SYSTEMATICS, MORPHOLOGY AND PHYSIOLOGY

Weevils Injurious for Roots of Citrus in São Paulo State, Brazil

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Curculionídeos que Atacam as Raízes dos Citros no Estado de São Paulo

RESUMO - São registradas dez espécies de Entiminae, Naupactini que ocorrem em *Citrus* no estado de São Paulo, Brasil. A maioria das espécies pertence ao gênero *Naupactus* Dejean, sendo: *N. rivulosus* (Olivier), *N. tarsalis* Boheman, *N. curtus* Boheman, *N. navicularis* Boheman, *N. versatilis* Hustache, *N. ambiguus* Boheman, e *N. cervinus* Boheman; uma espécie do gênero *Teratopactus*, *T. nodicollis* (Boheman); uma do gênero *Parapantomorus*, *P. fluctuosus* (Boheman); e uma de *Symmathetes* (gênero revalidado), *Symmathetes kollari* Schoenherr. As larvas vivem no solo alimentando-se das raízes dos citros, causando danos mais importantes que os adultos que consomem as folhas das plantas. O objetivo deste trabalho é fornecer uma chave, com o diagnóstico e fotografias dos adultos, para sua identificação. Também são apresentadas informações sobre a distribuição geográfica das espécies, associação com outras plantas e discutidos aspectos relevantes da sua biologia, com ênfase à oviposição.

PALAVRAS-CHAVE: Curculionidae, Naupactini, besouro-da-raiz, identificação, dano radicular

ABSTRACT - Ten species of broad nosed weevils belonging to Entiminae, Naupactini, are recorded as harmful for roots of citrus in São Paulo state, Brazil. Most species belong to *Naupactus* Dejean, *N. rivulosus* (Olivier), *N. tarsalis* Boheman, *N. curtus* Boheman, *N. navicularis* Boheman, *N. versatilis* Hustache, *N. ambiguus* Boheman, and *N. cervinus* Boheman; one species was assigned to *Teratopactus* Heller, *T. nodicollis* (Boheman); one to *Parapantomorus*, *P. fluctuosus* Schoenherr (Boheman) and one to *Symmathetes* Schoenherr (a genus herein reinstated), *S. kollari* Schoenherr. Larvae live in soil and bore on roots of the trees, causing more damages than adults, that feed on leaves. The main goal of this paper is to provide a key, diagnosis and habitus photographs of the species, in order to facilitate their identification. We also provide information on their geographic range in Brazil and previous plant associations, and we discuss some relevant biological features, especially those related to oviposition habits.

KEY WORDS: Curculionidae, Naupactini, identification, root damage

Weevils injurious for roots of *Citrus* spp. have increased their occurrence and population densities during the past ten years in São Paulo state, Brazil. Due to the damage caused, some species could become primary insect pests in certain areas. This fact, associated to their scarce systematic knowledge, as well as the lack of biological and behavioral information, made difficult their control managment, being current practices expensive and not very effective.

Until present, we have identified ten species of broad-nosed weevils, attacking citrus in São Paulo. They belong to subfamily Entiminae, tribe Naupactini, and most of them have been assigned to *Naupactus* Dejean, a genus with more than 150 described species, distributed along the Neotropics, from Mexico to Argentina, being Brazil the country with the highest species diversity (Wibmer & O'Brien 1986). There are other species of Naupactini that occur in areas of citrus production in São Paulo, however, since their frequences and populations densities are low, they are not included in the present study. The most important damages are caused by the larvae, that live in soil and are root feeders. Adult specimens feed on leaves and other green parts of the plants. The major threat for production of citrus in São Paulo, is that species herein studied occur in natural forests of the area, being usually frequent and abundant, therefore migrations from native plants to citrus groves are expected to be a common behaviour.

The main goal of this contribution is to provide systematic and some biological information on the weevil species harmful for citrus in São Paulo, in order to facilitate their recognition, and to contribute to take more effective strategies of control and pest management.

Material and Methods

Samples were taken during years 2000 and 2001, from eight localities of São Paulo state, having extensive citrus cultivation: Analândia, Barretos, Boa Esperança do Sul, Casa Branca, Divinópolis, Pederneiras, Piracicaba e Itapetininga. Collections were done in groves of about 50 to 100 acres, in which 40 to 50 trees of *Citrus sinensis* (varieties Natal, Pera and Valência) were sampled.

Adults were collected by beating the treetops, and using cuadrate sheets of 4 m, extended under them, to get the specimens that fall down from foliage. Some adults were killed in alcohol 70% for future systematic studies, and others were kept alive for biological research under laboratory conditions at ESALQ/USP (Escola Superior de Agricultura Luiz de Queiroz) Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, Piracicaba, SP. Specimens for systematic studies were mounted, labeled, and housed as voucher specimens at the entomological collections of ESALQ and Museo de La Plata (Argentina).

