LIFE HISTORY AND PESTICIDE SUSCEPTIBILITY OF *Cybocephalus nipponicus* ENDRÖDY-YOUNGA (COLEOPTERA: CYBOCEPHALIDAE) AND A TAXONOMIC REVISION OF THE CYBOCEPHALIDAE OF NORTH AMERICA AND THE WEST INDIES

By

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This document is dedicated to Stuart Fullerton without whom none of this would have been possible. I would also like to dedicate this dissertation to my wife Kathryn who has been very patient throughout my long academic journey.

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The life history of the predatory beetle *Cybocephalus nipponicus* Endrödy-Younga was studied by rearing the beetle on the cycad aulacaspis scale, *Aulacaspis yasumatsui* Takagi. Mean developmental times of egg (7.3 ± 0.8 days), larval (13.7 ± 1.1 days), and pupal (18.6 ± 1.6 days) stages were determined. Mortality in each life stage, adult longevity, and adult sex ratios also were measured. A clarification of differences between *C. nipponicus* and *C. binotatus* Grouvelle is included.

The susceptibility of the predatory beetles *C. nipponicus* Endrödy-Younga and *Rhyzobius lophanthae* Blaisdell to six pesticides commonly used for treating cycad aulacaspis scale was tested. Three concentrations (half field rate, field rate, and twice field rate) of each pesticide were tested against both beetle species using a coated glass vial bioassay. Nearly 100% mortality in both beetle species occurred at all concentrations when treated with methidathion, dimethoate, and malathion. Insecticidal soap, fish oils, and imidacloprid were much less toxic. At half the simulated field rate, *C. nipponicus* had 33% survivorship with insecticidal soap, 23% survivorship with imidacloprid, and 17% survivorship with fish oil. At half the simulated field rate, *R. lophanthae* had 56% survivorship with insecticidal soap, 36% survivorship with imidacloprid, and 53% survivorship with fish oil. Mortality rate for each beetle species rose with increasing concentration of each pesticide.

The 17 species of Cybocephalidae in North America (including Mexico) and the West Indies are revised. Included are redescriptions of *Cybocephalus aciculatus* Champion, *C. californicus* Horn, *C. nigritulus* LeConte, *C. nipponicus* Endrödy-Younga, *C. schwarzi* Champion, *Pycnocephalus metallicus* Sharp and a new combination of *P. deyrolli* (Reitter). Also included are descriptions of 10 new species: *C. antilleus, C. caribaeus*, *C. iviei, C. kathrynae, C. randalli, C. geoffreysmithi* and four as yet unnamed new species from Mexico. A key to species, illustrations of morphological features including detailed drawings of male genitalia, distribution data, and host lists are provided. The confusion involving *C. nipponicus* and *C. binotatus* Grouvelle is discussed and the differences between them are made evident.

CHAPTER 1
LITERATURE REVIEW

Cycads

Cycads are an ancient group of plants, sometimes called the “coelacanths of the plant world,” that date back to the Paleozoic era (Moretti 1990). However, the true rise and dominance of the cycads occurred during the Mesozoic era. Cycads are believed to be an evolutionary intermediate between ferns and flowering plants (Whiting 1962). Cycads belong to three families: Cycadaceae which includes a single genus, *Cycas*; Stangeriaceae which also contains only 1 genus, *Stangeria*; and Zamiaceae which contains 8 genera, *Bowenia, Ceratozamia, Dioon, Encephalartos, Lepidozamia, Macrozamia*, *Microcycas,* and *Zamia* (Whitelock 2002). There are almost 300 species of cycads worldwide, most of which are found in tropical and subtropical environments (Hill 2004). Many of these species are endangered or threatened, with this threat due more to determined collectors than to deforestation, agriculture, and urban sprawl (Giddy 1990).

While in some cases cycads are used for food or fertilizer, their chief economic importance is as ornamental landscape plants (Thieret 1958). These plants can be found in hundreds of nurseries all over the state of Florida. While older and consequently larger plants can be quite expensive, smaller 1 gallon pot size *C. revoluta* can sell for as little as $10.00 (Home Depot). Aside from its natural beauty and hardiness, *Cycas revoluta* is a very popular plant with growers because it can be propagated through cutting lateral outgrowths or “pups”.

General Scale Insect Information

The armored scale insects (Diaspididae) belong to the superfamily Coccoidea in the order Hemiptera. There are over 1,800 described species of armored scale worldwide (Ben-Dov 1993) and at least 300 occur in North America (Borror et al. 1989). Many of these scales are pests of agriculture and horticulture, generally weakening plants through sap feeding and often causing excessive sooty mold growth on excreted honeydew. In their native habitats scale insects are usually controlled by natural predators and parasitoids (Hodgson and Martin 2001). The soft-bodied females and early-instar males of the tribe Diaspidini live beneath a scale covering made of wax secreted by the insect and mixed with shed exuviae of earlier instars. The scale covering of males is usually smaller and more elongate than that of the females. The first instar, or “crawler,” stage is mobile and able to spread to other plants. Female crawlers will settle and insert their mouthparts into the plant, becoming sessile and remaining in that state throughout their lifetime. Females will molt twice after the crawler phase, becoming an adult in the third instar. Males become sessile after the crawler phase and remain in that state through the second and third instar before molting into a fourth prepupa stage. The emergent fifth instar male is winged and without mouthparts (Hamon 2000).

Cycad Aulacaspis Scale (CAS)

At least 20 species of scale insect occur on cycads in Florida, 19 of which cause very little damage to cycads (Dekle 1976). The cycad aulacaspis scale (CAS), *Aulacaspis yasumatsui* Takagi, is the most damaging scale found on cycads in Florida (Hodges et al. 2003). This scale is native to Southeast Asia. It has also been found on several islands in the Caribbean, as well as Hawaii (Ben-Dov et al. 2003). In 1992 *A. yasumatsui* became such a problem in Hong Kong that 70-100% mortality of *Cycas* *revoluta* Thunberg was recorded (Hodgson and Martin 2001). In Guam the endemic *Cycas micronesica* K.D. Hill has been severely affected by this damaging scale (R. Muniappan 2005, personal communication). The first detection of the CAS in Florida occurred in 1996 in Miami at the Montgomery Botanical Center. The scale is thought to have come in on infested cycads imported from Southeast Asia (Howard and Weissling 1999). By the end of 1997 the scale had spread throughout Miami and as far north as Lake Okeechobee and could be found on 20 species of cycads (Howard and Weissling 1999); however it seemed to prefer the genera *Cycas* and *Stangeria*, a very rare genus. This led to the spread of the scale to Hawaii in 1998 through the legal importation of infested cycads from Florida (Hodgson and Martin 2001). Currently CAS has been reported from Pensacola east to Jacksonville and south into the Florida Keys. How far north the scale is actually established is not known. It is suspected that many of the infested cycads in north Florida were in fact transplants from southern nurseries rather than the pest's natural progression north. However, this is just speculation.

Aulacaspis yasumatsui was first described by Dr. Sadao Takagi from specimens collected in Bangkok, Thailand (Takagi, 1977). This scale will feed on a large number of cycads; however, the most commercially significant are those of the genus *Cycas*. In Florida, *C. revoluta*, the king sago, and *Cycas rumphii* Miq., the queen sago, are the most popular cycads used in landscaping, and unfortunately, both of these cycads are severely attacked by the cycad scale (Howard et al. 1999). Mature *A. yasumatsui* females have a white armor 1.2-1.6 mm in diameter that is usually of a pyriform shape common in the tribe Diaspidini, with the exuviae at one end (Ben-Dov 1990). This is by no means the only shape in which this scale may appear. The females of this species may have a large number of shapes and sizes. The male has a very typical, of the tribe Diaspidini, tricarinate, 0.5-0.6 mm-long, white teste with the exuviae at the cephalic end (Howard et al. 1999).

In the field the magnolia white scale, *Pseudaulacaspis cockerelli* (Cooley), often found on cycads, is frequently confused with CAS. However, once the covers are removed major differences in the two species can be observed. All stages of the CAS life cycle, from egg to adult, are a uniform orange color, whereas all stages of the magnolia white scale are yellow. Also, the female CAS has a swollen prosoma and is quite compact, whereas the magnolia white scale has a slender prosoma and is relatively elongate (Hodges et al. 2003). The magnolia white scale populates more heavily on the adaxial surface, while CAS creates extremely dense populations on the abaxial surface with relatively few individuals settling on the upper surface (Howard and Weissling 1999). Most importantly, when a cycad is heavily infested with CAS, the sheer volume of individual scales can become so great that the entire plant is coated with a white crust usually made up mostly of male scales (Howard et al. 1996). By contrast, magnolia white scale infestations are much less severe (Howard and Weissling 1999). Lastly, CAS infests all parts of the cycad including the leaves, cones, fruits, megasporophylls, stems and roots (Howard and Weissling 1999), whereas the magnolia white scale attacks only the leaves.

Before the introduction of CAS the only scale of the genus *Aulacaspis* in Florida was *Aulacaspis rosae* (Bouché), a non-native pest of roses (Dekle 1976). *Aulacaspis rosae* may be a close relative of *A. yasumatsui* because the 2nd instar of *A. rosae* is very similar morphologically to that of *A. yasumatsui* (Takagi 1977), but with such different host plants these two scales are not often confused.

Chemical Control of CAS

There has been some success controlling the cycad aulacaspis scale with various pesticides. Oils, either an ultra-fine horticultural oil or a product containing fish oil, seem to be the most effective chemical control method (Hodges et al. 2003). This is not really surprising given that oils have long been used to control armored scale insects. The oil not only covers the insects and suffocates them but also covers the surface of the plant making it difficult for crawlers to settle onto the plant (Howard and Weissling 1999). The proper application of the oils is difficult due to the scale's tendency to heavily infest the abaxial surface of the leaves, which is difficult to spray (Howard and Weissling 1999). In the case of *C. revoluta*, the architecture of the plant itself, with the margins of the leaflets curling down and inward and forming a trough on the abaxial surface of the leaflet, makes foliar oil treatments difficult (Hodges et al. 2003). Frequent (every two weeks) or "as needed" use of oils seems to be the most effective technique for controlling this scale, and by mixing treatments of oil with treatments of contact insecticides such as malathion or carbaryl, even greater scale mortality can be achieved (Hodges et al. 2003). Horticultural oils also seem to at least help control CAS on the root systems of potted cycads. Hodges et al. (2003) found that drenching the roots of an infested cycad in 2% horticultural oil resulted in 100% mortality of mature females on the roots. However, a root drench would be very difficult to accomplish properly on field-grown cycads. The use of systemics such as methidathion and dimethoate has yielded mixed results, being very effective in some cases and completely ineffective at controlling the scale in other cases (Hodges et al. 2003). Imidacloprid as a soil drench can be very effective but

Howard and Weissling (1999) found that this product had to be mixed at such high concentrations that not only was the product not labeled for such high rates but also the whole process became extremely uneconomical. They were completely unable to control CAS using imidacloprid at label rates. Insect growth regulators such as pyroproxyfen, sold under the trade name Distance®, have met with some success controlling CAS (Emshousen and Mannion 2004). Homeowners have found that liberal application of soap can be a very effective control method as well (personal observation, 2004).

Biological Control of CAS

The cycad aulacaspis scale is considered a pest in Thailand, but native parasitoids are reported to control its populations (Tang et al. 1997). Howard et al. (1999) reported the lack of any native natural enemies in Florida as one of the major reason for the rapid spread of CAS. For this reason two natural enemies were imported from Thailand and released by Dr. Richard Baranowski of the UF/IFAS Tropical Research and Education Center at Homestead in 1998. These natural enemies were a parasitic wasp, *Coccobius fulvus* (Compere and Annecke), and a predacious beetle, which at the time was identified as *Cybocephalus binotatus* Grouvelle. In Hawaii the coccinellid *Rhyzobius lophanthae* (Blaisdell) was found to feed quite readily on CAS (Heu and Chun 2000). Howard (1997) mentions the use of *R. lophanthae* in Florida as a potential predator of CAS.

Cybocephalidae

The Cybocephalidae differ greatly from the Nitidulidae, the family in which they have been historically placed, not only because they are predatory but also because their basic morphology and anatomy are quite different. Cybocephalid adults have a 4-4-4 tarsal formula instead of 5-5-5 found in Nitidulidae. There are 5 visible ventral plates (leaving out the male anal plate) and 5 abdominal spiracles in cybocephalids instead of the 6 and 6 that occur in nititdulids. The body of cybocephalids is retractile allowing the mandibles in repose to rest against the metasternum, unlike any other nitidulid. The larvae of Cybocephalidae have a head without dorsal sutures, lack pregomphi and urogomphi on abdominal tergite XI, and have hypostomal rods with divergent hypostomal ridges present posteriorly, hypopharynx without a sclerome and bracons, maxillae without mola, and annular spiracles with 2 lateral air tubes. In contrast, the larvae of Nitidulidae have pregomphi and urogomphi, no hypostomal rods but with hypostomal ridges strongly convergent posteriorly, hypopharynx with a sclerome and bracons, maxillae with raised mola, and biforous spiracles (Kirejtchuk 1997). This has led to the cybocephalids being shuffled around between family (Murray, 1864, Parsons 1943, Endrödy-Younga 1968) and subfamily (Horn 1879, Arnett 1960, Habeck 2002) status.

Before the taxonomic study presented here, only one species of Cybocephalidae, *Cybocephalus nigritulus* LeConte, was known to be native to the state of Florida; a second species is described in Chapter 4. Howard and Weissling (1999) reported *C. binotatus* was released and has subsequently become established in south Florida. However, as will be shown later, this species was misidentified and is actually another Asian species, *Cybocephalus nipponicus* Endrödy-Younga. *Cybocephalus nipponicus* has been widely used in the United States as a biological control agent for the euonymus scale, *Unaspis euonymi* (Comstock), and for many other pest scale species around the world.

Cybocephalids as Biological Control Agents

With the exception of coccinellids, species of the genus *Cybocephalus* are the most important predators of armored scales (Blumberg and Swirski 1982). While cybocephalids are well-known armored scale feeders, their effectiveness as biological control agents have not been well studied (Drea and Carlson 1988). Even with such a limited understanding of the biology and ecology of this group of beetles, species of *Cybocephalus* are being released in many areas of the world. There is very little literature on cybocephalids and what there is usually consists of a small note about them being released and no evaluation data (Labuschange et al. 1996; Swirski and Wysoki 1995; Hodges et al. 2003). In South Africa, *C. nipponicus*, along with a parasitoid *Aphytis* sp., was imported from Thailand and successfully established in commercial mango orchards. In the following four seasons these beneficial insects seemed to effectively control the mango scale, *Aulacaspis tubercularis* Newstead, with augmentative releases. A similar release of *C. binotatus* (but most likely *C. nipponicus*) to control the Japanese bayberry whitefly, *Parabemisia myricae* (Kuwana), on citrus and avocado trees in Israel was less successful. In this case the researchers were unable to establish a viable population of the predatory beetle in the field (Swirski and Wysoki 1995).

Drea and Carlson (1988) and Van Driesche et al. (1998) were able to establish *C. nipponicus* in the Virginia/Maryland area as well as in New England. In 1995, the New Jersey Department of Agriculture embarked on an aggressive plan to combat the euonymus scale using *C. nipponicus* as a biological control agent (Hudson et al. 2001). By the year 2000, after many supplemental release and recovery plans had been implemented, it was obvious that the beetles had established populations all over the state where they were controlling and in some cases eradicating the euonymus scale.

Others have noted cybocephalids acting as a natural control of diverse species of armored scales, including at least eight species in Turkey (Erler and Tunç 2001), coconut scale (*Aspidiotus destructor* (Signoret)) in Brazil (Lima 2002), and the brown apricot scale (*Lecanium corni* Bouché) and San Jose scale (*Quadraspidiotus perniciosus* (Comstock)) (Heintz 2001) in California. However, in Mauritius the native *Cybocephalus mollis* Endrödy-Younga seemed unable to control the spread of the sugarcane scale, *Aulacaspis tegalensis* (Zhnt.), even when in conjunction with three other natural enemies of the scale (Williams and Greathead 1973).

Because many scale insects persist year-round, it is important that a biological control agent be found that is also persistent throughout the year. The cybocephalids are uniquely suited for this in that the placement of eggs and subsequent development of larvae beneath the armored scale allow them some protection from both the elements and pesticides (Alvarez and Van Driesche 1998a). In Greece, Katsoyannos (1984) found that *Cybocephalus fodori* Endrödy-Younga was able to survive in pesticide-treated fruit orchards. In date palm plantations in Israel, Kehat et al. (1974) found that while all coccinellids in a chemically treated plantation died, species of *Cybocephalus* survived.

The dietary needs of cybocephalids also make them good candidates for use as biological control agents. Alvarez and Van Driesche (1998a) found that at low scale densities cybocephalids were able to maintain their populations and keep euonymus and San Jose scale populations in check. In the case of *C. nipponicus*, an average of 19.5 scales were attacked over the entire larval lifetime, contrasted with an average of 199 green scales (*Ceroplastes japonicus* Green) consumed by the coccinellid *Chilocorus kuwanae* Silvestri (Xia et al. 1986). Thickness of the scale cover is also a factor in effectiveness of a beetle as a predator. Blumberg and Swirski (1982) found that *C. micans* and *C. nigreceps* were unable to feed on adult female diaspidid scales. It has also been noted that coccinellids are more likely to feed on scales with thin or easily penetrated scale covers (Honda and Luck 1995). *Cybocephalus nipponicus* seemed to be less affected by scale cover characteristics (Alvarez and Van Driesche 1998a). In fact, *C. nipponicus* was able to feed on the adult females of both the San Jose scale and the euonymus scale (Alvarez and Van Drieche 1998a). In the absence of prey, female cybocephalids are able to withhold eggs for up to 2 days, indicating that oviposition strategy is not only governed by food consumption but by some qualitative features of the scale population (Alvarez and Van Drieche 1998b). In the presence of greater scale densities cybocephalids will increase their egg production until they reach a constant. Again this allows cybocephalids to maintain their populations at low scale densities. If circumstances allow, female cybocephalids will lay only one egg under a single scale cover. However, if the number of scales in a patch is low and the beetle cannot find new scales it will lay eggs under a scale that has already been parasitized (Alvarez and Van Drieche 1998b). The beetle larvae consume more prey when feeding on young scales; therefore it seems that for greater survivability of their offspring female cybocephalids prefer to oviposit on older scales (Alvarez and Van Driesche 1998b). Alvarez and Van Driesche (1998b) found that the highest larval survival rate could be found in larvae feeding on scales older than 30 days. It was also noted by Blumberg and Swirski (1982) that *C. nigriceps* very rarely laid eggs under dead female scales.

Certain aspects of the biology of *Cybocephalus nigriceps* (J. Sahlberg), *Cybocephalus micans* Reitter, and *Cybocephalus gibbulus* Erichson were studied by

Nohara and Iwata (1988) and Blumberg and Swirski (1982). Tanaka and Inoue (1983) were the first to really study the feeding behavior of *C. nipponicus*. Later, Drea and Carlson (1988) and Alvarez and Van Driesche (1998a, 1998b) continued the biology of *C. nipponicus*. There remains much to be studied about the life cycle, breeding habits, oviposition behavior, or dietary requirements of *C. nipponicus* to determine whether it has any significant effect as a biological control agent of the cycad aulacaspis scale. Without some form of baseline data on the beetle, no real effectiveness research can be done.

Rhyzobius lophanthae

Rhyzobius (= *Lindorus*) *lophanthae* (Blaisdell) is a small, pubescent coccinellid belonging to the tribe Coccidulini. The adult is 2.4-2.5 mm in length and between 1.7 and 1.8 mm in width, and has black or brown elytra and an orange-brown thorax and head region. The body form is elongate or oval with a dense mat of hairs covering the dorsal surface. The head is partly concealed beneath the pronotum, with 11-segmented antennae, the last 3 segments of which are broader then the rest to form a club. The tarsal claws are not toothed. This beetle is often referred to as the singular black lady beetle or the scale destroyer.

Rhyzobius lophanthae is a coccoidophagous predator native to Australia. It is considered by many to be one of the most economically important natural enemies of armored scale insects (Yus 1973, Rosen 1990, Stathas 2001). This beetle has been released in many areas of the world to control a plethora of armored scale species (Honda and Luck 1995). There are many examples of successful control of scale insects using *R. lophanthae*, especially in the Mediterranean region (Greathead 1973). There have been some very high profile failures as well, such as the inability of *R. lophanthae* to control the California red scale in California (Greathead 1973). Honda and Luck (1995) found that the morphological characteristics of the scale itself are a major determining factor in how effective *R. lophanthae* will be in controlling a scale species. They discovered that *Rhyzobius* mandibles were not as effective as those of other species of coccinellids that specialize on armored scales, such as *Chilocorus cacti* (L.), a species frequently seen on scale-infested cycads in Florida (RD Cave 2006, personal communication). *Rhyzobius lophanthae* lacks a tooth at the apex used for prying scales from the substrate and the incisor region is neither as acutely angled nor as sharp as that of specialists like *C. cacti*.

Being much less specialized and more of a generalist predator has allowed *R. lophanthae* to be used to control a large number of pest species. *Rhyzobius lophanthae* seem to be especially effective in closed environments such as greenhouses or in botanical gardens (Anonymous 2003). They have been recorded feeding on many insects other than scales including aphids, small caterpillars, whitefly, mites, thrips, psyllids, mealybugs, and other soft bodied insects and their eggs. These beetles are also voracious feeders of the immature stages and eggs of scale insects.

The first introduction of *R. lophanthae* into the United States was initiated by Albert Koeble and releases occurred between 1889 and 1892 (Greathead 1973). It failed to control *Saissetia oleae* (Olivier), but did establish itself as a predator of armored scales on citrus and eventually spread throughout the rest of the United States. It was introduced into Hawaii from California in 1894 (Heu et al. 2003) and has been recorded feeding on CAS (Hara et al. 2004, personal observation). The larvae and adults have been observed feeding on eggs, immature, and adult CAS. This beetle was imported and officially released in Florida to control oleander scale, *Aspidiotus nerii* Bouché, and other "scale insects" after 1982 (Frank and McCoy 1994). However, many specimens in the Florida State Collection of Arthropods (FSCA) were collected in the state as early as 1936, indicating that this beetle has been established in Florida more than 70 years. Interestingly, on scale–infested cycads in Florida it has been seen only in downtown Tampa and on the campus of Florida State University in Tallahassee.

Following emergence from the egg, the small, gray larvae immediately begin to feed on scale eggs and crawlers, which are much more numerous than adult scales, but will feed on the adult scales as well. The larvae pass through 4 instars, growing to around 3 mm before pupation. The beetles will often pupate on the plant where the food source is found. At 25ºC, the total development of the life cycle of *R. lophanthae* takes about 34 days (Stathas et al. 2002). The adult beetles can live up to 9 months but average between 5 and 6 (Stathas 2000).

These beetles are exceptional biological control agents because of their high fecundity, lack of parasitoids, the absence of diapause, and their resistance to low temperature especially in the immature stages (Rubstov 1952, Smirnoff 1950, Stathas 2000). Female *R. lophanthae* are able to lay hundreds of eggs in a lifetime. Stathas (2001) found that not only did he not find any parasitized beetles in the field but even when reared with known parasitoids of other coccinellids in the laboratory none of the *Rhyzobius* larvae or adults were parasitized. This paralleled similar findings in nature (Rubstov 1952, Smirnoff 1950). Stathas (2001) also found that even in the winter in Greece *R. lophanthae* larvae could be found. In fact, both adults and larvae seem to be able to remain active at temperatures as low as 8-9ºC (Stathas 2000, Cividanes and Gutierrez 1996). *Rhyzobius lophanthae* also seems to be able to resist extreme heat, because Atkinson (1983) found that adult *R. lophanthae* had an LD_{50} at about 42ºC. Stathas (2000) found that in Greece *R. lophanthae* completed 6 generations a year, while Smirnoff (1950) speculated that they may be able to complete as many as 7-8 generations a year in Morocco.

This particular coccinellid was mentioned by Howard (1997) as a possible biological control of CAS; but never mentioned again. *Rhyzobius lophanthae* has also been labeled as “highly effective” in controlling CAS in Hawaii (Hara et al. 2004). However, there are no research data to support this claim. In Tampa, Florida, adults and larvae have been seen in large numbers feeding on CAS (personal observation 2004). The fact that this beetle is already found in Florida makes it an appealing candidate for the biological control of CAS. Label data with specimens in the FSCA indicate this predator was captured feeding on *Fiorinia theae* Green, *P. cockerelli*, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), and *Acutaspis morrisonorum* Kosztarab.

CHAPTER 2
LIFE HISTORY OF *Cybocephalus nipponicus* ENDRÖDY-YOUNGA A PREDATOR OF *Aulacaspis yasumatsui* TAKAGI (HOMOPTERA: DIASPIDIDAE)

Introduction

Cybocephalids are among the most economically important groups of natural enemies against scale insects (Alvarez and Van Driesche 1998a). Larvae and adults are voracious predators and have many desirable traits for use as biological control agents. *Cybocephalus nipponicus* Endrödy-Younga was released and later established in the Washington D.C./Maryland area to combat the euonymus scale, *Unaspis euonymi* (Comstock) (Drea and Carlson 1988, Drea and Hendrickson 1988). Alvarez and Van Driesche (1998a) later released and established populations of *C. nipponicus* in New England. This same species also was released, under the false identification of *Cybocephalus binotatus* (Grouvelle), into the Miami area in 1998 for control of the cycad aulacaspis scale, *Aulacaspis yasumatsui* Takagi (Anonymous 1998, Howard et al. 1999, Howard and Weissling 1999). While *C. nipponicus* and *C. binotatus* appear similar, they each have very distinctive male genitalia (Endrödy-Younga 1971), and *C. binotatus* (Fig. 2-1A) has two large black spots on the pronotum, which are absent in *C. nipponicus* (Fig. 2-1B). Although *C. nipponicus* previously was established in Florida before 1998 (according to specimen label data in the Florida State Collection of Arthropods), its range and abundance in the state before 1998 are unknown (Smith and Cave 2006b).

The cycad aulacaspis scale (CAS) is the most damaging scale found on *Cycas* in Florida (Hodges et al. 2003). CAS is native to Thailand but is found throughout China and southeastern Asia, as well as on several Caribbean islands, Florida, and Hawaii (Ben-Dov et al. 2003). In 1992, CAS had become such a problem in Hong Kong that 70-100% mortality was recorded in infested king sagos, *Cycas revoluta* Thunberg (Hodgson and Martin 2001). The first detection of CAS in Florida occurred in 1996 in Miami at the Montgomery Botanical Center. The scale was thought to have arrived on infested cycads imported from southeastern Asia (Howard and Weissling 1999). By the end of 1997, CAS had spread throughout Miami and as far north as Lake Okeechobee and could be found on 20 species of cycads (Howard and Weissling 1999); however it seems to prefer *Cycas* and *Stangeria* (Emshousen pers. comm. 2004). This led to the spread of CAS to Hawaii in 1998 through the legal importation of infested cycads from Florida (Hodgson and Martin 2001). At present, CAS has been reported from Pensacola east to Jacksonville and south into the Florida Keys. Infested cycads in northern Florida were suspected transplants from southern nurseries rather than natural progression of the scale northward.

The objective of this study is to collect life history data on *C. nipponicus* using CAS as prey, and compare these to the results from Tanaka and Inoue (1980) and Alvarez and Van Driesche (1998a) using euonymus scale as prey. A better understanding of these beetles using different prey will lead to greater understanding of how they perform as biological control agents in the field, and consequently increase success in controlling CAS.

Materials and Methods

A colony of CAS was reared on king sago in a sealed greenhouse to keep out possible predators and/or parasitoids. Small king sago specimens were infested with CAS by placing large numbers (>100) of eggs on each plant. Once infested, plants were then placed in contact with other non-infested plants to spread non-parasitized scales to other plants. Thus, we could be confident that parasitoids and predators did not invade the colony.

A colony of *C. nipponicus* was initiated from individuals collected in south Miami (N25º38’21” W80º20’09”). *Aphanogmus albicoxalis* Evans and Dessart (Hymenoptera: Ceraphronidae) parasitizes the pupae of *C. nipponicus* in southern Florida (Evans et al. 2005), but this parasitoid was excluded by collecting only adult beetles and subsequently rearing future generations in sealed cages (0.5m x 0.5m x 0.5m). Cycad leaves infested with CAS were cut from the colony plant, with rachis bases placed in floral water tubes for hydration, and then placed in rearing cages. The leaves and interior of the cage were misted with distilled water every three days. A moist sponge also was provided for hydration. Leaves were replaced every three weeks. Old leaves were held in separate cages for three weeks to recover emerging beetles. Beetle and scale voucher specimens were placed in the Florida State Collection of Arthropods (FSCA).

All life cycle studies were carried out in temperature- and humidity-controlled cabinets set at 25° C with a relative humidity of 80% and a photoperiod of 14:10 (L:D). Each treatment was initiated by isolating 25-30 mating pairs of beetles randomly selected from the laboratory colony. Each pair was placed in a 25-dram plastic vial with one *C. revoluta* leaflet infested with male and female CAS. After 24 hours the beetles were removed and eggs collected from beneath the scale armor on the leaflet. Eggs were measured (length and width), and then, to simulate natural conditions, placed on the surface of a small, clean piece of *C. revoluta* leaflet and covered with the armor of an adult female CAS. The leaflet piece was placed in the well of a rectangular tissue culture dish, covered with parafilm, and placed in the environmental chamber. Eggs were checked daily until larvae emerged.

Newly emerged larvae were placed in 25-dram plastic vials with freshly-cut, CAS-infested leaflets on top of sterilized sand in the bottom of the vial. Old leaflets were replaced with fresh, infested leaflets every five days throughout the life cycle. A fine mesh cloth was placed over the top of the vials to allow airflow. Larval and pupal development was checked daily. Upon emergence from the pupal case the adults remained in plastic vials and were provided with 20-30 fresh CAS every 3 days. Adults were checked daily until death.

Eggs, larvae, and pupae were critical-point dried in a Tousimis® samdri-780 A, and sputter coated with a gold-palladium alloy. Images were taken with a JEOL® JSM-5510LV scanning electron microscope and a Syncroscopy® automontage photography system.

Descriptive statistics were generated in SAS (2001) using a PROC UNIVARIATE analysis. The dependent variable was number of days in each stage and the independent variable was the stage itself. PROC UNIVARIATE and PROC t-test were used to generate statistics for adult longevity.

Results and Discussion

The egg of *C. nipponicus* is elongate oval with both ends rounded, relatively large measuring 0.42 mm by 0.20 mm (n=50) and usually light gray to purple. Eggs were usually found singly inside the vacated tubular cover of a male scale or under the armor of a female scale, usually with a live scale beneath but occasionally with a dead female. During low scale density, as many as 5 eggs under one female armor were observed. An egg deposited within the male scale cover fit snugly and had almost the same diameter as the scale cover, thereby allowing only one egg to be placed in one male cover. The surface was smooth aside from debris sticking to the surface (Fig. 2-2) and was slightly tacky, allowing the egg to stick to the substrate. Females typically laid about 3 eggs per day and on average 288 eggs in a lifetime (Alvarez and Van Driesche 1998a). Eggs hatched about 7 days after oviposition (Table 2-1). Eyespots could be seen 1-2 days before larval emergence.

When the larva emerged, the chorion split along the longitudinal axis and the larva wriggled free. This process took about 15 minutes compared to the 30 to 45 minutes reported by Blumberg and Swirski (1982) on the life history of *Cybocephalus micans* Reitter and *Cybocephalus nigriceps nigriceps* (J. Sahlberg). The neonate larvae were white or yellowish with long setae along the body, but after feeding for a day turned light purple or lavender, with 4 black stemmata on each side of the head (Fig 2-3A, B). Not only were larvae covered in long, slender setae but also shorter trumpet-shaped setae (Fig. 2-4). After emergence, larvae immediately began to feed either on the scale eggs sharing the space beneath the armor or rarely on the female scale. If an egg hatched in a male scale cover, the larva would go to the nearest food source. Larvae continued to move from scale to scale feeding on males, females, and eggs but spent the most time underneath female armor. They also were seen cannibalizing other larvae when scale density was extremely low, as mentioned by Alvarez and Van Driesche (1998a). Larvae fed for 9 to 10 days.

Three instars (Fig. 2-5A, B) were observed, similar to *C. micans* and *C. n. nigriceps* (Blumberg and Swirski 1982). However, Ahmad (1970) recorded four instars in *Cybocephalus semiflavus* Champion. When molting, the cuticle ruptured along the top of the head capsule and along the median dorsal region of the body. The larva emerged from the anterior portion of the old exuviae first, and then wriggled vigorously to extract the posterior body portion. The posterior portion of the old exuviae remained attached to the substrate. Average larval development was about 14 days (Table 2-1).

If bright light was shone on larvae they immediately moved underneath a scale armor or debris. Once disturbed larvae raised the head and body away from the leaf surface, arching the body into a C-shape, and holding to the substrate with the conical protuberance found on segments 8 and 9. This threat posture is similar to that used by the larva to extract themselves from old exuviae.

Larvae became less active 2 to 3 days prior to pupation, stopped feeding, eventually becoming immobile and attaching the posterior of the abdomen to the substrate before forming the pupal case. Larvae gathered pieces of scale armor and incorporated these pieces into an ovoid pupal chamber with one end flatter where it attached to the substrate (Fig. 2-6A).

Pupal chambers often were found in the anterior portion between leaflet and leaf rachis or near the leaflet base. However, pupal chambers also were observed along leaflet and rachis. When not given access to scales, larvae used sand or other organic material to construct the pupal chamber (Fig. 2-6B), sometimes attaching to the leaf or dropping to the sand. Infrequently, larvae dropped to the sand and made a sand cocoon even when scales were available. This behavior is common in *Cybocephalus* and has been suggested or recorded for other species (Clausen and Berry 1932, Flanders 1934, Smirnoff 1954, Blumberg and Swirski 1982). All pupae exhibited typical exarate features (Fig. 2-7A, B). Pupation lasted about 18 days (Table 2-1). Beetles exited the chamber by chewing an emergence hole.

There was no significant difference in developmental time from egg to adult between sexes (t=1.50, df=52, P=0.1389). Total development from egg to adult lasted about 40 days (Table 2-1), thus it is conceivable that 7-8 generations could be produced per year in southern Florida or other areas with amenable temperatures. Alvarez and Van Driesche (1998a) suggested that these beetles were capable of producing 3 generations per year in New England.

Preoviposition lasted about 4 days (n=29) with some females laying eggs as early as 2 days (n=2) after emergence. Adults (Fig. 2-8) began feeding soon after emergence and consumed an average of 4 scales per day, with females typically eating more than the males. Disproportionate feeding is probably due to size, because males are smaller than the females. Maximum female longevity was 190 days, with an average of about 110 days (Table 2-1). Average longevity of males was 89 days (Table 2-1) with a maximum of 155 days. Due to high variation, a t-test showed no significant difference between longevity of the sexes (t=1.50, df=52, P=0.1389). These findings are intermediate between the 78 days for males and 99 days for females reported by Alvarez and Van Driesche (1998a) at 22º C and 122 days for males and 143 days for females reported by Tanaka and Inoue (1980), who do not detail their experimental temperatures used. Shorter male longevity may be due to their more active nature. Males were observed moving around the cages more often than females. Often, 5 or 6 males would chase a female for hours before finding a new female to pursue. The sex ratio of emerging adults was 23:31 (male:female).

