, with information on biology and distribution (Hemiptera, Sternorrhyncha, Psylloidea)

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Abstract. – The psyllid *Crucianus latipennis* Burckhardt & Lauterer, 1989, is recorded from South America for the first time. Adults and immatures have been collected in three localities in French Guiana on *Spondias dulcis* (Anacardiaceae) on which the immatures induce leaf-roll galls and maybe other deformations of leaves on young shoots. Initially known from Peninsular Malaysia only, we report also the presence of *C. latipennis* in Sarawak, Thailand and Vietnam. This is the first discovery of *Crucianus* in the Neotropics. Previously, this genus was known from South-East Asia only. The hitherto unknown fifth immature stage is described, and elements of biology are discussed together with potential risks on *S. dulcis* fruit production.

Résumé. – **Première mention du psylle *Crucianus latipennis* en Amérique du Sud, avec des informations sur la biologie et la répartition (Hemiptera, Sternorrhyncha, Psylloidea)**. Le psylle *Crucianus latipennis* Burckhardt & Lauterer, 1989, est signalé d'Amérique du Sud pour la première fois. Adultes et immatures ont été collectés dans trois localités de Guyane Française sur *Spondias dulcis* (Anacardiaceae) sur lequel les immatures induisent un enroulement des bords de feuilles et peut-être d'autres déformations des feuilles des jeunes pousses. Connu jusqu'à présent seulement de Malaisie péninsulaire, nous signalons également la présence de *C. latipennis* au Sarawak, en Thaïlande et au Vietnam. Il s'agit de la première découverte de *Crucianus* dans la région néotropicale. Auparavant, ce genre n'était connu que d'Asie du Sud-Est. La forme immature de cinquième stade, jusqu'alors inconnue, est décrite, et des éléments de biologie sont discutés, ainsi que les éventuels risques sur la production de fruits de *S. dulcis*.

Keywords. – Immature, description, French Guiana, Malesia, *Spondias dulcis*, galls.

Jumping plant lice or psyllids, a superfamily of Sternorrhyncha, are characterised by their generally very narrow host ranges (Hollis, 2004; Hodkinson, 2009; Burckhardt *et al*., 2014a; Ouvrard *et al*., 2015). Several species are agricultural, horticultural or forestry pests (Burckhardt, 1994) of which a considerable number is adventive. A recent study of the psyllid fauna of Florida (U.S.A.) showed that only about two thirds of the known species are native to this state (Halbert & Burckhardt, 2020). It is likely that, at least in part, psyllids are inadvertently introduced into new areas along with their hosts but details are generally unknown. In some cases, even the origin of the psyllid is obscure as in *Ctenarytaina peregrina* Hodkinson, 2007, or *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014, two species described from Europe and associated with eucalypts but unknown from Australia from where they originate in all likelihood (Hodkinson, 2007; Burckhardt *et al.*, 2014b).

Recently, trees of *Spondias dulcis* Parkinson (Anacardiaceae) displaying conspicuously distorted and stunted leaves associated with psyllids, were discovered in French Guiana (fig. 1-3). The psyllid was identified as *Crucianus latipennis* Burckhardt & Lauterer, 1989 (fig. 4-5, 24-26),

Fig. 1-3. – Deformed leaves of *Spondias dulcis*. – **1**, Leaf roll galls induced by *Crucianus latipennis* Burckhardt & Lauterer. – **2-3**, Shoots with densely curled leaves possibly induced by pathogen transmitted by *C. latipennis*.

a species known only from the type series consisting of adults which were collected in Malaysia (Selangor) on sugar cane, an unlikely host. The genus *Crucianus* is a member of the subfamily Rhinocolinae and includes another two species from Borneo and one species each from Sulawesi and Seram. Apart from the host of the two species from Borneo, viz. *Pentaspadon motleyi* Hook.f. (Anacardiaceae), virtually nothing is known on the biology of *Crucianus* species (BURCKHARDT & LAUTERER, 1989).

