Description and Biology of A New Species of *Cybocephalus* Erichson (Coleoptera: Nitidulidae), A Predator of Australian Citrus Whitefly

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ABSTRACT   *Cybocephalus aleyrodiphagus* sp.n., a predator of Australian citrus whitefly, *Orchamoplatus citri* (Takahashi), is described from adults and larvae collected from southern New South Wales (where it appears to be the major natural enemy of *O. citri*) and South Australia. Eggs of *C. aleyrodiphagus* are laid singly near egg circles of *O. citri* and larvae feed on eggs, crawlers and nymphs. Adults feed on all immature stages of *O. citri*. Reproductive, but not non-reproductive, females contain greater quantities of stearic, oleic and linoleic acid than males indicating the possible presence of a sex pheromone. In southern New South Wales, *C. aleyrodiphagus* sp.n. overwinters as non-reproductive adults and produces two adult generations during December-January and March-May. The sex ratio is close to 1:1 during October-December (overwintered adults) but male biased (2.2:1) during January-July (new generation adults). Trends of abundance for *C. aleyrodiphagus* correspond well with those for *O. citri* nymphs/pupae indicating a functional response of the predator to prey, despite disruption by foraging ants.

Introduction

Cybocephaline beetles are well known predators of armoured scale insects (Coccoidea: Diaspididae) throughout tropical, sub-tropical and temperate regions of the world (Endrödy-Younga 1962, 1968, 1974; Kirejtshuk 1995). Most Australian species of *Cybocephalus* are found in association with diaspidid scales and remain undescribed. Despite reports that species of *Cybocephalus* are sometimes found in proximity to whiteflies (Kartman 1946), they have not previously been recorded feeding on these insects in the field.

Here we describe adults and larvae of *Cybocephalus aleyrodiphagus* sp.n., a predator of the Australian citrus whitefly, *Orchamoplatus citri* (Takahashi) (Hemiptera: Aleyrodidae). We also present information on the biology and seasonal population dynamics of *C. aleyrodiphagus* and its host in a citrus grove in southern New South Wales.

Abbreviations: AMS, Australian Museum, Sydney; ANIC, Australian National Insect Collection, CSIRO, Canberra; MACL, Macleay Museum, University of Sydney; NHL, Natural History Museum, London; QMB, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; SMS Staatliches Museum für Naturkunde, Stuttgart; ZIN, Zoological Institute of Russian Academy of Sciences, St Petersburg.

Cybocephalus aleyrodiphagus sp.n.
(Figs 1-13)

Types. New South Wales: holotype ♂, 34.36S, 146.25E, Leeton, 16.iv.1993, D. G. James, R. Heffer, on citrus (ANIC); paratypes (50 ♂♂, 79 ♀♀) (AMS, ANIC, MACL, NHL, QMB, SAM, SMS, ZIN), 34.36S, 146.25E, Leeton, 16.iv.1993, 3.iii.1994, 15.ii.1995 and 15.viii.1995, D. G. James, R. Heffer, on citrus and 5 larvae (ZIN); **South Australia:** 1 ♂, Loxton

Research centre, Loxton, 27.iii.1979, P. T. Bailey, eating citrus whitefly (SAM).

Male (holotype). *Measurements*: Length (with rolled head and pronotum) 1.0, width 0.6 and depth 0.4 mm. Oval (Fig. 1), rather strongly convex dorsally and flattened ventrally.

Colour, pubescence: Dark brown to blackish with yellow head, mouth parts, antennae, fore and mid legs. Hind legs pale brown with dark femora. Dorsum glabrous, smooth and shiny with ventral surface dull and clothed with short, dense hairs.

Head: Short with straight fore edge with weak trace of submarginal lines at antennal insertion, eye width only a narrow strip with facets faced downward. Antennae 11-segmented, length 0.6-0.7 head width, with apex of last segment oblique.