Diagnoses and the key to species, are based on external morphological characters easy to recognize macroscopically or using an stereoscopic microscope (e.g. for features of vestiture). The only internal character that was taken into account is the distal part of the ovipositor, because it can be seen without dissecting the genitalia, at the end of the body.

Identifications of species were confirmed through comparisons with type material hold at Naturhistoriska Riksmuseet, Stockholm, Sweden. Specimens from the entomological collections of the Museu de Zoologia da Universidade de São Paulo (Brazil); Departamento de Zoologia da Universidade Federal do Paraná (Brazil), and Museo de La Plata (Argentina) were examined to obtain additional information on distribution of species.

For each species, habitous photographs (dorsal view), synonyms, geographic range (country records and state records within Brazil), plant associations and biological information related to oviposition, are provided.

Acronyms for Brazilian states cited in the text are as follows: BA, Bahia; GO, Goiás; ES, Espírito Santo; RJ, Rio de Janeiro; MG, Minas Gerais; MT, Mato Grosso; SP, São Paulo; PR, Paraná; SC, Santa Catarina; RS, Rio Grande do Sul.

Results and Discussion

Taxonomic Placement of Species. Among the species herein studied, seven belong to *Naupactus* Dejean, *N. rivulosus* (Olivier), *N. tarsalis* Boheman, *N. curtus* Boheman, *N. navicularis* Boheman, *N. versatilis* Hustache, *N. ambiguus* Boheman (new senior synonym of *Pantomorus postfasciatus* Hustache), and *N. cervinus* Boheman; one species was assigned to *Teratopactus*, *T. nodicollis* (Boheman); one to *Parapantomorus*, *P. fluctuosus* (Boheman); and one to *Symmathetes*, *S. kollari* Schoenherr.

In the present paper *Naupactus* is considered in a broad sense, this is, including some species that in the literature are often named after *Pantomorus* Schoenherr. In a restrictive sense, *Naupactus* includes large species (more than 15 mm long), having well developed humeri and metathoracic wings fully developed; and *Pantomorus* Schoenherr, small species (6 to 10 mm), lacking humeri and metathoracic wings. From a phylogenetic perspective these characters are not sufficient to separate genera, and consequently, in recent years several species of *Pantomorus* have been transferred to *Naupactus* or to other genera of Naupactini.

Key to Species of Broad-Nosed Weevils Harmful to Roots of Citrus in São Paulo State

1. Pronotum with one tubercle on the middle of each flank. Humeri with distinct tubercles. Funicular article 2, more than twice as long as article 1 (Fig. 1c). Three pairs of tibiae with a line of denticles on inner surface, those of fore tibiae, strong (Fig. 1f, g). Ovipositor with unguiculate, strongly sclerotized hemisternites and lacking styli (Fig. 3c). Oviposition of single eggs (Fig. 3k).....*Teratopactus nodicollis* (Boheman) (Fig. 2a).
1'. Pronotum and humeri lacking tubercles. Funicular article 2, twice as long as, to same length of article 1 (Fig. 1d). Fore tibiae with a line of denticles on inner surface, middle and hind tibiae lacking denticles. Ovipositor with moderately to slightly sclerotized hemisternites and having styli (Fig. 3d). Oviposition in clusters of eggs.....2

2. Species 15 mm to 23 mm long (large size). Humeri very prominent. Elytral base bisinuate. Metathoracic wings fully d eveloped.....3
2'. Species 6 mm to 13 mm long (medium to small size). Humeri reduced to absent. Elytral base straight. Metathoracic wings vestigial to absent.....4

3. Eyes strongly convex (Fig. 1b). Pronotum with curved anterior margin and a longitudinal median groove. Integument lacking scales, except a pattern of narrow squamose stripes, colour greenish, orange, yellowish or redish, on pronotal disc and elytra.....*Naupactus rivulosus* (Olivier) (Fig. 2b).
3'. Eyes moderately convex (Fig. 1a). Pronotum with straight anterior margin and lacking median groove. Integument usually lacking scales, except two broad squamose stripes along sides of pronotum and elytra, colour greenish iridescent, greenish with yellowish powder, or whitish.....
.....*Naupactus tarsalis* Boheman (Fig. 2c).