Spondias is a genus of the family Anacardiaceae, comprising 12 species (accepted names) distributed across tropical regions (WFO, 2020). *Spondias dulcis*, known under many different local names, is widely cultivated as fruit tree and is used in traditional medicine for the treatment of many diseases in Southeast Asia, India and Sri Lanka, but also in Central America and Northern

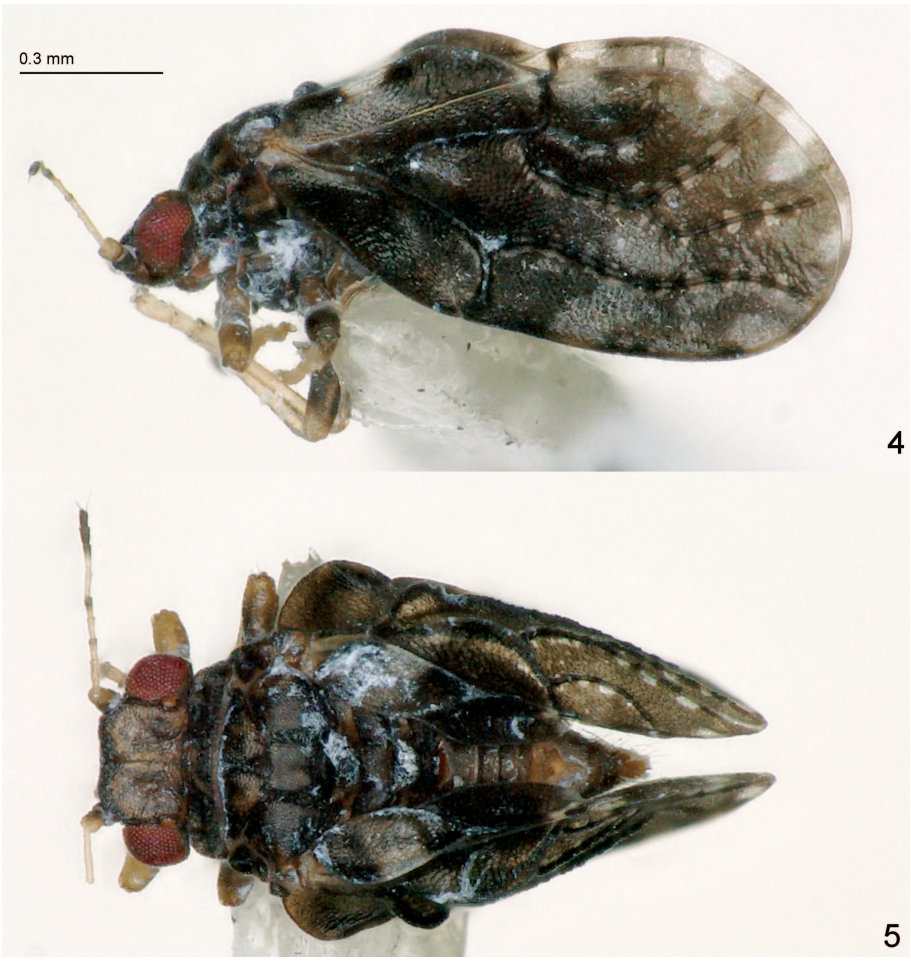

Fig. 4-5. – *Crucianus latipennis* Burckhardt & Lauterer, habitus. – **4**, Lateral view. – **5**, Dorsal view. Scale: fig. 5 same as fig. 4.

South America. The species probably originates from Polynesia (Mitchell & Daly, 2015). *Spondias* plants possess a wide range of properties such as antioxidant, ulcer protective, hepatoprotective, photoprotective, anti-inflammatory, antiarthritic, antidementia, antipyretic, analgesic, thrombolytic, hypoglycemic, antifertility, antihypertensive, antimicrobial and anthelmintic (Sameh *et al*., 2018). Islam *et al*. (2013) observed a strong antimicrobial activity of *S. dulcis* fruit against *Escherichia coli* and *Pseudomonas aeruginosa*. In Bangladesh, *S. dulcis* fruits are utilized to increase eyesight and to prevent eye infections (Rahmatullah *et al*., 2009).

Here we describe the previously unknown immatures of *C. latipennis*, provide a diagnosis for adults and immatures, list distributional data with new country records and report information on host and biology for the first time.

Material and methods

Adults, immatures and eggs have been collected in 2020, in three localities (Matoury, Iracoubo, and Montsinéry-Tonnégrande) in French Guiana on *Spondias dulcis* (Anacardiaceae). This material was sent to the Naturhistorisches Museum, Basel, Switzerland, where it was examined

and identified. Field observations, biology and plant damage also were observed at these three places. Specimens are preserved dry mounted on card points, slide mounted or preserved in 70% ethanol.