Dorsal surfaces: Head and pronotal surface with minute, broadly separated, oval punctures and smooth, shiny interspaces. Elytral surface similar but punctures larger and more distinct in distal parts. Pronotum as wide as elytra and about half as long. Elytra rather narrowed posteriorly and somewhat shorter than their combined width, with widely and separately rounded apices. Pygidium with dense, shallow punctures about as large as eye facets, with small, microreticulate interspaces. Pygidium almost transversely truncate at apex.

Ventral surfaces: Metasternum and first ventrite punctured and sculptured, but punctures less distinct and interspaces smoother. Punctation reduced and interspaces smooth on remainder of ventral surface. Metasternum slightly longer than pro- and mesosternum combined. All tibiae very narrow, almost parallel sided, fore tibia (Fig. 3) with simple outer edge bearing row of sparse, thin setae. Femora simple, about 2.5 times as wide as tibiae. Aedeagus (Figs 4-6) well sclerotised.

Female. Dark brown-black with yellow antennae and paler legs (particularly fore legs). Differs from male in widely rounded apices of pygidium and hypopygidium and dark head. Ovipositor with usual configuration of sclerites for the subfamily and moderately sclerotised.

Variation. Length 0.7-1.3 mm. General coloration varies from brown to black. The holotype has typical coloration, shared with almost all male specimens in the type series. Some are paler on the distal area of the abdomen. Many females with body and head concolorous, though some with a paler abdomen. Shallow emargination on apex of tegmen poorly expressed in some males.

Larvae. Elongate, subcylindrical (Fig. 7), very soft, creamy white body (up to 2.5 mm in length) with reddish mandibular apices and 4 relatively large stemmata on either side of epicranium. Surface covered with sparse, long setae, more numerous on thoracic and last abdominal segment. Setal tubercles scarcely raised and capitate setae absent. Abdominal segments (except 9th) well lobed laterally, each lobe having long, spiniform process directed posteriorly.
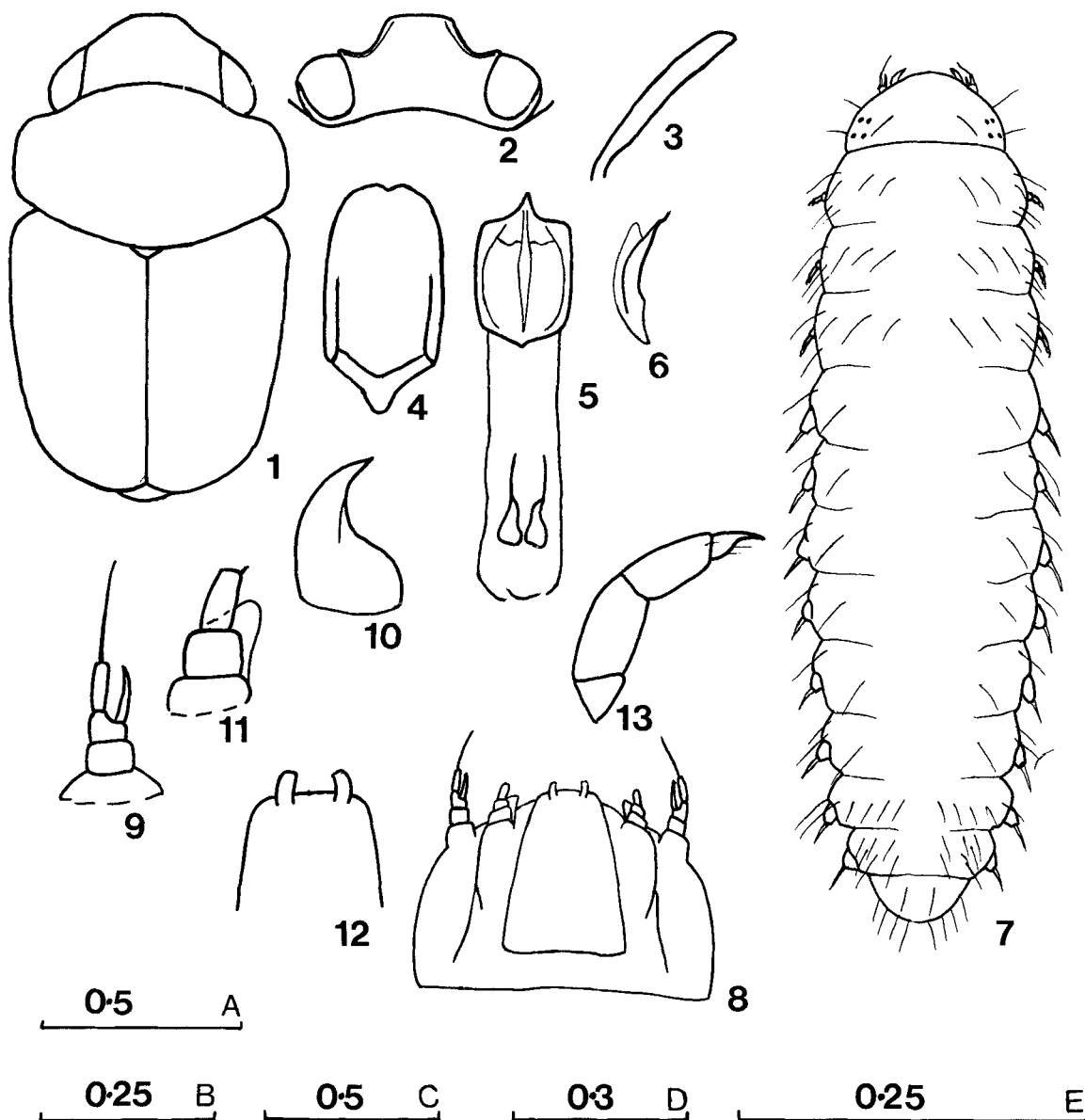
Figs 1-13. *Cybocephalus aleyrodiphagus* sp.n. adult **(1-6)**: **(1)** body, dorsal; **(2)** head, frontal; **(3)** male fore tibia, dorsal; **(4)** tegmen, ventral; **(5)** penis trunk, with armature of inner sac, dorsal; **(6)** penis trunk, lateral; Larva **(7-13)**: **(7)** body, dorsal; **(8)** epicranial surface, ventral; **(9)** antennae; **(10)** left mandible, dorsal; **(11)** maxilla, ventral; **(12)** labium, ventral; **(13)** hind leg, dorsal. Scale A for Figs 1-3; scale B for Figs 4-6; scale C for Fig. 7; scale D for Fig. 8; scale E for Figs 9-13; all in mm.