4. Pronotum globose, strongly convex dorsally (Fig 1j). Fore femora strongly robust, distinctly wider than middle and hind femora. Fore tibiae strongly curved inwards near distal end, with line of large denticles on inner surface (Fig. 1g).....*Naupactus curtus* Boheman (Fig. 2d).
4'. Pronotum subcylindrical, flat to slightly convex dorsally. Fore femora slightly wider than middle and hind femora. Fore tibiae slightly curved inwards near distal end, with medium sized to small denticles on inner surface.....5

5. Humeri moderately prominent. Vestiture sparse (black integument visible), with microscopic scales and setae, grey, pale-brown or greenish.....
.....*Naupactus versatilis* Hustache (Fig. 2e).
5'. Humeri reduced or absent. Vestiture composed of round scales and squamose setae..... 6

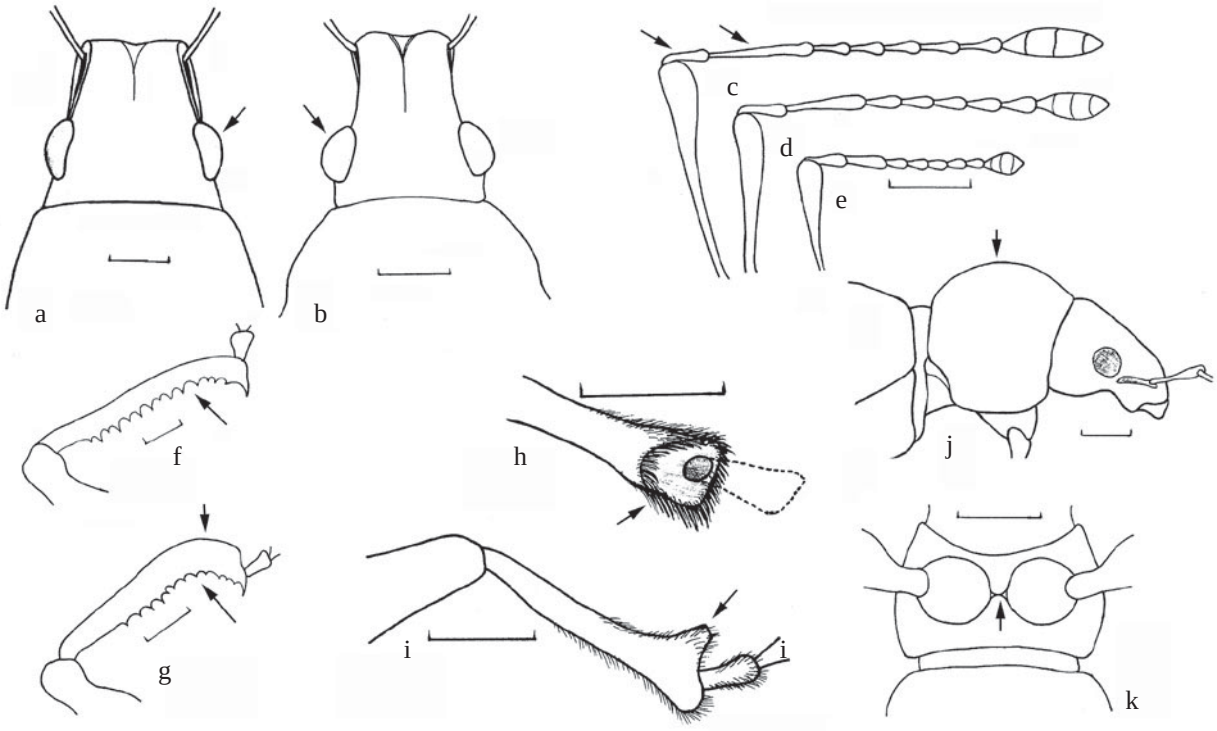

Figure 1. a) Eyes moderately convex, *N. nodicollis*; b) Eyes strongly convex, *N. rivulosus*; c) Antenna long, funicular article 2, more than twice as long as article 1, club fusiform, *T. rivulosus*; d) Antenna long, funicular article 2, about 1.5 x as long as article 1, club oval, *N. cervinus;* e) Antenna short, funicular article 2 and 1 about some length, club globose, *S. kollari*; f) Tibia with a line of strong denticles on inner surface, *T. nodicollis*; g) Tibia with a line of strong denticles on inner surface, and curved inwards near distal end, *N. curtus*; h) Corbel plate of hind tibia absent (= open); i) Distal end of hind tibia widened, *S. kollari*; j) Pronotum globose, very convex dorsally, *N. curtus*; k) Fore coxae separate, *P. fluctuosus*.