Material was examined from the following institutions: **FSCA**, Florida State Collection of Arthropods, Gainesville, FL, U.S.A.; **MHNG**, Muséum d'histoire naturelle, Genève, Switzerland; **NHMB**, Naturhistorisches Museum, Basel, Switzerland. Morphological terminology follows mostly Halbert & Burckhardt (2020).

Results

Crucianus latipennis Burckhardt & Lauterer, 1989

Crucianus latipennis Burckhardt & Lauterer, 1989: 688.

Material examined. – **French Guiana**. 8 ♂, 14 ♀, 61 immatures, Matoury, Rochambeau, 4.8353°N 52.3497°W, 10 m, 14.VIII.2020, *Spondias dulcis*, garden (*C. Gourmel*) (NHMB, 3 ♂, 4 ♀, dry and 1 ♂, 1 ♀, 8 immatures slide mounted, 4 ♂, 9 ♀, 53 immatures in 70% ethanol); 3 ♂, 5 ♀, 11 immatures, Iracoubo, Rococoua, 5.4579°N 53.3001°W, 10 m, 21.VII.2020, *Spondias dulcis*, plantation (*L. Demade-Pellorce*) (NHMB, in 70% ethanol). – **Malaysia**. 1 ♀, Sarawak, Santubong, 32 km N Kuching, 1.7473°N 110.3133°E, 0–50 m, 28–29.V.1994, along edge of secondary lowland forest (*I. Löbl & D. Burckhardt*) #13b(-) (MHNG, dry mounted); 1 ♂, 1 ♀ paratypes of *Crucianus latipennis*, Selangor, Setapak, 27.XII.1967, on stem of *Saccharum officinarum* (*Department of Agriculture*) C.I.E. A2210:20119 (MHNG, slide mounted). – **Thailand**. 1 ♀, Chiang Rai Province, Mae Sai District, near Phayanak Cave, 20.3714°N 99.8722°E, 460 m, 18.XII.2003 (*P. Schwendiger*) #21 (MHNG, dry mounted). – **Vietnam**. 3 ♀, Tiền Giang, 3.VI.1997, *Spondias cytherea* (= *Spondias dulcis*) (*R. & T. Đ. Nguyễn*) (FSCA, in 70% ethanol).

A few adults and immatures of *Crucianus latipennis* were also found on a single tree of *Spondias dulcis* in the municipality of Montsinéry-Tonnégrande (French Guiana) on 14.X.2020 (*C. Gourmel leg.*). The tree was heavily affected and displayed the characteristic leaf deformations.

Diagnosis. – *Adults*. Head (fig. 6) rounded anteriorly, lacking genal processes; coronal suture almost fully developed, reduced only at base. Antennal segment 10 (fig. 7) bearing one terminal seta shorter and one longer than its length.

Propleurites (fig. 8) with episternum smaller than epimeron. Process on trochanteral cavity of metacoxa (fig. 9) weakly sclerotised, long, tubular. Metatibiae with an open crown of 8 or 9 sclerotised apical spurs.

Forewings (fig. 10) 1.7–1.8 times as long as wide, dark brown or black with a few light spots; vein Cu shorter than Cu_{1b}; vein A raised, forming wing-like lobe; surface spinules (fig. 12), bold, covering cells up to veins, forming irregular transverse rows or cells. Hindwings (fig. 11) almost as long as forewings; costal margin lacking setae proximal to costal break, distal to costal break setae grouped, 2 proximally and 2–3 distally; bases of veins M and Cu indistinct. Male terminalia (fig. 13) with one-segmented proctiger; subgenital plate slightly elongate.

Parameres (fig. 16) triangular, in profile, bearing long setae along fore margin and an irregular, oblique row on the inner face. Distal segment of aedeagus (fig. 17) with apical hook and membranous dorsal dilation; sclerotised end tube of ductus ejaculatorius long, straight, situated in apical third of segment.

Female terminalia (fig. 14) cuneate, in profile; proctiger blunt apically, with long setae not arranged in distinct pattern; subgenital plate pointed apically; circumanal ring cruciform. Valvula dorsalis (fig. 15) cuneate, dorsal margin in apical half serrate.