Our results were similar to those of Alvarez and Van Driesche (1998a) and Tanaka and Inoue (1980). However, all stages developed slower in the former study (9.1 days for eggs, 14.5 days for larvae, and 20.4 days for pupae) in comparison to our results, but this maybe due to their lower experimental temperatures or the food source. Population differences may account for some discrepancies in the life history parameters of the beetles in each study. The beetles studied by Tanaka and Inoue (1980) originated in Japan and those studied by Alvarez and Van Driesche (1998a) originated in Beijing, China. Our beetles may have originated in Thailand, however, this is only speculation considering the beetles were present in Florida before the recorded introduction in 1998 (Smith and Cave, in press). Mortality rates in our study also were slightly higher, possibly due to high humidity. Fungal growth was a consistent problem in the humid environment of our rearing chambers. Scales often became so encrusted on the cycad leaflet that saprophytic fungi quickly spread. Alvarez and Van Driesche (1998a) did not record relative humidity, thus a comparison cannot be made.

Mortality was highest during the larval stage. The first few days of larval development proved to be most difficult (Fig. 2-9). Eggs and pupae seemed to be quite hardy with mortality of 22% and 9%, respectively (Table 2-2), which are similar to the 14% and 8% mortality rates found by Alvarez and Van Driesche (1998a). Therefore, the 86% mortality rate in the larval stage (Table 2-2) is interesting and not predicted. However, when reared on San Jose scale, *Quadraspidiotus perniciosus* (Comstock), Alvarez and Van Driesche (1998a) found the larval stage of *C. nipponicus* had a correspondingly high 77% mortality rate.

Certain aspects of the biology and life history of other *Cybocephalus* species have been studied, typically as part of biological control projects, e.g., *Cybocephalus rufifrons* Reitter (De Marzo 1995), *Cybocephalus freyi* Endrödy-Younga (Lupi 2003), and *Cybocephalus fodori* Endrödy-Younga (Katsoyannos 1984) have been studied in Europe; and *Cybocephalus semiflavus* Champion (Ahmad 1970) and *Cybocephalus gibbulus* Erichson (Nohara and Iwata 1988) have been studied in Asia. In the Middle East, several studies have been carried out on *C. aegyptiacus*, *C. binotatus*, *C. micans*, and *C. n. nigriceps* (Blumberg 1973, 1976; Blumberg and Swirski 1974 a,b, 1982). In Australia, Kirejtshuk et al. (1997) described *Cybocephalus aleyrodephagus* and studied its life cycle. The life histories of these species do not differ dramatically from *C. nipponicus*, and there seems to be fairly consistent life cycle and feeding habits.

In the absence of prey, female cybocephalids are able to withhold eggs for up to 2 days, indicating that oviposition strategy is not only governed by food consumption but also by qualitative features of the scale population (Alvarez and Van Driesche 1998b). In the presence of high scale density, cybocephalids increase egg production until an asymptote is reached. Again, this allows cybocephalids to maintain their populations at low scale densities. If circumstances allow, female cybocephalids will lay only one egg under a single scale cover. However, if the number of scales in a patch is low, and the beetle cannot find new scales, it will lay eggs under a scale under which eggs are already present (Alvarez and Van Driesche 1998b). The beetle larvae are forced to consume more prey when feeding on younger scales, therefore for greater offspring survivability female cybocephalids prefer oviposition on older scales that provide a larger food source and require less searching (Alvarez and Van Driesche 1998b). Alvarez and Van Driesche

(1998b) found that the highest larval survival rate could be found in larvae feeding on scales older than 30 days. Blumberg and Swirski (1982) noted that *C. n. nigriceps* rarely laid eggs under dead female scales.

Evans et al. (2005) described two species of *Aphanogmus* that parasitize *C. nipponicus* pupae. *Aphanogmus inamicus* Evans and Dessart emerged in quarantine from hosts collected in Thailand, and *A. albicoxalis* occurs naturally in Florida. The latter species is broadly distributed in southern Florida, with collection sites in Collier, Miami-Dade, and St. Lucie counties. The levels of parasitism in *C. nipponicus* populations in Florida are currently undetermined, but large numbers of these wasps occasionally have been seen on cycads.

Cybocephalus nipponicus will probably always be considered a supplementary predator for the control of CAS. However, some attributes make these beetles very attractive as biological control agents, including a long lifespan, some ability to resist or protect themselves from pesticides (Alvarez and Van Driesche 1998a, Katsoyannos 1984, Kehat et al. 1974), and most importantly, the ability to persist at low scale densities (Alvarez and Van Driesche 1998b). However, even in combination with the parasitoid *Coccobius fulvus* Compere and Annecke (Hodges et al. 2003) these beetles are unable to adequately control populations of CAS in Florida.

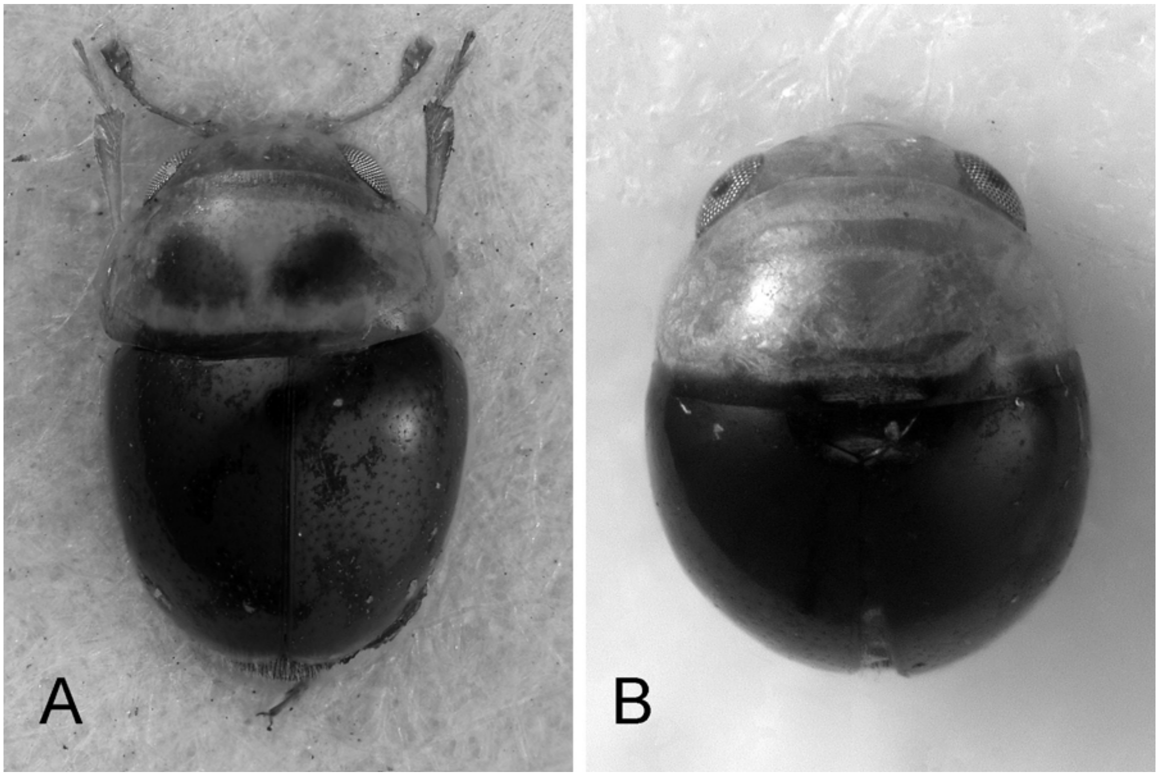


Figure 2-1. Dorsal habitus. A, *Cybocephalus binotatus*. B, *Cybocephalus nipponicus*.

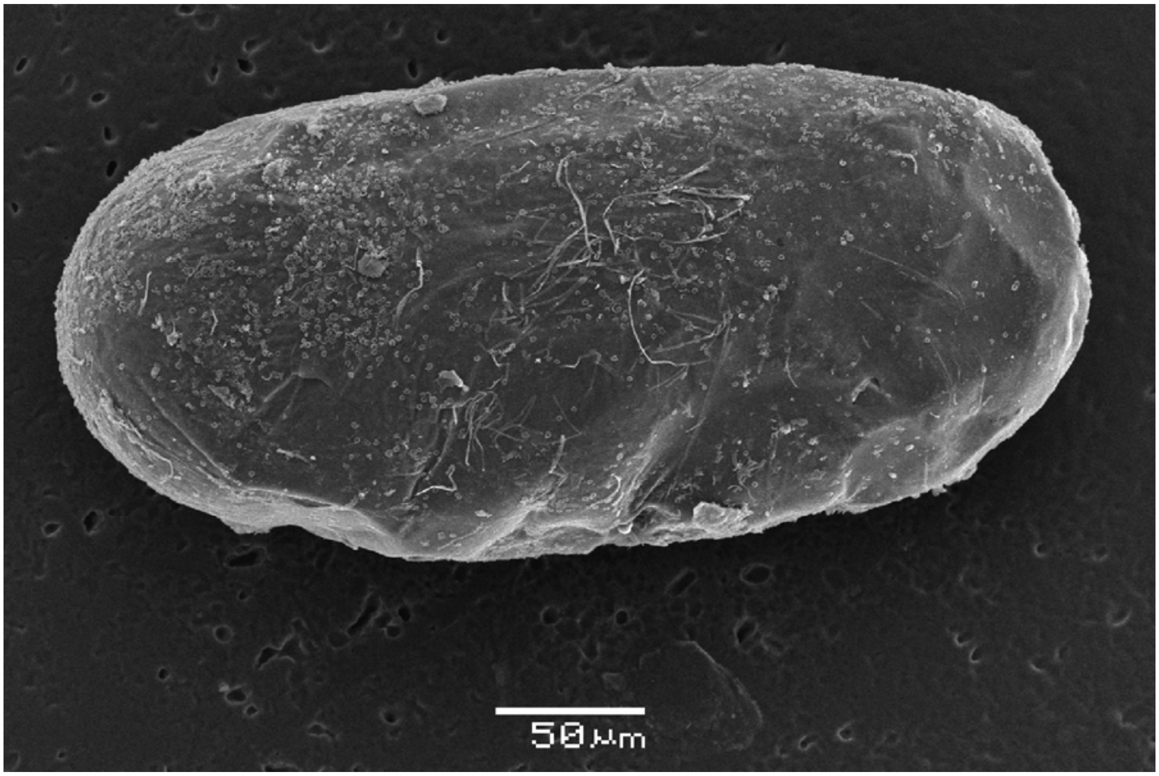


Figure 2-2. Egg of *Cybocephalus nipponicus*.

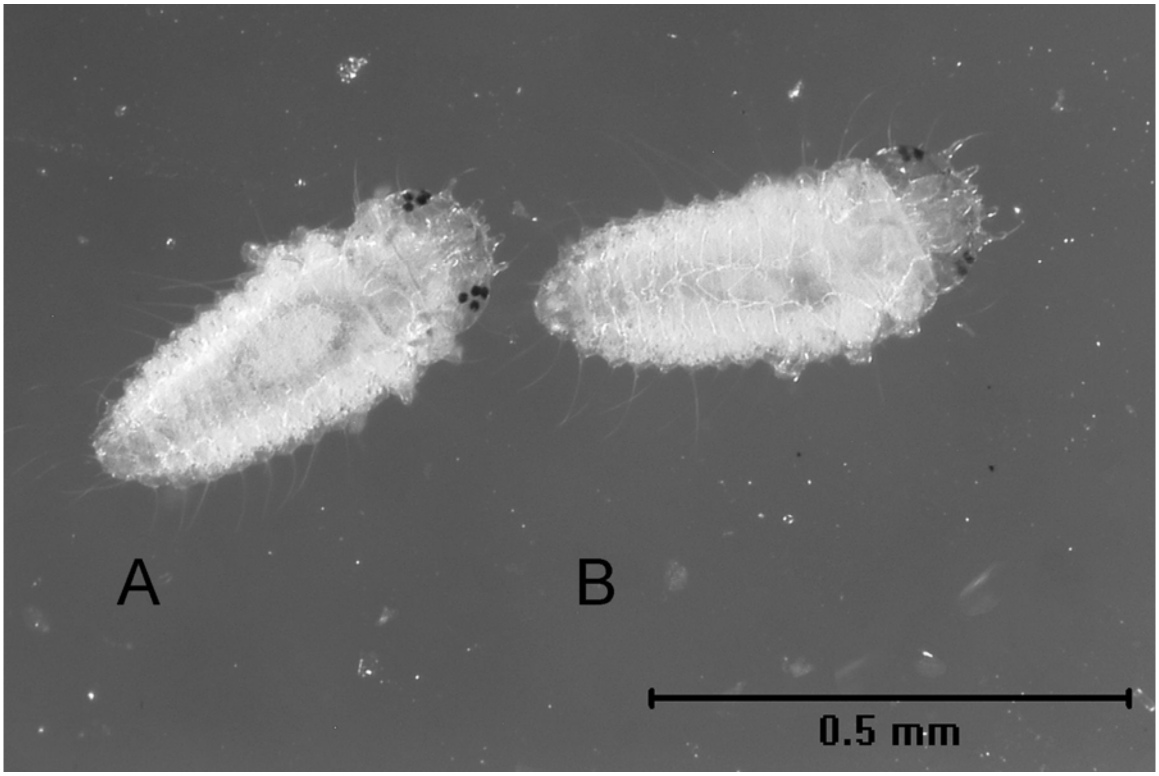


Figure 2-3. First instar larva of *Cybocephalus nipponicus*. A, Dorsal habitus. B, Ventral habitus.

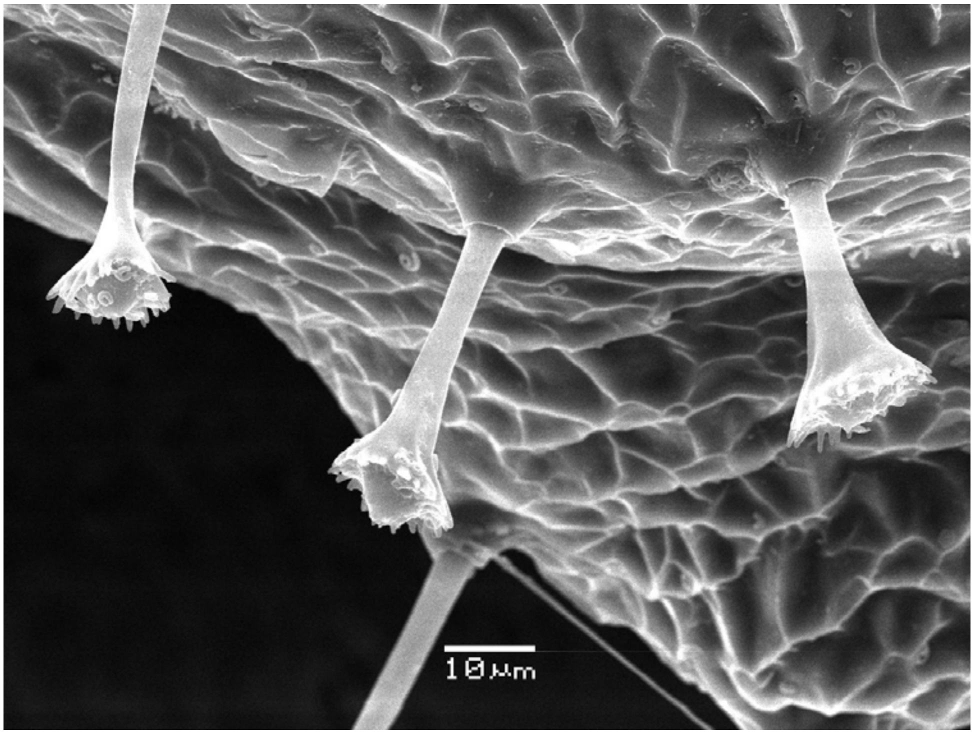


Figure 2-4. Short trumpet-shaped setae on third instar larva of *Cybocephalus nipponicus*.

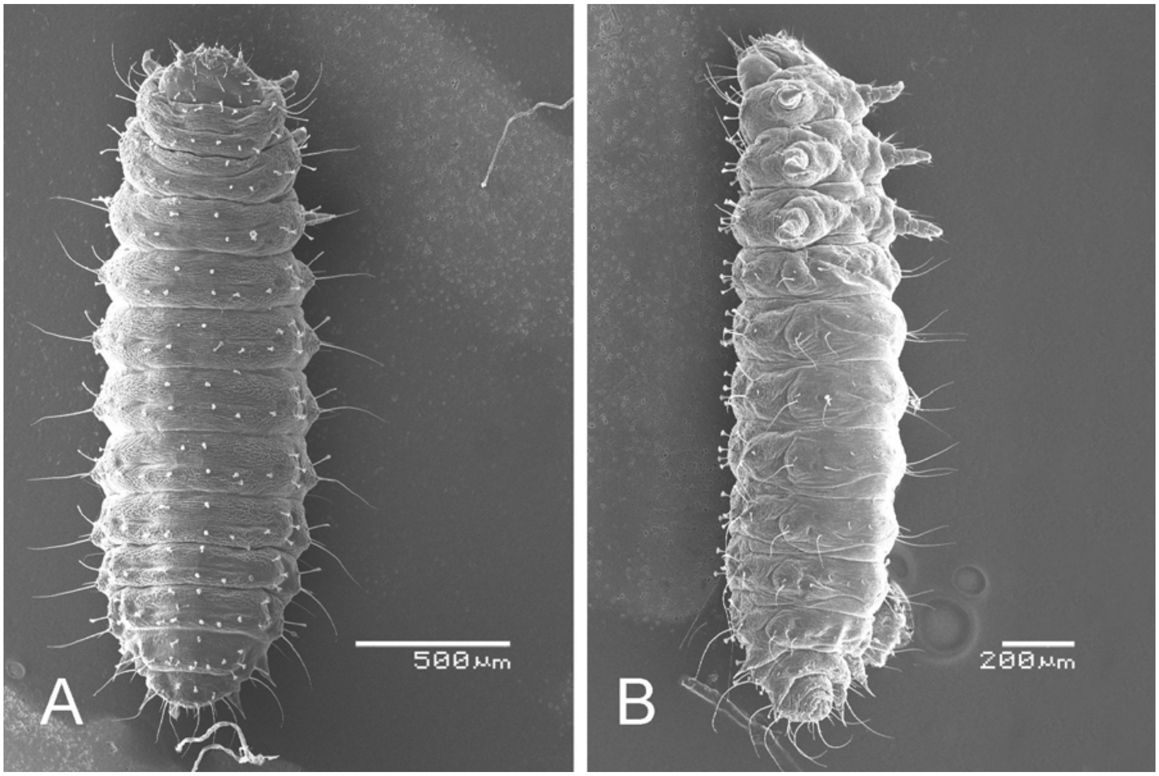


Figure 2-5. Third instar larva of *Cybocephalus nipponicus*. A, Dorsal habitus. B, Ventral oblique habitus.

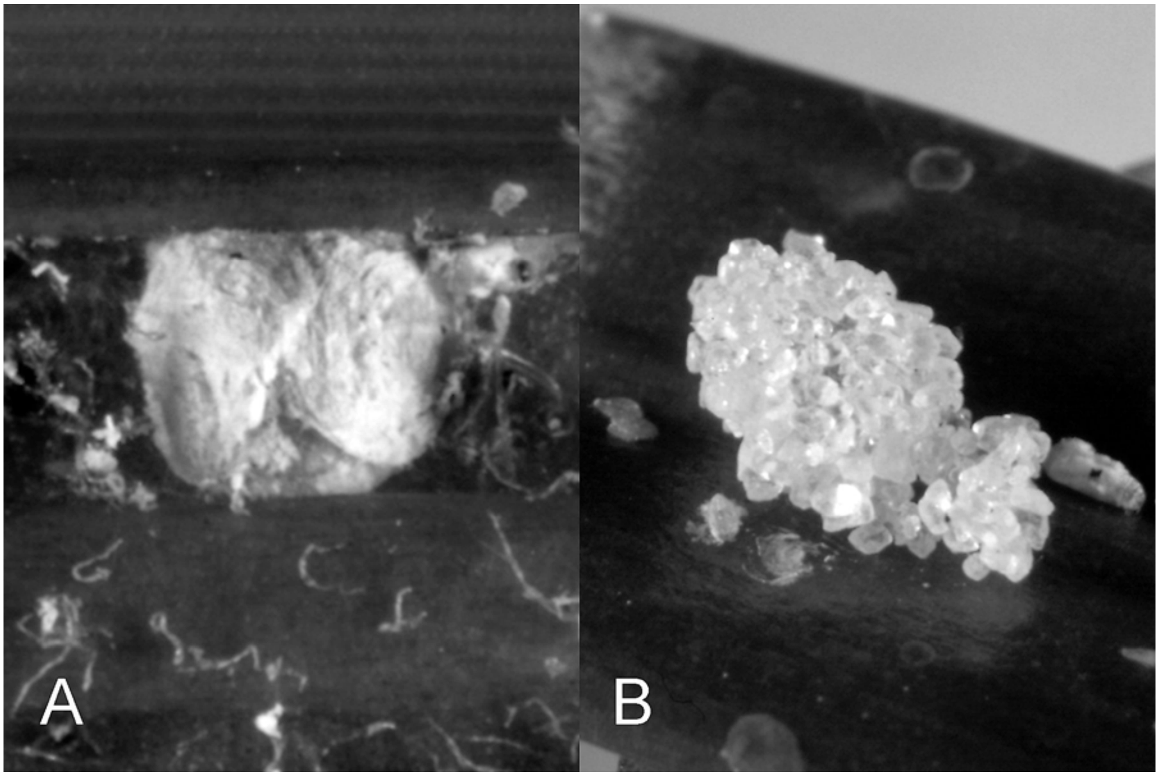


Figure 2-6. Pupal chambers of *Cybocephalus nipponicus*. A, Pupal chamber made from female scale covers. B, Pupal chamber made from sand.

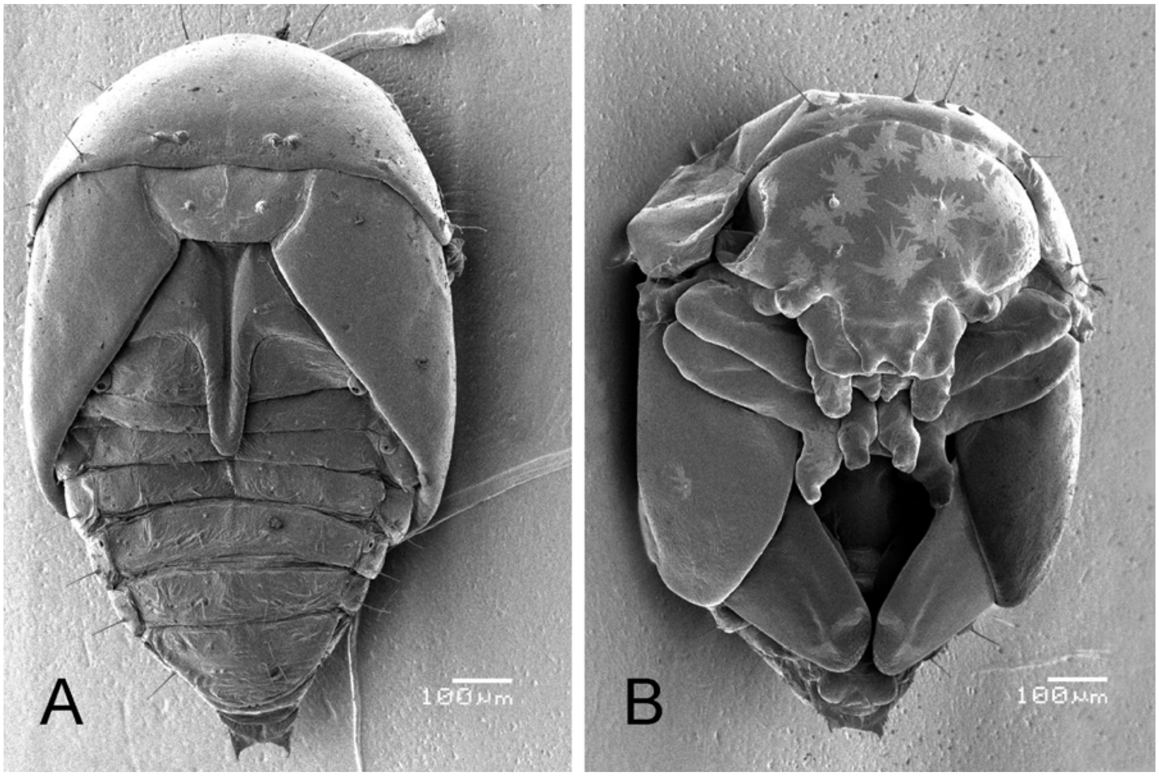


Figure 2-7. Pupa of *Cybocephalus nipponicus*. A, Dorsal habitus. B, Ventral habitus.

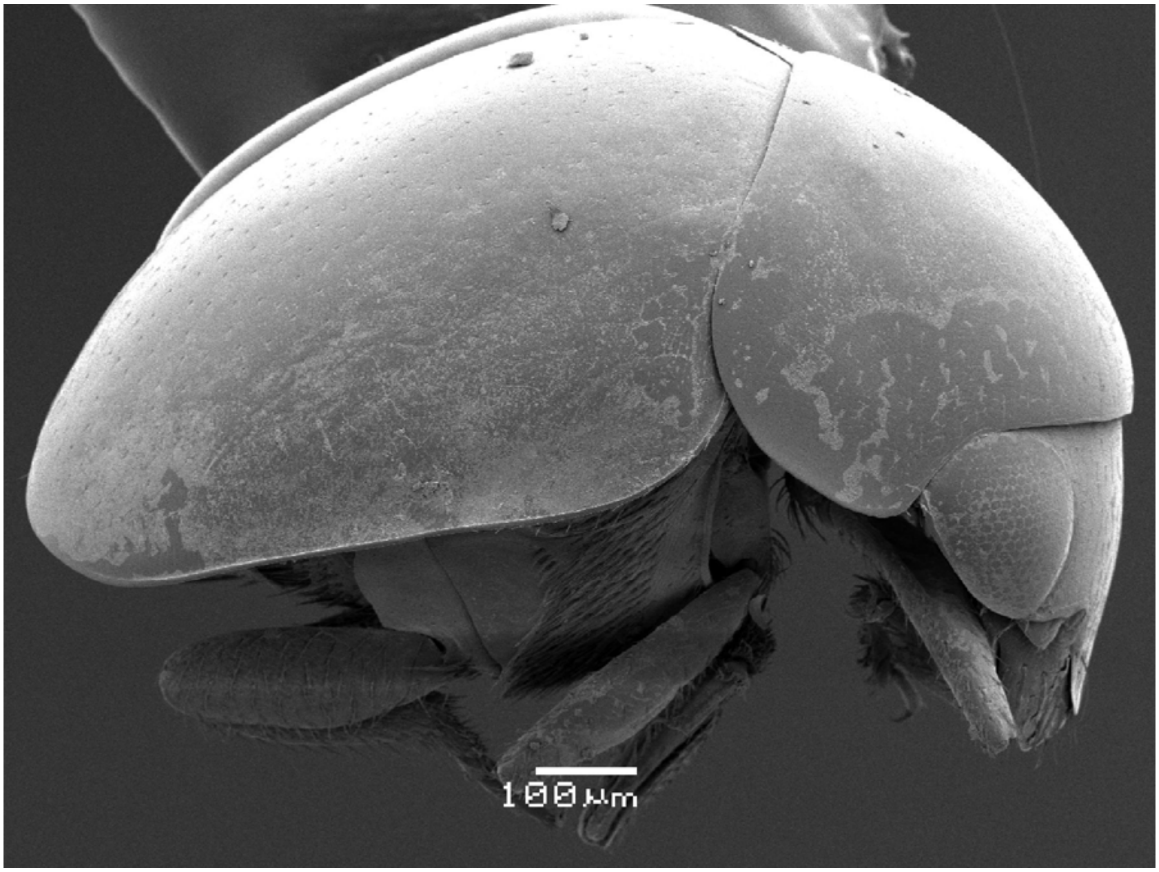


Figure 2-8. Adult *C. nipponicus*, lateral habitus.

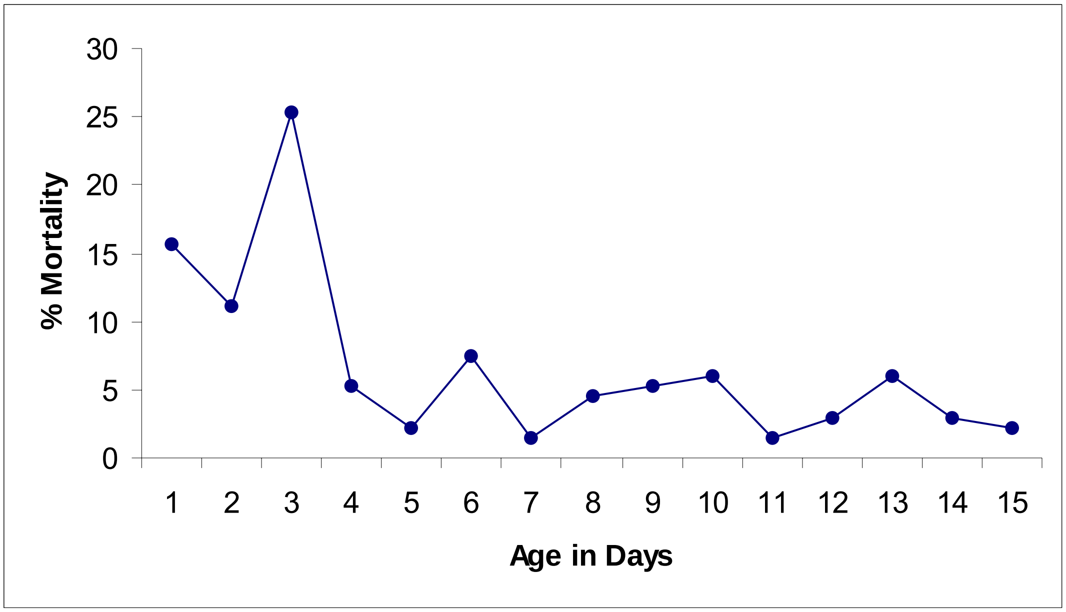


Figure 2-9. Larval mortality over time.

Table 2-1. Development of Cybocephalus nipponicus on Aulacaspis yasumatsui.

Stage	Mean (Days)	SE	Range (min-max) (Days)	N
Egg	7.3	0.1	4 (5-9)	131
Larva	13.7	0.1	4 (12-16)	94
Pupa	18.6	0.2	6(16-22)	44
Total development time	39.5			
Male life-span	89.1	9.7	146 (9-155)	23
Female life-span	110.0	9.6	175 (15-190)	31

Table 2-2. Mortality (%) of immature stages of *Cybocephalus nipponicus* during rearing on *Aulacaspis yasumatsui*.

Stage (x)	No. Alive at Start (l_x)	No. Dying in Stage (d_x)	Apparent Mortality (q_x)
Egg	200	44	0.22
Larva	156	134	0.86
Pupa	22	2	0.09
Adult	20		

CHAPTER 3
PESTICIDE SUSCEPTIBILITY OF *Cybocephalus nipponicus* AND *Rhyzobius lophanthae* (COLEOPTERA: CYBOCEPHALIDAE, COCCINELLIDAE)

Introduction

Beetles of the families Coccinellidae and Cybocephalidae are the most economically important groups of predators of diaspidid scales in the world (Blumberg and Swirski 1982). *Cybocephalus nipponicus* Endrödy-Younga (Cybocephalidae) and *Rhyzobius lophanthae* Blaisdell (Coccinellidae) are commonly used as biological control agents for many armored scale pests. *Rhyzobius lophanthae* has been established in Florida since the 1930s (according to specimen label data in the Florida State Collection of Arthropods). *Cybocephalus nipponicus*, misidentified as *Cybocephalus binotatus* Grouvelle, was recently released in south Florida in an effort to control the cycad aulacaspis scale (CAS), *Aulacaspis yasumatsui* Takagi (Anon. 1998; Howard et al. 1999; Howard and Weissling 1999). CAS is the most economically damaging scale to cycads that the state of Florida has ever seen (Hodges et al. 2003). Although *C. nipponicus* is present in Hawaii (Heu and Chun 2000), *R. lophanthae* is usually suggested as the better control agent of CAS (Heu et al. 2003; A. Hara, personal communication). In both places, CAS has continued to spread and multiply. A more promising approach to controlling CAS would be one using integrated pest management (IPM). In this manner, a combination of pesticides and biological control would be used to combat CAS.

There has been some success controlling CAS with various pesticides. Oils, either an ultra-fine horticultural oil or a product containing fish oils, seem to be the most effective chemical control method (Hodges et al. 2003). This is not surprising given that oils have long been used to control armored scale insects. The oil not only covers the insects and suffocates them but also covers the surface of the plant making it difficult for crawlers to settle onto the plant (Howard and Weissling 1999). Soaps are quite popular with homeowners; but they must be applied frequently, in some cases once a week (personal observation). The effective application of pesticides for control of CAS is difficult due to the scale's tendency to heavily infest the abaxial surface of leaves, which is difficult to spray (Howard and Weissling 1999). In the case of *C. revoluta*, the architecture of the plant itself, with the margins of the leaflets curling down and inward to form an arch on the abaxial surface of the leaflet, makes foliar treatments inefficient (Hodges et al. 2003). Frequent or "as needed" applications of oils seems to be the most effective technique for controlling CAS, and by mixing oil with contact pesticides such as malathion, even greater scale mortality can be achieved (Hodges et al. 2003). The use of systemic pesticides such as dimethoate and contact pesticides like methidathion has yielded mixed results, being very effective in some instances and completely ineffective in other cases (Hodges et al. 2003). Imidacloprid used as a soil drench can be very effective, but Howard and Weissling (1999) found that this product had to be mixed at very high concentrations to be effective. This product can also be used as a foliar spray.

The reproductive biology of *C. nipponicus* makes it a good biological control agent. Alvarez and Van Driesche (1998a) found that, at low scale densities, *C. nipponicus* was able to maintain its populations and maintain populations of euonymus scale, *Unaspis euonymi* (Comstock), and San Jose scale, *Quadraspidiotus perniciosus* (Comstock), in check. In the presence of greater scale densities, *C. nipponicus* will increase its egg production accordingly. With a total life cycle from egg to adult only taking around 44 days (Smith and Cave 2006b), it is conceivable that 5-6 generations could be produced every year in Florida. *Cybocephalus nipponicus* is available commercially in the U.S. market.

Rhyzobius lophanthae is an exceptional biological control agent because of its high fecundity, lack of parasitoids, the absence of diapause, and resistance to low temperatures especially in the immature stages (Rubstov 1952; Smirnoff 1950; Stathas 2000). Female *R. lophanthae* are able to lay hundreds of eggs in a lifetime (Stathas 2000). *Rhyzobius lophanthae* also seems to be able to resist extreme heat. Atkinson (1983) found that adult *R. lophanthae* could not survive for long at 42º C. *Rhyzobius lophanthae* is also available commercially in the U.S. market.