6. Species more than 10 mm long. Elytra slender, elongate, acute towards apex, with pair of small terminal tubercles. Antennae long, funicular article 2 about twice as long as article 1, club oval. Pronotum subcylindrical, about as long as wide.....*Naupactus navicularis* Boheman (Fig. 2f).
6'. Species less than 10 mm long. Elytra oval, lacking pair of terminal tubercles. Antennae medium length to short, funicular article 2 as long as, to 1.5x longer than article 1 (Fig. 1d). Pronotum subcylindrical, wider than long.....7

7. Hind tibiae with typical, widened, distal end; corbel plate very broad, squamose (Fig. 1i). Vestiture of polyhedrical smooth, contiguous scales. Antennae short, funicular article 2, about as long as article 1 (Fig. 1e).....
.....*Symmathetes kollari* Schoenherr (Fig. 2g).
7'. Distal end of hind tibiae without characters of the former species; corbel plates narrow to absent (Fig. 1h). Scales rounded, with microscopic striae, overlapped. Antennae medium length, funicular article 2, about 1.5x as long as article 1.....8

8. Fore coxae separate (Fig. 1k). Corbel plate of hind tibiae narrow. Vestiture pale-brown with pattern of white stripes, two longitudinal stripes on side of pronotal disc and three pairs of irregular, transversal stripes on elytra. Elytral setae recumbent.....*Parapantomorus fluctuosus* (Boheman) (Fig. 2h).
8'. Fore coxae joint together on midline of prosternum. Corbel plates absent (= open). Colour pattern different from that of former species. Elytral setae erect.....9

9. Pronotum strongly convex. Elytra globose. Vestiture pale-brown with transversal dark-brown stripes on posterior third of elytra; erect setae on whole elytral surface.....
.....*Naupactus ambiguus* Boheman (Fig. 3a).

10. Pronotum slightly convex. Elytra oval, somewhat depressed. Vestiture pale-brown, usually with oblique white stripes on elytral flanks; erect setae only present on elytral apex..... *Naupactus cervinus* Boheman (Fig. 3b).

Characterization of Species

***Teratopactus nodicollis* (Boheman, 1833)**
Naupactus nodicolis Boheman
Naupactus angulicollis Lucas
Naupactus paulanus Fonseca & Autuori
Naupactus serripes Boheman

Females 15 mm to 23 mm long (Fig. 2a). Integument mostly covered with grey to brownish scales, except elytral suture and flanks. One pair of white, diffuse, marginal stripes usually present from anterior margin of pronotum to apex of elytra. Antennae long, funicular article 2, about 3x as long as article 1, club fusiform. Pronotum with a tubercle