Epicranium depressed, partly retracted into prothoracic segment. Cephalic margin of clypeal region subabrupt; labrum fused to clypeus, labroclypeal epipharyngeal surface without clear armature. Frontal and frontoclypeal sutures untraceable. Antennae (Fig. 9) with short first and second segments. Setose apex of third segment at same level as apex of sensory appendix of second segment. Mandible (Fig. 10) simple, lacking teeth, mola and prostheca. Maxilla (Fig. 11) with terminal palpomere longest; mala membranous, lacking setae or processes. Labium (Fig. 12) with pair of small 1-segmented palps.

Trapezium-like mentum very long and not separated from prementum. Hypopharyngeal sclerome indistinct. Terga without trace of distinctly outlined sclerite. Legs moderately exposed from above; tarsungulus without capitate setae. Tenth abdominal segment reduced and scarcely separated from ninth. Abdominal spiracles annular and simple, without visible air tubes, located lateral-dorsally.

Notes. This new species is well characterised by yellow-headed males, head shape, aedeagal structure and rather narrow legs. It differs from *C. australiae* (Lea 1926a) in sexual colour dimorphism, punctation and dorsum sculpture and from *C. leai* (Endrödy-Younga 1974) (= *C. semiflavus* Lea 1926b, non *C. semiflavus* Champion 1925) in having shorter elytra with well-rounded apices, a dark pronotum in males and dark hind legs in both sexes. The larvae of *C. aleyrodiphagus* differ from descriptions of other species in this genus (Silvestri 1910; Hayashi 1978; Lawrence 1991) and *Pycnocephalus* (Parker 1951) by being more elongate with relatively longer legs and having abdominal segments 1-8 with long, posteriorly directed spiniform processes. The absence of capitate setae on the tarsungulus, whilst evident in *Pycnocephalus argentinus* (Parker 1951), is not a feature in previously described *Cybocephalus larvae*. *C. aleyrodiphagus* and *P. argentinus* both have little trace of distinct tergites but appendages and dorsal setae are more reduced in *P. argentinus*.

Notes on biology

Field-collected adult *C. aleyrodiphagus* were kept in the laboratory (20-30 °C) in glass specimen tubes with gauze-capped lids or small plastic boxes (29 × 13 × 8 cm) with gauze lids. All stages of *O. citri* on citrus leaves were supplied as a food source and changed every few days. Adults lived for 3 to 4 months in these containers and produced numerous eggs and larvae. The pale-coloured, elongate eggs were laid singly, usually inside or alongside egg circles of *O. citri*. A single larva of *C. aleyrodiphagus* usually devoured all the eggs or crawlers from this egg circle (usually 50-150 individuals) before moving onto another egg circle or group of crawlers. Adults also fed on eggs and crawlers as well as nymphs, although the latter were not favoured. Pupation occurred in a white, fibrous cocoon constructed on the underside of citrus leaves. Egg shells and exuviae from *O. citri* were used in cocoon construction and were prominent exterior decorations. In the field cocoons remain attached to leaves for up to 6 months after beetle emergence.

It is possible that the natural host range of *C. aleyrodiphagus* includes whitefly species other than *O. citri*. Adult *C. aleyrodiphagus* confined in laboratory cages with the cosmopolitan whitefly pest *Trialeurodes vaporariorum* (Westwood) (greenhouse whitefly) on tomato plants, fed and survived on this prey for 2 months, although little reproduction occurred. Adult *C. aleyrodiphagus* also fed on pollen of the water weed, *Typha orientalis* Presl. Blumberg and Swirski (1974) examined food acceptability of the armoured scale predator *C. micans* Reitter and found despite being able to feed on a range of food including eggs of various soft scale species, immature stages of the whitefly, *Bemisia tabaci* Gennadius and mite eggs, development and reproduction only occurred when reared on armoured scale hosts.

The well known production of aggregation pheromones by males in the nitidulid genus *Carpophilus* (James *et al.* 1994 and references therein), prompted us to analyse solvent extracts of whole beetles to see if sexual dimorphism in chemical composition occurs in *C. aleyrodiphagus*, indicating the possible presence of a sex or aggregation pheromone. Standard gas chromatography and mass spectrometry analyses of heptane extracts of 10 male and 10 female beetles (all reproductive) revealed that both sexes contained similar quantities of ethyl esters of stearic, oleic and linoleic acids. However, females contained greater amounts of the free acids than males. The higher absolute ester concentration in male extracts was also detectable by odour (Chris Moore, Queensland Department of Primary Industry pers. comm.). This difference was not observed in hexane extracts of non-reproductive male and female *C. aleyrodiphagus*. The possibility of a male or female-produced pheromone in reproductive *C. aleyrodiphagus* should be examined further.