This study was conducted to determine the susceptibility of *C. nipponicus* and *R. lophanthae* to six pesticides commonly used in the control of CAS. Given the established presence of both predators on cycads in south Florida and their commercial availability, it is very important to learn what effects the commonly used pesticides against CAS will have on them. This information is vital for development of IPM programs aimed at controlling CAS.

Materials and Methods

Insects

Adult *R. lophanthae* were reared at and purchased from Rincon-Vitova Insectaries (Ventura, California). Adult *C. nipponicus* were also purchased from Rincon-Vitova but were reared by Philip Alampi Beneficial Insect Laboratory, New Jersey Department of Agriculture. Both beetle species were maintained in Plexiglas cages at 25º C prior to testing. All life stages of CAS were provided as a food source.

Food was not provided during testing because of the very small size of the beetles (1 mm and 2.5 mm in length). The beetles could have conceivably perched on the food source for long periods of time, never coming into contact with the walls of the treated vial. Preliminary studies indicated that a 24-hour period without food would not unduly stress the beetles. On average, untreated *C. nipponicus* survived for 8-9 days (n=30) and untreated *R. lophanthae* lived for 5-6 days (n=30) before dying of starvation. Cotton used to stopper the vials was soaked in water to prevent dehydration.

Bioassays Using Coated Glass Vial Method

A coated glass vial method (Plapp 1971; Amalin et al. 2000; Snodgrass 1996; Snodgrass et al. 2005) was used to determine the chemical susceptibility of adult *R. lophanthae* and *C. nipponicus* to six pesticides used to control CAS (Howard et al. 1997; Howard and Weissling 1999; Weissling et al. 1999; Hodges et al. 2003; Emshousen and Mannion 2004). This is a very effective method for testing the chemical susceptibility of small arthropods (Amalin et al. 2000) such as *R. lophanthae* and especially *C. nipponicus* because of its extremely small size. The six pesticides tested were fish oil emulsion (Organocide®), insecticidal soap (Garden Safe, Inc.), imidacloprid (Provado®), malathion (Spectracide, Inc.), methidathion (Supracide®), and dimethoate (Cygon®). The fish oil and insecticidal soap were purchased at commercial grade, while the imidacloprid (99% purity), malathion (98% purity), methidathion (98.6% purity), and dimethoate (98.7% purity) were purchased in the technical grade from Chem Service (West Chester, PA).

All pesticides were dissolved in acetone, except the insecticidal soap which does not dissolve in acetone. Instead, the insecticidal soap was dissolved in 95% ethanol. The fish oil was shaken in a paint shaker after being placed in acetone in order to break up the oil into fine globules. Each pesticide was separated into three dilutions: field rate, twice field rate, and one-half field rate. The field rate was taken from label data for each pesticide as directed for use against scale insects. A small amount (0.5 ml) of the pesticide working solution was dispensed into 20-ml scintillation vials. Concentrations of active ingredient for the working solution and the amount of active ingredient residue within the vials can be seen in Table 3-1. Vials were hand turned until the acetone or ethanol completely evaporated leaving an insecticidal residue on the inner surface. Vials treated with only acetone or ethanol, as well as untreated vials, were used as controls. A single beetle was placed into a treated vial. All beetles had emerged from pupae within the previous 14 days. Vials were sealed with cotton soaked in water allowing the beetles to drink. Vials were placed upright in a ventilated cabinet with a fume hood and at a constant temperature of 25º C and 80% relative humidity for 24 hours. For each treatment of 10 beetles, 5 females and 5 males were used. Each treatment of 10 beetles was replicated 3 times for each dosage. All trials were carried out the same day as the pesticide was applied to the vials.

Mortality of beetles was determined immediately after the 24-hour period. A beetle was considered dead if it was not moving or could not right itself. Percent survivorship was measured as the proportion of 30 beetles alive after a 24-hour exposure to the pesticides.

Statistical Analysis

All descriptive statistics were generated in EXCEL (Microsoft 2000). The mortality rates for each pesticide were compared using the Student-Newman-Keuls mean separation test (SAS Institute 2001).

Results

Of the six pesticides tested on adult *C. nipponicus* and *R. lophanthae*, three (methidathion, dimethoate, and malathion) caused >90% mortality at all concentrations, while the other three (fish oil, insecticidal soap, and imidacloprid) were less toxic but still caused very high mortality (Tables 3-2 & 3-3).

Effects of Pesticide on *C. nipponicus*

Cybocephalus nipponicus was extremely susceptible to all pesticides. The three least toxic pesticides were imidacloprid, insecticidal soap, and fish oil (Table 3-2). There were significant differences in mortality between concentrations amongst these three pesticides (Table 3-4). Fish oil was still quite toxic to this beetle, and due to its very small size, *C. nipponicus* would often get trapped in small globules of oil, eventually dying from suffocation.

Effects of Pesticide on *R. lophanthae*

Rhyzobius lophanthae was more tolerant than *C. nipponicus* to the experimental pesticides, although mortality rates were also high for this species. The three least toxic pesticides to *R. lophanthae* were imidacloprid, insecticidal soap, and fish oil (Table 3-3). There were significant differences in survivorship between concentrations of these three pesticides (Table 3-4). *Rhyzobius lophanthae*, about twice the size of *C. nipponicus*, had much less difficulty traversing oil globules on the surface of the vials.

Discussion

There was a significant difference between mortality in the control and that of even the lowest pesticide concentration. This sensitivity to pesticides makes an IPM approach to the control of CAS quite difficult. Unfortunately, most of the success in chemically controlling CAS has involved very toxic pesticides often being used at higher than recommended doses (Howard and Weissling 1999, Weissling et al. 1999).

The high mortalities experienced by *C. nipponicus* and *R. lophanthae* are not unexpected. Nakao et al. (1985) found that all 18 species of Coccinellidae inhabiting Japanese citrus groves were severely affected by the application of pesticides, including methidathion and dimethoate. They also found that *Cybocephalus gibbulus* Erichson, one of the most common scale predators found in Japanese citrus groves, was virtually eliminated by long-term pesticide use. Oils have proven to be the most effective pesticides used against many plant-sucking pests, while maintaining the natural enemy populations. Erkiliç and Uygun (1997) found that oils were much less toxic to *Cybocephalus fodori minor* (Endrödy-Younga) and *Chilocorus bipustulatus* (Linnaeus) than was methidathion. In fact, they went as far as to say that methidathion should not be used in IPM programs.

In natural conditions, the predatory beetles may not likely be in contact with the pesticide for as long as the exposures in this experiment. However, *C. nipponicus* and *R. lophanthae* are uniquely suited for life in chemically-treated environments. Both beetle species place their eggs underneath the scale cover and at least part of larval development takes place beneath the armored scale, allowing the beetles some protection from both the elements and pesticides (Smirnoff 1950; Alvarez and Van Driesche 1998; Stathas 2001). In Greece, Katsoyannos (1984) found that *C. fodori* was able to survive in pesticide-treated fruit orchards. In date palm plantations in Israel, Kehat et al. (1974) found that, while all coccinellids in a chemically-treated plantation died, species of *Cybocephalus* survived.

It is apparent from these tests that, for some pesticides, the lower the concentration of the pesticide the higher the survivorship. However, these tests were conducted in a laboratory environment in which the test subjects were in constant contact with the pesticide for 24 hours. A whole host of factors, such as humidity, UV degradation, evaporation, and precipitation, will influence pesticide activity in the field. Nevertheless, whenever possible, insecticidal soaps and fish oils should be used. While many homeowners use various types of soaps to treat CAS, this method requires treatment every 10 to 14 days, thus increasing exposure of the beetles to the pesticide. If more toxic pesticides must be used, then applying them to “hot spots” rather than broadcast spraying may protect the scale predators from complete annihilation. This type of selective spraying may also protect other entomophagous insect populations from being decimated (Kuznetsov 1997). The results of these laboratory experiments yield some baseline data from which more research in the field can be conducted.

Table 3-1. Field rates (1X) for each pesticide used.

Insecticide	Working Solution (μg*AI/ml)	Insecticide residue (μg*AI/cm^2)
Organocide®	47000	8.29
Insecticidal Soap®	512300	27.71
Imidacloprid	106	2.40
Methidathion	233	5.26
Dimethoate	305	6.91
Malathion	1990	45.07

* AI = Active Ingredient

Table 3-2. Percent mortality of *Cybocephalus nipponicus* per 30 individuals exposed. X = field rate.

Pesticide	% beetle mortality at 0X	% beetle mortality at 0.5X	% beetle mortality at 1X	% beetle mortality at 2X
Organocide®	-	83	100	96
Insecticidal Soap®	-	66	86	96
Imidacloprid	-	76	93	100
Methidathion	-	100	100	100
Dimethoate	-	100	96	100
Malathion	-	93	100	100
Control (Acetone)	0	-	-	-
Control (Ethanol)	0	-	-	-
Control (No coating)	0	-	-	-

Table 3-3. Percent mortality of *Rhyzobius lophanthae* per 30 individuals exposed. X = field rate.

Pesticide	% beetle mortality at 0X	% beetle mortality at 0.5X	% beetle mortality at 1X	% beetle mortality at 2X
Organocide®	-	46	83	100
Insecticidal Soap®	-	43	76	96
Imidacloprid	-	63	80	100
Methidathion	-	100	100	100
Dimethoate	-	100	96	100
Malathion	-	93	90	96
Control (Acetone)	0	-	-	-
Control (Ethanol)	6	-	-	-
Control (No coating)	0	-	-	-

Table 3-4. Student-Newman-Keuls test showing ranked values of mortality of adult *Cybocephalus nipponicus* and *Rhyzobius lophanthae*.

C. nipponicus	Dose	Imidacloprid	Organocide®	Insecticidal soap
	0.0X	2.0A	2.0A	2.0A
	0.5X	5.5B	5.3B	5.3B
	1.0X	8.5C	8.6C	8.3C
	2.0X	10.0C	10.0C	10.3C

R. lophanthae	Dose	Imidacloprid	Organocide®	Insecticidal soap
	0.0X	2.0A	2.0A	2.0A
	0.5X	5.6B	5.0B	5.3B
	1.0X	7.3B	8.0C	7.8C
	2.0X	11.0C	11.0D	10.8D

* Mean ranks within columns with the same letter are not significantly different (P=0.05).

CHAPTER 4
THE CYBOCEPHALIDAE (COLEOPTERA) OF AMERICA NORTH OF MEXICO

Introduction

The family Cybocephalidae consists of seven genera: *Cybocephalus* (Erichson 1844), *Endrodiellus* (Endrödy-Younga 1962a), *Hierronius* (Endrödy-Younga 1968), *Horadion* (Endrödy-Younga 1976), *Pastillodes* (Endrödy-Younga 1968), *Pastillus* (Endrödy-Younga 1962a), and *Pycnocephalus* (Sharp 1891). By far the largest of these is *Cybocephalus*, which contains more than 150 described species found throughout the world (Tian 2000, Yu and Tian 1995).

The Cybocephalidae differ in many ways from the Nitidulidae. They are predatory, almost exclusively feeding on scale insects, while nitidulids are known for feeding on decaying plant material and fruits, plant sap, fungi, and occasionally pollen and honey. The morphology of the Cybocephalidae is also quite different from that of the Nitidulidae. Cybocephalid adults have a 4-4-4 tarsal formula instead of 5-5-5 found in Nitidulidae. There are 5 visible ventral plates (leaving out the male anal plate) and 5 abdominal spiracles in cybocephalids instead of the 6 and 6 that occur in nititdulids. The body of cybocephalids is retractile allowing the mandibles in repose to rest against the metasternum, unlike any other nitidulid. The larvae of Cybocephalidae have a head without dorsal sutures, lack pregomphi and urogomphi on abdominal tergite XI, and have hypostomal rods with divergent hypostomal ridges present posteriorly, hypopharynx without a sclerome and bracons, maxillae without mola, and annular spiracles with 2 lateral air tubes. In contrast, the larvae of Nitidulidae have pregomphi and urogomphi, no hypostomal rods but with hypostomal ridges strongly convergent posteriorly, hypopharynx with a sclerome and bracons, maxillae with raised mola, and biforous spiracles (Kirejtchuk 1997). These larval differences were also illustrated by Bøving and Craighead (1931) and Hayashi (1978). In spite of this, the group has been shuffled between family (Jacquelin du Val 1858, Murray 1864, Bøving and Craighead 1931, Parsons 1943, Smirnoff 1954, Endrödy-Younga 1968) and subfamily (Erichson 1844, Horn 1879, Grouvelle 1913, Kirejtshuk 1997, Habeck 2002) status. We chose to recognize the Cybocephalidae as a family in accordance with the work of the world expert in this group, Sebastian Endrödy-Younga.

The adults of *Cybocephalus* are often confused with those of Clambidae, Phalacridae, and sometimes Coccinellidae (*Microweisea* Cockerell and *Gnathoweisea* Gordon). The major feature that distinguishes members of *Cybocephalus* from all of these families is their extremely broad head. The head of *Cybocephalus* is almost as wide as the pronotum, unlike that of all the aforementioned families. Adult clambids have extremely enlarged hind coxae, a clypeus that entirely covers the mouthparts, and a 2-segmented antennal club, whereas cybocephalids have small hind coxae, a relatively short clypeus and a 3-segmented antennal club. Phalacrids have a much more elongate club than cybocephalids and a 5-5-5 tarsal formula rather than the 4-4-4 formula found in cybocephalids. *Gnathoweisea* has an extremely long head compared to a short, wide head in cybocephalids. Also, both *Gnathoweisea* and *Microweisea* have the head inserted into the prothorax, unlike cybocephalids which have the head completely outside the pronotum, and both genera have distinctive tarsomeres easily distinguishing them from the Cybocephalidae.

Cybocephalids are primarily known for feeding on armored scales (Diaspididae) (Flanders 1934, Clausen 1940, Vinson 1959, Endrödy-Younga 1968, Blumberg and Swirski 1974a,b, Rosen and DeBach 1978, Alvarez and Van Dreische 1998a). However, they have also been reported feeding on whiteflies (Aleyrodidae) (Clausen and Berry 1932, Chandra and Avasthy 1978, Swirski, *et al.* 1987, Kapadia and Puri 1993, Kajita *et al.* 1991, Kirejtshuk *et al.* 1997, Ramani 2000, Tian and Ramani 2003), mealybugs (Pseudococcidae) (Endrödy-Younga 1982), and citrus red mite, *Panonychus citri* (McGregor) (Tanaka and Inoue 1980).

These minute beetles can be found throughout the world, but relatively few of them have been studied. Grouvelle (1913) described 5 species of *Cybocephalus* from the Seychelles, while Vinson (1959) found at least 8 new species in addition to the two known species of *Cybocephalus* from the small Mascarene Islands. More recently, Tian and Peng (1997) recorded at least 8 species of *Cybocephalus* from Hainan Island in China. It seems very unlikely that all of these island groups, with such a finite amount of land area, would contain such rich *Cybocephalus* diversity while larger land masses would not. Considering that there are 150 described species of *Cybocephalus*, these studies would seem to indicate that these beetles are often overlooked or simply ignored.

Cybocephalus species are particularly difficult to identify because they are very small (0.5-2.5 mm.), compact, extremely convex and have a deflexed head and the ability to retract their appendages. For this reason, descriptions of male genitalia are an important accompaniment to any description or key to species within this genus (Vinson 1959). Male genitalia in conjunction with other useful diagnostic characters such as the form of the antenna can make identification less difficult.

The objectives of this study are to 1) develop techniques for the identification of the cybocephalids of America north of Mexico; 2) validate and review the identification of adventive cybocephalids released in Florida; 3) describe new North American species; 4) determine major prey species of these cybocephalids; and 5) report the known distribution of each species in America north of Mexico.

Because some species of *Cybocephalus* are being released in several countries as biological control agents, it is absolutely imperative that a clear and concise form of identification be devised. "Taxonomic support is especially important because correct identification of pests and their natural enemies are [sic] absolutely essential for effective biological control" (Van Driesche and Bellows 1993).

Taxonomic History

The genus *Cybocephalus* was described by Erichson in 1844, who also described five species from Europe, Africa, and Asia. LeConte (1863) described the first New World cybocephalid, *Cybocephalus nigritulus*. Horn described a second species, *Cybocephalus californicus*, from North America in 1879. Since that time no new species of *Cybocephalus* have been described from America north of Mexico. The only other species known to occur in this region is *Cybocephalus nipponicus* Endrödy-Younga, which was brought from Asia as a biological control agent in the late 1980s (Drea and Carlson 1988). Most taxonomic research on this group was carried out by Endrödy-Younga (1962a,b, 1963, 1964a,b, 1965, 1967a,b, 1968, 1969, 1971a,b, 1976, 1979, 1982, 1984) on beetles found in Africa, Eurasia, and Oceania. Lately, an enormous amount of work has been done on the cybocephalids of China and southern Asia by M. Tian and co-workers (Tian 1995, 1996, 2000; Tian and Pang 1994; Tian and Ramani 2003; Tian and Yu 1994; Tian and Peng 1997; Yu, 1994, 1995a,b; Yu and Tian 1995).

Materials and Methods

Materials

For this study, 871 specimens belonging to the genus *Cybocephalus* were examined. The holotype of *C. nigritulus*, the lectotype of *C. californicus* and a topotype of *Cybocephalus binotatus* (Grouvelle) were included. Specimens were borrowed from the following institutions and private collections; names of the curators and owners are in parentheses:

AAIC	Albert Allen Insect Collection, Boise, ID, (Albert Allen)
BMNH	Natural History Museum, London [formerly British Museum (Natural History)], UK, (Maxwell Barclay)
CSCA	California State Collection of Arthropods, Sacramento, CA, (Chuck Bellamy)
CNCI	Canadian National Collection of Insects, Ottawa, Ontario, (Anthony Davies)
EMEC	Essig Museum of Entomology, University of California, Berkeley, CA, (Cheryl Barr)
FSCA	Florida State Collection of Arthropods, Gainesville, FL, (Paul Skelley and Michael Thomas)
HGIC	Holly Glenn Insect Collection, Homestead, FL, (Holly Glenn)
INHS	Illinois Natural History Survey, University of Illinois, Champaign, IL, (Colin Favret)
LACM	Los Angeles County Museum of Natural History, University of California, Los Angeles, CA, (Weiping Xie)
LSAM	Louisiana State Arthropod Museum, Louisiana State University, Baton Rouge, LA, (Andrew Cline and Chris Carlton)
MTEC	Montana Entomology Collection, Montana State University, Bozeman, MT, (Michael Ivie)
MCZC	Museum of Comparative Zoology Collection, Harvard University, Cambridge, MA, (Philip Perkins)

OSUC	Ohio State University Collection, Museum of Biological Diversity, Columbus, OH, (Norman Johnson)
OSAC	Oregon State Arthropod Collection, Oregon State University, Corvallis, OR, (Jason Leathers)
SBMN	Santa Barbara Museum of Natural History, Santa Barbara, CA, (Michael Caterino)
SEMC	Snow Entomological Museum, University of Kansas, Lawrence, KA, (Zack H. Falin)
TAMU	Texas A&M University, Department of Entomology, College Station, TX, (Ed G. Riley)
TRSC	Trevor Randall Smith Collection, Gainesville, FL, (Trevor Randall Smith)
UCDC	University of California Davis, R. M. Bohart Museum of Entomology, Davis, CA, (Steve L. Heydon)
UCRC	University of California Riverside, Entomology Research Museum, Riverside, CA, (Doug Yanega)
UCFC	University of Central Florida Insect Collection, University of Central Florida, Orlando, FL, (Stuart Fullerton)
WFBM	W. F. Barr Entomological Museum, University of Idaho, Moscow, ID, (Frank Merickel)
USNM	United States National Museum, Smithsonian Institute, Washington D.C., (Gary Hevel)

Methods

If possible, genitalia were removed using minuten pins glued to wooden applicator sticks. The minutens were bent and twisted into whatever shape tools were necessary. While it is possible to remove only the genital plate and then extract male genitalia, this technique is extremely difficult and time-consuming. All dissections took place in glycerine due to the convex body form of *Cybocephalus* beetles. Typically, the abdomen was separated from the rest of the body and the entire aedeagus (Fig. 4-1) removed from the abdomen. This technique leaves most of the specimen intact, and the removed abdomen can be glued to the point behind the specimen. The tegmen and median lobe are compressed and held together by the tegminal (lateral) struts. To separate these two parts, a minuten was wedged between the median lobe and the tegminal strut breaking one lobe of the tegminal strut, and separating the two pieces. In some cases, the internal sac can be removed, and the tegmen can be moved backwards sliding both tegminal struts over the posterior portion of the median lobe as well as the median strut, effectively separating the two parts without damaging the tegminal struts, the median strut, or the dorsal piece of the tegmen. The median lobe and tegmen (basal plate) can then be slide-mounted or, to avoid distortion, mounted on a point in dimethyl hydantoin formaldehyde (DMHF). This solution is water soluble and dries clear. If possible, genitalia should be mounted on very shallow depression slides to avoid distortion (Fig. 6, 19, 32). This is especially true of a median lobe with a large and raised median plate.

Specimens were cleared in 10% KOH at 24˚C in preparation for disarticulation. After 24 hours, beetles were sufficiently cleared and softened for dissection. Due to their convex body form and very small size, specimens were disarticulated in glycerine. All disarticulated parts, including genitalia, were then washed in 95% ethanol and mounted on microscope slides using Hoyer's solution. Label data were copied onto slides verbatim with label breaks indicated by a slash (/).

Definitions

Median lobe (Fig. 4-1): Also referred to as penis (Endrödy-Younga 1968, 1971a, 1971b; Kirejtshuk *et al.* 1997; Lupi 2003; Yu 1995a, 1995b).

Basal plate (Fig. 4-1): This is a reference to the basal plate of the tegmen (Endrödy-Younga 1968, 1971a, 1971b; Lupi 2003; Yu 1995a, 1995b).

Cybocephalus Erichson 1844

Cybocephalus Erichson 1844: 441-442.

Redescription. *Form:* Ovate and very convex; body contractile (Fig. 4-2). *Head:* Broad and deflexed. Labrum emarginate. Epistoma slightly prolonged at middle. Mandibles in repose resting against metasternum, acute at tip with a small tooth posteriorly. Maxillae with one lobe. Antennae slightly longer than width of head, antennal club flat with 3 antennomeres, antennal grooves small and convergent. Scape large and round. *Thorax:* Pronotum margined at base, covering base of elytra, sides very short. Prosternum acutely carinate in front, not prolonged behind the procoxae, procoxal cavities open behind. Mesosternum broad, oblique. Metasternum protuberant and clothed in hairs. Both the meso- and metasternum are impressed for the reception of the middle and hind legs. *Scutellum:* Large, triangular. *Elytra:* Covering or nearly covering tip of the abdomen, apices curved. *Abdomen:* Five visible ventral plates (omitting the small male anal plate), and 5 abdominal spiracles. *Legs:* Tibiae simple, tarsi four-jointed, each tarsomere slightly dilated ventrally, second and third tarsomeres bilobed, claws simple. *Median lobe:* Trunk heavily sclerotized and dorsoventrally compressed. *Tegmen:* No parameres.

Key to the species of *Cybocephalus* of America north of Mexico

1. Antennal club without a serrated margin (Fig. 4-12); scutellum with slightly concave margins (Fig. 4-11) ....*kathrynae* **new species**

1’. Antennal club with a serrated margin (Fig. 4-4); scutellum with straight or slightly convex margins (Fig. 4-10)..2

2(1’) Terminal antennomere of the antennal club rounded (Fig. 4-30) .... …………...*randalli* **new species**

2’ Terminal antennomere of the antennal club truncate (Fig. 4-17) or slightly emarginate (Fig. 4-3, 4-4) 3

3(2’). Antennomere 3 slightly shorter than 4 and 5 combined; male bicolored with head, prothorax, and mesosternum yellow or tan, rest of body black (Fig. 4-29); basal plate coming to a rounded point (Fig. 4-26); median lobe as in Figs. 4-24, 4-25 .... *nipponicus* Endrödy-Younga

3’. Antennomere 3 as long or longer than 4 and 5 combined; male with head, prothorax and mesothorax black or dark brown 4

4(3’). All legs and antennae brown or black; elytral apices with a large and wide impunctate area of yellowish translucence; male basal plate evenly rounded, without a protuberance (Fig. 4-8); median lobe as in Figs. 4-5-4-7 .... *californicus* Horn

4’. At least profemora yellow or amber and usually antennae amber or tan; translucent impunctate area at the apices of elytra much smaller; male basal plate with a protuberance in the middle (Fig. 4-21) median lobe as in Figs. 4-18-420...... .... *nigritulus* LeConte

***Cybocephalus californicus* Horn**

(Figs. 4-3-4-9)

Cybocephalus californicus Horn 1879: 320-321.

Diagnosis. Male and female are black, brown, or aeneous. Antennal club is smaller than the eye and truncate or slightly emarginate at the apex, unlike the 11th antennomere of *C. randalli*, which is rounded. Each antennomere of the club is distinctly separated, forming a serrated margin, unlike *C. kathrynae* which has a smooth club margin. Apices of the elytra have a large, wide area of yellowish translucence that is without punctation, which distinguishes this species from *C. nigritulus*. In males, the basal plate and median lobe are easily distinguished from those of all other species.

Redescription. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 0.95-1.30 mm (measured from apex of clypeus to apex of elytra); breadth: 0.85-1.20 mm (measured at base of elytra). *Color:* Head, thorax, elytra and underside black with surface sometimes aeneous, lateral margin of pronotum and posterior margin of elytra yellowish and translucent; legs and antennae brown or black. *Head:* Broad and convex, clypeus moderately produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above but slightly explanate when viewed laterally. Dorsal surface smooth under high magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere truncate (Fig. 4-3) or emarginate (Fig. 4-4), setose and about as long as wide. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^{1}/_{5}$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (30:38). Uniformly punctate along dorsal surface, smooth at sides and base with a large impunctate area at apices of elytra. Appearing alutaceous under high magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. The protibiae with short hairs along outer margin.

Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel or slightly divergent curving into a point with declivous sides from apex (Figs. 4-5, 4-6). In profile, strongly curved from middle (Fig. 4-7). Median plate on surface elevated. *Basal plate:* Sides parallel at base, evenly rounded at apex (Fig. 4-8).

Female. Nearly identical to male.

Geographic distribution. Arizona, British Columbia, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington (Fig. 4-9).

Hosts. This species is known to feed on or was found in association with *Aonidiella aurantii* (Maskell) (from label data), *Chionaspis pinifolia* (Fitch) (from label data), *Diaspidiotus perniciosus* (Comstock) (Heintz 2001), *Diaspis echinocacti* (Bouché) (from label data), *Diaspis manzanitae* Whitney (from label data), *Ehrhornia cypressi* (Ehrhorn) (Flanders 1934; Kartman 1946; Clausen 1940), *Lecanium corni* Bouché (Heintz 2001), *Lepidosaphes beckii* (Newman) (from label data), *Mercetaspis halli* (Green) (Kartman 1946), and *Parlatoria blanchardi* Targioni Tozzetti (from label data), all of which belong to the family Diaspididae. It has also been seen in association with *Phoenicococcus marlatti* Cockerell (from label data) belonging to the family Phoenicococcidae, and some species of aleyrodids (from label data).

Type material examined. The so-called lectotype in the MCZC is a male specimen glued to a point with the following labels: Cal (printed) [small white rectangular label with the edge of one side dipped in purple ink] / LectoTYPE (printed) 3216 (handwritten) [red rectangular label] / Horn Coll H (printed) 3751 (handwritten) [white rectangular label] / C. californicus Cr. (handwritten) [white rectangular label] /

MCZ Type (printed) 7970 (handwritten) [red rectangular label] / *Cybocephalus californicus* Horn Det: Trevor Smith (printed) [white rectangular label]. While this specimen is a syntype, it is not a valid lectotype because this designation was never published. This is consistent with many of Horn's type specimens that had lectotype labels placed on them around 1930 without corresponding publications. This occurred when the Horn collection was located at the Academy of Natural Sciences, Philadelphia (Philip D. Perkins 2005, personal communication). Two female specimens, labeled as paratypes in the MCZC, were also examined. The first "paratype" has the following labels: Cala (printed) ε (handwritten) [small white rectangular label] / Para-Type (printed) 3216.4 (handwritten) [blue rectangular label] / Horn Coll H (printed) 3751 (handwritten) [white rectangular label] / Type 7970 (handwritten) [red rectangular label] / *Cybocephalus californicus* Horn Det: Trevor Smith (printed) [white rectangular label]. The second paratype label has the following labels: Cal (printed) j (handwritten) [small white rectangular label] / Para-Type (printed) 3216.3 (handwritten) [blue rectangular label] / Horn Coll H (printed) 3751 (handwritten) [white rectangular label] / Type 7970 (handwritten) [red rectangular label] / *Cybocephalus californicus* Horn Det: Trevor Smith (printed) [white rectangular label]. Two male syntypes in the MCZC were also examined. The syntypes are both glued to a single card with the following labels: Type (printed) 7970 (handwritten) [orange rectangular label] / Cybocephalus californicus Horn (handwritten with Cr. crossed and Horn written in a different colored ink) [large white rectangular label] / *Cybocephalus californicus* Horn Det: Trevor Smith (printed) [white rectangular label].

Other material examined. CANADA: BRITISH COLUMBIA: R. D. Okanagan-Similkameen, Penticton, Dog Lake, September 23, 1927, coll. W. Mathers (3 ♂, 1 ♀, OSAC; 1 ♂, 1 ♀ TRSC); R. D. Okanagan-Similkameen, Summerland, August 15, 1955, coll. M. D. Proverbs, feeding on immature *Phenacaspis pinifolia* (4 ♂, 3 ♀, CNCI; 1 ♂, 1 ♀ TRSC); R. D. Okanagan-Similkameen, Summerland, August 21, 1964, *Pinus ponderosa* (1 ♀, CNCI); R. D. East Kootenay, Wardner, August 21, 1977, coll. B. F. & J. L. Carr (1 ♀, CNCI); **UNITED STATES: ARIZONA:** Apache Co., Adamana, May 7, 1903, coll. H. S. Barber (2 ♂, USNM); Apache Co., Canyon de Chelly, May 30, 1974, coll. K. Stephan (1 ♂, LSAM); Apache Co., Jct. I-40 & Hwy. 191, August 20-22, 1999, coll. E. Riley & M. Yoder (1 ♂, TAMU); Cochise Co., Dragoon Mts. Wood Canyon, April 29, 1972, coll. K. Stephan (1 ♀, FSCA); Cochise Co., Cochise Stronghold Recreation Area, August 3, 1990, coll. B. F. & J. L. Carr (1 ♂, CNCI); Coconino Co., Fredonia, August 9, 1966, coll. B. F. & J. L. Carr (1 ♂, 1 ♀, CNCI); Coconino Co., Walnut (1 ♀, SEMC); Coconino Co., Walnut, coll. Wickam (1 ♂, SEMC); Coconino Co., Walnut, July, 1922, coll. Wickam (1 ♂, SEMC); Coconino Co., Williams, May 26, coll. Barber & Schwarz (1 ♂, USNM); Gila Co., Roosevelt Reservoir, September 29, 1980, coll. B. F. & J. L. Carr (1 ♂, CNCI); Graham Co., S. Graham Mts. 5000ft, July 20, 1974, coll. K. Stephan (1 ♂, LSAM; 3 ♂,1 ♀, FSCA); Maricopa Co., Apache Lake, September 23, 1989, coll. B. F. & J. L. Carr (1 ♂, CNCI); Maricopa Co., Phoenix, January 24, 1930, coll. S. Flanders (1 ♂, UCRC); Mohave Co., Hot Springs, June 25, coll. Barber & Schwarz (2 ♂, USNM); Navajo Co., Winslow, July 31, coll. Barber & Schwarz (2 ♂, USNM); Pima Co., Greaterville, October 8, 1980, coll. B. F. & J. L. Carr (1 ♂, CNCI); Pima Co., Vail, May 3, 1975, coll. K. Stephan (1 ♂, FSCA); Pima Co., Tucson, December 21, coll. Hubbard & Schwarz (2 ♂, 3 ♀, USNM); Pima, Co., Tucson, January 5, coll. Hubbard & Schwarz, *Prosopis juliflora* (1 ♀, USNM); Pinal Co., Oracle, January 9, June 29, July 5, 6, coll. Hubbard & Schwarz (3 ♂, 8 ♀, USNM); Pinal Co., Superior, September 22, 1989, coll. B. F. & J. L. Carr (1 ♀, CNCI); Santa Cruz Co., Santa Rita Mts., 5000 to 8000 ft., July, coll. F. H. Snow (1 ♀, SEMC); Santa Cruz Co., Santa Rita Mts., June 20, coll. Hubbard and Schwarz (1 ♀, USNM); Yuma Co., Ft. Yuma, January 21, coll. Hubbard & Schwarz (1 ♀, USNM); **CALIFORNIA:** Butte Co., Chico, May 14, 1942, coll. E. H. Fosen (5 ♂, 1 ♀, USNM; 1 ♂, 1 ♀, TRSC); Colusa Co., Letts Lake, April 30, 1980, coll. Fred G. Andrews, S. Kuba, & T. D. Eichlin (1 ♂, 1 ♀, CSCA); Contra Costa Co. Mt. Diablo, April 5, 1952, coll. R. Schuster (3 ♂, 5 ♀, EMEC; 1 ♂, 1 ♀, TRSC); Contra Costa Co., 3mi S. Martinez, November 26, 1987, coll. L. G. Varela, on pear foliage (27 ♂, 16 ♀, EMEC; 3 ♂, 4 ♀ TRSC; 1 ♂, 3 ♀ FSCA); Contra Costa Co., Albany, reared in Albany insectary (2 ♂, EMEC); Fresno Co., Selma, May 11, 1950, coll. P. DeBach, on red scale on grapefruit (1 ♀, UCRC); Fresno Co., Fresno, October 16, 1951 (2 ♂, EMEC); Imperial Co., Brawley, Apr. 13, 1976, ex. Lemon trees (1 ♂, 1 ♀, CSCA); Imperial Co., El Centro, May 4, 1951, coll. B. H. Harrigan, on red scale (1 ♀, UCDC); Imperial Co., Brawley, February 26, 1959, coll. E. I. Schlinger, collected by vacuum insect net in alfalfa field (1 ♂, UCRC); Imperial Co., Brawley, January 29, 1959, coll. E. I. Schlinger, *Medicago sativa* (1 ♀, UCRC); Imperial Co., Imperial Valley, June 11, 1971, coll. Flanders, on citrus (1 ♂, 1 ♀, UCRC); Inyo Co., Bishop, July 26, 1921, coll. L. L. Muchmore, sage (4 ♂, 3 ♀, LACM; 1 ♂, TRSC); Inyo Co., Westgard Pass, August 20, 1960, coll. E. I. Schlinger, on *Chrysothamnus* (2 ♂, 2 ♀, UCRC; 1 ♂, TRSC); Kern Co., 12mi. NW Rosamond, July 22, 1955, coll. R. A. Flock, *Lycium cooperi* A.