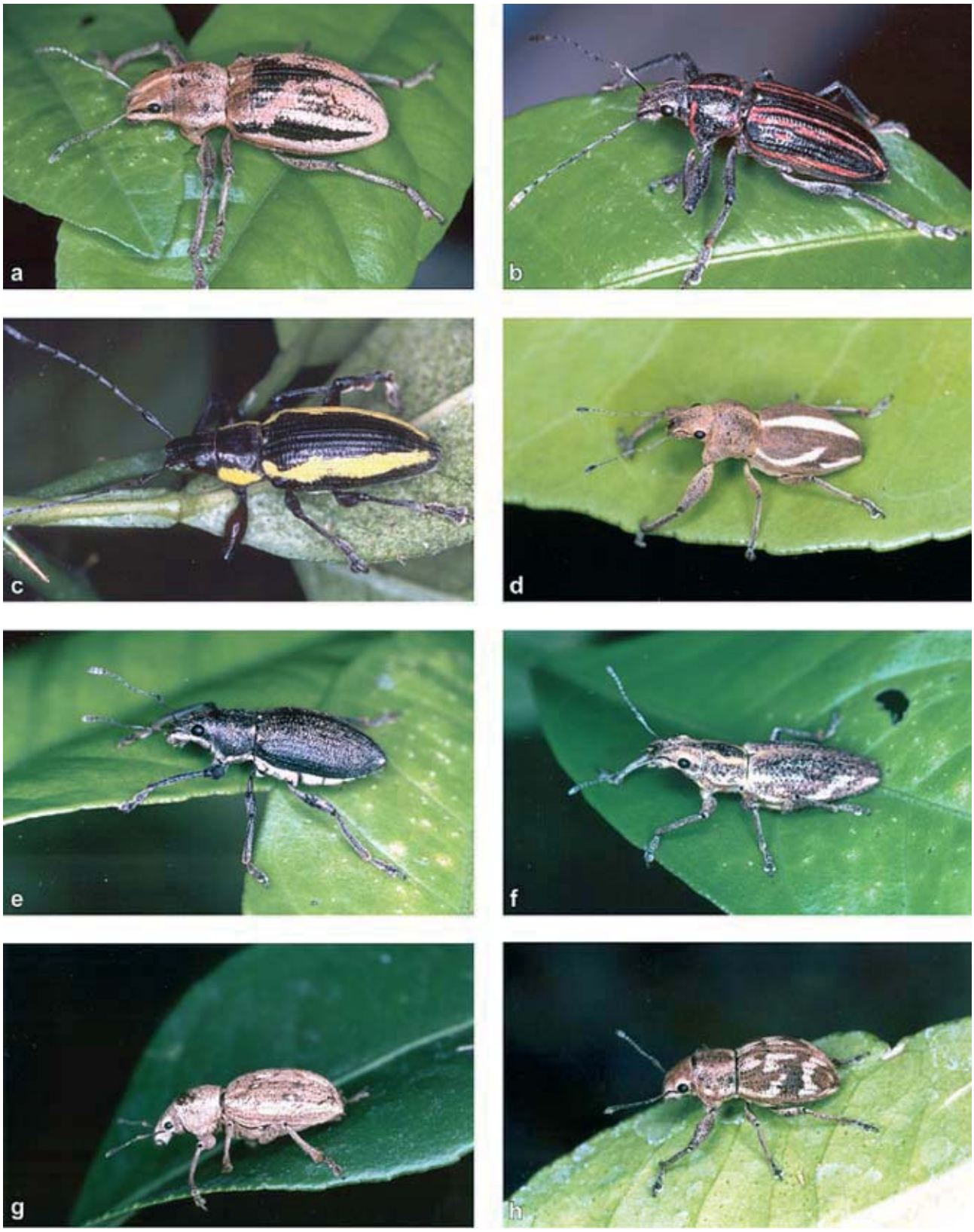

Figure 2. a) *Teratopactus nodicollis*; b) *Naupatcus rivulosus*; c) *N. tarsalis*; d) *N. curtus*; e) *N. versatilis*; f) *N. navicularis*; g) *Symmathetes kollari*; h) *Parapantomorus fluctuosus*.

Figure 3. a) *Naupactus ambiguus*; b) Lateral view, *N. cervinus*; c) Distal end of ovipositor, with unguiculate, strongly sclerotized hemisternites, and lacking styli, *Teratopactus nodicollis*; d) Distal end of ovipositor, with moderately sclerotized hemisternites and having styli, *Naupactus* spp.; e) Larva, *N. cervinus*; f) Pupa, *N. cervinus*; g-h) Damage on roots of *Citrus* spp.; i-j) Damage on leaves of *Citrus sinensis*; k) Oviposition of single eggs, *T. nodicollis*; l) Oviposition underneath calix of fruit, *N. cervinus*; m) Cluster of eggs, *Naupactus* spp.

on middle of each flank. Humeri prominent, with distinct tubercles. Metathoracic wings fully developed. Fore coxae separate. Three pairs of tibiae with line of denticles on inner surface, those of fore tibiae very strong. Corbel plate of hind tibiae absent (= open). Ovipositor with strongly sclerotized, unguiculate hemistenites, and lacking styli.

Males slightly smaller and more slender than females.

Taxonomic Note. *Teratopactus perpastus* (Boheman) and *T. tuberculatus sensu* Hustache, are probably synonyms of *T. nodicollis*.

Geographic Range. Brazil (MT, SP, PR), Argentina, Bolivia, Paraguay and Uruguay

Plant Associations. *Citrus* spp., *Zea mays*, *Vitis vinifera*, *Solanum tuberosum*, *Baccharis dracunculifolia*, *Panicum campestre*, *Paspalum plicatum* (Silva *et al*. 1968)

***Naupactus rivulosus* (Olivier 1790)**
Curculio rivulosus Olivier

Females 15 mm to 23 mm long. Integument lacking scales except narrow, squamose stripes, colour greenish, orange, yellowish or redish, on pronotal disc and elytra. The most common pattern is a longitudinal vitta on center of pronotum and two transversal stripes near its anterior and posterior margins; two longitudinal stripes on elytral interval 2 and 4, joint at elytral base, and two or more short stripes on intervals 5 and/ or 6. Eyes strongly convex. Antennae long, funicular article 2, about twice as long as article 1, club fusiform. Pronotum subtrapezoidal with curved flanks and a longitudinal groove at midline. Elytra navicular, base bisinuate, humeri very prominent. Metathoracic wings fully developed. Fore tibiae with line of small denticles on inner surface. Corbel plate of hind tibiae present (= close) broad.

Males slightly smaller and more slender than females (Fig. 1b).

Taxonomic Note. It is the type species of the genus *Naupactus*.

Geographic Range. Brazil (BA, GO, ES, RJ, MT, MG, SP, PR, RS), Argentina and Paraguay

Plant Associations. It has been found on cotton (*Gossypium hirsutum*), sweet potatoes (*Ipomaea batatas*), grapes (*Vitis vinifera*), *Hibiscus bifurcatus*, *Citrus* spp. and *Eucalyptus*, in Brazil (Silva *et al*. 1968); on *Citrus* sp. and *Hibiscus* sp., in Argentina (Bosq 1943).