Fifth instar immature. Antennae 7-segmented. Legs 4-segmented (fig. 18); claws developed, tarsal arolium oval (fig. 21).

Forewing pads lacking humeral lobe, with slender, pointed or blunt lanceolate setae in variable numbers at or near margins (fig. 22).

Anus ventral. Outer circumanal ring (fig. 20) transverse, slightly bent anteriad laterally; consisting of a single row of pores; extra pore fields present as each a curved band laterally on either side of circumanal ring.

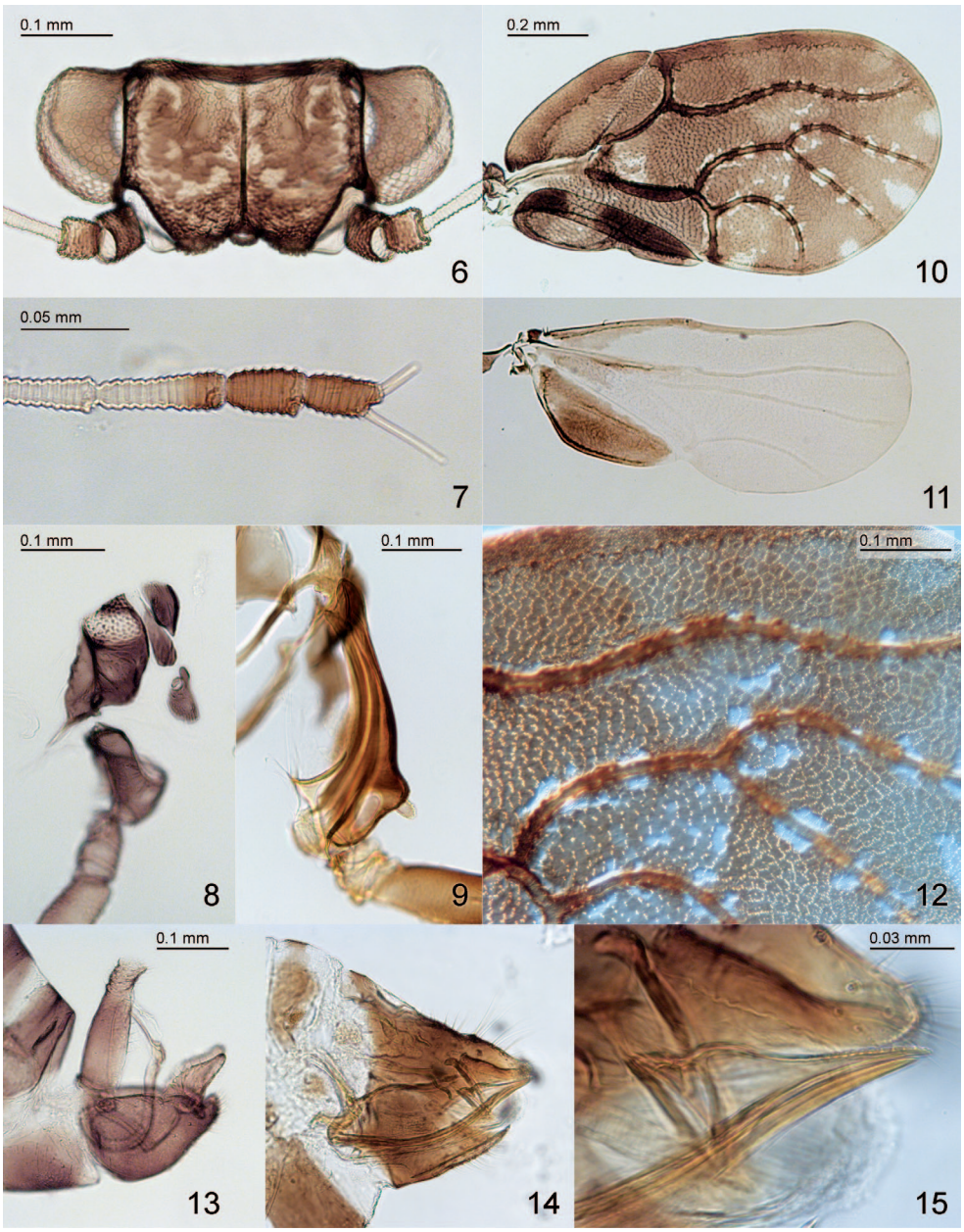

Fig. 6-15. – *Crucianus latipennis* Burckhardt & Lauterer, adult. – **6**, Head, dorsal view. – **7**, Antennal segments 8–10. – **8**, Propleurites, procoxa and trochanter, left cephalad. – **9**, Metacoxa. – **10**, Forewing. – **11**, Hindwing. – **12**, Detail of forewing showing distribution of surface spinules. – **13**, Male terminalia, in profile. – **14**, Female terminalia, in profile. – **15**, dorsal and ventral valvulae, in profile. Scales: fig. 11 same as fig. 10; fig. 14 same as fig. 13.