Seasonal population biology

Populations of *C. aleyrodiphagus* and *O. citri* were monitored in a citrus grove at Leeton in the Murrumbidgee Irrigation Area (MIA) of southern New South Wales (type locality) from 4 October 1994 to 25 July 1995. During the study foraging ants belonging to the *Iridomyrmex rufoniger* group of species consistently attended honeydew-producing nymphs of *O. citri*. A sample of 15 fresh flush shoots (each 30 cm long) was collected randomly from a 1 ha block of valencia orange trees weekly, transported to the laboratory in
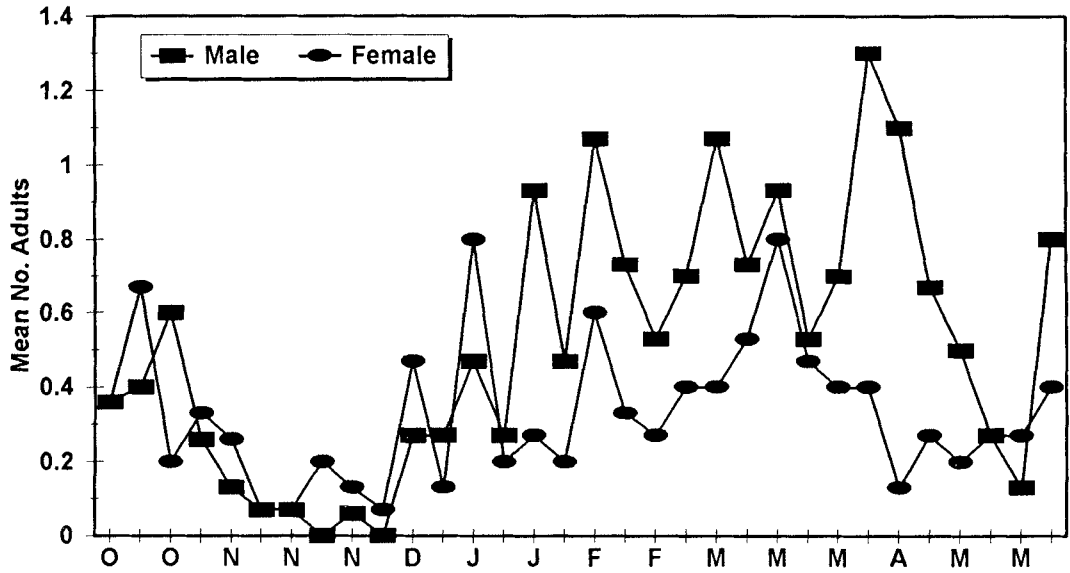
Fig. 14. Mean number of male and female *C. aleyrodiphagus* sp.n. per citrus shoot during October-July 1994-95.
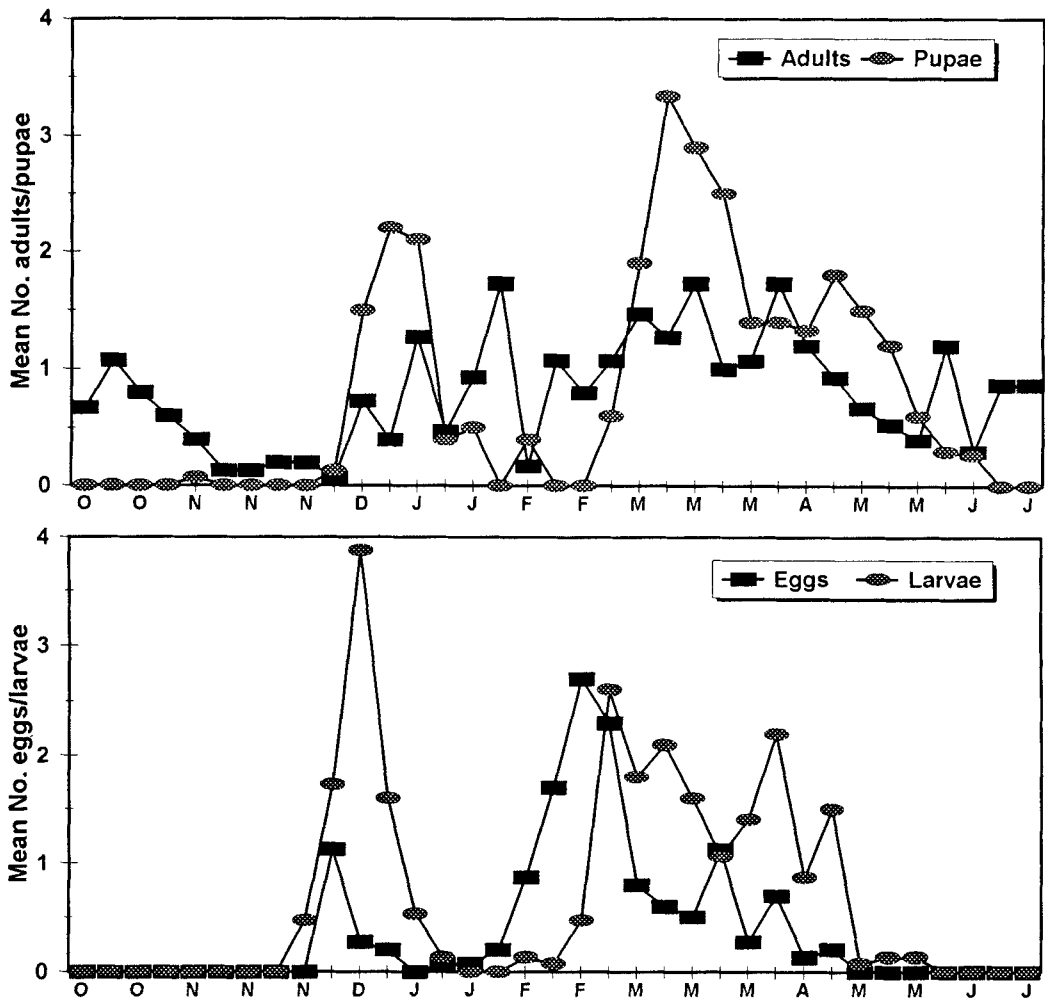