Naupactus tarsalis* Boheman, *1840
Naupactus albidiventris Hustache
Naupactus glaucivittatus Blanchard

Females 15 mm to 18 uma espécie do gênero mm long (Fig. 2c). Integument usually lacking scales, except two broad squamose stripes along sides of pronotum and elytra, colour greenish iridescent, greenish with yellowish powder, or whitish. In some specimens, integument between stripes is not naked, but covered with pale minute scales and setae. Eyes moderately convex. Antennae long, funicular article 2, twice as long as article 1, club fusiform. Pronotum subtrapezoidal, with curved flanks. Elytra navicular, base bisinuate, humeri very prominent. Metathoracic wings fully developed. Fore tibiae with line of small denticles on inner surface. Corbel plate of hind tibiae almost obsolete.

Males slightly more slender than females.

Geographic Range. Brazil (GO, RJ, MG, MT, SP), Argentina, Bolivia and Paraguay

***Naupactus curtus* Boheman, 1833**
Naupactus unicolor Boheman

Females 10 mm to 12 mm long (Fig. 2d). Vestiture of brown scales, with one white stripe along elytral suture, extended on midline of pronotum, and a pair of oblique white stripes on elytral flanks. Eyes moderately convex. Antennae long, funicular article 2, about twice as long as article 1, club oval. Pronotum subcylindrical, strongly convex dorsally. Elytra oval, base straight, humeri absent. Metathoracic wing vestigial. Fore femora strongly widened; fore tibiae strongly curved inwards near distal end, with line of large denticles on inner surface. Corbel plate of hind tibiae present, narrow.

Males with pronotum more convex, elytra more slender and fore legs longer than in females.

Taxonomic Note. *Naupactus curtus* is closely related to *N. transversus* Boheman.

Geographic Range. Brazil (BA, SP, PR, SC)

***Naupactus versatilis* Hustache, 1947**
Naupactus imbellis Hustache

Females 10 mm to 13 mm long (Fig. 2e). Vestiture sparse (black integument visible), with microscopic scales and setae, grey, pale-brown or greenish. Eyes moderately convex. Antennae long, funicular article 2, about twice as long as article 1, club fusiform. Pronotum subcylindrical, distinctly wider than long. Elytra oval, base straight, humeri moderately prominent. Metathoracic wings vestigial. Fore tibiae with line of small denticles on inner surface. Corbel plate of hind tibiae absent.

Males smaller and more slender than females. Unknown for Brazilian populations.

Geographic Range. Brazil (SP), Argentina and Paraguay

***Naupactus navicularis* Boheman, 1840**

Females about 10 mm to13 mm long (Fig. 2f). Vestiture dense, with large rounded scales, mostly pinkish-brown; pronotum with pair of yellow stripes on disc; elytra with irregular pattern of diffuse, short, longitudinal stripes, white and yellow. Eyes strongly convex. Antennae long, funicular article 2, about twice as long as article 1, club oval. Pronotum subcylindrical about as long as wide. Elytra slender, elongate,

acute towards apex, with one pair of terminal small tubercles; base straight, humeri reduced. Metathoracic wings vestigial. Fore tibiae with line of small denticles on inner surface. Corbel plate of hind tibiae broad.

Males unknown.

Taxonomic Note. Based on its colour pattern, shape of elytra and presence of one pair of tubercles on its apex, *N. navicularis* resembles *N. xanthographus* (Germar).

Geographic Range. Brazil (RJ, MG, SP, PR) and Argentina

***Symmathetes kollari* Schoenherr, 1847**
Pantomorus kollari (Schoenherr)

Females 7.5 mm to 10 mm long (Fig. 2g). Vestiture dense, with typical polyhedrical scales, smooth, contiguous, cream, pale-brown and dark-brown, and a pattern of white, marginal stripes, from pronotum to apex of elytra. Eyes moderately convex. Antennae short, funicular articles 1 and 2 about same length, club globose. Pronotum sybcylindrical. Elytra oval, base straight, humeri absent. Metathoracic wings absent. Fore tibiae with line of small denticles on inner surface; hind tibiae with typical, widened, distal end; corbel plates present, very broad, squamose.

Males smaller and more slender than females.

Taxonomic Note. In catalogues and checklists, *S. kollari* has been usually assigned to *Pantomorus*. We consider that *Symmathetes* Schoenherr, 1847, is a valid genus, based on the diagnostic characters of vestiture, antennae and hind tibiae.