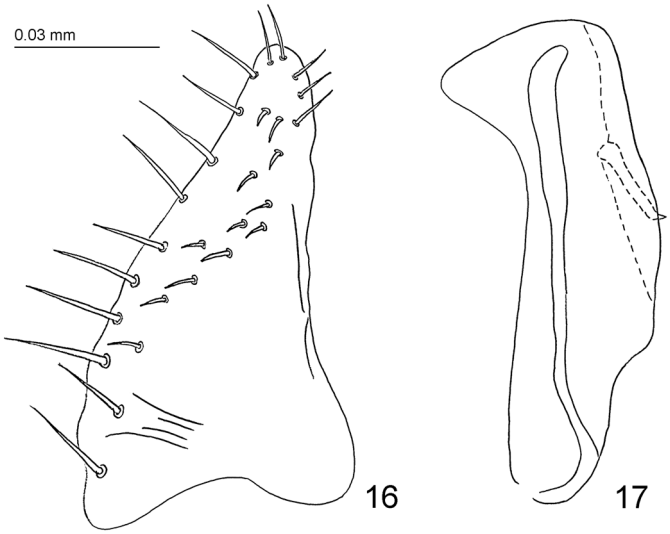

Fig. 16-17. – *Crucianus latipennis* Burckhardt & Lauterer, details of male terminalia. – **16**, Paramere, inner face, in profile. – **17**, Distal portion of aedeagus, in profile. Scale: fig. 17 same as fig. 16.

Description. – Adults were described and illustrated by BURCKHARDT & LAUTERER (1989).

Fifth instar immature (fig. 18, 25). *Colour*. White to yellowish. Eyes dark red. The two apical thirds of the ultimate antennal segment and tip of rostrum dark brown to almost black. Bacteriome dark yellow or orange.

Structure. Body elongate, 1.3–1.5 times as long as wide; weakly sclerotised, dorsal surface sparsely beset with moderately long, simple setae.

Head with following numbers of slender, pointed or blunt lanceolate setae (one side only): anterior setae 0 or 1 (rarely 2), ocular seta 1, postocular setae 1 (rarely 2). Antennae 7-segmented; 0.9–1.1 times as long as forewing pads; beset with a few short setae, bearing two thick uneven terminal setae; with a subapical rhinarium on each of segments 3 and 5 and two rhinaria on segment 7.

Thoracic tergites small. Legs clothed in a few moderately long setae; apical tarsal segment differentiated, i.e. leg consisting of four segments; tarsus bearing two long, apically curved setae, two fully developed, equally sized claws and a rounded arolium that is just slightly longer than claws (fig. 21).

Forewing pads lacking humeral lobe, strongly curved in basal third laterally, broadly rounded apically; fore and hindwing pads with slender, pointed or blunt lanceolate setae in variable numbers at or near margins (fig. 22) and 2 or 3 dorsally.

Abdominal tergites with slender lanceolate, mostly truncate setae sparsely dorsally, more numerously laterally (fig. 19, 23). Caudal plate (fig. 19, 20) 1.4–1.6 times as wide as long, irregularly rounded caudally. Anus ventral. Outer circumanal ring (fig. 20) transverse, slightly bent anteriad laterally, 0.4–0.6 times as wide as caudal plate; consisting of a single row of pores; extra pore fields present as each a curved band laterally on either side of circumanal ring.

Measurements (8 immatures, in mm). Body length 0.96–1.20; antenna length 0.34–0.42; forewing pad length 0.38–0.46; caudal plate width 0.38–0.48.

Egg (fig. 24). Colour mostly yellow, apex orange. Oblong oval, lacking apical filament.