Gray (1 ♀, UCRC); Kern Co., 7mi. NW Mohave, July 16, 1965, coll. C. W. O'Brien, ex. *Lycium cooperi* (3 ♂, 5 ♀, EMEC; 4 ♂, 4 ♀, FSCA; 1 ♂, 1 ♀, TRSC); Kern Co., Ft. Tejon, July 3, August 3, 1930 (9 ♂, 8 ♀, TAMU); Los Angeles Co., July, coll. Coquillett (1 ♂, USNM); Placer Co., August, coll. A. Koebele (1 ♂, USNM); Placer Co., Towle, Mar. 7, 1913, ex. *Aulacaspis manzanitae* (1 ♀, CSCA); Plumas Co., Lake Almanor, Apr. 23, 1971, coll. Fred G. Andrews, ex. pine litter (1 ♀, CSCA); Los Angeles Co., Pomona (1 ♂, 1 ♀, LACM; 2 ♂, INHS); Los Angeles Co., Arroyo Seco, February 21, 1971, coll. A Mayor (1 ♂, UCRC); Los Angeles Co., Little Rock, September 3, 1944, April 8, 1945, coll. G. P. Mackenzie (3 ♂,UCRC); Los Angeles Co., Los Angeles, February 1944, coll. R. H. Smith (4 ♀, UCRC; 1 ♂, TRSC; 1 ♀, FSCA); Los Angeles Co., Vincent, August 4, 1952, coll. Timberlake, on *Atriplex canescens* (1 ♀, UCRC); Merced Co., Merced, July 18, 1949, coll. R. L. Doutt, ex. *Lepidosaphes ficus* (1 ♂, EMEC); Monterey Co., UC Big Creek Reserve, Big Devils Ck. confluence, 36.077º N 121.594º W, May 26-27, 2002, coll. S. Lew (1 ♂, SBMN); Orange Co., Santa Ana, December 18, 1936, coll. C. E. Norland, *Diaspis echinocacti* (3 ♂, 4 ♀, LACM; 1 ♂, 1 ♀, TRSC); Orange Co., Costa Mesa, January 21, 1943, (rest illegible) (1 ♂, UCRC); Placer Co., February 7, 1913, coll. B. B. Whitney (1 ♂, 2 ♀, UCRC); Riverside Co., Mecca, February 25, 1914, coll. J. D. Neils, feeding on *Parlatoria blanchardi* (1 ♂, USNM); Riverside Co., Indio, May, 1926, coll. F. S. Stickney, eating Marlatt scale (6 ♂, 6 ♀, USNM); Riverside Co., Mecca, April 17, 1967, coll. B. F. & J. L. Carr (1 ♂, 3 ♀, CNCI); Riverside Co., Ripley, June 25, 1946, coll. W. F. Barr, *Pluchea sericea* (1 ♀, WFBM); Riverside Co., Riverside, March 29, 1989, coll. F. D. Bennett, cactus (4 ♀, FSCA); Riverside Co. Oasis, July 1967, coll. Fred G. Andrews (1 ♀, CSCA); Riverside Co., 31mi N Blythe, Apr. 27, 1978, coll. A. R.

Hardy and Fred G. Andrews, collected on *Pluchea sericera* (1 ♀, CSCA); Riverside Co., 5 mi. N Aguanga, 116º 52’ 30” W 33º 32’ 30” N, August 17, 1978, coll. J. B. Woolley (2 ♀, UCRC); Riverside Co., Riverside, August 23, 1965, coll. M. E. Irwin (2 ♀, UCRC); Riverside Co., Mecca, November 17, 1970, coll. R. C. Dickson, on sticky board (2 ♂, 2 ♀, UCRC; 1 ♂, TRSC; 1 ♀, FSCA); Riverside Co., Riverside, August 1, 1924, feeding on Aleyrodids, (rest is illegible) (2 ♂, UCRC; 1 ♂, 1 ♀, TRSC); Riverside Co., Riverside, March 1926, on *Aphidiotus* on walnut, (rest is illegible) (1 ♂, 2 ♀, UCRC); Riverside Co., Riverside, January 20, 1927, coll. Timberlake (rest illegible) (1 ♀, UCRC); Riverside Co., Coachella Valley, February 23, 2000, coll. G. R. Ballmer, on lettuce (1 ♂, UCRC); Riverside Co., Whitewater Canyon, 650m, 33º 57’ 18” N 116º 38’ 39” W, September 4, 1999, coll. Yanega and Gates (1 ♀, UCRC); Riverside Co., Indio, 1mi. E. Jefferson Street, Kennedy Ranch, July 1963, coll. H. T. Reynolds, ex. cotton suction machine (2 ♂, UCRC); San Bernardino Co. 2mi. W. Phelan, June 7, 1958, coll. E. I. Schlinger, ex. scale on manzanita (1 ♀, UCRC); San Bernardino, Morongo, September 20, 1944, on *Acacia greggi*, (rest is illegible) (2 ♂, UCRC); San Diego Co., San Diego, 1922, coll. Armitage, on cactus (2 ♂, 2 ♀, UCRC); San Luis Obispo Co., Cuyama River, nr. Cuyama, August 6, 1999, coll. G. R. Ballmer, on *Atriplex canescens* root grown (1 ♀, UCRC); San Luis Obispo Co., Carrizo Plain N. M., Caliente Ridge, 35º12’27” N 119º 82’88” W, December 5, 2003 – January 1, January 1-24, February 29-March 17, March 17-April 2, 2004, coll. M. Caterino, malaise, flight intercept, unbaited pitfall (2 ♂, 2 ♀, SBMN; 3 ♂, TRSC); San Luis Obispo Co., Carrizo Plain N. M., Selby Campground, 35º12’27” N 119º82’88” W, February 7-29, January 1-24, February 29-March 17, 2004, coll. M. Caterino, flight intercept (1 ♂, 2 ♀, SBMN); Santa Clara Co., San Jose, June (1 ♂, OSUC); Santa Clara Co. (1 ♀, OSUC); Sonoma Co., Healdsburg, Apr. 21, 1971, ex. *Prunus* (1 ♂, CSCA); Tehama Co., Mill Creek, August 31, 1947, coll. Timberlake, (rest is illegible) (1 ♀, UCRC); Tulare Co., Visalia, April 21, 1930, collected from sugar pine (2 ♂, LACM); Yuba Co., coll. E. J. Branigan (2 ♂, 2 ♀, UCRC; 1 ♂, 1 ♀, TRSC); **COLORADO:** Las Animas Co., June 16, 1982, coll. B. F. & J. L. Carr (1 ♂, CNCI); **IDAHO:** Boise Co., 1mi. S Ten Mile, June 14, 1988, coll. A. Allen, sweeping (1 ♂, AAIC); Canyon Co., Parma, 2224 ft., June 15, 1929, coll. C. Wakeland (1 ♀, WFBM); Canyon Co., 4.8 NW Walters Ferry, May 16, 1995, coll. W. F. Barr, sweeping *Atriplex canescens & confertifolia* (1 ♀, WFBM); Elmore Co., Mt. Home, 3138 ft., July 31, 1952, coll. W. F. Barr, *Artemisia* (1 ♀, OSAC); Fremont Co., Warm River Camp Campground, June 7, 1986, coll. B. F. & J. L. Carr (1 ♂, CNCI); Latah Co., Moscow, April 17, 1994, coll. M. M. Furniss (1 ♂,WFBM); Owyhee Co., Harpers Fairy Crossing, August 20, 1979, coll. A. Allen, on sage brush (1 ♀, AAIC); Twin Falls Co., Shoshone Falls, July 10, September 21, 1975, coll. A. Allen, sweeping sagebrush (3 ♀, AAIC); Twin Falls Co., August 5, 1978, coll. A. Allen, sweeping *Artemisia* (1 ♀, AAIC); Twin Falls Co., Derkies Lake, Snake River Canyon, June 29, 1977, coll. A. Allen, sweeping sagebrush (1 ♂, AAIC); **MONTANA:** Roosevelt Co., Snowden Bridge, June 11, 1991, coll. D. L. Gustafson (1 ♂, MTEC); Powder River Co., 5mi W. Broadus, June 7, 1999, coll. D. L. Gustafson (1 ♂, MTEC); Madison Co., 5mi E. Norris, Bear Trap Prim. Area Madison, 5000 ft., July 26, 1986, S. M. Fondriest (1 ♀, MTEC); **NEVADA:** Elco Co., Ruby Mtns. 7000 ft., May 14, 1975, coll. James H. Baker (4 ♂, USNM); **NEW MEXICO:** (1 ♂, 1 ♀, INHS); Eddy Co., Lincoln National Forest, 4.5mi SW Queen, Hwy. 137, 1675m, 32º12’01” N 104º 40’10” W, August 15-25, 2001, coll. J. C. Schaffner

(1 ♀, TAMU); Socorro Co., Beartrap Canyon, Mt. Withington, July 31, 1990, coll. B. F. & J. L. Carr (1 ♀, CNCI); **OKLAHOMA:** Latimer Co., March 1986, coll. K. Stephan (2 ♂, TAMU); **OREGON:** Klamath Co., Klamath Falls, June 6, 1956, coll. Joe Schuh (1 ♂, 3 ♀, OSAC); Klamath Co., Upper Klamath Lk., Geary Canal, May 23, 1958, coll. Joe Schuh (1 ♂, OSAC); Wasco Co., Bear Springs, October 6, 1940, coll. K. M. & I. M. Fender (1 ♂, OSAC); **TEXAS:** Brewster Co., Big Bend Nat. Pk., 14mi E. Panther jct., September 9, 1985, coll. W. F. Barr, Croton (1 ♂, WFBM); Cameron Co., Brownsville, January 18, 1915, coll. Timberlake, assoc., with *Dactylopius* (1 ♂, 1 ♀, UCRC); Gaines Co., Seminole, June 13, 1983, coll. B. F. & J. L. Carr (1 ♀, CNCI); Hudspeth Co., Indio Mountains Research Station, vic. Indio ranch house, 4040 ft., 30º46’37” N 105º00’43” W, June 12-13, 2002, coll. E. G. Riley, R. Diaz & M. J. Yoder (1 ♂, 2 ♀, TAMU; 1 ♂, 1 ♀, TRSC); Hudspeth Co., Indio Mountains Research Station, Cougar Canyon, 4040 ft., 30º46’59” N 105º01’06” W, March 30-April 12, 2002, coll. A. R. Gillogly, Malaise Trap (1 ♂, TAMU); Hudspeth Co., Indio Mountains Research Station, Squaw Spring, 30º47’49” N 105º00’43” W, April 12-13, 2002, coll. E. G. Riley, & M. J. Yoder (1 ♀, TAMU); Hudspeth Co., Indio Mountains Research Station, Squaw Creek, 4200 ft., 30º47’49” N 105º00’43” W, March 30-April 12, 2002, coll. R. Caesar & A. R. Gillogly (1 ♂, 2 ♀, TAMU); Kennedy Co., 13.5mi S Sarita, October 11, 1994, coll. E. G. Riley (1 ♀, TAMU); Pecos Co., Hwy. 385 rest stop, 28mi S Ft. Stockton, April 19, 1997, coll. E. Riley (1 ♂, TAMU); Presidio Co., Big Bend Ranch St. Nat. Ar., Aqua Adento, June 18-23, 1990, coll. D. Judd, Malaise Trap (1 ♂, 7 ♀, TAMU; 1 ♂, 1 ♀, TRSC); San Augustine Co., 10mi SE Broaddus, Coleman Cemetery, March 19, 1994, coll. E. Riley (1 ♀, TAMU); Travis Co., vic. Long Hollow Ck., 30º27’43”97º52’19”, May 8, 26, 1993,

coll. Alexander, Quinn, Riley, Wharton, et al., on *Juniperus ashei* (3 ♂, 4 ♀, TAMU; 1 ♂, 1 ♀, TRSC); Travis Co., vic. Long Hollow Creek and Cypress Creek, 30º27’43”97º52’19”, 30º25’58”97º52’01”, March 26, June 18-19, 1994, coll. M. Quinn, E. Riley, R.Wharton, on *Quercus buckleyi* (2 ♀, TAMU); Val Verde Co., Amistad Reservoir, Hwy 406, June 2, 2000, coll. E. G. Riley (3 ♂, 4 ♀, TAMU; 1 ♂, TRSC); **UTAH:** Washington Co., St. George, coll. Wickham (1 ♂, SEMC); **WASHINGTON:** Benton Co., Hanford Works, 640 ft., July 30, 1952, September 17, 1952, September 24, 1952, coll. R. H. Whittaker, Sagebrush (3 ♀, OSAC).

Remarks. Specimens are most often collected while sweeping brush, especially *Artemisia* spp. This beetle seems to occupy a similar niche to that of *C. randalli*, which is often collected in the same areas and on the same plants. While the distribution of this beetle is quite extensive, it does not seem to occur east of the Mississippi River.

Cybocephalus kathrynae **T. R. Smith, New Species**

(Figs. 4-11, 4-12-4-16)

Diagnosis. Male and female black. Antennal club has a smooth margin without a serrated edge and the scutellum has concave margins (Figs. 4-11), distinguishing this species from *C. randalli, C. californicus, C. nigritulus* and *C. nipponicus*.

Etymology. This species is named for Kathryn Lang Zara-Smith, wife of the species name’s author.

Description. Male. *Form:* Elongate oval; strongly convex dorsally. Length: 1.3-1.6 mm (measured from apex of clypeus to apex of elytra); width: 0.8-1 mm (measured at base of elytra). *Color:* Head, thorax, elytra and underside dark brown or black, the extreme edge of elytral apices with brown border. Front legs and antennae light brown or brown, middle and hind legs black or dark brown. *Head:* Broad and convex, clypeus wide and moderately produced. Eyes large and tear-shaped with internal margins distinct. Genae just visible from above and slightly explanate. Dorsal surface smooth but distinctly alutaceous with uniform punctation. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ the size of eye. Club flat and distinctly separated from funicle and with a smooth margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere emarginate (Fig. 4-12). Antennomere 3 as long or longer than 4 and 5 combined. *Pronotum:* Strongly convex and shiny, lateral margin curved; anterior angle more narrowly arcuate than posterior. Surface evenly punctured and alutaceous. *Scutellum:* Alutacous and triangular with concave margins. *Elytra:* Uniform width narrowing at the apical $^1/_5$. Strongly convex, sides almost parallel but slightly sinuous, apices rounded, length shorter than combined width (29:38). Very alutaceous along dorsal surface and distinctly punctured, punctation ending before base of elytra, forming a narrow impunctate area at base and sides. Median margin and edge of elytra bordered. Distinct striations at apices of elytra. *Underside:* Metasternum extremely alutaceous and roughly punctate, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* All femora glossy with short hairs. Profemora narrowing slightly at basal end, meso- and metafemora extremely flattened and expanded. All tibiae slightly but distinctly curved and dilated toward the apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides curving and convergent forming a sharp point (Fig. 4-13). In profile, curved (Fig. 4-14). Median plate on surface very slightly elevated. *Basal plate:* Sides convergent and emarginate at apex (Fig. 4-15).

Female. Nearly identical to male.

Geographic distribution. Known only from the southern coast of Florida (Fig. 4-16).

Hosts. *Cybocephalus kathrynae* has been collected in very close proximity to *Haliaspis nakaharai* Howell and *Haliaspis uniolae* Takagi (Diaspididae). While these beetles have not actually been observed feeding on the aforementioned scale species, they were the only scale species in the beetle's habitat and exhibited signs of predation.

Type material examined. The holotype, deposited in the MCZC, is a male specimen glued to a point with the following labels: USA: Florida, Monroe Co., Bahia Honda State Park southeast end of island N24°39'54"-W81°15'21" (printed) [white rectangular label] / V-14-2005, Trevor Smith & R. D. Cave, sifting sand dune leaf litter around *Uniola paniculata* (printed) [white rectangular label] / HOLOTYPE *Cybocephalus kathrynae* T. R. Smith Det: Trevor Smith (printed) [red rectangular label]. The designated allotype, deposited in the MCZC, is a female specimen glued to a point with the following labels: USA: FL: Monroe Co. Bahia Honda St. Pk. SE. end of island 3-III-2005, Trevor Smith, M. C. Thomas, sand litter, primary dune (printed) [white rectangular label] / ALLOTYPE *Cybocephalus kathrynae* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label]. Designated paratypes are as follows: **UNITED STATES: FLORIDA:** Monroe Co., Bahia Honda State Park, southeast end of island, December 1, 1999, coll: Paul Skelley, berlese litter under trees of 2° dunes (1 ♂, TRSC); Monroe Co., Bahia Honda State Park, southeast end of island, N24°39'54"-W81°15'21", May 14, 2005, coll: Trevor Smith & R. D. Cave, sifting sand dune leaf litter around *Uniola paniculata* (3 ♂, 4 ♀, FSCA); Miami-Dade Co., Key Biscayne, Bill Baggs Cape Florida State Park., N25°40’08”-W80°09’17”, June 30, 2005, coll: Trevor Smith, sifting sand dune leaf litter (1 ♂, 4 ♀, FSCA).

Remarks. This species was collected by sifting sand and leaf litter in primary and secondary sand dunes where sea oats (*Uniola paniculata* L.) and seashore dropseed (*Sporobolus virginicus* (L.)) were present. The sea oats were infested with *H. uniolae* and the seashore dropseed was infested with *H. nakaharai*. It has only been collected on Bahia Honda Key in Monroe County and in Bill Baggs Cape Florida State Park in Miami-Dade County but may occur in other areas of Florida with naturally occurring sand dunes where sea oats are present and infested with armored scales.

***Cybocephalus nigritulus* LeConte**

(Figs. 4-17-4-22)

Cybocephalus nigritulus LeConte 1863: 64.

Diagnosis. Male and female black and very glossy. Size similiar to *C. californicus* but slightly larger. Antennal club smaller than eye and truncate at terminal antennomere; each antennomere of club distinctly separated forming a serrated edge, distinguishing this species from *C. kathrynae*. The truncate terminal club antennomere distinguishes this species from *C. randalli* which has a rounded terminal antennomere. Protibia more dilated than in *C. californicus* and the translucent impunctate area at the apices of elytra much smaller than in *C. californicus*. Male basal plate and median lobe are unique and easily distinguished from all other species.

Redescription. Male. *Form:* Elongate, oval; contractile; strongly convex dorsally. Length: 1.0-1.55 mm (measured from apex of clypeus to apex of elytra);

width: 0.85-1.19 mm (measured at base of elytra). *Color:* Head, thorax, elytra glossy black, underside black, with lateral margin of pronotum and apical margin of elytra yellowish and translucent. Front legs and antennae amber, middle legs amber or light brown, hind legs brown or dark brown. *Head:* Broad and convex, clypeus moderately produced. Eyes tear-drop shaped and large with internal margins distinct. Genae not visible from above but slightly explanate when viewed laterally. Dorsal surface smooth, but under high magnification very finely alutaceous, finely punctured. Antennae 11-segmented including a club with 3 antennomeres; club length, ½-⅔ the width of eye; club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere much larger than first and third club antennomeres and about as long as wide; terminal antennomere of club truncate, setose, and about as long as wide (Fig. 4-17). Antennomere 3 about the same length as antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, under high magnification finely alutaceous with extreme lateral edges curving slightly and almost straight, anterior angle more narrowly arcuate than posterior. Surface punctation uniform, but distinct, and somewhat sparse, surface shiny. *Scutellum:* Alutaceous and triangular with slightly convex margins. *Elytra:* Uniform width narrowing at the apical $^{1}/_{5}$. Strongly convex, sides almost parallel but slightly sinuous, apices rounded. Length somewhat shorter than combined width (34:44). Punctation distinct except along extreme edge of apex which is smooth and without punctation; under high magnification finely alutaceous. Median margin and apex of elytra bordered. *Underside:* Metasternum extremely alutaceous, roughly punctured and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about same width from end to end. Metafemora expanded in middle. Tibiae slightly but distinctly curved and dilated towards apex. Protibiae much more dilated than others and with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres combined. *Median lobe:* Sides parallel or slightly convergent curving into a large triangular point (Fig. 4-18, 4-19). In profile strongly curved from middle (Fig. 4-20). Median plate on surface elevated. *Basal plate:* Sides parallel sides at base, very slightly tapering towards apex. Apex flat with a distinct triangular protuberance in center (Fig. 4-21).

Female. Nearly identical to male.

Geographic distribution. Alabama, Florida, Georgia, Indiana, Louisiana, Massachusetts, Michigan, Minnesota, Mississippi, Ontario, Pennsylvania, Rhode Island, South Carolina (Fig. 4-22).

Hosts. Like all cybocephalids, the primary food source of these beetles is armored scale insects (Diaspididae). *Cybocephalus nigritulus* has been seen in association with or reported feeding on *C. pinifolia* (Riley 1882), *Fiorinia theae* Green (Flanders 1934; from label data), *Pseudaulacaspis cockerelli* (Cooley) (from label data), and *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Collins and Whitcomb 1975).

Type material examined. The holotype in the MCZC is a male specimen glued to a point with the following labels: orange disc / Type (printed) 6987 (handwritten) [dark orange rectangular label] / Cybocephalus nigritulus Lec. (handwritten) [white rectangular label] / *Cybocephalus nigritulus* LeConte Det: Trevor Smith (printed) [white rectangular label]. The orange disc indicates that the specimen was collected in the southern or gulf states. Two specimens in the MCZC that are possibly syntypes were also examined. One male and one female are glued to points on separate pins, but have the same labels as follows: Detroit, Mich. (printed) [white rectangular label] / *Cybocephalus nigritulus* LeConte Det: Trevor Smith [white rectangular label]. These specimens may be the Michigan specimens referred to by Horn (1879) in his redescription of this species.

Other material examined. CANADA: ONTARIO: Kent Co., Tilbury, August 1967, coll. K. Stephan, sifting (1 ♀, FSCA); Essex Co., Wheatley, June 1967, coll. K. Stephan, coccids on aspen (1 ♂, FSCA); **UNITED STATES: ALABAMA:** Walker Co., Jasper, September 23, 1979, coll. Tim King, at light (1 ♂, AAIC); **FLORIDA:** Alachua Co., Gainesville, San Felasco Hammock St. Pres., Apr. 10, June 10, June 26, 2004, coll. Trevor Smith, feeding on *Pseudaulacaspis cockerelli* on *Magnolia grandiflora* (20 ♂, 20 ♀, TRSC; 8 ♂, 10 ♀, FSCA); Alachua Co., Gainesville, University of Florida Natural Area., March 12, 2005, coll. Trevor Smith, feeding on *Pseudaulacaspis cockerelli* on *Magnolia grandiflora* (20 ♂, 20 ♀, FSCA); Alachua Co., Gainesville, Haile Plantation, March 30, 2005, coll. Trevor Smith, feeding on *Pseudaulacaspis cockerelli* on *Magnolia grandiflora* (5 ♂, 5 ♀, FSCA); Alachua Co., Gainesville, Wilmont Gardens, March 8, 1974, coll. Fred Collins, on Camellia (1 ♀, USNM; 1 ♀, FSCA); Alachua Co., Gainesville, July 18, 1964, coll. R. E. White (1 ♀, USNM); Alachua Co., Gainesville, July 18,19, May 23, 24, 1964, coll. R. E.White (5 ♂, FSCA); Alachua Co., Gainesville, Devil's Millhopper, September 28, 1997, coll. Vince Golia, beating trees (1 ♀, FSCA); Alachua Co., Gainesville, May 28, 1988, coll. F. D. Bennett, pred. on *Fiorina theae* on Camellia (1 ♂, FSCA); Alachua Co., N. E. Gainesville, May 16, 2000, coll. J. Eric

Cronin, feeding on *Pseudaulacaspis cockerelli* on *Magnolia grandiflora* (1 ♂, 1 ♀, FSCA); Alachua Co., Gainesville, San Felasco Hammock St. Preserve, March 20, 2004, coll. M. C. Thomas, ex. *Magnolia* sp. (1 ♀, FSCA); Brevard Co., Titusville, SR 405, Enchanted Forest Sanct., White Trail, September 14-28, 2000, January 15-31, 2001, coll. Z. Prusak, P. J. Russell, S. M. Fullerton, malaise trap, xeric oak hammock (1 ♂, 1 ♀, UCFC); Dade Co., Miami, Snapper Creek Plaza, October 20, 1991, coll. F. D. Bennett, *Pseudaulacaspis cockerelli* / *Strelitzia* (1 ♀, FSCA); Gadsen Co. Quincy, Hyw. 267, March 6, 1974, coll. Fred Collins, on Camellia (1 ♂, USNM); Gadsen Co., March 6, 1974, sawdust, *Melia azedarach* (1 ♀, FSCA); Orange Co., Orlando, UCF, April 5, 1999, coll. P. Russell, S. Fullerton, malaise trap, pond pine community/dahoon holly (2 ♀, UCFC); Orange Co., Orlando, UCF, April 19, 1999, coll. P. Russell, S. Fullerton, malaise trap, maidencane marsh (2 ♀, UCFC); Orange Co., Orlando, UCF, May 11, 17, 24, June 2, 1999, coll. P. Russell, S. Fullerton, malaise trap, cypress forest (1 ♂, 3 ♀, UCFC); Orange Co., Orlando, UCF, July 2, 1997, coll. S. Fullerton, malaise trap, long leaf pine/sand pine/turkey oak (1 ♂, UCFC); **GEORGIA:** Berrien Co., Alapaha, May 6, 2004, coll. Trevor Smith, on *Magnolia grandiflora* feeding on *Pseudaulacaspis cockerelli* (2 ♂, 1 ♀, TRSC); **LOUISIANA:** East Baton Rouge Parish, Baton Rouge, Bluebonnet Swamp, August 18, 2000, coll. A. R. Cline, mv light (1 ♀, LSAM); **MASSACHUSETTS:** Suffolk Co., Boston, Arnold Arboretum, July 14, 1921, coll. Harold Morrison, swept from 5-leaf pines behind lab (1 ♂, USNM); **MISSISSIPPI:** Smith Co., July 22, 1956 (1 ♀ TRSC); **PENNSYLVANIA:** Allegheny Co. (1 ♂, SEMC); **SOUTH CAROLINA:** Dorchester Co., Summerville, April 2, 1909, coll. J. G. Sanders, on tea scales (1 ♂, USNM).

Remarks. These beetles are usually collected by hand, either beating or simply by gleaning and aspirating. They are also occasionally picked up in Malaise traps. While they are sometimes found in urban areas, they seem to be collected more often in forested areas. The senior author collected hundreds of these beetles by spotting and aspirating them from *Magnolia grandiflora* L. infested with *P. cockerelli*. While this beetle seems to be very widespread, ranging from Canada to Florida and west to the Mississippi River, there are relatively few specimens in collections. There is also relatively less known about the hosts of this particular species.

Cybocephalus nipponicus Endrödy-Younga

(Figs. 4-10, 4-23-4-27, 4-29)

Cybocephalus nipponicus Endrödy-Younga 1971a: 244-245.

Diagnosis. Male bicolored with yellow or tan head, pro- and mesosternum, antennae and legs and remainder of the body black, thus distinguishing this species from all other *Cybocephalus* in North America. The female is almost completely black with yellow front legs and antennae, with remaining legs either light brown or brown. The antennal club is smaller than the eye, truncate and each antennomere is distinctly separated to form a serrated edge. The male basal plate and median lobe are distinctly different from other species.

Redescription. Male. *Form:* Elongate, oval; contractile; strongly convex dorsally. Length: 1.0-1.35 mm (measured from apex of clypeus to apex of elytra); width: 0.9-1.30 mm (measured at base of elytra). *Color:* Head, prothorax, mesothorax, antennae and legs yellow or yellowish brown; metathorax, elytra and abdomen black. *Head:* Broad and convex, clypeus moderately produced and comparatively narrow. Eyes large, oblong, with internal margins distinct. Genae not visible from above and not explanate. Dorsal surface smooth, but under high magnification finely alutaceous, punctation fine. Antennae 11-segmented including a club with 3 antennomeres; club length short, about ½-⅔ the length of eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. All club antennomeres wider than long and creating a serrated edge on inside margin of club. First club antennomere wider than long, second club antennomere larger than first and third club antennomeres and slightly wider than long. Terminal club antennomere truncate, setose, and slightly wider than long (Fig. 4-23). Third antennomere slightly shorter than segments 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins slightly curved or nearly straight; anterior angle more narrowly arcuate than posterior. Dorsal surface under high magnification finely alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with slightly convex margins. *Elytra:* Uniform width narrowing at the apical $^1/_5$. Strongly convex, sides almost parallel but slightly sinuous, apices rounded. Length somewhat shorter than combined width (33:40). Fine punctation at the base disappearing completely at distal edge but toward middle clearly three-armed and finely alutaceous. Median margin and apex of elytra bordered. *Underside:* Metasternum extremely alutaceous, roughly punctured and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about same width from end to end. Metafemora expanded in middle. Tibiae slightly but distinctly curved and dilated towards apex. Protibiae much more dilated than others and with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres combined. *Median* *lobe:* Sides parallel at base, extending to a large apical triangle (Fig. 4-24), in profile strongly curved at tip (Fig. 4-25). *Basal plate:* Sides parallel at base, tapering apically (Fig. 4-26).

Female. Similar to male except all black, lateral margin of the prothorax yellow or translucent and apical margin of elytra and middle and hind legs light brown or brown.

Geographic distribution. Connecticut, Delaware, Florida, Hawaii, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, Texas, Virginia, Washington D.C. (Fig. 4-27), Asia, Europe, Micronesia, West Indies and South Africa. This is a recently introduced species native to Southeast Asia, therefore specimens are rarely found in North American collections. For more information on the distribution of these beetles, see Drea and Carlson (1988), Jefferson *et al.* 1995, Van Driesche *et al.* (1998), Hudson *et al.* (2000), Deepak *et al.* (2003), Spichiger (2004), and HDA (2004).

Hosts. This predator has been reported in association with or feeding on a large number of armored scale insects (Diaspididae): *Aonidiella* sp. (Endrödy-Younga 1971a), *Aspidiotus destructor* Signoret (Endrödy-Younga 1971a,b; from label data), *Aulacaspis crawii* (Cockerell) (from label data), *Aulacaspis yasumatsui* Takagi (Heu and Chun 2000; from label data), *Chrysomphalus bifasciculotus* Ferris (Hayashi 1978; Tanaka and Inoue 1980), *Fiorinia externa* Ferris (Spichiger 2004; from label data), *Hemichionaspis* sp. (Endrödy-Younga 1971a), *P. cockerelli* (Cooley) (from label data), *P. pentagona* (Targioni-Tozzetti) (Yasuda 1981; Endrödy-Younga 1971a,b), *Diaspidiotus macroporanus* (Takagi) (Tachikawa 1974), *Quadraspidiotus perniciosus* (Comstock) (Alvarez and Van Driesche 1998a), *Unaspis euonymi* (Comstock) (Alvarez and Van Driesche 1998b; Drea and Carlson 1988), and *Unaspis yanonensis* Kuwana (Tanaka and

Inoue 1980). It has also been reported feeding on the citrus red mite, *P. citri* (Tanaka and Inoue 1980).

Material examined. UNITED STATES: CONNECTICUT: Hartford Co., Windsor, Connecticut Agricultural Experiment Station, Valley Laboratory, Sept. 15, 2005, coll. R. S. Cowles, feeding on *Fiorinia externa* Ferris on *Abies fraseri* (Pursh.) (15 ♂, 20 ♀, FSCA); **FLORIDA:** Collier Co., Naples, Apr. 25, 2002, coll. S. Krueger, on *Cycas* sp. (1 ♂, 3 ♀, FSCA); Dade Co., Turnpike, Snapper Creek Plaza, June 25, 1990, coll. F. D. Bennett, ex. *Pseudaulacaspis cockerelli* on *Ravenela madagascarensis* (4 ♂, 2 ♀, FSCA); Dade Co., S. Miami, Mar. 24, 2004, coll. P. Duetting, feeding on *Aulacaspis yasumatsui* on *Cycas revoluta* (10 ♂, 10 ♀, TRSC); Dade Co., S. Miami, jct. US-1 & SW 141 St., March 24, Apr. 12, 2004 coll. Trevor Smith, feeding on *Aulacaspis yasumatsui* on *Cycas revoluta* (10 ♂, 10 ♀, TRSC; 10 ♂, 10 ♀, FSCA); Hillsborough Co., Plant City, May 14, 2004, coll. Trevor Smith, feeding on *Aulacaspis yasumatsui* on *Cycas revoluta* (10 ♂, 10 ♀, TRSC; 10 ♂, 10 ♀, FSCA); Hillsborough Co., Tampa, Downtown, July 14, 2005, coll. Trevor Smith, feeding on *Aulacaspis yasumatsui* on *Cycas revoluta* (10 ♂, 10 ♀, FSCA); Manatee Co., Terra Ceia, Feb. 3, 1994, coll. M. Runnals, oleander (2 ♂, 4 ♀, FSCA); Orange Co., Orlando, UCF, April 26, 1999, coll. P. Russell, S. Fullerton, malaise trap, maidencane marsh (1, UCFC); Sarasota Co., Sarasota, 1315 38th St., Jan. 8, 2005, coll. J. H. Frank, feeding on *Aulacaspis yasumatsui* on *Cycas rumphii* (3 ♂, 3 ♀, TRSC); Seminole Co., Longwood, Oct. 7, 2004, coll. Trevor Smith, feeding on *Aulacaspis yasumatsui* on *Cycas revoluta* (7 ♂, 5 ♀, TRSC); **MARYLAND:** Prince George's Co., Beltsville, August 4, 1989, coll. R. Hendrickson, J. Drea, ex: *Unaspis euonymi* on: *Euonymus* sp. (3 ♂, 2 ♀, TAMU; 1 ♂, 1 ♀ TRSC); **TEXAS:** Brazos Co., Texas A&M

West Campus, September 27, 2000, coll. M. Yoder (1 ♂, TAMU); **INSECTARIES: CALIFORNIA:** Orange Co., Anaheim, January 30, 1935, Insectary (3 ♂, 3 ♀, LACM; 1 ♂, TRSC); Orange Co., Anaheim, October 15, 1952, coll. P. DeBach, on purple scale (1 ♂, 5 ♀, UCRC); Orange Co., Santa Ana, July 1, 1944, (rest is illegible) (2 ♂, 3 ♀, UCRC; 1 ♂, 1 ♀ TRSC); Orange Co., Insectary, January, 1948 (1 ♂, UCRC);Ventura Co., Ventura, Rincon-Vitova Insectaries, Sept. 8, 2004 (10 ♂, 10 ♀, TRSC; 10 ♂, 10 ♀, FSCA); **NEW YORK:** Cayuga Co., Locke, IPM Laboratories Inc., June 2001, ex. China (1 ♂, 6 ♀, FSCA; 1 ♂, 1 ♀, LSAM); **PENNSYLVANNIA:** Delaware Co., Swarthmore, July 16-20, 1988, coll. Mike Rose, Texas A&M Quarantine Lab (native to Korea) (4 ♂, 8 ♀, TAMU);

Remarks. *Cybocephalus nipponicus* is the only U.S. cybocephalid which has a sexually dimorphic color pattern (Fig. 4-28). This species, now widely distributed throughout the eastern U.S., was misidentified as *C. binotatus* and released in south Florida in 1998 to combat *A. yasumatsui* (Anon. 1998; Howard and Weissling 1999) on sago palms (*Cycas* spp.). These two species have been confused in the past as evidenced by Endrödy-Younga mixing specimens of *C. binotatus* (Fig. 4-28) and *C. nipponicus* (Fig. 4-29) in the description of *C. binotatus* in his 1968 monograph of the Palearctic cybocephalids. He later clarified this in his description of *C. nipponicus* and a redescription of *C. binotatus* (Endrödy-Younga 1971a). A male topotype of *C. binotatus* was compared to the beetles released in Florida. Two black spots on the yellow pronotum, a metallic sheen on the elytra, and distinctive male genitalia clearly separate *C. binotatus* from *C. nipponicus*. It was believed that the 1998 release of *C. nipponicus* from Thailand was the first introduction of these beetles into the state of Florida (Howard et al. 1999). However, specimens dating back to 1989 were found in the FSCA and identified as *C. nipponicus*.