Geographic Range. Brazil (SP)

Plant Associations. A series of specimens at the Museu de Zoologia da Universidade de São Paulo were collected on citrus in São Paulo, Guatapará, in 1958.

***Parapantomorus fluctuosus* (Boheman, 1840)**
Naupactus fluctuosus Boheman
Pseudopantomorus sharpi Heller
Parapantomorus sharpi (Heller)

Females 7 mm to 9 mm long (Fig. 2h). Vestiture dense, with pale-brown scales and recumbent setae, and a pattern of white stripes (two longitudinal stripes on pronotal disc and three pairs of irregular, transversal stripes on elytral disc). Eyes strongly convex. Antennae medium length, funicular article 2, about 1.5x as long as article 1, club oval. Pronotum subcylindrical, with moderately curved flanks. Elytral oval, base straight, humeri absent. Metathoracic wings lacking. Fore tibiae with line of medium- sized denticles on inner margin. Corbel plate of hind tibiae narrow.

Males smaller and more slender than females, and less abundant than females in samples.

Taxonomic Note. *Parapantomorus* shares most characters with *Pantomorus*, except the presence of separate fore coxae.

Geographic Range. Brazil (GO, SP, MT), Argentina, Bolivia and Paraguay

***Naupactus ambiguus* Boheman, 1840**
Asynonychus postfasciatus Hustache
Pantomorus postfasciatus (Hustache)

Females 7 mm to 9 mm long (Fig. 3a). Vestiture dense, with round, imbricate scales and erect broad setae; colour mostly pale-brown with a dark-brown area on pronotal disc and near posterior third of elytra. Eyes strongly convex. Antennae medium length, funicular article 2, about 1.5x as long as article 1, club oval. Pronotum subcylindrical, globose (with strongly curved flanks). Elytral globose (short oval), base straight, humeri absent. Metathoracic wings lacking. Fore tibiae with line of medium- sized denticles on inner margin. Corbel plate of hind tibiae absent.

Males more slender than females and usually less abundant in samples.

Taxonomic Note. It is a "*Pantomorus* like" species. Hustache (1947) placed it in *Asynonychus*, along with *N. cervinus*, based on the absent of corbel plate of hind tibiae.

Geographic Range. Brazil (SP), Argentina, Paraguay and Uruguay

Plant Associations. *Citrus* spp. and alfalfa (*Medicago sativa*), in Argentina (Lanteri 1994)

***Naupactus cervinus* Boheman, 1840**
Pantomorus cervinus (Boheman)
Asynonychus godmanni Crotch
Pantomorus godmanni (Crotch)
Aramigus fulleri Horn
Naupactus simplex Pascoe
Pantomorus olindae Perkins
Strophomorphus canariensis Uyttenboogaart

Females 6 mm to 10 mm long (Fig. 3b). Vestiture moderately dense, with brown scales and erect, white setae, near elytral apex, and a pattern of oblique, white stripes on flanks of elytra. Eyes strongly convex. Antennae medium length, funicular article 2, about 1.5x as loong as article 1, club oval. Pronotum subcylindrical, with slightly curved flanks. Elytra oval, base straight, humeri absent. Metathoracic wings lacking. Fore tibiae with line of medium-sized denticles on inner margin. Corbel plate of hind tibiae absent.

Males smaller and more slender than females, only known for some argentinian populations (Misiones and Rio de La Plata forests) (Lanteri 1993). In areas where *N. cervinus* has been introduced, males are unknown, and females exhibit parthenogenetic reproduction (Lanteri & Normark 1995).

Taxonomic Note. It is a "*Pantomorus* like" species.

Geographic Range. Native to Brazil, Argentina, Bolivia, Paraguay and Uruguay. Introduced in Chile, Central America,

USA, Europe, Africa, Japan, Australia, New Zealand, Hawaii, Eastern Island. Within Brazil it has been recorded to the following states: MG, SP, PR, SC, RS

Plant Associations. In USA it is well known as "fuller's rose weevil" for its damages to ornamental plants in greenhouses. It is also harmful for several vegetable species, such as *Vicia faba*, *Ipomaea batatas, Pyrus communis*, *Prunus armeniaca*, *Ilex paraguariensis*, *Saccharum officinarum*, *Medicago sativa* and *Citrus* sp. (Lanteri 1994). On *Casearia silvestris* and *Eugenia uniflora* in Rio Grande do Sul, Brazil (Costa & Bogorni 1996).

Biological Aspects

Females start laying eggs about 5 to 15 days after emergence. In most species egg layings are batches or clusters of 10 to 50 eggs, in one or two layers, covered with an adhesive substance secreted during oviposition. This kind of egg laying has been described as number 9 by Howden (1995). Under laboratory conditions the number of eggs per posture is higher (90 eggs or more). Moreover, number of egg layings varies among species, and even within the same species, according to the body size of females, the extent of food consumption and the species of plants they eat (Marvaldi 1999).