Host plant. – *Spondias dulcis* Parkinson (Anacardiaceae).

Biology. – Immatures of *C. latipennis* develop in small colonies on *S. dulcis* on the abaxial leaf surface (fig. 27) or in open or closed twisted leaf roll galls (fig. 25, 28-30). They are sparsely covered in wax threads when exposed (fig. 25, 27, 28) though the galls can be filled with large amounts of wax and honeydew (fig. 29). Adults and different instars of immatures can be found at the same time, suggesting that the species is polyvoltine with overlapping

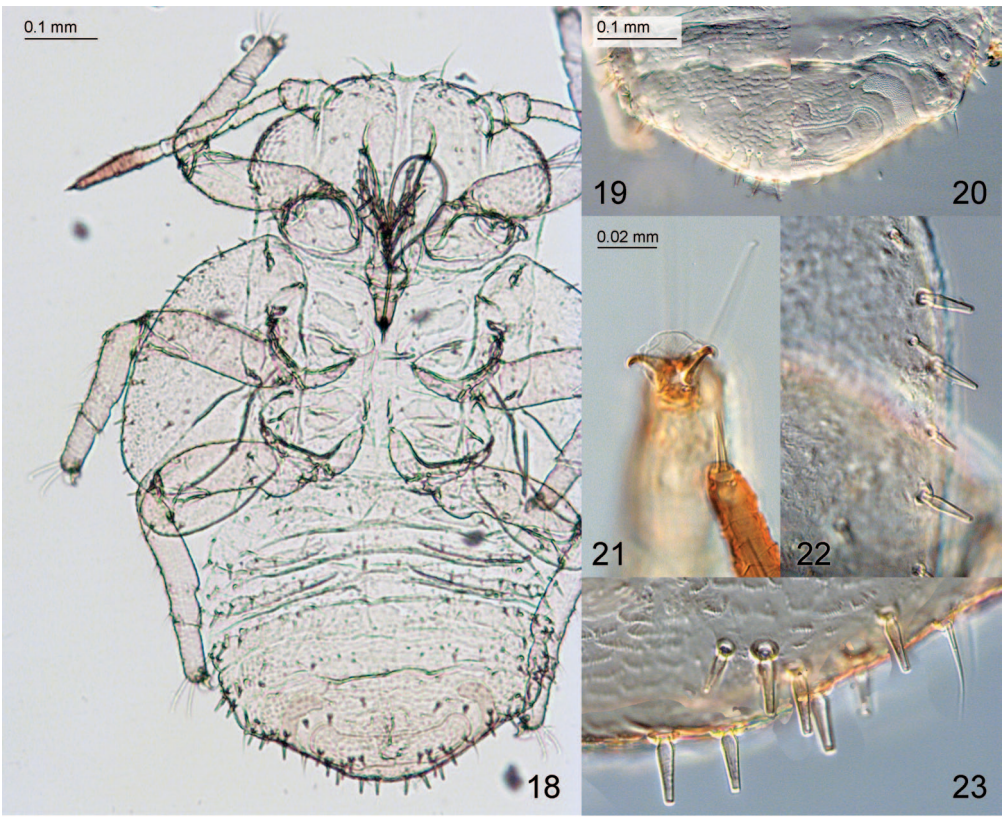

Fig. 18-23. – *Crucianus latipennis* Burckhardt & Lauterer, fifth instar immature. – **18**, Habitus, dorsal view. – **19**, Caudal plate, dorsal view. – **20**, Caudal plate, ventral view. – **21**, Apex of tarsus with claws and arolium. – **22**, Detail of forewing pad with marginal lanceolate setae. – **23**, Detail of caudal plate near apex with marginal lanceolate setae. Scales: fig. 20 same as fig. 19; fig. 22-23 same as fig. 21.

generations. On the same plants, also the polyphagous scale *Rastrococcus invadens* Williams, 1986 (Pseudococcidae), is present, often mixed with *C. latipennis* (fig. 31). This scale, native to Asia, became invasive in Africa in the 1980s and was detected in French Guiana in 2014 (Germain *et al.*, 2015). The trees colonised by the psyllids and scales are in poor condition with some yellowish, dry or dead branches, though they still produce fruits. The most impressive symptoms are stunted shoots with densely curled leaves (fig. 2-3).