Notes about type material of *C. binotatus*. The studied topotype specimen in the BMNH is a male glued to a card with the following labels: W. Almora, Kumaon, H.G.C. (printed) [white rectangular label] / Cybocephalus binotatus, Grouv. (printed) [white rectangular label] / Ent. Mo. Mag. 1923 Det. G.C.C. (printed) [upside down white rectangular label] / H. G. Champion Coll. B. M. 1953-156 (printed) [white rectangular label] / Kirejtshuk det 1996 (printed) Cybocephalus binotatus (handwritten) [white rectangular label]. This specimen is one of six collected by Champion (1923), of which one specimen of this series was designated as the neotype by Endrödy-Younga (1971a) when he could not find the original holotype deposited in the Assam Coll. (Grouvelle 1908).

Cybocephalus randalli T. R. Smith, New Species

(Figs.4-30-4-36)

Diagnosis. Male and female black. Clypeus much broader and more extended than in *C. californicus*. Antennal club is unlike all other North American species in that it is as large or larger than the eye, and the terminal antennomere of the club is rounded apically rather than truncate as in *C. californicus, C. nigritulus,* and *C. nipponicus.* Each club antennomere is distinctly separated and forming a serrated edge, unlike *C. kathrynae*. Front tibia is quite dilated, much more so than in *C. californicus*. In males, the basal plate and median lobe are easily recognizable.

Etymology. This species is named in honor of Randall Edwards Smith, father of the species name’s author.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.2-1.3 mm (measured from apex of the clypeus to apex of elytra); width: 0.85-0.95 mm (measured at base of elytra). *Color:* Head, thorax, elytra and underside black, lateral margin of pronotum and apical margin of elytra yellowish and translucent; legs and antennae dark brown or black. *Head:* Broad and convex, clypeus wide and produced. Eyes comparatively small, oblong with internal margins distinct. Genae not quite visible from above and slightly explanate. Dorsal surface smooth, under high magnification distinctly alutaceous with fine punctation. Antennae 11-segmented including a club with 3 antennomeres; club large and about same size as or larger than eye. Club flat and distinctly separate from funicle and with a distinctly serrated margin. First and second club antennomeres wider than long, terminal club antennomere longer than wide, apically rounded and quite setose (Fig. 4-30). Third antennomere shorter than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex and glossy; anterior angle more narrowly arcuate than posterior. Surface finely punctate and alutaceous. *Scutellum:* Triangular with straight or slightly convex margins. *Elytra:* Uniform width narrowing at the apical $^{1}/_{5}$. Strongly convex, sides almost parallel, apices rounded, length somewhat shorter than combined width (30:38). Very sparsely punctate and distinctly alutaceous, punctation ending before the base of elytra, smooth at sides and base. Median margin and apex of elytra bordered. Apices of elytra with distinct striations (Fig. 4-35). *Underside:* Metasternum extremely alutaceous and roughly punctate, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* All femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width from end to end.

All tibiae slightly but distinctly curved and dialated toward the apex. Metafemora expanded in the middle. Protibiae much more dilated than the others and with short hairs along the outer margin. Meso- and metatibiae with long stiff hairs along the outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres combined. *Median lobe:* Sides parallel before curving into a triangular apex (Fig. 4-31, 4-32). In profile, slightly curved at tip (Fig. 4-33). Median plate not elevated. *Basal plate:* Sides parallel at base, narrowing slightly before rounding at apex with a large concavity in the center (Fig. 4-34).

Female. Nearly identical to male.

Geographic distribution. California, Idaho, Nevada, Utah, Washington (Fig. 4-36).

Hosts. Specimens of *C. randalli* were collected while sweeping *Artemisia* spp., therefore it is a distinct possibility that these beetles feed on a scale found on *Artemisia*.

Type material examined. The holotype, deposited in the MCZC, is a male specimen glued to a point with the following labels: USA: IDAHO FALLS CO. SHOSHONE FALLS 14 VII 1975 LEG: A ALLEN SWEEPING SAGE BRUSH (printed) [white rectangular label] / HOLOTYPE *Cybocephalus randalli* T. R. Smith Det: Trevor Smith (printed) [red rectangular label]. The designated allotype, deposited in the MCZC, is a female specimen glued to a point with the following labels: Calif: Inyo Co. Saline Valley Dunes III-30-1976 cereal bowl pit trap D. Giuliani (printed) [white rectangular label] / ALLOTYPE *Cybocephalus randalli* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label]. Designated paratypes are as follows: **UNITED STATES: CALIFORNIA:** San Benito Co., 8.2 mi on Panoche rd. from I-5, Feb. 4, 1979

- Mar. 15, 1979, coll. A. J. Gilbert, Ethylene glycol pit trap in Ephedra area (1 ♂, TRSC); San Benito Co., 8.2 mi on Panoche rd. from I-5, March 15 - April 14, 1979, coll. A. J. Gilbert, antifreeze pit trap (1 ♀, CSCA); Riverside Co., Slover Ave. dump, 315m, 34º 03' 56" N 117º 21' 32" W, April 24, 2001, coll. Hawks and Yanega (1 ♂, UCRC); **IDAHO:** Twin Falls Co., Shoshone Falls, July 10, 1975, coll. A. D. Allen (1 ♂, USNM); Twin Falls Co., Shoshone Falls, September 21, 1975, coll. A. Allen, sweeping sagebrush (1 ♂, TRSC; 1 ♀, AAIC); **NEVADA:** Churchhill Co., 6mi East of Frenchman, August 22, 1972, coll. Stephen J. Chaplin (1 ♀, USNM; 1 ♀, TRSC); Nye Co., Mercury, July 21, 1964, on *Aritri* (1 ♂, USNM); Nye Co., Mercury, February 7, 1961 (1 ♀, USNM); **UTAH:** Washington Co., St. George, July, coll. Wickham (1 ♀, CNCI); Washington Co., St. George (1 ♀, MTEC); **WASHINGTON:** Grant Co., Smyrna, June 19, 1932, coll. M. H. Hatch (1 ♂, FSCA);

Remarks. This species is less frequently collected than the sympatric *C. californicus*. Whether this beetle is actually less common than *C. californicus* or whether they just occupy a slightly different niche is unknown. While these beetles are usually picked up by sweeping, they occasionally show up in pitfall traps. This is probably a case of the optimal collecting technique not being employed to obtain this species.

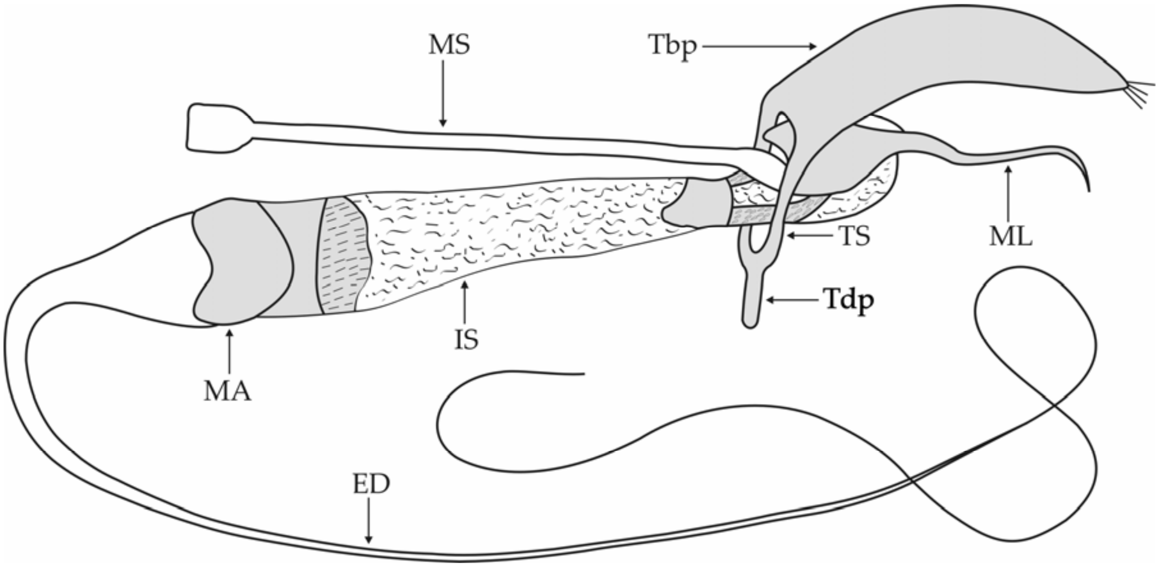


Figure 4-1. Complete *Cybocephalus nipponicus* genitalia: ED = ejaculatory duct; IS = internal sac; MA = muscle attachment; ML = median lobe; MS = median strut; Tbp = tegmen basal plate; Tdp = tegmen dorsal piece; TS = tegminal strut.

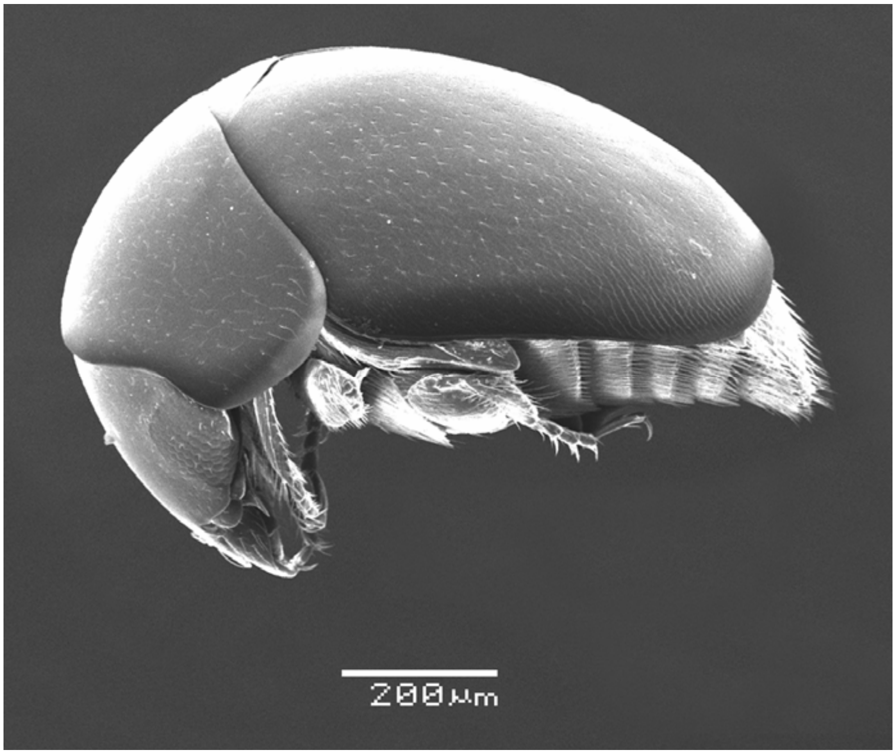
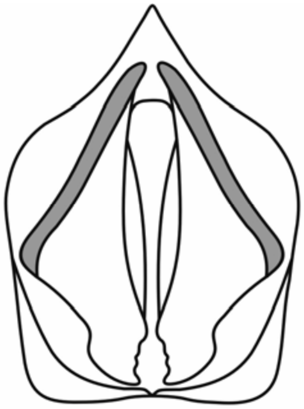


Figure 4-2. Lateral habitus of *Cybocephalus randalli*.

4-3

4-4



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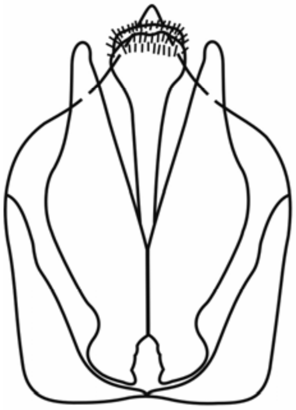

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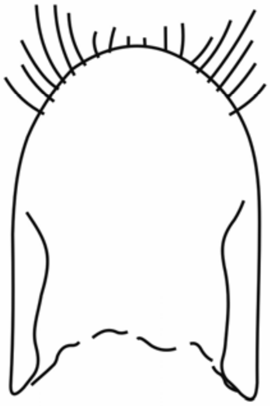


4-8

Figure 4-3. Truncate antenna of *C. californicus*.

Figure 4-4. Emarginate antenna of *C. californicus*.

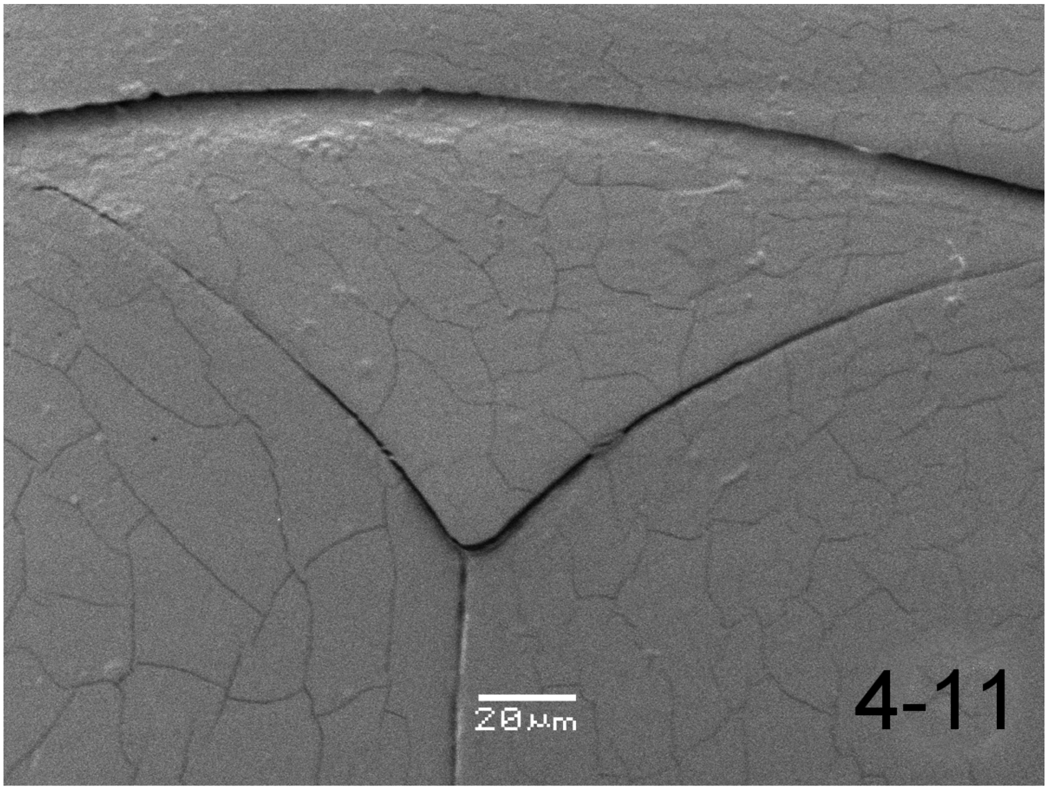
Figure 4-5. Median lobe, dorsal view, of *C. californicus*.

Figure 4-6. Median lobe, dorsal view (slide mounted), of *C. californicus*.

Figure 4-7. Median lobe, lateral view, of *C. californicus*.

Figure 4-8. Basal plate, ventral view, of *C. californicus*.

Figure 4- 9. U.S. states and Canadian provinces from which specimens of *Cybocephalus californicus* have been collected.



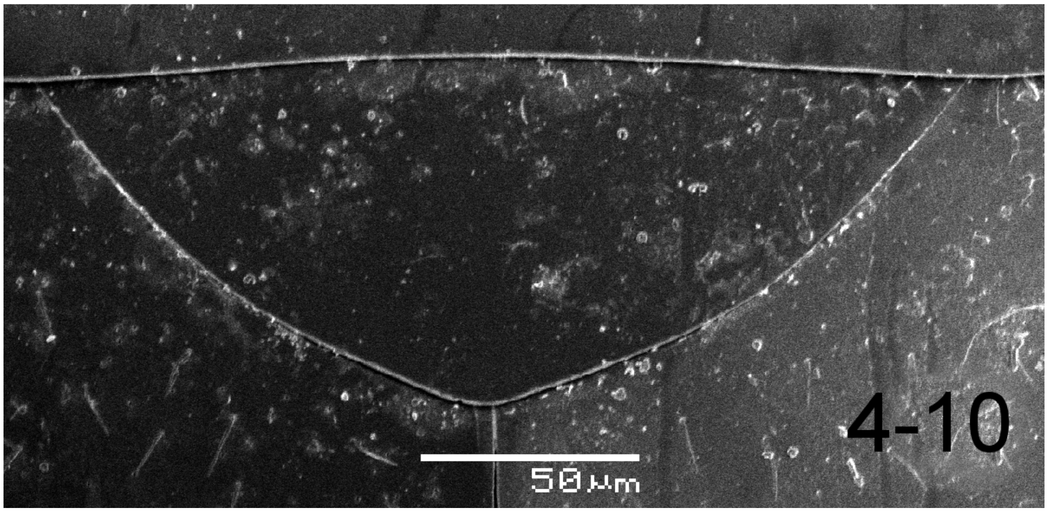
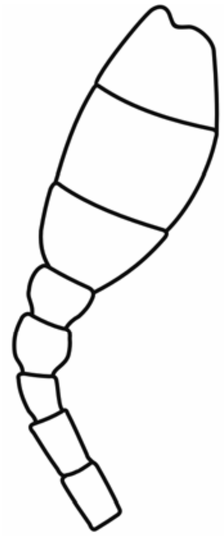
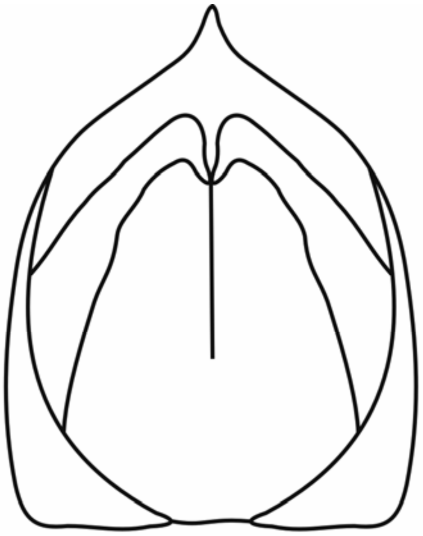


Figure 4-10. Scutellum of *Cybocephaus nipponicus*.

Figure 4-11. Scutellum of *Cybocephalus kathrynae*.



4-12



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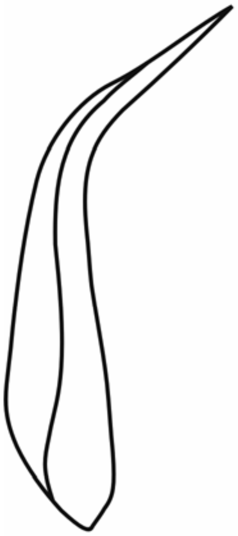

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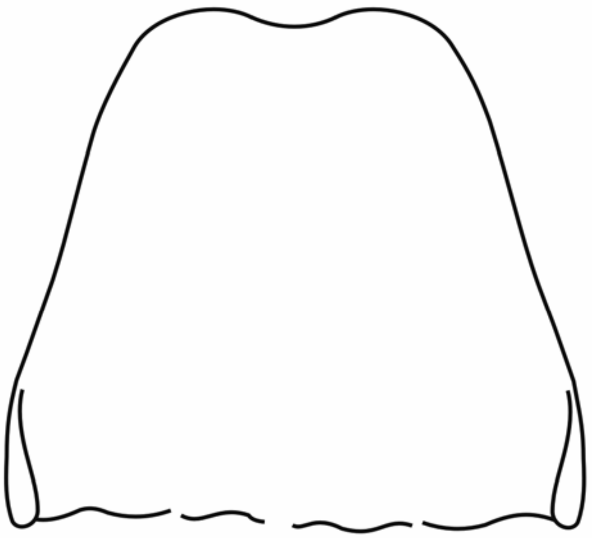


4-15

Figure 4-12. Antenna of *C. kathrynae*.

Figure 4-13. Median lobe, dorsal view (same as slide mounted), of *C. kathrynae*.

Figure 4-14. Median lobe, lateral view, of *C. kathrynae*.

Figure 4-15. Basal plate, ventral view, of *C. kathrynae*.

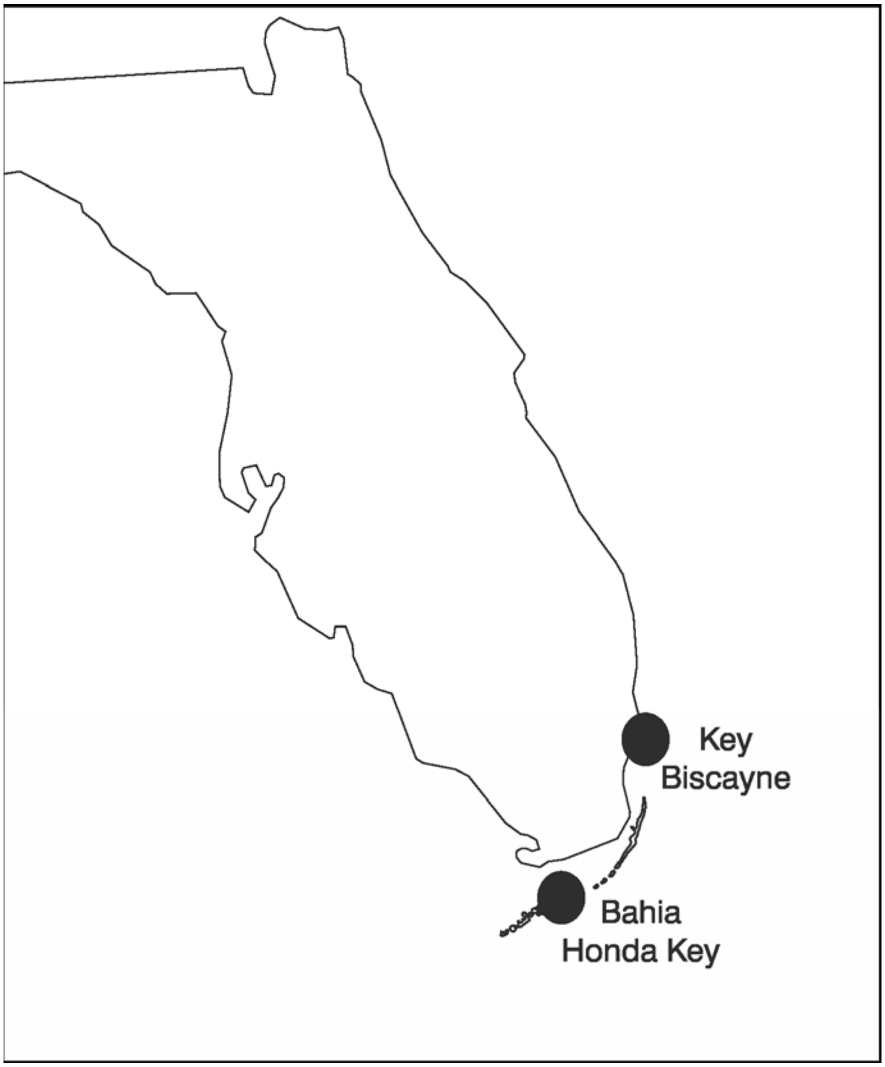
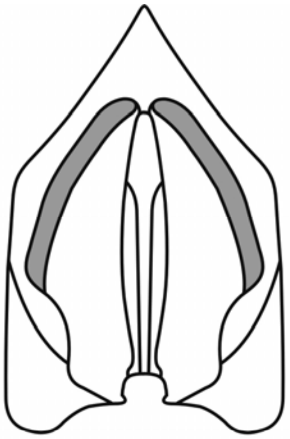
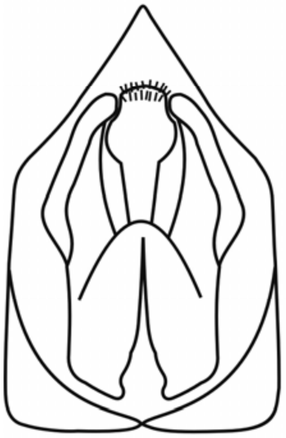


Figure 4-16. Collection localities of *Cybocephalus kathrynae* in Florida.


4-17


4-18


4-19


4-20

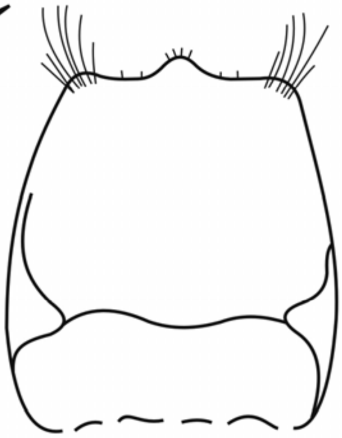

4-21

Figure 4-17. Antenna of *C. nigritulus*.

Figure 4-18. Median lobe, dorsal view, of *C. nigritulus*.

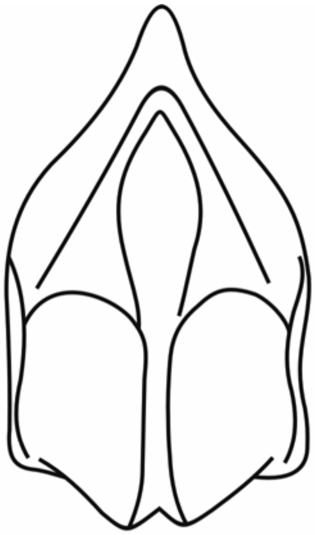
Figure 4-19. Median lobe, dorsal view (slide mounted), of *C. nigritulus*.

Figure 4-20. Median lobe, lateral view, of *C. nigritulus*.

Figure 4-21. Basal plate, ventral view, of *C. nigritulus*.

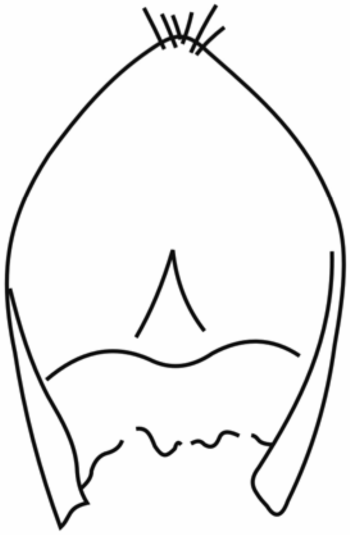
Figure 4-22. U.S. states and Canadian provinces from which specimens of *Cybocephalus nigritulus* have been collected.

4-23



4-24

4-25



4-26

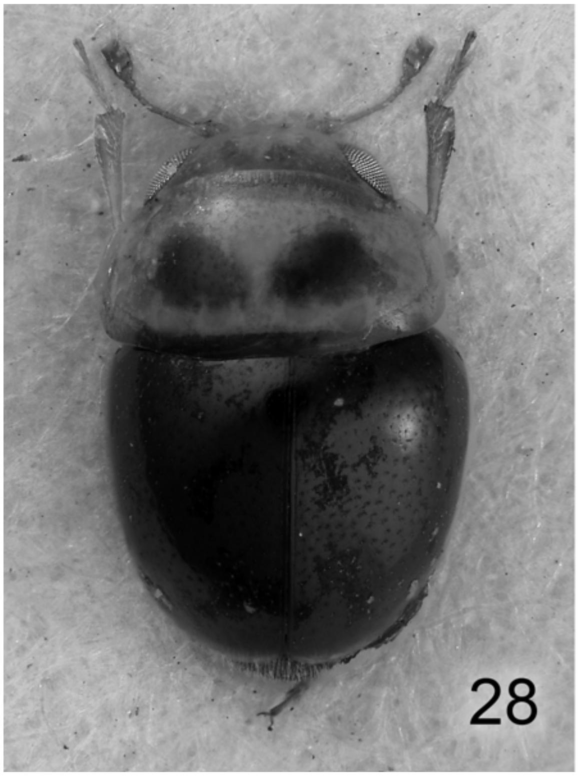
Figure 4-23. Antenna of *C. nipponicus*.

Figure 4-24. Median lobe, dorsal view (same as slide mounted), of *C. nipponicus*.

Figure 4-25. Median lobe, lateral view, of *C. nipponicus*.

Figure 4-26. Basal plate, ventral view, of *C. nipponicus*.

Figure 4-27. U.S. states from which specimens of *Cybocephalus nipponicus* have been collected.



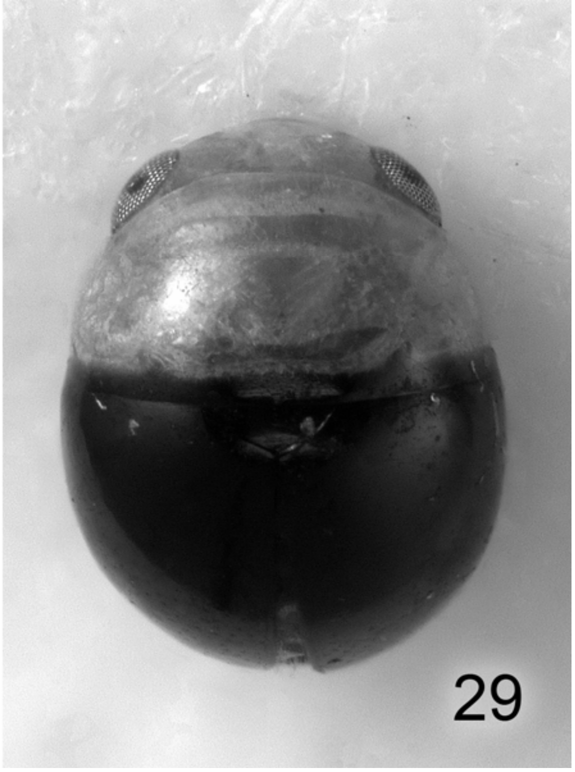
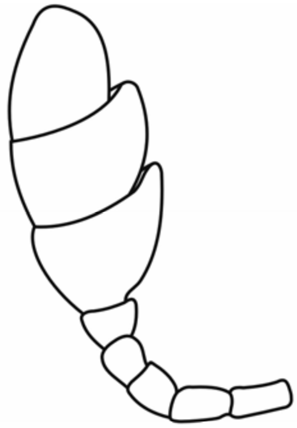
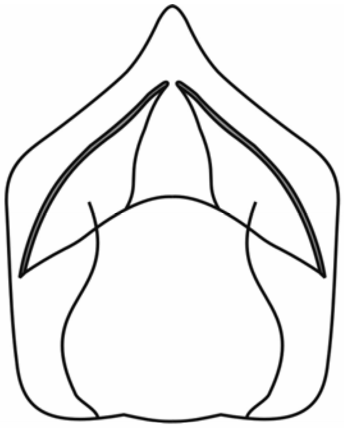


Figure 4-28. Dorsal habitus of *C. binotatus*.

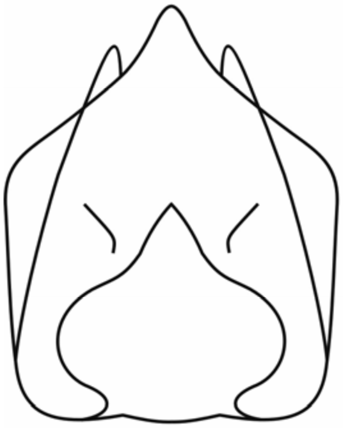
Figure 4-29. Dorsal habitus of *C. nipponicus*.



4-30

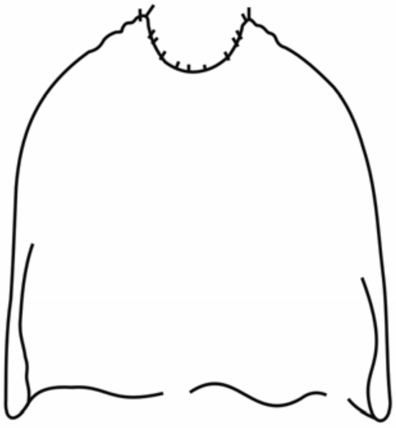


4-31



4-32

4-33



4-34

Figure 4-30. Antenna of *C. randalli*.

Figure 4-31. Median lobe, dorsal view, of *C. randalli*.

Figure 4-32. Median lobe, dorsal view (slide mounted), of *C. randalli*.

Figure 4-33. Median lobe, lateral view, of *C. randalli*.

Figure 4-34. Basal plate, ventral view, of *C. randalli*.

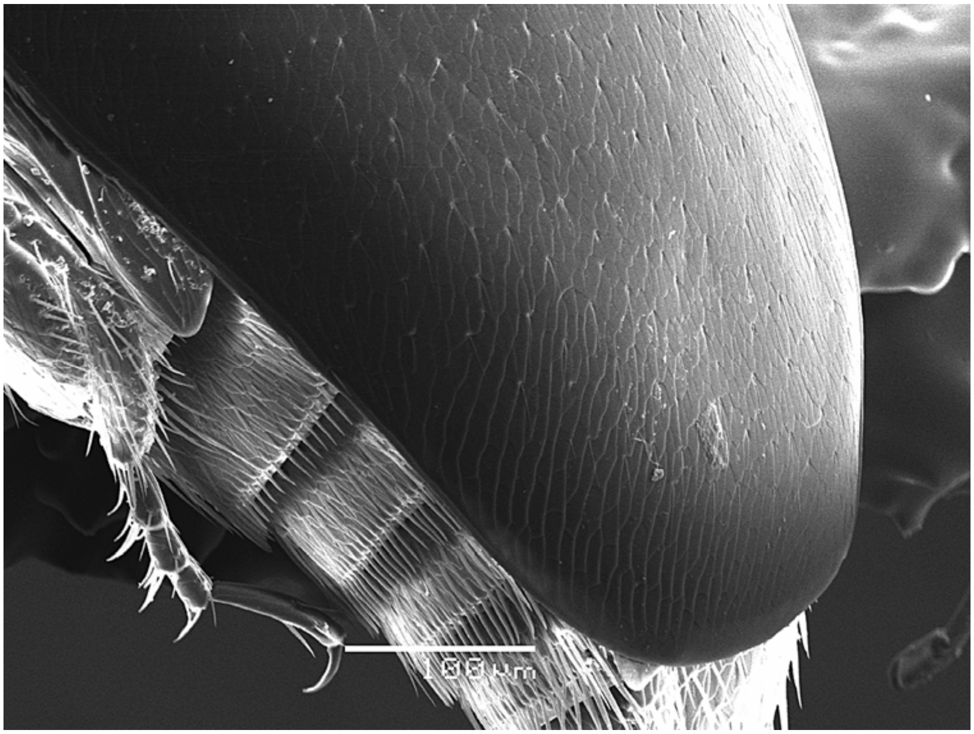


Figure 4-35. Striations at the apices of elytra on *C. randalli*.