Biological studies on several species of Naupactini *e.g*. *Naupactus leucoloma* Boheman, *N. peregrinus* (Buchanan), *N. xanthographus* (Germar), *N. cervinus* Boheman, *N. verecundus* Hustache, *N. ruizi* (Brethes), indicate that females lay clusters of eggs, and place them between adjoining surfaces of leaves, cracks in the soil, crevices, litter, and various niches near the soil (Junqueira 1957, Campos & Sazo 1983, Ripa 1983, Lanteri 1994, McCoy 1994, Lanteri *et al*. 1997, Marvaldi 1999). In citrus groves of São Paulo, egg layings of *N. cervinus*, *N. ambiguus*, *N. versatilis* and *P. fluctuosus* are usually underneath the calices of fruits (Fig. 3l). An exception to this oviposition habit has been recorded for *T. nodicollis*, which females lay single eggs at ramdom in the soil (Fig. 3k). This behaviour has been observed in the field and under laboratory conditions. Oviposition in the soil belongs to category 10 of Howden (1995) and it is associated to the presence of rigid ovipositors.

Lanteri (1981) described the ovipositors typical of *Teratopactus* and *Naupactus*, and suggested that their morphological differences could be related to different oviposition habits. In *Teratopactus*, the ovipositor is a strong tube supported by two pairs of curved rows (ventral and dorsal) called baculi, ending in a pair of unguiculate hemisternites or coxites (Fig. 3c). Our biological observations on the behaviour of *T. nodicollis*, make us to draw the conclusion that these morphological features are functional adaptations to lay eggs in the soil.

In most *Naupactus* the ovipositor is a flexible tube, supported by one pair of baculi (the ventral ones), having moderately to slightly sclerotized hemisternites, and ending in a pair of styli bearing setae (Fig. 3d). This kind of ovipositor is well adapted to enter narrow spaces and crevices, to hide the eggs.

Embryos develop in about 10 to 25 days, depending on the species. First instar larvae of species that oviposite beneath calices of fruits (*N. cervinus, N. ambiguus, N. versatilis* and *P. fluctuosus*), fall down from treetops to the ground, in order to continue their development. Larvae and pupae of all species occur in the soil (Figs. 3e, f). They feed on roots, digging external tunnels and cutting fine radicels (Figs. 3g, h). The most important damages for plants occur when injures caused by larvae provide entry points for soil-borne pathogens, particularly *Phytophthora* spp., agent of gomosis of the citrus. Adults feed on margins of leaves, cutting them in a characteristic shape (Figs. 3i, j). They are less harmful than larvae.

Larval stage lasts three to nine months, depending on the species, and pupal stage, about a month. Duration of larval stage depends on the season when the eggs are laid and the amount of nutritional resources available for the larvae. For eggs laid during spring or at the beginning of the summer (November to January) the period of larval stage is usually shorter (about three months) than for eggs laid later on. Since in São Paulo state temperatures are optimal for the development of species of *Naupactus*, and there are always abundant nutritional resources available, adults occur most of the year (their populations decline only in winter, from June to August) and larvae are in the soil throughout the year. In some species there are probably two annual generations. In temperate areas of Argentina, species of *Naupactus* usually have only one generation per year, and in cool regions of the USA, introduced *Naupactus* such as *N. peregrinus* used to complete its life cycle in two years (Lanteri 1994).

Larvae of *T nodicollis*, *N. rivulosus* and *N. tarsalis*, produce serious damages on roots of the trees, due to their large size, but since their population densities are low, they are not so harmful for citrus groves. The most frequent and abundant species throughout areas of citrus production of São Paulo, are *N. cervinus, N. versatilis, N. ambiguus* and *P. fluctuosus.* These species are "*Pantomorus* like" and, at least some lineages, would reproduce by parthenogenesis (= reproduction of virgin females). Parthenogenetic species are usually very harmful for crops, because of their high reproductive potential, and their capability to colonize disturbed habitats, such as agroecosystems (Lanteri & Normark 1995).

The increase of population densities of species of Naupactini, in certain areas of São Paulo, could be correlated to the replacement of biologically diverse forests by simplified agricultural ecosystems, practice that has been intensified during the last two decades (Pinto 1996). *Naupactus*, *Pantomorus*, and related genera, with hundreds of polyfagic species native of forests from Brazil, represent a potential threat for citrus production. There is much to be done in order to know and to understand the systematics and biology of this group of weevils, and to have enough information to control the species that could become pests.

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