Distribution. – Recorded from Malaysia (Selangor) (Burckhardt & Lauterer, 1989). New for French Guiana, Malaysia (Sarawak), Thailand and Vietnam.

Discussion and conclusions

Sapindales is among the most important orders of psyllid hosts. Four of its nine constituent families rank among the 10 host families with the largest number of associated psyllid genera, i.e. Anacardiaceae and Rutaceae each with 16, Sapindaceae with 13 and Meliaceae with 12 genera. Additional psyllid genera are associated with Burseraceae, Nitrariaceae and Simaroubaceae. None of these taxa ranks among the 30 most species-rich plant families (Ouvrard *et al*., 2015). Confirmed host plants (as defined by Burckhardt *et al*., 2014a) from the Sapindales occur in six of the seven families of Psylloidea currently recognised (Burckhardt *et al*., 2021) and are particularly well represented in the Calophyinae (Calophyidae) and Rhinocolinae (Aphalaridae),

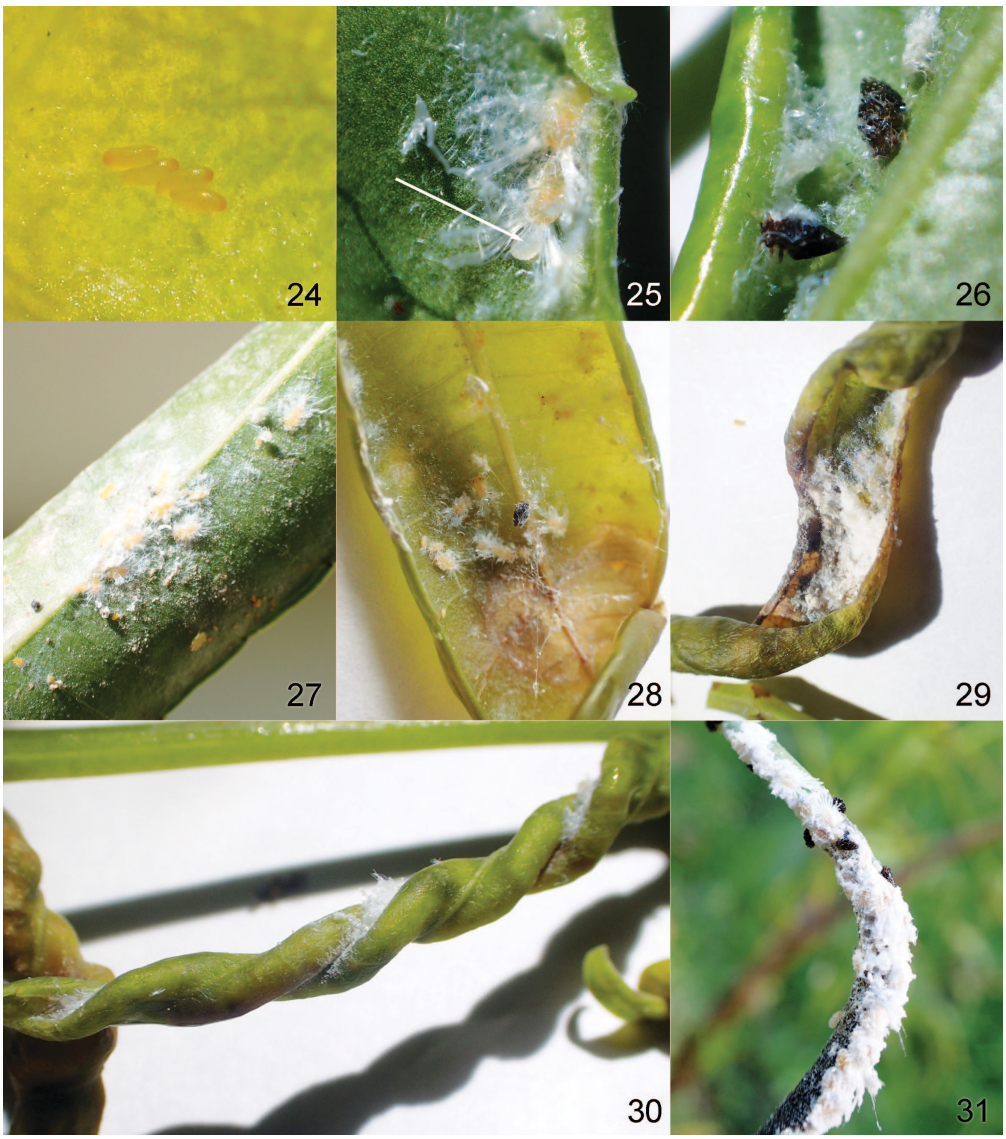

Fig. 24-31. – **24-26**, Habitus of *Crucianus latipennis* Burckhardt & Lauterer: **24**, eggs; **25**, immatures with waxy secretions and droplet of honeydew (arrow); **26**, adults. – **27-31**, Galls on *Spondias dulcis*: **27**, leaf with colony of immatures of *C. latipennis* with secretions of honeydew and wax; **28-29**, opened galls induced by *C. latipennis*; **30**, closed gall induced by *C. latipennis*; **31**, colony of *Rastrococcus invadens* densely covered in waxy secretions with a few adults of *C. latipennis*.

but also Phacopteroninae (Aphalaridae). The Rhinocolinae have a worldwide distribution with almost 60 described species in 15 genera (BURCKHARDT & LAUTERER, 1989; BURCKHARDT & BASSET, 2000; OUVRARD, 2020). Apart from *Anomalopsylla insignita* Tuthill, 1952, developing on *Olearia spp*. (Asterales, Asteraceae) and the three *Lisronia* species on *Cistus spp*. (Malvales, Cistaceae), the members of Rhinocolinae are associated with Sapindales, as far as host plants are known. The species are usually monophagous or narrowly oligophagous. Within this context, the host association of *C. latipennis* with Anacardiaceae is not surprising.

The only other known associations between psyllids and *Spondias* trees reflect evolutionary independent host-plant relationships: *Calophya spondiadis* Burckhardt & Mendez *in* Mendez *et al*. (2016), and *Calophya spondiasae* (Crawford, 1915), both members of the family Calophyidae although phylogenetically distant, on *Spondias purpurea* L. and *Spondias pinnata* (L. f.) Kurz respectively (Mendez *et al.*, 2016).