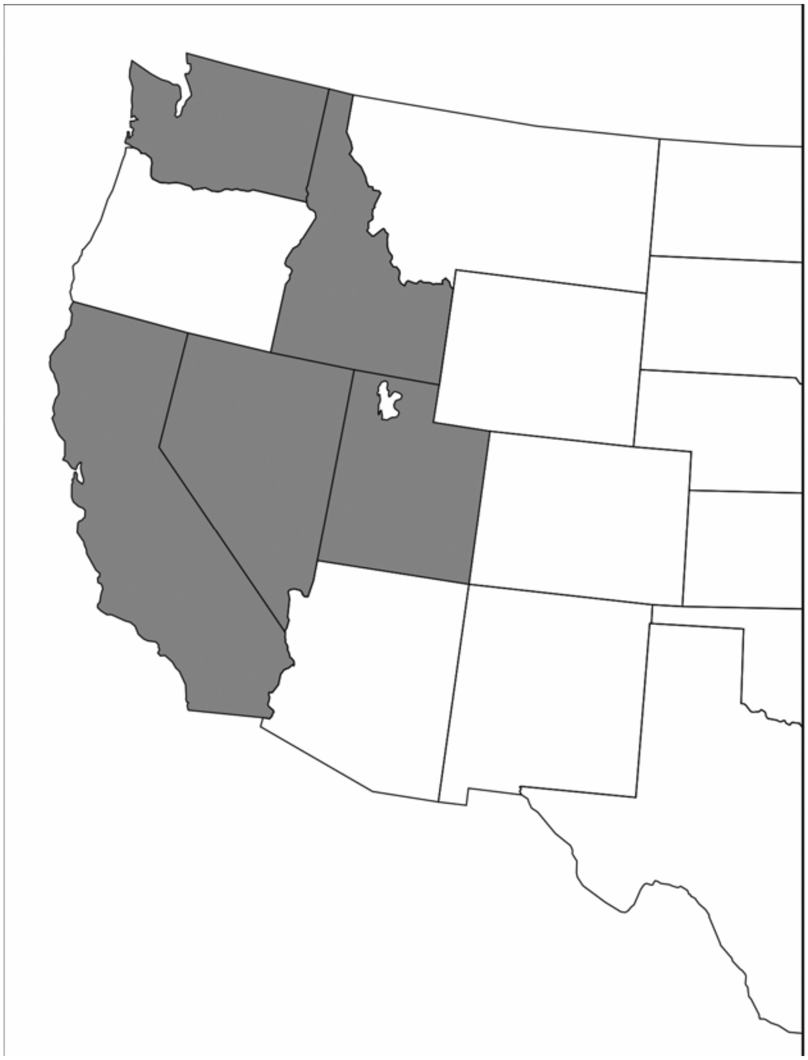


Figure 4-36. U.S. states from which specimens of *Cybocephalus randalli* have been collected.

CHAPTER 5
THE CYBOCEPHALIDAE (COLEOPTERA) OF THE WEST INDIES AND TRINIDAD

Introduction

Sixteen species of Cybocephalidae have been described from the New World, all belonging to the genera *Cybocephalus* Erichson and *Pycnocephalus* Sharp (Brethes 1922, Champion 1913, Reitter 1874, 1875, Sharp 1891, T.R. Smith 2006a, Waterhouse 1877). This is in stark contrast to the over 150 species belonging to six genera in the Old World. Smith and Cave (2006a) recently revised the five species known to occur in America north of Mexico, but the Neotropical species have never been treated taxonomically.

Cybocephalids are known to feed on a wide variety of hosts (Smith and Cave 2006a); however their most common food source is scale insects. In North America, *Cybocephalus nipponicus* Endrödy-Younga is a predator of *Aulacaspis yasumatsui* Takagi (Smith and Cave 2006b), *Fiorinia externa* Ferris (Spichiger 2004), and *Unaspis euonymi* (Comstock) (Drea and Carlson 1988, Alvarez and Van Driesche 1998a,b). In the western United States, *Cybocephalus californicus* Horn is a common natural predator of *Ehrhornia cypressi* (Ehrhorn) (Flanders 1934; Kartman 1946; Clausen 1940), *Lecanium corni* Bouché (Heintz 2001), and *Diaspidiotus perniciosus* (Comstock) (Heintz 2001). In the eastern United States, *Chionaspis pinifoliae* (Fitch) (Riley 1882), *Fiorinia theae* Green (Flanders 1934), *Pseudaulacaspis cockerelli* (Cooley) (Smith and Cave 2006a), and *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Collins and Whitcomb

1975) are prey species of *C. nigritulus* LeConte. *Pycnocephalus argentinus* Bréthes is a predator of *Ceroplastes* sp. (Bréthes 1922, Parker 1951) in South America.

To date, no cybocephalid species have been described from the West Indies. Due to the collecting techniques required to obtain these beetles and their very small size, these beetles are often overlooked and are rarely found in collections. Cybocephalids do not come to light traps and are usually collected by beating vegetation, extracted from leaf litter samples, or from flight intercept traps. With collectors using collecting techniques such as sifting sand and leaf litter as well as the increased use of flight intercept traps in the West Indies, more of these beetles will be collected and subsequently described.

The objectives of this study are to 1) present a key for the identification of the cybocephalids of the West Indies and Trinidad, 2) describe new West Indian species, and 3) record the distribution of each species in the Caribbean Basin.

Materials and Methods

Materials

For this study, 222 specimens belonging to the genus *Cybocephalus* and 31 specimens belonging to the genus *Pycnocephalus* were examined. One female specimen from the Dominican Republic is at hand, but without associated males their identification cannot be ascertained. Specimens were borrowed from the following institutions and private collections (name of the curator or owner in parentheses):

AAIC	Albert Allen Insect Collection, Boise, ID (Albert Allen)
BMNH	Natural History Museum, London [formerly British Museum (Natural History)], UK (Maxwell Barclay)
FMNH	Field Museum of Natural History, Chicago, IL (James H. Boone)

FSCA	Florida State Collection of Arthropods, Gainesville, FL (Paul Skelley and Michael Thomas)
SEMC	Snow Entomological Museum, University of Kansas, Lawrence, KS (Zack H. Falin)
TAMU	Texas A&M University, Department of Entomology, College Station, TX (Ed G. Riley)
USNM	United States National Museum, Smithsonian Institution, Washington D.C. (Gary Hevel)
WIBF	West Indian Beetle Fauna Project Collection, Montana State University, Bozeman, MT (Michael Ivie)

Methods

Genitalia were removed and disarticulation was carried out using the methods described in Smith and Cave (2006a).

Definitions

Median lobe: Also referred to as penis (Endrödy-Younga 1968, 1971a, 1971b; Kirejtshuk et al. 1997; Lupi 2003; Yu 1995a, 1995b).

Basal plate: This is a reference to the basal plate of the tegmen (Endrödy-Younga 1968, 1971a, 1971b; Lupi 2003; Yu 1995a, 1995b).

Key to the Cybocephalidae of the West Indies and Trinidad

1. Head very short with extremely short, slightly concave clypeus (Fig. 5-2); femora and tibiae of the posterior two pairs of legs extremely dilated and laminiform (Fig. 5-27); male with blue-green metallic sheen on head and apical half of pronotum.. *Pycnocephalus deyrollei* (Reitter) **new combination**

1’ Head not short, clypeus of normal size and not concave at the apex (Fig. 5-1); only hind femora dilated, middle femora and tibiae of the posterior two pairs of legs not or only slightly dilated; male without metallic sheen................................2

2(1’) Antennal club without a serrated margin and terminal antennomere rounded (Fig. 5-11); scutellum with concave margins (Fig. 5-15).. *Cybocephalus iviei* **new species**

2’. Antennal club with at least 2 antennomeres forming a serrated margin and terminal segment truncate (Fig. 5-3); scutellum with straight or slightly convex margins (Fig. 5-16) 3

3(2'). Margin smooth between club antennomeres 1 and 2 but terminal club antennomere clearly much narrower than club antennomere 2 (Fig. 5-3); basal plate rounded (Fig. 5-6); median lobe as in Figs.5-4 and 5-5.................................. ……………………………………………*Cybocephalus antilleus* **new species**

3'. Antennal club with a clearly serrated margin (Fig. 5-7).......................................4

4(3'). Male bicolored with head, prothorax, mesosternum and legs yellow or tan, rest of body black; basal plate coming to a rounded point (Fig. 5-21); median lobe as in Figs. 5-19 and 5-20 ....*Cybocephalus nipponicus* Endrödy-Younga

4'. Male not bicolored 5

5'. Male basal plate rounded with a slight concavity at the apex (Fig. 5-10); median lobe as in Figs. 5-8 and 5-9.......................... *Cybocephalus caribaeus* **new species**

5(4') Male basal plate evenly rounded and without concavity (Fig. 5-25); median lobe as in Figs. 5-23 and 5-24....................... *Cybocephalus geoffreysmithi* **new species**

Cybocephalus Erichson 1844

Cybocephalus Erichson 1844: 441-442.

For a description of the genus, see Smith and Cave (2006a).

Cybocephalus antilleus T. R. Smith, New Species

(Figs. 5-3-5-6)

Diagnosis. Male and female are black but with a matte-like appearance. The antennal club has a distinctive shape (Fig. 5-3) unlike any other species in the West Indies. In males, the basal plate (Fig. 5-6) and median lobe (Fig.5-4) are easily distinguished from those of all other species.

Etymology. This species is named after the chain of islands (the Antilles) in which it occurs.

Description. Male. *Form:* Elongate round, contractile; strongly convex dorsally. Length: 1.3 mm (measured from apex of the clypeus to apex of elytra); breadth: 0.7 mm (measured across elytral humeri). *Color:* Black, shiny but with a matte-like appearance.

Head, thorax, and elytra black or dark brown, underside dark brown to black; legs and antennae dark brown. *Head:* Broad and convex, clypeus moderately produced and wide. Eyes large, round, facets distinct. Surface distinctly alutaceous and minutely but uniformly punctate. Clypeus wide and short. Genae not visible from above, slightly explanate when viewed laterally. Dorsal surface alutaceous and finely punctured. Antenna with 11 antennomeres including a 3-segmented club. Club large, only slightly smaller than height of the eye, flat and distinctly separated from funicle. First and second club antennomeres wider than long, terminal club antennomere about as long as wide. Margin smooth between club antennomeres 1 and 2, but terminal club antennomere clearly much narrower than club antennomere 2 (Fig. 5-3). Antennomere 3 shorter than 4 and 5 combined. *Pronotum:* Alutaceous and punctuate. Strongly convex, lateral margins curved; anterior angles more narrowly arcuate than posterior angles. *Scutellum:* Very small, alutaceous. *Elytra:* Uniform width narrowing at the apical 1/5. Strongly convex, sides slightly sinuous and apices round, length shorter than combined width (30:39). Punctation ending just before apices. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctuate with long coarse hairs thinly covering the surface. *Legs:* All tibiae slightly but distinctly curved and dilated toward the apex. Protibiae with short hairs along the outer margin. Meso- and metatibiae with long, stiff hairs along the outer margin. All femora glossy, wide, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout their length. Metafemora expanded in the middle. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres. *Median lobe:* Sides parallel until converging sharply towards an acute, extended point at the apex (Fig. 5-4). In profile, slightly curved ventrally at tip (Fig. 5-5). Median plate only slightly elevated (Fig. 5-5). *Basal Plate:* Sides parallel at base, with a uniformly rounded tip (Fig. 5-6).

Female. Similar to male except for genitalic structures.

Distribution. Dominica.

Material examined. The holotype, deposited in the TAMU insect collection, is a partly disarticulated male specimen glued to a point with the following labels: DOMINICA: St. Paul Par. Springfield Estate V-27-VI-12-1994 J. B. Woolley, 94/020 malaise trap (printed) [white rectangular label] / HOLOTYPE *Cybocephalus antilleus* T. R. Smith Det: Trevor Smith (printed) [red rectangular label]. The allotype, deposited in the TAMU insect collection, is a female specimen glued to a point with the following labels: DOMINICA: St. Paul Par. Springfield Estate V-27-VI-12-1994 J. B. Woolley, 94/020 malaise trap (printed) [white rectangular label] / ALLOTYPE *Cybocephalus antilleus* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label]. Paratype: **Dominica:** St. Paul Par., Pont Cassé, 19-VI-2004, coll. R. Turnbow (1♂, FSCA)

Remarks. These beetles were collected in heavily forested habitat. Nothing is known about the preferred prey of these beetles.

Cybocephalus caribaeus T. R. Smith, New Species

(Figs. 5-7-5-10)

Diagnosis. Male and female are black or dark brown. Each antennomere of the antennal club is distinctly separated to form a serrated edge and the terminal antennomere is truncate (Fig. 5-7). In males, the basal plate (Fig. 5-10) and median lobe (Fig. 5-8) are easily distinguished from all other species.

Etymology. This species is named after the general region (the Caribbean Sea) in which it occurs.

Description. Male. *Form:* Round, contractile; strongly convex dorsally. Length: 1.35 mm (measured from apex of clypeus to apex elytra); breadth: 1.0 mm (measured across elytral humeri). *Color:* Head, thorax, elytra black or dark brown, underside dark brown to black; front legs light brown, middle and hind legs and antennae dark brown. *Head:* Broad and convex, clypeus moderately produced and relatively narrow. Eyes large, tear-shaped, facets distinct. Dorsal surface distinctly alutaceous and minutely but uniformly punctate. Genae not visible from above and slightly explanate when viewed laterally. Antenna with 11 antennomeres including a 3-segmented club about ½ the height of the eye. Club flat and distinctly separated from funicle. All club antennomeres wider than long; terminal club antennomere short and truncate (Fig. 5-7). Antennal club margin serrated. Antennomere 3 shorter than 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angles more narrowly arcuate than posterior angles. Alutaceous and punctuate. *Scutellum:* Triangular, alutaceous, and with margins slightly convex. *Elytra:* Uniform width narrowing at the apical 1/5. Strongly convex, sides slightly sinuous and apices rounded, length shorter than combined width (33:43). Punctation ending just before apices. Median margin and apices of elytra bordered. *Underside:* Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. *Legs:* All tibiae slightly but distinctly curved and dilated toward the apex. The protibiae with short hairs along the outer margin. Meso- and metatibiae with long, stiff hairs along the outer margin. All femora shiny, wide, flattened and sparsely covered with short hairs. Metafemora expanded in the middle. Pro- and mesofemora only very slightly dilated in the middle. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres. *Median lobe:* Sides extending parallel to one another, turning in towards the apex to form a sharp point, with a slight notch on either side of lobe ¾ of the way up towards the apex (Fig. 5-8). In profile, strongly curved from the middle (Fig 5-9). Median plate very elevated (Fig. 5-9). *Basal Plate:* Parallel sides at base narrowing slightly toward apex, emarginate at the apical end (Fig. 5-10).

Female. Similar to male except for genitalic structures.

Distribution. Curaçao

Material examined. The holotype, deposited in the USNM, is a disarticulated male specimen glued to a point with the following labels: CURAÇAO, Coral Specht 3 km. E. Willemstad 9-15 February 1987 W. E. Steiner & J. M. Swearingen (printed) [white rectangular label] / Flight-intercept yellow pan trap in mesquite-acacia desert scrub near coast (printed) [white rectangular label] / HOLOTYPE *Cybocephalus caribaeus* T. R. Smith Det: Trevor Smith (printed) [red rectangular label]. The allotype, deposited in the USNM, is a female specimen glued to a point with the following labels: CURAÇAO, Coral Specht 3 km. E. Willemstad 9-15 February 1987 W. E. Steiner & J. M. Swearingen (printed) [white rectangular label] / flight-intercept yellow pan trap in mesquite-acacia desert scrub near coast (printed) [white rectangular label] / ALLOTYPE *Cybocephalus caribaeus* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label].

Remarks. This species was collected in desert habitat. Nothing is known about the diet or plant associations of this beetle.

Cybocephalus iviei T. R. Smith, New Species

(Figs. 5-11-5-15, 5-17)

Diagnosis. Male and female are black. Size is extremely small (<1mm). The antennal club has a smooth margin (Fig. 5-11) without a serrated edge and the terminal segment is somewhat rounded. The scutellum has concave margins (Fig.5-15), distinguishing this species from all others in the West Indies. The apices of the elytra have a distinct invagination (Fig. 5-17), a character also unique to this species.

Etymology. This species is named in honor of Dr. Michael Ivie, a thorough collector of microcoleoptera and the first to collect this species.

Description. Male. *Form:* Ovate; contractile; strongly convex dorsally. Length: 0.80 mm (measured from apex of the clypeus to apex of elytra); breadth: 0.38 mm (measured across the elytral humeri). *Color:* Head, thorax, elytra black or dark brown, underside brown to dark brown; legs and antennae brown. *Head:* Broad and convex, clypeus moderately produced and wide. Eyes large, oblong with internal margins distinct. Genae extended laterally and easily visible from above and slightly explanate when viewed laterally. Dorsal surface alutaceous and finely punctured. Antenna with 11 antennomeres including a 3-segmented club only slightly smaller than height of eye. Club flat and distinctly separated from funicle. First club antennomere wider than long. Second club antennomere larger than either first or third club antennomere and not as long as wide. Terminal club antennomere rounded and roughly trapezoidal in shape and about as long as wide (Fig. 5-11). Antennomere 3 slightly shorter than 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angles more narrowly arcuate than posterior angles. Surface distinctly punctured. *Scutellum:* Very wide with very concave margins (Fig. 5-15); alutaceous and very sparsely punctured.

Elytra: Uniform width narrowing at the apical 1/5. Strongly convex dorsally, sides slightly sinuous and apices with a distinct invagination (Fig. 5-17). Length about half of combined width (17:30). Very alutaceous, distinctly punctured. Median margin and apices of elytra bordered. *Underside:* Abdominal sternites alutaceous and punctuate with long coarse hairs thinly covering the surface. Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. *Legs:* All tibiae slightly but distinctly curved and dilated toward the apex. Protibiae with short hairs along the outer margin. Meso- and metatibiae with long, stiff hairs along the outer margin. All femora shiny, wide, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width from end to end. Metafemora expanded in the middle. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres. *Median lobe:* Sides extending parallel to one another, turning in sharply towards the apex and coming to a blunt point (Fig. 5-12). In profile, strongly curved from middle (Fig. 5-13). Median plate only slightly elevated (Fig. 5-13). *Basal Plate:* Sides parallel at base, rounding to a slightly flat top (Fig. 5-14).

Female. Similar to male except for genitalic structures.

Distribution. U. S. Virgin Islands**:** Buck Island (St. Croix), St. John, St. Thomas

Type material examined. The holotype, deposited in the USNM, is a male specimen glued to a point with the following labels: Virgin Is: St. John Est. Concordia 12 May 1984, litter under cactus and agave, W. Muchmore (printed) [white rectangular label] / HOLOTYPE *Cybocephalus iviei* T. R. Smith Det: Trevor Smith (printed) [red rectangular label] / WIBF 014005 (printed with a barcode, upside down) [white rectangular label]. The allotype, deposited in the USNM, is a female specimen glued to a point with the following labels: Virgin Is: St. John Est. Concordia 12 May 1984, litter under cactus and agave, W. Muchmore (printed) [white rectangular label] / ALLOTYPE *Cybocephalus iviei* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label] / WIBF 013987 (printed with a bar code, upside down). Paratypes: **UNITED STATES VIRGIN ISLANDS: BUCK ISLAND:** Buck Island Reef National Monument, 140 ft., V-VI-1993, coll. Z. Hillis, flight intercept trap #14 (1 ♂, WIBF); Buck Island Reef National Monument, 340 ft., VII-VIII-1993, coll. Z. Hillis, flight intercept trap #15 (1 ♀, WIBF); Buck Island Reef National Monument, 340 ft., 30-III-29-VI-1995, coll. Z. Hillis and M. Hillis, flight intercept trap #15 (1 ♂,1 ♀, WIBF); Buck Island Reef National Monument, 9-V-1996, coll. Z. Hillis, M. Hillis and B. Phillips, flight intercept trap (1 ♂,2 ♀, WIBF)**; ST. JOHN:** Maho Bay, 12-III-1984, coll. W. B. Muchmore, under trees nr. road (1 ♀, WIBF); Est. Concordia, 12-V-1984, coll. W. B. Muchmore, litter under cactus and dung (3 ♂,11 ♀, WIBF; 2 ♂, TRSC, 2♀, USNM); Est. Concordia, 12-V-1984, coll. W. B. Muchmore, litter under cactus and agave (5 ♂,10 ♀, WIBF; 1 ♂,1 ♀, MCZC; 1 ♂,3 ♀, FSCA); **ST. THOMAS:** Red Hook, 27-VII-1980, coll. M. A. Ivie, ex. Dead Stump (3 ♀, WIBF); Est. Nazareth, 40 ft., 26-VII-19-X-1994, coll. M. A. and L. L. Ivie, flight intercept #9 (2 ♂, 2 ♀, WIBF).

Remarks. While much smaller, this species has characteristics similar to *C. kathrynae* T. R. Smith which is found in southern Florida. Both species have similarly shaped antennal clubs and scutella. *Cybocephalus iviei* has almost always been collected in flight intercept traps or in leaf litter. It was often collected in litter at the base of cacti and agave, therefore there is a good chance that one of their hosts is a scale insect found on one of these plants.

Cybocephalus nipponicus Endrödy-Younga

(Figs. 5-1, 5-16, 5-18-5-21)

Cybocephalus nipponicus Endrödy-Younga 1971a: 244-245.

Diagnosis. The male is bicolored with a yellow or tan head, pro- and mesosternum, antennae, and legs but the remainder of the body is black, thus distinguishing this species from all other *Cybocephalus* in the West Indies. The female is almost completely black with yellow front legs and antennae, with the remaining legs either light brown or brown. The antennal club is smaller than the eye, truncate and each segment is distinctly separated to form a serrated edge (Fig. 5-18). The male basal plate (Fig. 5-21) and median lobe (Fig. 5-19-5-20) are distinctly different from those of all other species.

Description. For descriptions of both sexes, see Smith and Cave (2006a).

Distribution. West Indies: Cayman Islands, St. Kitts / Nevis, Barbados; World: Asia, southern Europe, Micronesia, eastern North America, and South Africa.

Hosts. This predator has been reported feeding on at least 14 species of armored scale around the world (see Smith and Cave (2006a) for references). According to label data, this beetle has only been recorded feeding on *A. yasumatsui* and *Aspidiotus destructor* Signoret in the West Indies. This beetle was introduced, using specimens collected in Florida, to Barbados where it quickly became established and contributes to the biological control of *A. yasumatsui* on ornamental king sagos, *Cycas revoluta* Thunberg (I. Gibbs, personal communication).

Material examined. British West Indies: Cayman Islands: Grand Cayman, 15-VI-2001, coll. S. Frederick, feeding on cycad scale on *Cycas revoluta* (8 ♂, 6 ♀, FSCA); **West Indies: St. Kitts / Nevis**: **St. Kitts,** 14-II-1997, coll. R. D. Gautan, feeding on *Aspidiotus destructor* (6 ♂, 3♀, BMNH); **Nevis,** nr. Charlestown, 9-XI-1995, coll. G.

Watson, on coconut palm infested with whitefly (1 ♂, 2♀, BMNH); Four Seasons Resort, 9-XI-1995, colls. G. Watson, M. Cock & E. Clarke, on coconut palm infested with *Aspidiotus destructor* and whiteflies (43 ♂, 34♀, BMNH); Nisbet Plantation, 10-XI-1995, coll. G. Watson, on coconut palm (20 ♂, 14♀ BMNH); Nisbet Estate, 20-II-1997, coll. R. G. Booth, on coconut palm (3 ♂, 2♀ BMNH); Potwork, 10-XI-1995, coll. E. Clarke & G. Watson, on coconut palm infested with scale and whitefly (2♀, BMNH).

***Cybocephalus geoffreysmithi* T. R. Smith, New Species**

(Figs. 5-22-5-25)

Diagnosis. Male and female are black or dark brown. Each antennomere of the antennal club is distinctly separated to form a serrated edge and the terminal antennomere is truncate (Fig. 5-22). Scutellum with convex margins. In males, the basal plate (Fig. 5-25) and median lobe (Figs. 5-23, 5-24) are easily distinguished from all other species.

Etymology. This species is named in honor of Geoffrey Edwards Smith, paternal grandfather of the species name’s author.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.1 mm (measured from apex of clypeus to apex of elytra); breadth: 0.9 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside dark brown, a narrow band along the lateral margin of pronotum and posterior margin of elytra yellowish and translucent; front legs and antennae amber or light brown, middle and hind legs dark brown. *Head:* Broad and convex, clypeus moderately produced and narrow. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere slightly wider than long, second club antennomere larger than either first or third club antennomere and wider than long. Terminal club antennomere truncate (Fig. 5-22), setose and wider than long. Antennomere 3 about as long as antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Very large, alutaceous and triangular with convex margins. *Elytra:* Uniform width narrowing at apical $^{1}/_{5}$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (28:36). Uniformly punctate along dorsal surface, smooth at sides and base with a narrow impunctate area at apices of elytra. Appearing alutaceous under high magnification. Median margin and apices of elytra bordered. Apices with distinct striations. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. The protibiae with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel or slightly divergent curving into a point (Fig. 5-23). In profile, strongly curved from middle (Fig. 5-24). Median plate on surface elevated. *Basal plate:* Sides slightly convergent, evenly rounded at apex (Fig. 5-25).

Female. Nearly identical to male.

Distribution. Jamaica and Trinidad.

Type material examined. The holotype, deposited in the BMNH, is a male specimen glued to a card with the following labels: Jamaica: Hope River. 26.v.1908. Dr. M. Cameron. B.M. 1936-555 (printed) [white rectangular label with a yellow line running horizontally the length of the label] / British Mus. (printed) [white rectangular label] / HOLOTYPE *Cybocephalus geoffreysmithi* T. R. Smith Det: Trevor Smith (printed) [red rectangular label]. The designated allotype, deposited in the BMNH , is a female specimen glued to a card with the following labels: Jamaica: Constant Spring. 29.vii.1908. Dr. M. Cameron. B.M. 1936-555 (printed) [white rectangular label with a yellow line running horizontally the length of the label] / British Mus. (printed) [white rectangular label] / ALLOTYPE *Cybocephalus geoffreysmithi* T. R. Smith Det: Trevor Smith (printed) [blue rectangular label]. Paratypes: **Jamaica:** Rocky Spring, 8-III-1908, coll. M. Cameron (1♂, BMNH); Constant Spring, IV-1908, coll. M. Cameron (2♂, BMNH); Hope River, 26-V-1908, coll. M. Cameron (2♀, BMNH); Kingston, 16-II-1908, coll. M. Cameron (2♂, BMNH); Kingston, Palisadoes, 25-VIII-1966, coll. Howden & Becker (1♀, CNCI); **Trinidad:** St. Augustine, VI-1955, coll. F. D. Bennett, on *Stachytarpheta* sp. (2♂, 2♀, BMNH)

Remarks. *Cybocephalus geoffreysmithi* has been collected on *Stachytarpheta*, therefore it stands to reason that its host is a scale found on this plant. Species of *Stachytarpheta* occur in both Jamaica and Trinidad.

***Pycnocephalus* Sharp 1891**

Pycnocephalus Sharp 1891: 373.

Description. *Form:* Ovate and very convex; body contractile. *Head:* Very broad and short; deflexed (Fig. 5-2). Epistoma slightly prolonged at middle. Mandibles in repose resting against the metasternum, acute at tip with a small tooth posteriorly.

Maxillae with one lobe. Antennae shorter or as long as width of head, antennal club flat with three antennomeres, antennal grooves small and convergent. Scape greatly enlarged and of a particular shape (Fig. 5-26). *Thorax:* Pronotum margined at base, covering the base of elytra, sides very short. Prosternum acutely carinate in front, not prolonged behind the procoxae, procoxal cavities open behind. Mesosternum broad, oblique. Metasternum not or only slightly protuberant and with very short and sparse hairs. Both the meso- and metasternum are deeply impressed for reception of middle and hind legs. *Scutellum:* Small and broad, triangular. *Elytra:* Covering or nearly covering tip of abdomen, apices curved. *Abdomen:* Five visible ventral plates (omitting the small male anal plate), and 5 abdominal spiracles. *Legs:* Femora and tibiae of the posterior two pairs of legs dilated and laminiform. Tibiae simple. Tarsi four-segmented, each tarsomere slightly dilated ventrally, second and third segments bilobed, claws simple. *Median lobe:* Heavily sclerotized and dorsoventrally compressed. *Tegmen:* Fused.

Pycnocephalus deyrollei **(Reitter), New Combination**

(Figs. 5-2, 5-26-5-30)

Cybocephalus deyrollei Reitter 1875: 55-56.

Diagnosis. The male is black with a blue-green metallic sheen on the head, anterior portion of the pronotum, and scape. The female is black and without the metallic sheen. Size is ca 2.5 mm. The extremely large and dilated middle and hind tibiae as well as the extremely short, broad head (Fig. 5-2) distinguish this species from all other cybocephalids in the West Indies.

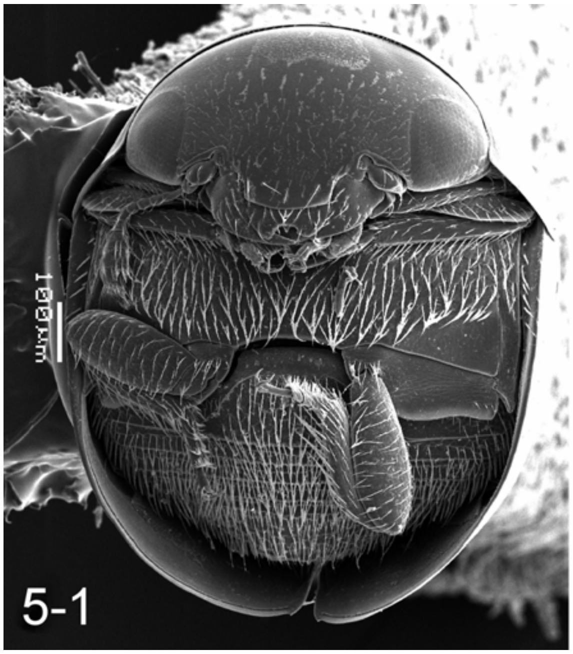
Description. Male. *Form:* Elongate, ovate; contractile; strongly convex dorsally. Length: 2.4-2.5 mm (measured from apex of clypeus to apex of elytra); breadth: 1.75-1.85 mm (measured across elytral humeri). *Color:* Head and apical portion of pronotum dark but with a blue or green metallic sheen, posterior portion of pronotum, elytra, and underside black, front legs light brown or amber, middle and hind legs brown or dark brown, scape dark with a blue-green metallic sheen, remaining 10 antennomeres brown or amber. *Head:* Broad, convex and very short, clypeus extremely short and broad, with a slightly concave apical margin. Eyes very large, fairly round and oblong with internal margins distinct. Genae not visible from above. Dorsal surface alutaceous and finely punctate. Antenna with 11 antennomeres including a 3-segmented club about 1/3-1/2 the height of the eye. Club flat, distinctly separated from funicle, and with a distinctly serrated margin. First and second club antennomeres wider than long, terminal club antennomere longer than wide, apically rounded and setose (Fig. 5-26). Third antennomere subequal to antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior angles. Surface finely punctuate. *Scutellum:* Triangular with margins slightly convex and sinuous; alutaceous and very sparsely punctured. *Elytra:* Uniform width narrowing at the apical 1/5. Strongly convex, sides almost parallel and apices rounded, length shorter than combined width (50:72). Distinctly alutaceous and punctate, punctation extending to lateral edges and almost to apices. Median and lateral margins of elytra bordered. *Underside:* Metasternum alutaceous and roughly punctured, with short coarse hairs uniformly distributed. Abdominal sternites alutaceous and punctate with long, coarse hairs thinly covering the surface. *Legs:* Protibiae expanded towards the distal end and setose, profemora narrowing slightly at the distal end. Meso- and metatibiae with long, stiff hairs along the outer margin. Meso- and metafemora and tibiae very alutaceous, laminiform and greatly dilated (Fig. 5-27). Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres combined. *Median lobe:* Sides rounded and curving to a rounded tip (Fig. 5-28). A patch of long hairs on either side of lobe about halfway between base and apex (Fig. 5-28). In profile, sinuous and slightly curved at tip (Fig. 5-29). Median plate not elevated. *Basal Plate:* Sides angling in before forming a flat top (Fig. 5-30).

Female: Similar to male but head, pronotum, and first antennal segment black and without blue-green metallic sheen.

Distribution. Trinidad and Tobago, Venezuela, and Brazil

Material examined. West Indies: Trinidad and Tobago: Trinidad, St. George Co., Anma Asa Wright Nature Centre, 7-VII-1994, coll. C. Chaboo, beating vegetation (1 ♂, SEMC); Port-of-Spain, St. Clair, Savanna, 24-X-1918, coll. Harold Morrison (1 ♂, USNM); Arouca V, 1953, coll. NLH Krauss (1 ♀, USNM); 26-II-1956, coll. V. F. Hayes, on coffee berries (1 ♂, USNM); Talparo, 24-V-7-VI-1990, coll. H. L. Dozier (4 ♂, FSCA; 1 ♂, 1 ♀, TRSC); Talparo, July 25-VII-1991, coll. H. L. Dozier (1 ♀, FSCA); Arima Valley, Simla, W. Beebe tropical research station, 12-VII-1989, coll. H. L. Dozier (1 ♂, 4 ♀, FSCA); St. Augustine, Mt. St. Benedict Abby, 7-VII-1996, coll. B. K. Dozier (2 ♂, 1 ♀, FSCA); Arima Valley, road at mountain crest, 2-VII-1990, coll. H. L. Dozier (1 ♂, FSCA); N. range, Arima-Blanchisseuse Rd., mile 10, 11-V-1985, coll. C. W. & L. B. O'Brien (1 ♀, FSCA); St. Augustine, IX-1962, coll. F. D. Bennett, on croton (1 ♂,BMNH); 1905, coll. C. E. Bryant (5 ♂, 1 ♀, BMNH); St. George Co., Anma, Asa Wright Nature Centre, 7-VII-1994, coll. C. Chaboo, ex. beating vegetation (1 ♂, SEMC); Morne Bleu, 2700', 25-VIII-1969, colls. H. & A. Howden (1 ♂, FMNH); Balandra Bay, 23-III-1922 (1 ♂, FMNH).**Remarks.** When Reitter described *Cybocephalus deyrollei* in

1875 there was only one described genus in the family Cybocephalidae. It was not until 1891 that Sharp described a second genus, *Pycnocephalus*. Sharp recognized that the size and shape of the head as well as the dilated middle and hind tibiae justified the creation of a new genus. *Cybocephalus deyrollei* clearly exhibits the features described by Sharp; therefore we place it in *Pycnocephalus*. The type specimens of *Pycnocephalus metallicus* Sharp, the genotype, were also examined and compared to *C. deyrollei.* The identification of *C. deyrollei* specimens was based on the published description since type specimens were not available for examination.