Fig. 15. Mean number of eggs, larvae, pupae and adults of *C. aleyrodiphagus* sp.n. per citrus shoot during October-July 1994-95.

sealed plastic bags and examined under a stereomicroscope for all stages of *C. aleyrodiphagus* and *O. citri*.

The total number of adult beetles on the 15 sampled shoots ranged from 1 (7 December) to 26 (24 January, 16 March, 7 April). The greatest number of eggs (41) was recorded on 16 February, larvae (58) on 16 December and pupae (50) on 10 March. The overall sex ratio was significantly male biased (1.6:1) (P < 0.01, ANOVA). However, the ratio was close to 1:1 during October-December (overwintered beetles) but significantly male biased (2.2:1) (P < 0.01, ANOVA) during January-July (new generation beetles) (Fig. 14).

C. aleyrodiphagus overwintered as non-reproductive adults and two adult generations were produced during spring-autumn (Fig. 15). A new adult generation appeared during December-January and was reproductive; the second adult generation emerged during March-May and was probably largely non-reproductive, and formed the overwintering population. Numbers of overwintered adults declined progressively during spring and oviposition did not begin until late November, shortly after the appearance of *O. citri* eggs. Large numbers of larvae and pupae in mid-December produced adults during December-January (Fig. 15). Oviposition by this generation peaked in February and large numbers of larvae and pupae occurred during March-April. Adults which emerged during March-May did not appear to add greatly to the resident population suggesting that dispersal occurred prior to over-wintering. Ahmad (1970) considered the "remarkable power of dispersion" to be a major attribute of *Cybocephalus* as biological control agents. No immature stages of *C. aleyrodiphagus* were found during winter (June-July) or early spring (October).

O. citri followed a similar annual cycle with two generations of adults (November and February-March) although overwintering occurred as nymphs and pupae. The apparent stimulation of *C. aleyrodiphagus* oviposition by the appearance of whitefly egg circles in late November and the invariable placement of eggs adjacent to these circles, suggests that eggs, crawlers and possibly younger nymphs are preferred prey. From late November to late March, immature stages of *O. citri* were present on virtually all sampling occasions. However, during autumn, winter and early spring (when no reproduction of *C. aleyrodiphagus* occurred), only later instar nymphs and pupae were available as prey.