The cultivation of *S. dulcis* fruits in French Guiana covered 80 hectares and produced 950 tons/year in 2018 (DAAF, 2019). The largest orchard sampled during this study counts 5000 *Spondias* trees, with a total surface of 7 hectares, with a few other plants between rows [mostly *Citrus*, but also some papaya trees, sugar cane, sweet potato, pitayas (*Hylocereus spp*.) and parepou palm trees (*Bactris gasipaes* Kunth)]. All *S. dulcis* trees in this orchard show more or less severe leave deformations. It is noteworthy that the most common *S. dulcis* variety planted in French Guiana is by far the dwarf variety, on which all psyllids were collected.

With the scarce information on the biology available, it is difficult to predict if *C. latipennis* is capable of colonising native *Spondias* species in the New World. According to Weeks *et al*. (2014) and Mitchell & Daly (2015) within *Spondias*, *S. dulcis* belongs to a monophyletic Old World clade that is sister to a monophyletic group of New World species. Since *S. dulcis* is only distantly related, the colonisation of native American *Spondias* species by *C. latipennis* seems relatively unlikely. As *S. dulcis* originates from Oceania, we can assume that also *C. latipennis* comes from this region and has to be considered adventive in Malaysia, Thailand and Vietnam. The wide distribution of the species in Southeast Asia suggests that the species has the potential to become invasive in the Neotropics wherever the host occurs.

The stunted shoots with densely curled leaves observed on *S. dulcis* (fig. 2-3) in French Guiana are always associated with *C. latipennis* though the tissue deformation cannot be directly (visually) connected to *C. latipennis* populations. Many colonies of *R. invadens* were examined, in places where the former species was absent, and they all lacked the stunting and curling of the new leaves though often, they were associated with sooty mould (CG, pers. observation). This is consistent with what Agounké *et al*. (1988) observed, i.e. that *R. invadens* does not inject toxins nor cause deformations on the attacked plants and, therefore, does not transmit any pathogens. On the other hand, when *C. latipennis* is present, the deformations are present though the psyllids are not particularly numerous on the most affected tissues. White waxy secretions were observed on curled leaves, but in small amounts (CG, pers. observation). Molecular analyses will be necessary to examine whether pathogens, vectored by the psyllids, are responsible for the conspicuous deformations.

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