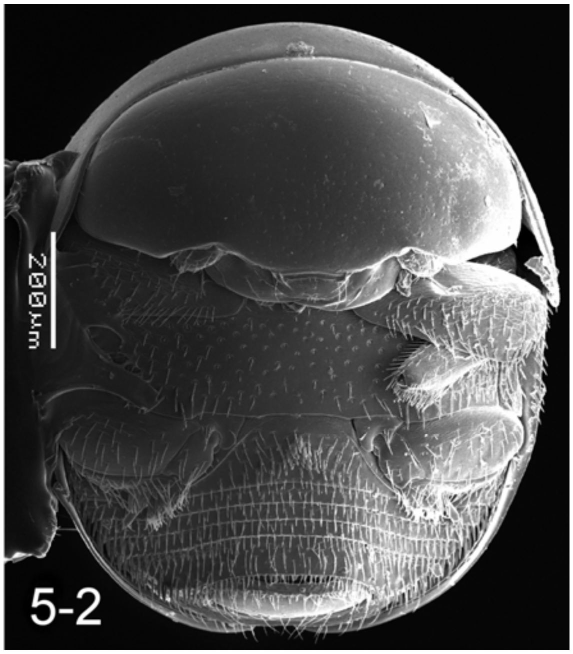
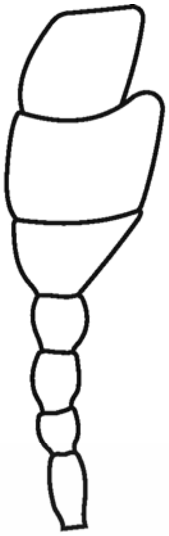


Figure 5-1. Ventral habitus of *C. nipponicus*.

Figure 5-2. Ventral habitus of *P. deyrollei*.



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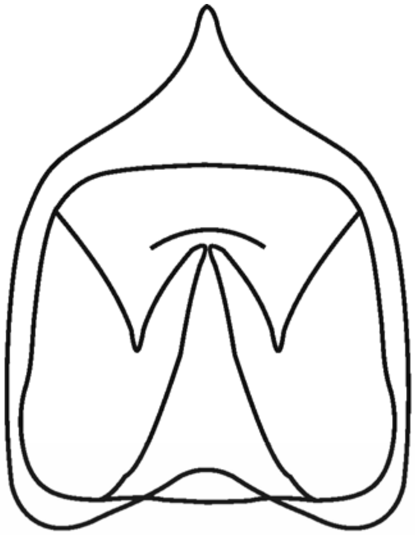

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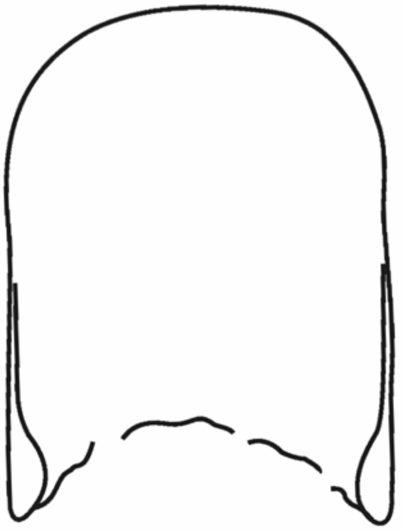

5-6

Figure 5-3. Antenna of *C. antilleus*.

Figure 5-4. Median lobe, dorsal view, of *C. antilleus*.

Figure 5-5. Median lobe, lateral view, of *C. antilleus*.

Figure 5-6. Basal plate, ventral view, of *C. antilleus*.

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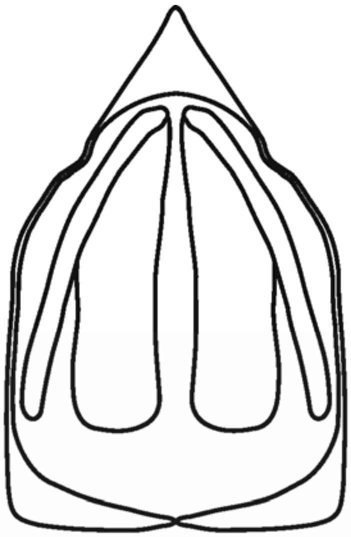

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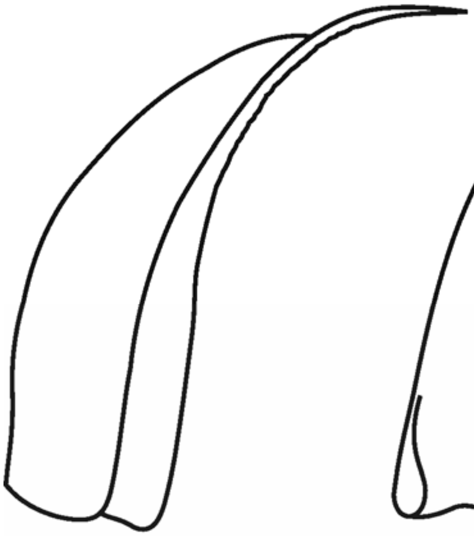

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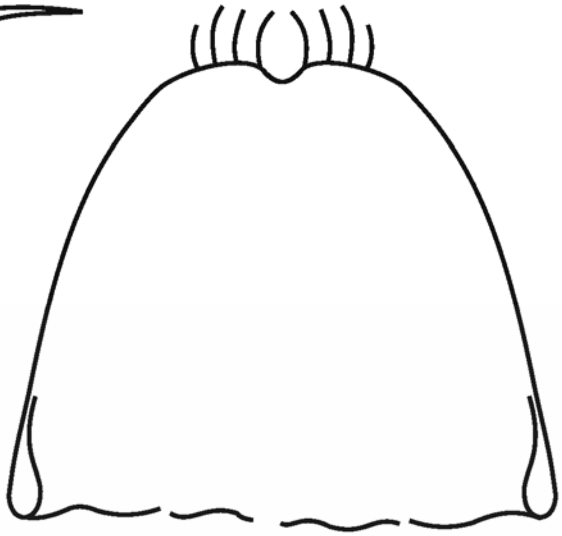

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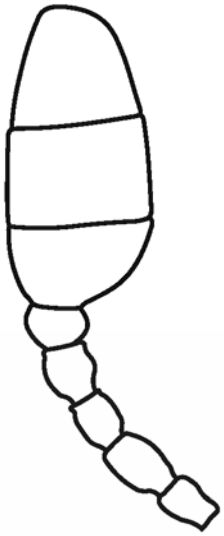
Figure 5-7. Antenna of *C. caribaeus*.

Figure 5-8. Median lobe, dorsal view, of *C. caribaeus*.

Figure 5-9. Median lobe, lateral view, of *C. caribaeus*.

Figure 5-10. Basal plate, ventral view, of *C. caribaeus*.



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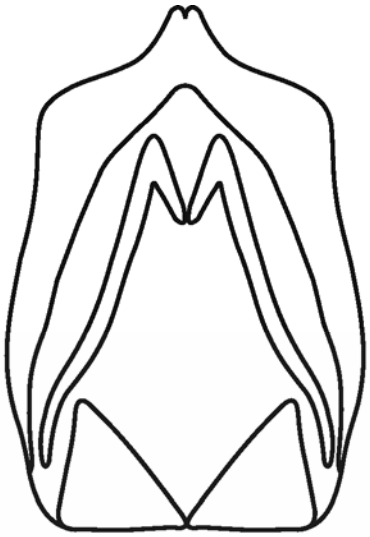

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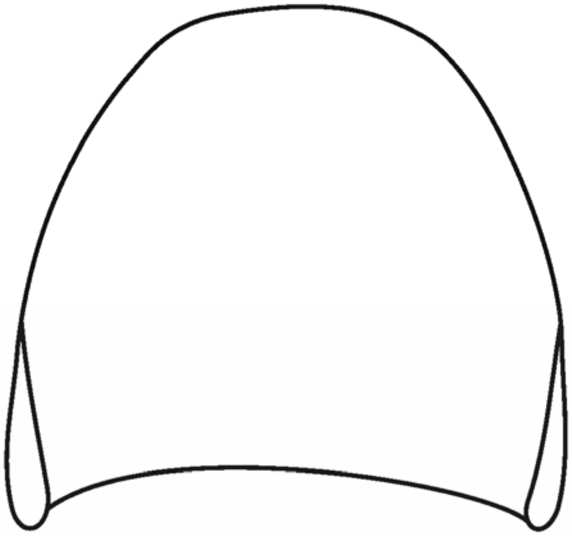


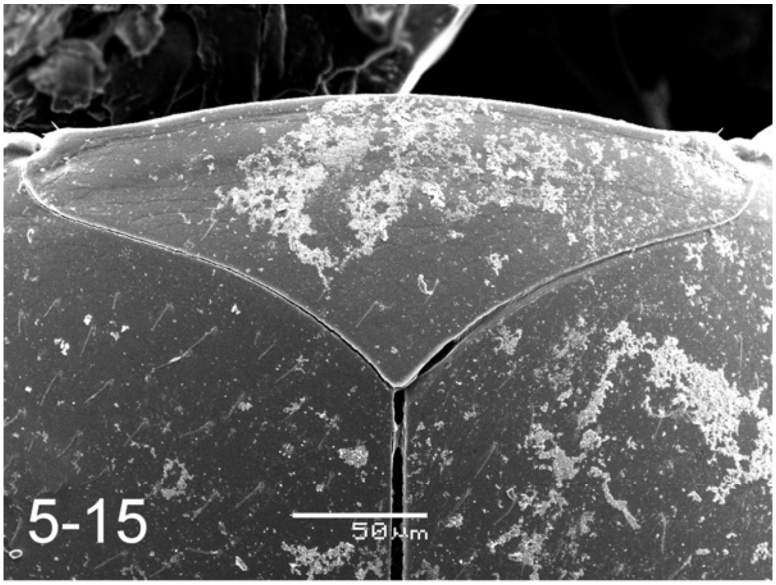
5-14

Figure 5-11. Antenna of *C. iviei*.

Figure 5-12. Median lobe, dorsal view, of *C. iviei*.

Figure 5-13. Median lobe, lateral view, of *C. iviei*.

Figure 5-14. Basal plate, ventral view, of *C. iviei*.



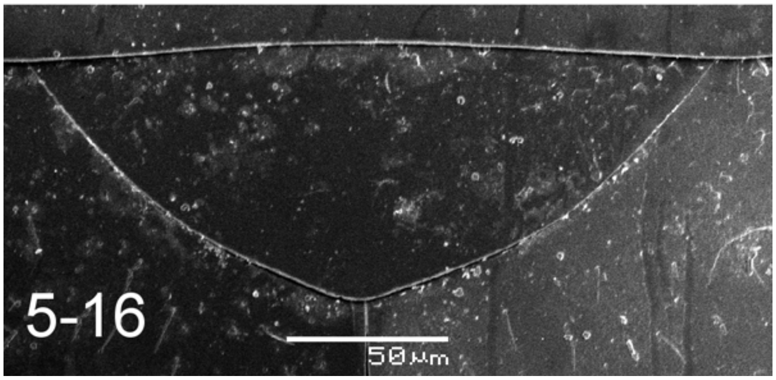


Figure 5-15. Scutellum of *C. iviei*.

Figure 5-16. Scutellum of *C. nipponicus*.

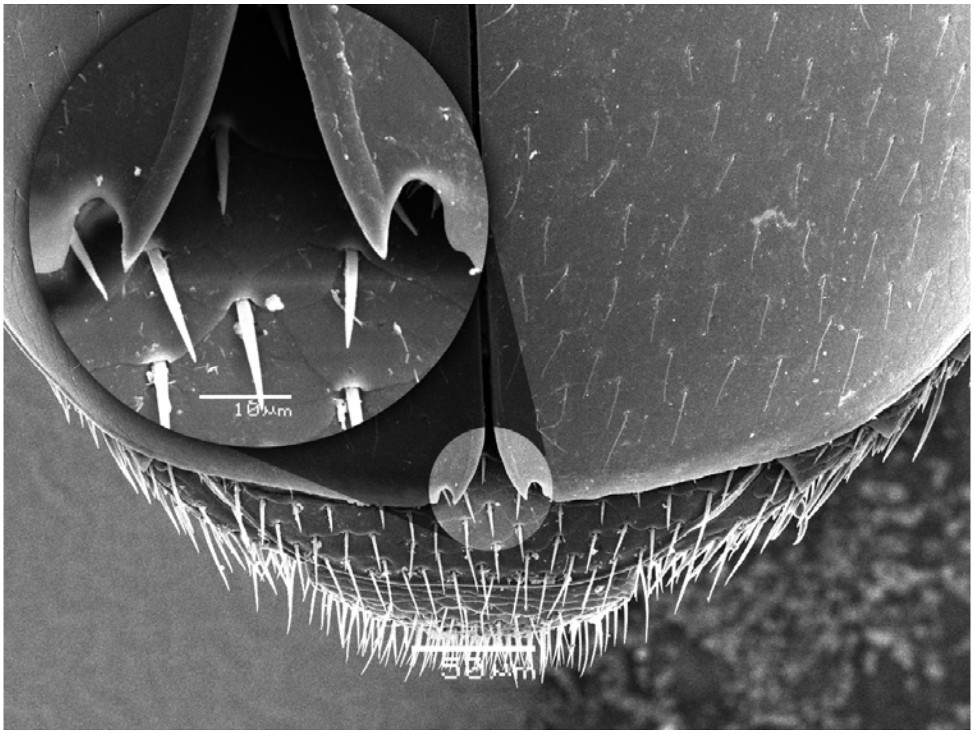


Figure 5-17. Invaginations at the elytral apices of *C. iviei*.

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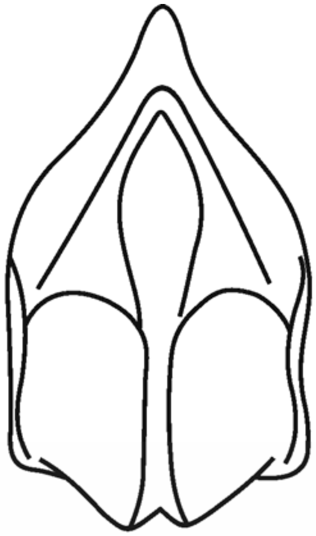

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Figure 5-18. Antenna of *C. nipponicus*.

Figure 5-19. Median lobe, dorsal view, of *C. nipponicus*.

Figure 5-20. Median lobe, lateral view, of *C. nipponicus*.

Figure 5-21. Basal plate, ventral view, of *C. nipponicus*.

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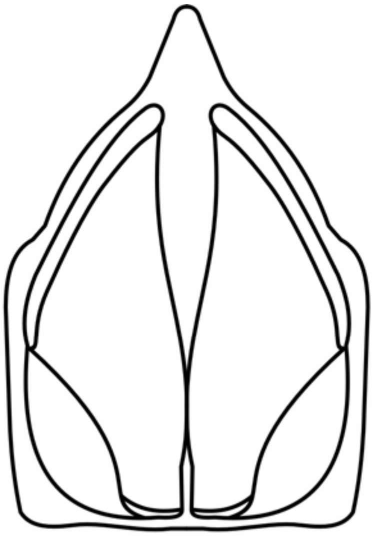

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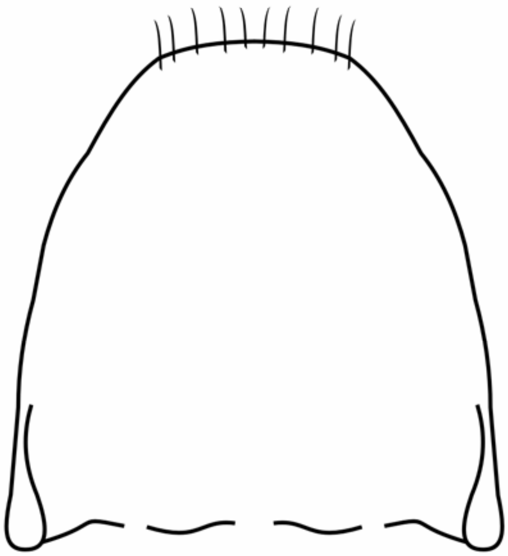

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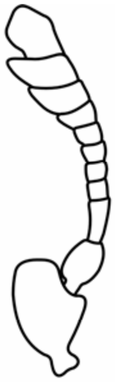
Figure 5-22. Antenna of *C. geoffreysmithi*.

Figure 5-23. Median lobe, dorsal view, of *C. geoffreysmithi*.

Figure 5-24. Median lobe, lateral view, of *C. geoffreysmithi*.

Figure 5-25. Basal plate, ventral view, of *C. geoffreysmithi*.



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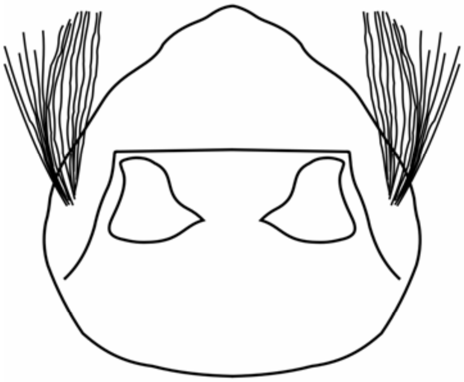

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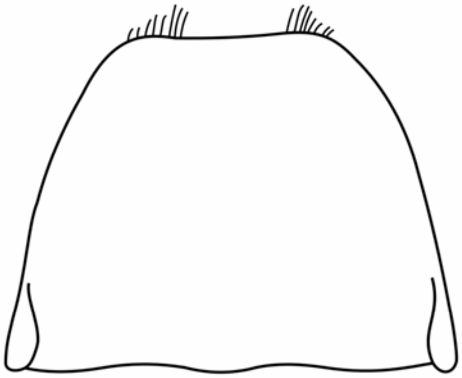

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Figure 5-26. Antenna of *P. deyrollei*.

Figure 5-27. Hind leg of *P. deyrollei*.

Figure 5-28. Median lobe, dorsal view, of *P. deyrollei*.

Figure 5-29. Median lobe, lateral view, of *P. deyrollei*.

Figure 5-30. Basal plate, ventral view, of *P. deyrollei*.

CHAPTER 6
THE CYBOCEPHALIDAE (COLEOPTERA) OF MEXICO

Introduction

Cybocephalid beetles are mainly predators of scale insects (Vinson 1959, Endrödy-Younga 1968, Alvarez and Van Dreische 1998a,b, Smith and Cave 2006b) but have also been known to feed on whiteflies (Chandra and Avasthy 1978, Kirejtshuk *et al.* 1997, Tian and Ramani 2003), and other arthropod pests (Tanaka and Inoue 1980, Endrödy-Younga 1982). Twenty-two species of Cybocephalidae have been described from the New World, all belonging to the genera *Cybocephalus* Erichson and *Pycnocephalus* Sharp. This is a very poorly studied family of beetles in the Western Hemisphere and only recently has there been any type of taxonomic study of this group. Smith and Cave (2006a) recently revised the five species known to occur in America north of Mexico, and also the Neotropical species occurring in the West Indies and Trinidad (Smith and Cave 2007). However the Mexican species have never been revised.

The objectives of this study are to 1) develop techniques for the identification of the cybocephalids of Mexico, 2) describe new Mexican species, and 3) report the known distribution of each species known to occur in Mexico.

Material and Methods

Materials

For this study, 103 specimens belonging to the genus *Cybocephalus* and 8 specimens belonging to the genus *Pycnocephalus* were examined. One female *Cybocephalus* specimen from Tampico is at hand, but without associated males its identification cannot be ascertained. Specimens were borrowed from the following institutions and private collections (name of the curator or owner in parentheses):

AAIC	Albert Allen Insect Collection, Boise, ID, (Albert Allen)
BMNH	Natural History Museum, London [formerly British Museum (Natural History)], UK (Maxwell Barclay)
CSCA	California State Collection of Arthropods, Sacramento, CA, (Chuck Bellamy)
CNCI	Canadian National Collection of Insects, Ottawa, Ontario, CANADA (Serge Laplante and Pat Bouchard)
EMEC	Essig Museum of Entomology, University of California, Berkeley, CA, (Cheryl Barr)
FSCA	Florida State Collection of Arthropods, Gainesville, FL (Paul Skelley and Michael Thomas)
OSMN	Orma J. Smith Museum of Natural History, Albertson College of Idaho, Caldwell, ID (William Clark)
UCRC	University of California Riverside, Entomology Research Museum, Riverside, CA (Doug Yanega)
USNM	United States National Museum, Smithsonian Institute, Washington D.C. (Gary Hevel)

Methods

Genitalia were removed and disarticulation was carried out using the methods described in Smith and Cave (2006a).

Definitions

Median lobe: Also referred to as penis (Endrödy-Younga 1968, 1971a, 1971b; Kirejtshuk et al. 1997; Lupi 2003; Yu 1995a, 1995b).

Basal plate: This is a reference to the basal plate of the tegmen (Endrödy-Younga 1968, 1971a, 1971b; Lupi 2003; Yu 1995a, 1995b, Smith and Cave 2006a, 2007).

Key to the Cybocephalidae of Mexico

1. Head extremely short and broad with very short antennae and slightly concave clypeus; femora and tibiae of the posterior two pairs of legs extremely dilated and laminiform; male with green metallic sheen on head and apical half of pronotum; size >1.5 mm…………………………….............*Pycnocephalus metallicus* Sharp

1’ Head not short, clypeus of normal size and not concave at the apex; only hind femora dilated, middle femora and tibiae of the posterior two pairs of legs not or only slightly dilated; male without metallic sheen; size <1.5 mm..........................2

2(1’) Terminal antennomere of the antennal club rounded (Fig.6-25) 3

2’ Terminal antennomere of the antennal club truncate (Fig. 6-16) or slightly emarginate (Fig. 6-6, 6-7) 4

3(2’) Head and pronotum with a greasy appearance; antennal club small, at most only about half the size of the eye............................*Cybocephalus aciculatus* Champion

3’ Head and pronotum without greasy appearance; antennal club large, about the same size as eye; basal plate and median lobe as in Figs. 6-26-6-28 .... *Cybocephalus randalli* T. R. Smith

4(2’) Terminal antennomere of the antennal club longer than wide (Fig. 6-16); basal plate and median lobe as in Figs. 6-17-6-19 ....*Cybocephalus* new species 3

4’ Terminal antennomere of the antennal club wider than long 5

5(4’) Male basal plate emarginate at the apex 6

5’ Male basal plate not emarginate at the apex 7

6(5’) Terminal antennomere very short and wide (Fig. 6-2); basal plate with very shallow emargination at the apex (Fig. 6-5); when viewed laterally the median plate on the median lobe only slightly elevated (Fig. 6-4); median lobe as in Fig. 3 ....*Cybocephalus* new species 1

6’ Terminal antennomere about as long as wide (Fig. 6-33); basal plate deeply emarginate at the apex (Fig. 6-36); when viewed laterally the median plate on the median lobe is extremely elevated (Fig. 6-35); median lobe as in Fig. 34 ....*Cybocephalus* new species 4

7(5’) Male basal plate protuberant at the apex (Figs. 6-15, 6-23) 8

7’ Male basal plate not protuberant at the apex 9

8(7’) Sides of male basal plate slightly convergent towards apex, with distinct protuberance at the apex (Fig. 6-23); median lobe as in Figs. 6-21 and 6-22 .... *Cybocephalus nigritulus* LeConte

8’ Sides of male basal plate parallel, with a gradual and weakly discernible protuberance at the apex (Fig. 6-15); median lobe as in Figs. 6-13 and 6-14 .... *Cybocephalus* new species 2

9(7’) Male basal plate evenly rounded at apex (Fig. 6-10); when viewed laterally the median plate on the median lobe is very elevated (Fig. 6-9); median lobe as in Fig. 6-8 .... *Cybocephalus californicus* Horn

9’ Male basal plate with a wide, flat apex (Fig. 6-32); when viewed laterally the median plate on the median lobe is not elevated (Fig. 6-31); median lobe as in Fig. 6-30 .... *Cybocephalus schwarzi* Champion

Cybocephalus Erichson 1844

Cybocephalus Erichson 1844: 441-442.

For a description of the genus, see Smith and Cave (2006a).

Cybocephalus aciculatus Champion

(Figs. 6-1, 6-11)

Cybocephalus aciculatus Champion 1913: 71.

Diagnosis. Male and female are black but with a matte-like appearance. The terminal club antennomere is rounded (Fig. 6-1), separating this species from all other Mexican *Cybocephalus* except *C. randalli*. This species differs from *C. randalli* by the greasy sheen on the head and pronotum, larger eyes with many more ommatidia than *C. randalli*, and the antennal club smaller than the eye.

Redescription. Female. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.2-1.3 mm (measured from apex of clypeus to apex of elytra); breadth: 0.85-0.90 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside black, lateral margin of pronotum and posterior margin of elytra yellowish and translucent; legs and antennae brown or black. *Head:* Broad and convex with a slightly greasy appearance, clypeus produced, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae just visible from above and slightly explanate when viewed laterally. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length small, about ¼-½ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and wider than long. Terminal club antennomere rounded (Fig. 6-1), setose and about as long as wide. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation and a greasy appearance. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^1/_5$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (32:38). Uniformly punctate along dorsal surface, smooth at sides and base with a small impunctate area at apices of elytra. Appearing very alutaceous under 100 times magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long, coarse hairs. Abdominal sternites alutaceous and punctate with long, coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened, and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Mesoand metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it.

Male. Unknown.

Geographic distribution. Federal District: Mexico City (Fig. 6-11).

Type material examined. The lectotype, deposited in the BMNH, is a female specimen glued to a card with the following labels: LECTO-TYPE (printed) [white circular label with a purple outer margin] / Mexico city. (printed) Flohr (handwritten) [white rectangular label] / Tr. Ent. Soc. L. 1913 det. Champion (printed) [white rectangular label] / Cybocephalus aciculatus Ch (handwritten) [white rectangular label] / LECTOTYPE *Cybocephalus aciculatus* Champion Det: Trevor Smith (printed) [red rectangular label]. While this specimen is a syntype, prior to this publication it was not a valid lectotype, despite the round lectotype label placed on the specimen, because this designation was never published. The designated paralectotype is as follows: **Mexico: Federal District,** Mexico City, coll. J. Flohr (1♀, BMNH).

Other material examined. Mexico: Tamaulipas, Tampico, 6-?-1912, coll. E. A. Schwarz (1♀, BMNH).

Remarks. With only female type specimens it is very difficult to identify this species with any certainty.

***Cybocephalus* New Species 1**

(Figs. 6-2-6-5, 6-11)

Diagnosis. Male is dark brown. Terminal club antennomere slightly emarginate, separating this species from *C. aciculatus* and *C. randalli*, and very distinctive by being much wider than long (Fig. 6-2), easily differentiating this species from *Cybocephalus* new species 3. In males, the basal plate (Fig. 6-5) and median lobe (Figs. 6-3 and 6-4) are easily distinguished from all other species.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.6 mm (measured from apex of clypeus to apex of elytra); breadth: 0.85-1.20 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside dark brown, lateral margin of pronotum and posterior margin of elytra yellowish and translucent; legs and antennae brown. *Head:* Broad and convex, clypeus moderately produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere truncate (Fig. 6-2), setose and wider than long. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Very large, alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^1/_5$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (35:41). Uniformly punctate along dorsal surface, smooth at sides and base with a large impunctate area at apices of elytra. Appearing alutaceous under high magnification. Median margin and apices of elytra bordered. Apices with distinct striations. *Underside:*

Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened, and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long, stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel and curving into a point, apex shaped like a spearhead (Fig. 6-3). In profile, slightly curved from middle (Fig. 6-4). Median plate on surface slightly elevated. *Basal plate:* Sides slightly rounded, apex with a very shallow concavity (Fig. 6-5).

Female. External morphology identical to male.

Geographic distribution. Sinaloa: nr. El Palmito (Fig. 6-11).

Type material examined. The holotype, deposited in the CNCI, is a partially disarticulated male specimen glued to a card with the following labels: 15 mi. W. El Palmito, Sin. MEX. VII-29-64 H. F. Howden (printed) [white rectangular label]. The allotype, deposited in the CNCI, is a female specimen glued to a point with the following labels: 15 mi. W. El Palmito, Sin. MEX. VII-28-64 H. F. Howden (printed) [white rectangular label]. One female paratype is labelled as follows: Mexico: Sinaloa**,** 8 mi. W E. Palmito, 7-VIII-1964, coll. H. F. Howden (CNCI).

Cybocephalus californicus Horn

(Figs. 6-6-6-11)

Cybocephalus californicus Horn 1879: 320-321.

For a redescription of the species, see Smith and Cave (2006a).

Diagnosis. Male and female are black, brown, or aeneous. Antennal club is smaller than the eye and truncate or slightly emarginate at the apex (Figs. 6-6 and 6-7), separating this species from *C. aciculatus* and *C. randalli*. The terminal club antennomere is wider than long, unlike *Cybocephalus* new species 3, but not as short as *Cybocephalus* new species 1. In males, the basal plate (Fig. 6-10) and median lobe (Figs. 6-8 and 6-9) are easily distinguished from all other species.

Geographic distribution. Baja California and northern Mexico (Fig. 6-11).

Material examined. Mexico: Baja California Sur, Las Barracas, 2-V-1986, coll. P. DeBach, Ex. cactus scale on *Opuntia cholla* (3♂, 5♀**,** UCRC); 50.3 km. SE Guerrero Negro, 15-I-1974, E. L. Sleeper (2♂, CSCA); **Baja California Norte,** 6 mi. N Guerrero Negro, 16-III-1981, F. Andrews & D. Faulkner, collected in flowers of *Sphaeralcea axillaris* (1♂, 1♀**,** CSCA); 12.7 km. E El Rosario, 30º04'15"N 115º37'10"W, 180 m., 18-VII-1991-28-V-1992, coll. W. H. Clark, E. M. Clark, P. E. Blom & D. M. Ward, ethylene glycol trap (1♀, OSMN); 12.7 km. E El Rosario, km. 68, 30º04'15"N 115º37'10"W, 180 m., 7-II-1984-2-IV-1985, coll. W. H. Clark & P. E. Blom, ethylene glycol trap (1♀, OSMN); **Sonora,** Hermosillo, 28-VIII-1954, coll. R. Debach, Ex. *Aonidiella aurantii* (Maskell) (6♂, 4♀**,** UCRC); Punta Chueca, 18-IV-1978, Ex. Jojoba (9♂, 11♀**,** CSCA); Nogales, 3-VIII-1966, coll. Schwenke (1♂, USNM); **Tamaulipas,** 18 mi. SE Estacion Manuel, 1-XI-1982, coll. J. Huber (1♀, CSCA).

Remarks. Label data indicate that this species feeds on the armored scale *Aonidiella aurantii* (Maskell) and a scale insect infesting *Opuntia* (*Cylindropuntia*) sp. For a detailed host list north of Mexico see Smith and Cave (2006a).

Cybocephalus New Species 2

(Figs. 6-12-6-15, 6-24)

Diagnosis. Male and female are black. The antennal club is smaller than the eye and the terminal club antennomere is truncate and wider than long (Fig. 6-12), separating this species from *C. aciculatus*, *C. randalli*, and *Cybocephalus* new species 3. The terminal club antennomere is not as short as in *Cybocephalus* new species 1. In males, the basal plate (Fig. 6-15) and median lobe (Figs. 6-13 and 6-14) are easily distinguished from all other species.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.4 mm (measured from apex of clypeus to apex of elytra); breadth: 1.0 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside black, posterior margin of elytra yellowish and translucent; legs and antennae brown or black. *Head:* Broad and convex, clypeus moderately produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere truncate (Fig. 6-12), setose and a little wider than long. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^1/_5$.

Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (34:40). Uniformly punctate along dorsal surface, smooth at sides and base with an impunctate area at apices of elytra. Appearing alutaceous under 100x magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel or slightly divergent, curving into a triangular point (Fig. 6-13). In profile, strongly curved from middle (Fig. 6-14). Median plate on surface elevated. *Basal plate:* Sides parallel at base, rounded at apex with a very slight protuberance in the center (Fig. 6-15).

Female. Unknown.

Geographic distribution. Jalisco: Puerto Vallarta (Fig. 6-24).

Type material examined. The holotype, deposited in the USNM, is a disarticulated male specimen glued to a card with the following labels: MEXICO Jalisco Puerto Vallarta 25 Jan 1984 G. E. Bohart (printed) [white rectangular label].

***Cybocephalus* New Species 3**

(Figs. 6-16-6-19, 6-24)

Diagnosis. Male and female are black. The antennal club is smaller than the eye and the club antennomere is truncate and much longer than wide (Fig. 6-16), separating this species from all others in Mexico. In males, the basal plate (Fig. 6-19) and median lobe (Figs. 6-17 and 6-18) are easily distinguished from all other species.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.1 mm (measured from apex of clypeus to apex of elytra); breadth: 0.9 mm (measured across elytral humeri). *Color:* Head, thorax, elytra, and underside dark brown, posterior margin of elytra translucent; legs and antennae brown or black. *Head:* Broad and convex, clypeus moderately produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere about as long as wide. Terminal club antennomere truncate (Fig. 6-16), setose and longer than wide. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^{1}/_{5}$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (32:37). Uniformly punctate along dorsal surface, smooth at sides and base with a large impunctate area at apices of elytra. Appearing alutaceous under 100 times magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long, coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long, stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel curving abruptly into a rounded protuberance, with a patch of long hairs on either side of the lobe at the apical curvature (Fig. 6-17). In profile, strongly curved from middle (Fig. 6-18). Median plate on surface elevated. *Basal plate:* Sides divergent, apex with very large triangular emargination (Fig. 6-19).

Female. External morphology identical to male.

Geographic distribution. Tamaulipas: Tampico (Fig. 6-24).

Type Material Examined. The holotype, deposited in the USNM, is a disarticulated male specimen glued to a card with the following labels: Tampico Mex (printed) 6-12 (handwritten) [white rectangular label] / EA Schwarz Collector (printed) [white rectangular label]. The allotype, deposited in the USNM, is a female specimen glued to a point with the following labels: Tampico Mex (printed) 24-12 (handwritten) [white rectangular label] / EA Schwarz Collector (printed) [white rectangular label].

***Cybocephalus nigritulus* LeConte**

(Figs. 6-20-6-24)

Cybocephalus nigritulus LeConte 1863: 64.

For a description of the species, see Smith and Cave (2006a).

Diagnosis. Male and female are black and very glossy. The antennal club is smaller than the eye and truncate at the terminal antennomere (Fig. 6-20), distinguishing this species from *C. aciculatus* and *C. randalli*. The terminal club antennomere is wider than long, unlike *Cybocephalus* new species 3. In males, the basal plate (Fig. 6-23) and median lobe (Figs. 6-21 and 6-22) are easily distinguished from all other species.

Geographic distribution. Durango, Durango; San Luis Potosí, Ciudad del Maíz (Fig. 6-24).

Material examined. Mexico: San Luis Potosí: Ciudad del Maíz, 24-V-1996, coll. H. L. Dozier (1♂, 1♀, FSCA); **Durango:** Durango, 26-XI-1909, coll. F. C. Bishop (1♂, USNM).