The suppressive impact of *C. aleyrodiphagus* on *O. citri* populations in this study was inhibited by the presence of foraging ants. In a concurrent study in the same block investigating the impact of foraging ants on populations of predatory insects, numbers of *C. aleyrodiphagus* were 2.5 times greater on sticky-banded, ant-free trees than on ant-infested trees (James unpubl.). Foraging ant activity interfered with feeding and other activities of adult *C. aleyrodiphagus* causing them to take flight. Ants are also likely to have preyed on the eggs and larvae of *C. aleyrodiphagus*. Consequently, *C. aleyrodiphagus* did not reach its full potential as a regulator of *O. citri* in this study. Despite this, whitefly populations did not reach economically damaging levels. *O. citri* becomes a pest only when honeydew production by nymphs results in sooty mould growth and downgrading
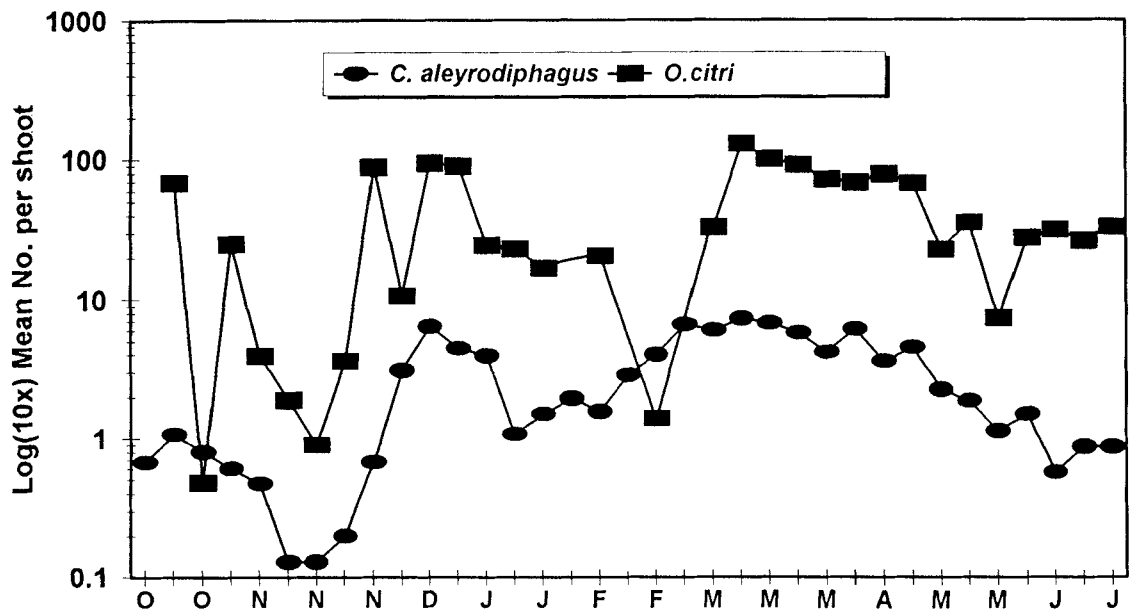

Fig. 16. Log (10×) mean number of nymphs/pupae of *O. citri* and all stages of *C. aleyrodiphagus* sp.n. per citrus shoot during October-July 1994-95.

of citrus fruit (Hely *et al.* 1982). Trends of abundance for *C. aleyrodiphagus* (all stages) corresponded well with those for *O. citri* nymphs/pupae indicating a functional response of the predator to prey, despite disruption by ants (Fig. 16). In MIA citrus groves which do not have high ant populations *C. aleyrodiphagus* appears to be a highly effective predator with populations of *O. citri* usually very small and hard to find. Most nymphs are destroyed before they start producing copious amounts of honeydew and these ill-fated colonies are usually characterised by the presence of old cocoons of *C. aleyrodiphagus*. The role of *C. aleyrodiphagus* in biological control of *O. citri* deserves greater study because it is the only citrus whitefly predator reported to date which appears capable of regulating populations by itself. Barbagallo *et al.* (1992) in their review of biological control of citrus whiteflies in Italy, concluded that predators (Coleoptera, Neuroptera, Thysanoptera, etc.) are incapable by themselves of maintaining whitefly populations below economic thresholds; a role provided only by hymenopterous parasitoids. Parasitoids of *O. citri* are uncommon in the MIA and *C. aleyrodiphagus* appears to be the dominant natural enemy of this pest.

Acknowledgments

References

AHMAD, R. (1970). Studies in West Pakistan on the biology of one nitidulid species and two coccinellid species (Coleoptera) that attack scale insects (Hom., Coccoidea). Bull. ent. Res. 60: 5-16.

BARBAGALLO, S., LONGO, I., PATTI, C. and RAPISARDA, C. (1992). Efficiency of biological control against citrus whiteflies in Italy. Boll. Zool. agr. Bachic. 24: 121-135.

BLUMBERG, D. and SWIRSKI, E. (1974). The development and reproduction of cybocephalid beetles on various foods. Entomophaga 19: 437-443.

CHAMPION, G. C. (1925). Some Indian (and Tibetan) Coleoptera. Entomologist's mon. Mag. 61: 260-273.

ENDRÖDY-YOUNGA, S. (1962). Die äthiopischen Arten der Gattung *Cybocephalus* Er. (Coleoptera: Cybocephalidae). Acta Zool. Acad. Sci. Hung. 8: 335-384.

ENDRÖDY-YOUNGA, S. (1968). Monographie der palaear Arten der Familie Cybocephalidae (Coleoptera: Clavicornia). Acta Zool. Acad. Sci. Hung. 14: 27-115.

ENDRÖDY-YOUNGA, S. (1974). A revision of the described Australian and New Zealand species of the family Clambidae (Coleoptera) with description of a new species. Rec. S. Aust. Mus. 17: 1-10.

HAYASHI, N. (1978). A contribution to the knowledge of the larvae of Nitidulidae occurring in Japan (Coleoptera: Cucujoidea). Insecta matsum. 14: 1-97.

HELY, P. C., PASFIELD, G. and GELLATLEY, J. G. (1982). Insect pests of fruit and vegetables in NSW. Inkata Press: Melbourne.

JAMES, D. G., BARTELT, R. J. and FAULDER, R. J. (1994). Attraction of *Carpophilus* spp. (Coleoptera: Nitidulidae) to synthetic aggregation pheromones and host-related coattractants in Australian stone fruit orchards: beetle phenology and pheromone dose studies. J. chem. Ecol. 20: 2805-2819.

KARTMAN, L. (1946). A new host for *Cybocephalus* sp., a predator of Diaspine Coccidae. J. econ. Ent. 39: 814.

KIREJTSHUK, A. G. (1995). New species and notes on taxonomy of nitidulid beetles (Coleoptera: Nitidulidae) of Indochina and adjacent territories. Proc. Zool. Inst. Russ. Acad. Sci. 254: 91-126 (in Russian).

LAWRENCE, J. F. (1991). Nitidulidae (Cucujoidea). *In* Immature insects. Stehr, F. W. (ed.) pp. 456-460. Kendall/Hunt: Dubuque.

LEA, A. M. (1926a). On some Australian Coleoptera collected by Charles Darwin during the voyage of the 'Beagle' (Part II). Trans. ent. Soc. London 74: 279-288.

LEA, A. M. (1926b). Notes on some miscellaneous Coleoptera with description of new species. Part VI. Trans. R. Soc. S. Aust. 50: 45-85.

PARKER, H. L. (1951). Notes on *Pycnocephalus argentinus* Brethes, parasitic on *Ceroplastes* sp. in Uruguay (Coleoptera: Cybocephalidae). Proc. ent. Soc. Wash. 53: 35-41.

SILVESTRI, F. (1910). Metamorfosi del *Cybocephalus rufifrons* Reitter e notizie sui suoi costumi. Boll. Labor. Zool. gen. agr. portici. 4: 221-227.