Remarks. This species is typically found east of the Mississippi River in the United States, however specimens have been collected west of the Mississippi along the gulf coast (Smith and Cave 2006a). Therefore, it is not surprising that this species is found in Mexico. For a detailed host list north of Mexico see Smith and Cave (2006a).

Cybocephalus randalli **T. R. Smith**

(Figs. 6-25-6-28, 6-41)

Cybocephalus randalli T. R. Smith 2006.

For a description of the species see Smith and Cave (2006a).

Diagnosis. Male and female are black. The antennal club is as large as or larger than the eye (Fig. 6-25), separating this species from all other Mexican *Cybocephalus*. In males, the basal plate (Fig. 6-28) and median lobe (Figs. 6-26 and 6-27) are easily distinguished from all other species.

Geographic distribution. Baja California (Fig. 6-41).

Material examined. Mexico: Baja California Sur, 30 mi. S El Arco, 6-III-1977, coll. H. Marz ((1♂, FSCA); **Baja California Norte,** El Arco, 10-VIII-1980, coll. Bill Clark (1♀**,** AAIC); Valle Montevideo La Laguna wash, 18 km. W Bahia Los Angeles, 28º55'N 113º44"Wº, 380 m, January 3-I-12-VIII-1982, ethylene glycol pitfall trap (1♀**,**

AAIC); Sierra Juarez, 4 mi. S El Topo, 10-III-1962, coll. E. L. Sleeper (1♂, CSCA); km. 147, 2 mi. SE Rancho Sonora, 29º54'N 114º55'W, 600 m., 16-VII-1991-27-V-1992, coll. W. H. Clark, E. M. Clark, P. E. Blom & D. M. Ward Jr., ethylene glycol pitfall trap (3♂, 6♀, OSMN); Mesa Palmarito,29º 54'N 114º44'W, 800 m., 27-VIII-1989-27-IV-1990, coll. W. H. Clark, M. H. Clark & P. E. Blom, ethylene glycol pitfall trap (1♂, 4♀, OSMN); Mesa Palmarito, 29º 47'N 114º44'W, 800 m., 27-X-1990, ethylene glycol pitfall trap (1♀, OSMN); 2 km. E. El Berrendo West, 30-III-2005, ungrazed out of the oasis, ethylene glycol pitfall trap (1♀, OSMN); 9 km. NW Rancho Santa Ynes, 29º 46'N 114º46'W, 550 m., 4-I-1982-25-VIII-1982, coll. W. H. Clark & P. E. Blom, ethylene glycol pitfall trap (1♂, 1♀, OSMN); 9 km. NW Rancho Santa Ynes, , 29º 46'N 114º46'W, 550 m., 22-VIII-1982, coll. W. H. Clark & P. E. Blom, uv-light trap (1♀, OSMN); Valle Montevideo, 18 km. W Bahia de Los Angeles, 28º 55'N 113º44'W, 380 m., 14-VII-1991-13-V-1992, coll. W. H. Clark & P. E. Blom, ethylene glycol pitfall trap (1♂, 1♀ OSMN); Valle Montevideo, La Laguna wash, 28º 55'N 113º44'W, 380 m., 19-III-1991-14-VII-1991, coll. W. H. Clark, M. H. Clark, C. J. Clark, K. D. Clark & J. E. Luther, ethylene glycol trap (2♂, 3♀, OSMN); San Agustin, 29º 56'N 114º58'W, 9-IV-1985-9-III-1986, coll. W. H. Clark & P. E. Blom, ethylene glycol pitfall trap (4♀, OSMN); 4 mi. E San Agustin, 29º 59'N 114º56'W, 17-I-2001-14-XII-2001, coll. W. H. Clark & D. M. Ward, ethylene glycol pitfall trap (2♀, OSMN); 4.3 km. NE Pozo Aleman, 28º 14'N 113º15'W, 300 m., 15-VI-1990-19-V-1992, W. H. Clark & P. E. Blom, ethylene glycol pitfall trap (1♂, OSMN); 12 km. NE El Arco, 28º 18'N 113º15'W, 300 m., 24-IV-1990-15-VI-1990, W. H. Clark, M. H. Clark & D. Ward Jr., ethylene glycol pitfall trap (1♂, OSMN); 1 km. NE Santa Catarina (ranch), 29º 44'N 115º09'W, 20-III-1991-3-VII-1991, ethylene glycol pitfall trap (1♀, OSMN).

Remarks. Unlike all other species of *Cybocephalus*, this species is frequently collected in pitfall traps. *Cybocephalus randalli* is typically collected in desert habitats and their reduced eyes may indicate that this species spends part of its time under the sand. This behavior has been seen in *Cybocephalus kathrynae* T. R. Smith which is collected by sifting loose sand near grass clumps in Florida.

***Cybocephalus schwarzi* Champion**

(Figs. 6-29-6-32, 6-41)

Cybocephalus schwarzi Champion 1913: 72.

Diagnosis. Male and female are dark brown. The antennal club is smaller than the eye and its apex is truncate (Fig. 6-29), unlike *C. aciculatus* and *C. randalli*. The terminal antennomere is wider than long, unlike *Cybocephalus* new species 3, but not as short as *Cybocephalus* new species 1. In males, the basal plate (Fig. 6-32) and median lobe (Figs. 6-30 and 6-31) are easily distinguished from all other species.

Redescription. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.3 mm (measured from apex of clypeus to apex of elytra); breadth: 0.9 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside dark brown, lateral margin of pronotum and posterior margin of elytra yellowish and translucent; legs and antennae brown or black. *Head:* Broad and convex, clypeus moderately produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere truncate (Fig. 6-29), setose and slightly wider than long or about as long as wide. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^1/_5$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (32:40). Uniformly punctate along dorsal surface, smooth at sides and base with a large impunctate area at apices of elytra. Appearing alutaceous under 100 times magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long, coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel or slightly convergent, curving abruptly into a sharp point (Fig. 6-30). In profile, curved from the lower middle region (Fig. 6-31). Median plate on surface elevated. *Basal plate:* Sides parallel at base, rounding to a flat apex (Fig. 6-32).

Female. External morphology identical to male.

Geographic distribution. Tamaulipas: Tampico (Fig. 6-41).

Type material examined. The lectotype, deposited in the BMNH, is a male specimen glued to a card with the following labels: LECTO-TYPE (printed) [white circular label with a purple outer margin] / Tampico (printed) 18-12 (handwritten) [white rectangular label] / E. A. Schwarz Collector (printed) [white rectangular label] / U.S. Nat. Mus.1913-253 (printed) [upside down white rectangular label] / Cybocephalus schwarzi Ch. (handwritten) [white rectangular label] / LECTOTYPE *Cybocephalus schwarzi* Champion Det: Trevor Smith (printed) [red rectangular label]. While this specimen is a syntype, prior to this publication it was not a valid lectotype, despite the round lectotype label placed on the specimen, because this designation was never published. A paralectotype is labelled as follows: **Mexico: Tamaulipas,** Tampico, 14-?-1912, coll. E. A. Schwarz (1♀, BMNH).

Cybocephalus New Species 4

(Figs. 6-33-6-36, 6-41)

Diagnosis. Male and female are dark brown. The antennal club is smaller than the eye and the terminal antennomere is truncate (Fig. 6-33), unlike *C. aciculatus* and *C. randalli*, and wider than long, unlike *Cybocephalus* new species 3. In males, the basal plate (Fig. 6-36) and median lobe (Figs. 6-34 and 6-35) are easily distinguished from all other species.

Description. Male. *Form:* Elongate oval; contractile; strongly convex dorsally. Length: 1.1 mm (measured from apex of clypeus to apex of elytra); breadth: 0.9 mm (measured across elytral humeri). *Color:* Head, thorax, elytra and underside dark brown, lateral margin of pronotum and posterior margin of elytra translucent; legs and antennae brown or black. *Head:* Broad and convex, clypeus produced, narrow, and slightly reflexed. Eyes large, oblong, with internal margins distinct. Genae not visible from above. Dorsal surface smooth under 100 times magnification, distinctly alutaceous and finely punctate. Antennae 11-segmented including a club with 3 antennomeres, club length about ½-⅔ size of the eye. Club flat and distinctly separated from funicle and with a distinctly serrated margin. First club antennomere wider than long, second club antennomere larger than either first or third club antennomere and about as long as wide. Terminal club antennomere truncate (Fig. 6-33), setose and about as long as wide. Antennomere 3 as long or slightly longer than antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior. Surface distinctly alutaceous with fine punctation. *Scutellum:* Alutaceous and triangular with straight to slightly convex margins. *Elytra:* Uniform width narrowing at apical $^{1}/_{5}$. Strongly convex, sides slightly sinuous and apices rounded. Length slightly shorter than combined width (31:38). Uniformly punctate along dorsal surface, smooth at sides and base with a large impunctate area at apices of elytra. Appearing alutaceous under 100 times magnification. Median margin and apices of elytra bordered. *Underside:* Metasternum alutaceous, roughly punctured, and clothed in long coarse hairs. Abdominal sternites alutaceous and punctate with long coarse hairs thinly covering the surface. *Legs:* Femora glossy, broad, flattened and sparsely covered with short hairs. Pro- and mesofemora about the same width throughout length. All tibiae slightly but distinctly curved and dilated towards apex. Protibiae with short hairs along outer margin. Meso- and metatibiae with long, stiff hairs along outer margin. Four tarsomeres, claw tarsomere as long or almost as long as 2 tarsomeres preceding it. *Median lobe:* Sides parallel or slightly convergent curving into a sharp point (Fig. 6-34).

In profile, strongly curved from base (Fig. 6-35). Median plate on surface very elevated. *Basal plate:* Sides curving to an evenly rounded apex with a deep, narrow concavity in the center (Fig. 6-36).

Female. Unknown.

Geographic distribution. Puebla: nr. Tehuacan; **Sinaloa**: El Dorado (Fig. 6-41).

Type material examined. The holotype, deposited in the UCRC, is a male specimen glued to a point with the following labels: MEXICO, Sinaloa, El Dorado, 14-II-1929, coll. S. E. Flanders (printed) [white rectangular label]. One male paratype deposited in the UCRC has the same data as the holotype and one male paralectotype EMEC is labelled as follows **Mexico: Puebla,** 6 km. N Tehuacan, 22-VIII-1987, coll. J. Doyen.

***Pycnocephalus* Sharp 1891**

Pycnocephalus Sharp 1891: 373.

For a description of the genus, see Smith and Cave (2007).

***Pycnocephalus metallicus* Sharp**

(Figs. 6-37-6-41)

Pycnocephalus metallicus Sharp 1891: 373.

Diagnosis. The male is black with a green metallic sheen on the head, anterior portion of the pronotum, and scape. The female is black and without the metallic sheen. This species is larger (>1.5 mm.) than any of the *Cybocephalus* in this region. The extremely large and dilated middle and hind tibiae as well as the extremely short, broad head distinguish this species from all other cybocephalids in the Mexico.

Description. Male. *Form:* Elongate, ovate; contractile; strongly convex dorsally. Length: 1.8-2.2 mm (measured from apex of clypeus to apex of elytra); breadth: 1.3-1.5

mm (measured across elytral humeri). *Color:* Head and apical portion of pronotum dark but with a green metallic sheen, posterior portion of pronotum, elytra, and underside black, front legs light brown or amber, middle and hind legs brown or dark brown, scape dark with a blue-green metallic sheen, remaining 10 antennomeres brown or amber. *Head:* Broad, convex and very short, clypeus extremely short and broad, with a slightly concave apical margin. Eyes very large, fairly round and oblong with internal margins distinct. Genae not visible from above. Dorsal surface alutaceous and finely punctate. Antenna with 11 antennomeres including a 3-segmented club about 1/3-1/2 the height of the eye. Club flat, distinctly separated from funicle, and with a distinctly serrated margin. First and second club antennomeres wider than long, terminal club antennomere is the largest club segment and slightly longer than wide, apically rounded and setose (Fig. 6-37). Third antennomere subequal to antennomeres 4 and 5 combined. *Pronotum:* Strongly convex, lateral margins curved; anterior angle more narrowly arcuate than posterior angles. Surface finely punctuate. *Scutellum:* Triangular with margins slightly convex and sinuous; alutaceous and very sparsely punctured. *Elytra:* Uniform width narrowing at the apical 1/5. Strongly convex, sides almost parallel and apices rounded, length shorter than combined width (57:70). Distinctly alutaceous and punctate, punctation extending to lateral edges and almost to apices. Median and lateral margins of elytra bordered. *Underside:* Metasternum alutaceous and roughly punctured, with short coarse hairs uniformly distributed. Abdominal sternites alutaceous and punctate with long, coarse hairs thinly covering the surface. *Legs:* Protibiae expanded towards the distal end and setose, profemora narrowing slightly at the distal end. Meso- and metatibiae with long, stiff hairs along the outer margin. Meso- and metafemora and tibiae very alutaceous, laminiform and greatly dilated. Four tarsomeres, claw tarsomere as long or almost as long as 2 preceding tarsomeres combined. *Median lobe:* Sides slightly rounded and curving to a gradual rounded tip (Fig. 6-38). In profile, sinuous and curved from middle (Fig. 6-39). Median plate on surface slightly elevated. *Basal Plate:* Sides parallel at base, evenly rounded with 2 small protuberances on either side of a flat surface at apex (Fig. 6-40).

Female: Similar to male but head, pronotum, and first antennal segment black and without green metallic sheen.

Geographic distribution. Mexico: Tamaulipas: Ciudad Victoria Cañon La Libertad, Tampico (Fig. 6-41) and Guatemala.

Type material examined. The holotype, deposited in the BMNH, is a female specimen glued to a card with Pycnocephalus metallicus, with Cyb being scribbled out and replaced with Pycn, Type D. S. Tamahu, Guat. Champion handwritten on the same card the specimen is glued to. The remaining labels are as follows: TYPE (printed) [white circular label with an orange outer margin] / Tamahu, Vera Paz. Champion (printed) [white rectangular label] / Sp. figured. (printed) [white rectangular label] / B. C. A. Col. II. l. Pycnocephalus metallicus Sharp / Pycnocephalus metallicus Sharp (handwritten) det. A. Kirejtshuk 1999 (printed) [white rectangular label] / HOLOTYPE *Pycnocephalus metallicus* Sharp Det: Trevor Smith (printed) [red rectangular label]. While this specimen is a syntype, prior to this publication it was not a valid holotype, despite the round type label placed on the specimen, because this designation was never published. One female paralectotype is labelled as follows: **Guatemala: San Geronimo,** Tamahu (BMNH).

Other material examined. Mexico: Tamaulipas, Ciudad Victoria Cañon La Libertad, 7-III-1986, coll. P. W. Kovarik (1♀, FSCA); Tampico, 27-?-1912, coll. E. A. Schwarz (1♀, USNM); Tampico, 26-?-1912, coll. E. A. Schwarz (1♂, USNM); Tampico, 24-?-1912, coll. E. A. Schwarz (1♂, USNM); Tampico, 26-?-1912, coll. E. A. Schwarz (1♂, 1♀ BMNH).

Remarks. The type specimen is a female, however enough associated male specimens were available for comparisons and a male description including figures of male genitalia to be made.

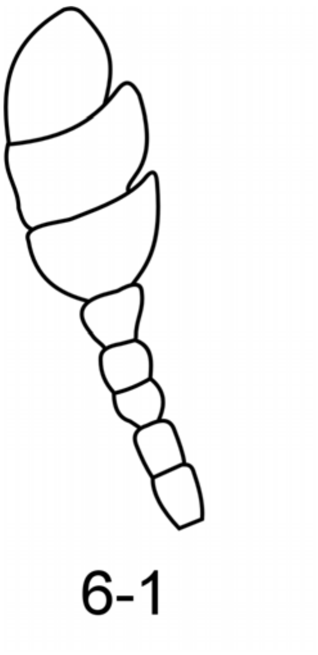

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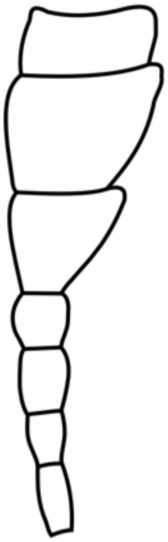
Figure 6-1. Antenna of *C. aciculatus*.



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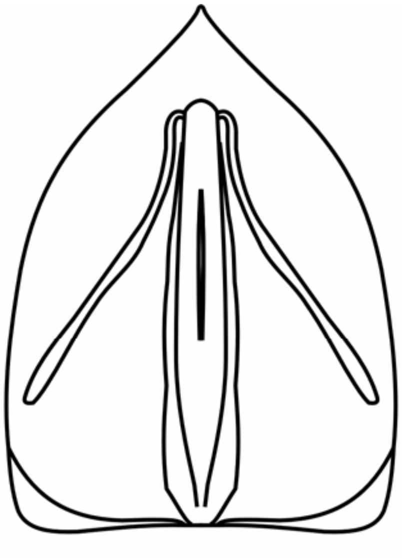

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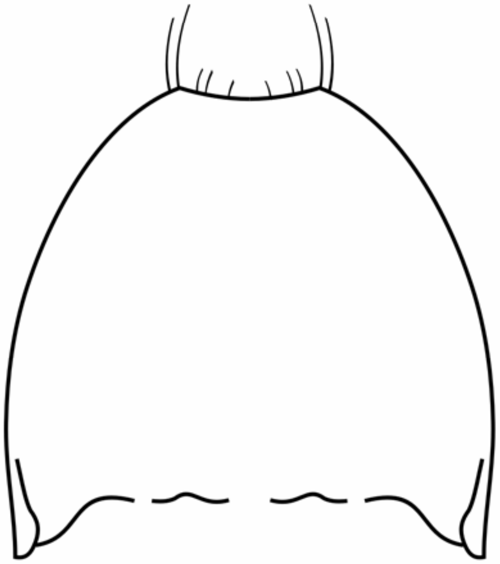

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Figure 6-2. Antenna of *Cybocephalus* new species 1.

Figure 6-3. Median lobe, dorsal view, of *Cybocephalus* new species 1.

Figure 6-4. Median lobe, lateral view, of *Cybocephalus* new species 1.

Figure 6-5. Basal plate, ventral view, of *Cybocephalus* new species 1.

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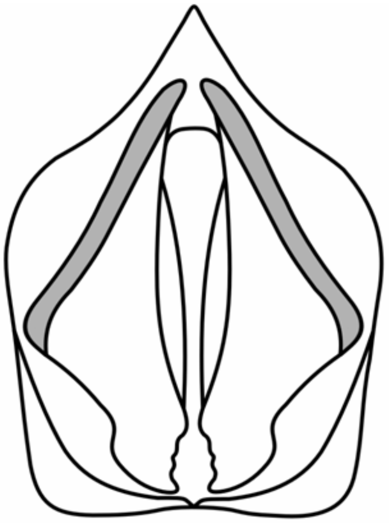

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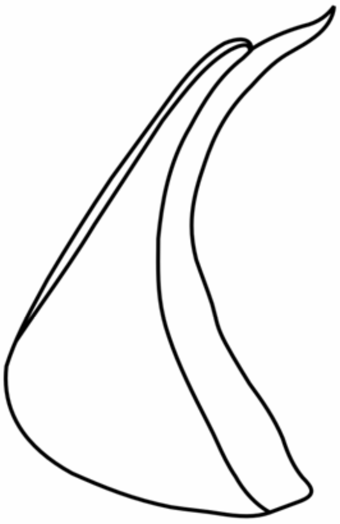

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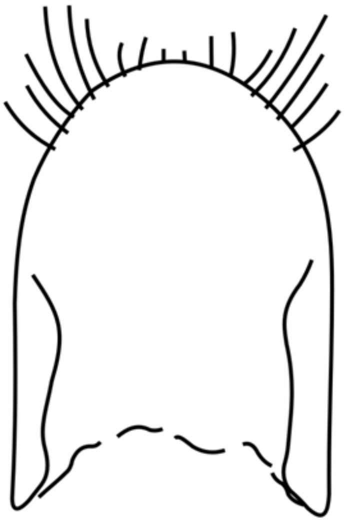

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Figure 6-6. Truncate antenna of *C. californicus*.

Figure 6-7. Emarginated antenna of *C. californicus*.

Figure 6-8. Median lobe, dorsal view, of *C. californicus*.

Figure 6-9. Median lobe, lateral view, of *C. californicus*.

Figure 6-10. Basal plate, ventral view, of *C. californicus*.

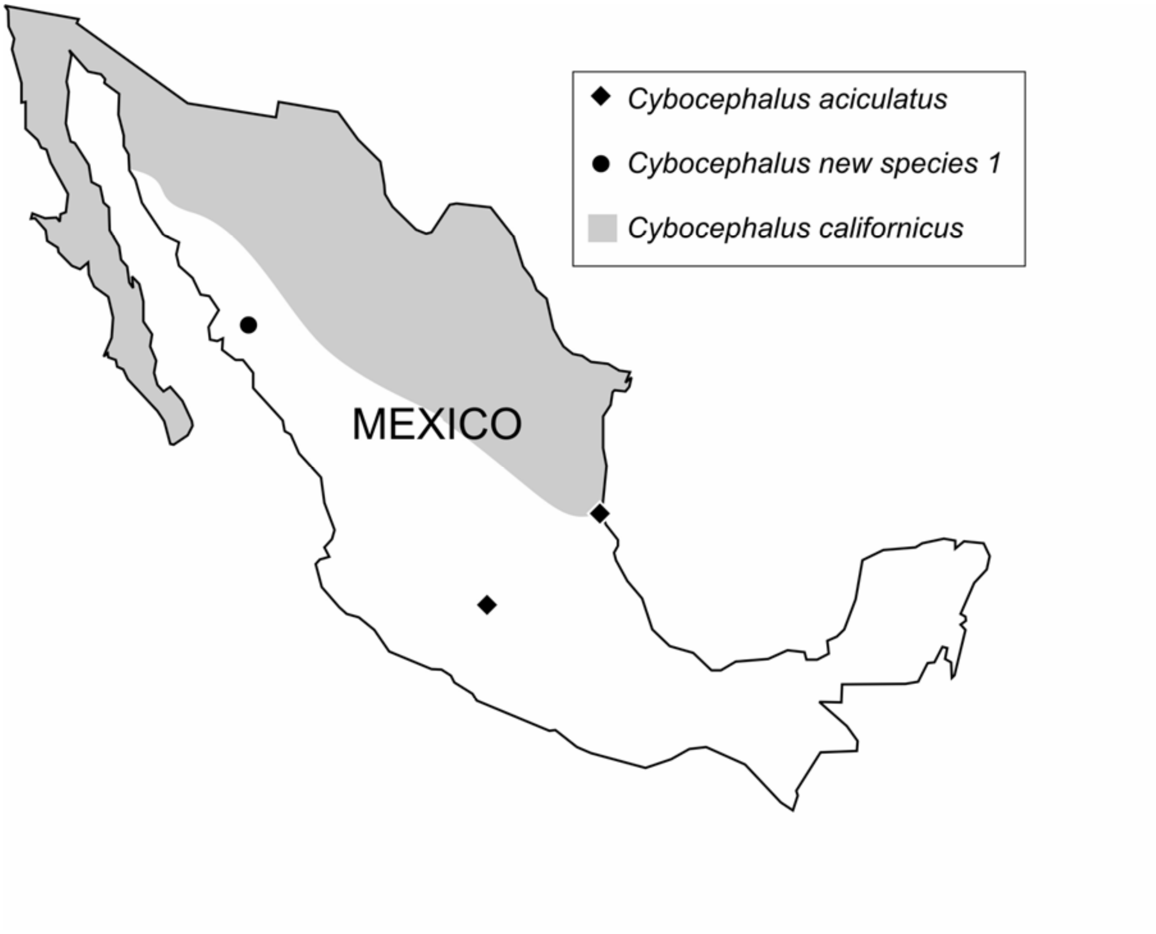
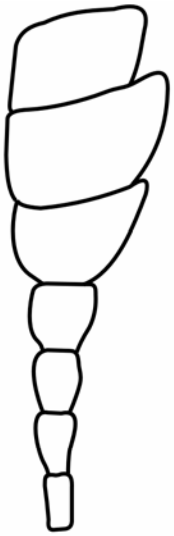


Figure 6-11. Collection localities of *Cybocephalus aciculatus, Cybocephalus* new species 1 and *Cybocephalus californicus* in Mexico.



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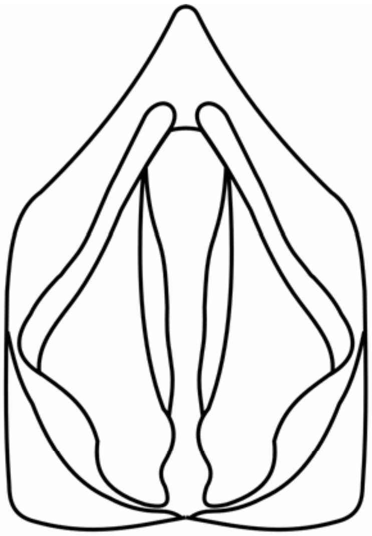

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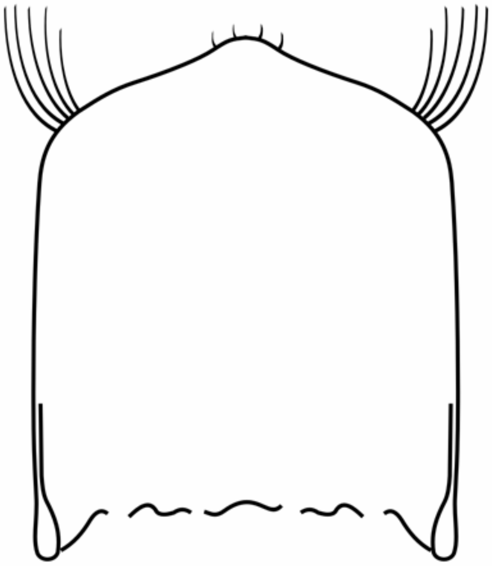

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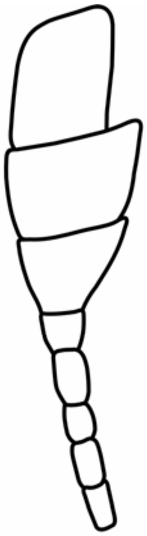
Figure 6-12. Antenna of *Cybocephalus* new species 2.

Figure 6-13. Median lobe, dorsal view, of *Cybocephalus* new species 2.

Figure 6-14. Median lobe, lateral view, of *Cybocephalus* new species 2.

Figure 6-15. Basal plate, ventral view, of *Cybocephalus* new species 2.



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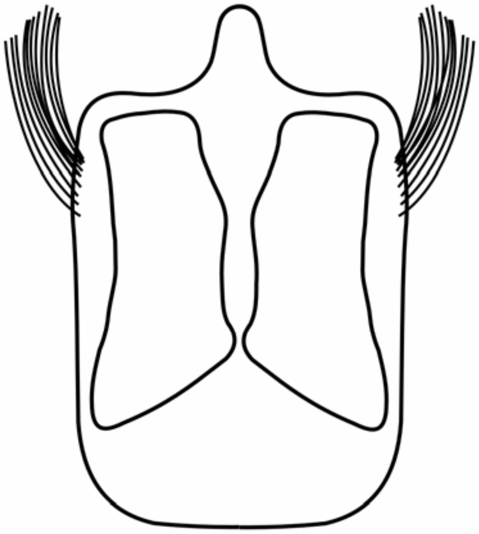

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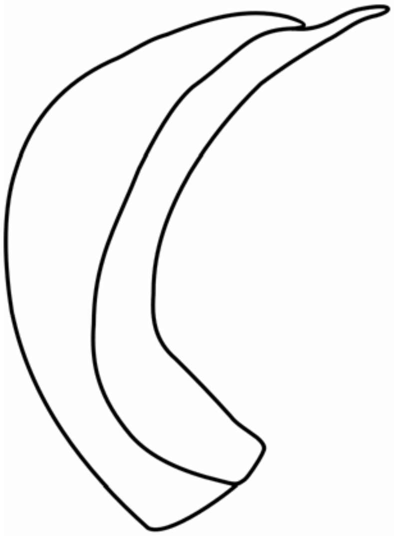

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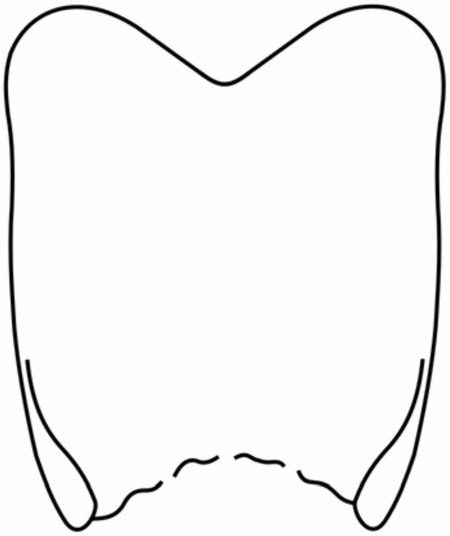

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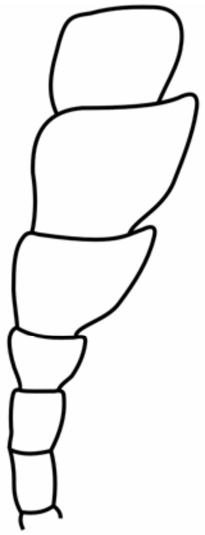
Figure 6-16. Antenna of *Cybocephalus* new species 3.

Figure 6-17. Median lobe, dorsal view, of *Cybocephalus* new species 3.

Figure 6-18. Median lobe, lateral view, of *Cybocephalus* new species 3.

Figure 6-19. Basal plate, ventral view, of *Cybocephalus* new species 3.



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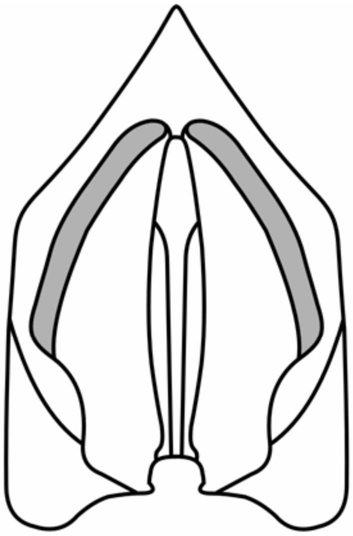

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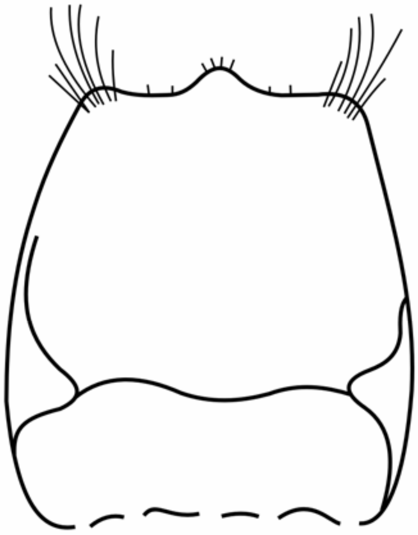

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Figure 6-20. Antenna of *C. nigritulus*.

Figure 6-21. Median lobe, dorsal view, of *C. nigritulus*.

Figure 6-22. Median lobe, lateral view, of *C. nigritulus*.

Figure 6-23. Basal plate, ventral view, of *C. nigritulus*.

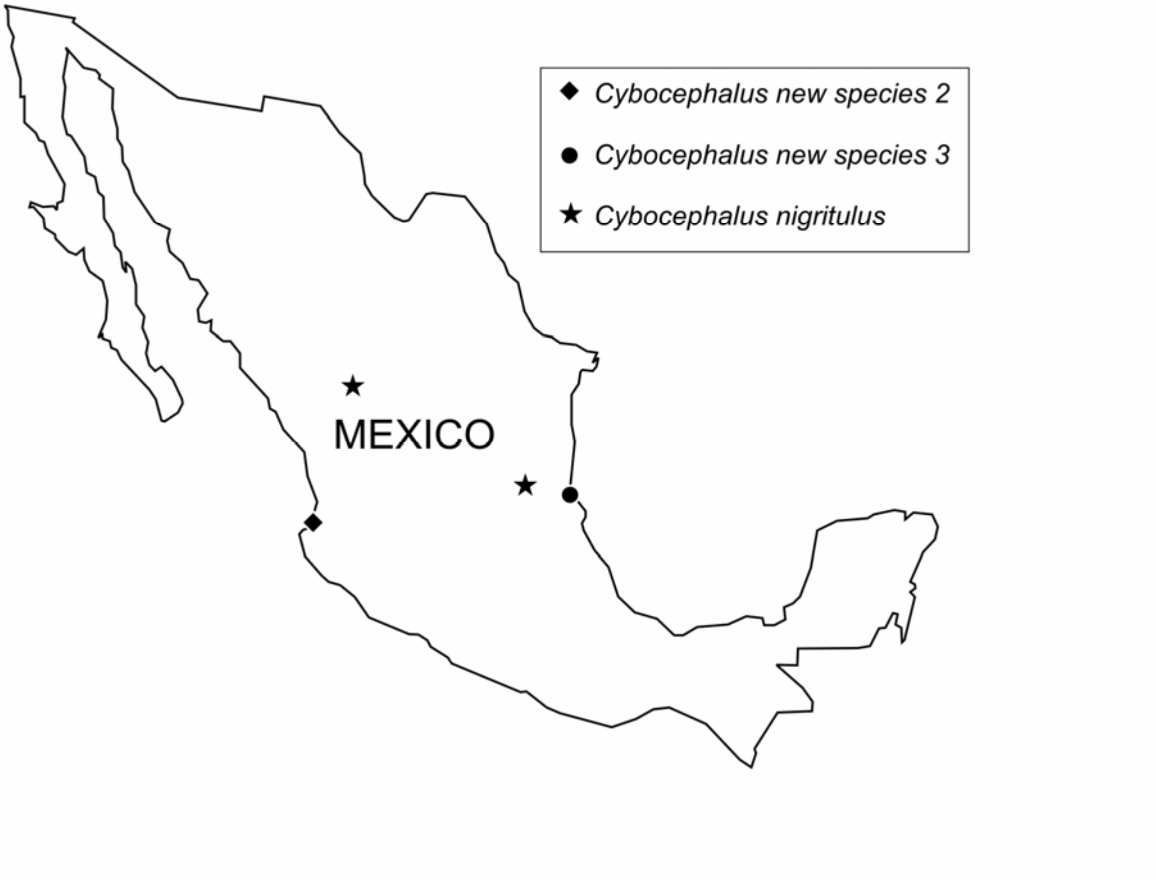
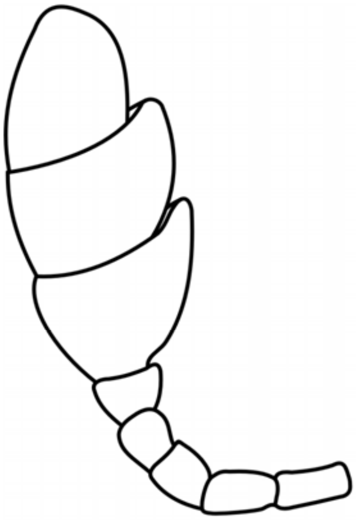


Figure 6-24. Collection localities of *Cybocephalus* new species 2, *Cybocephalus* new species 3 and *Cybocephalus nigritulus* in Mexico.



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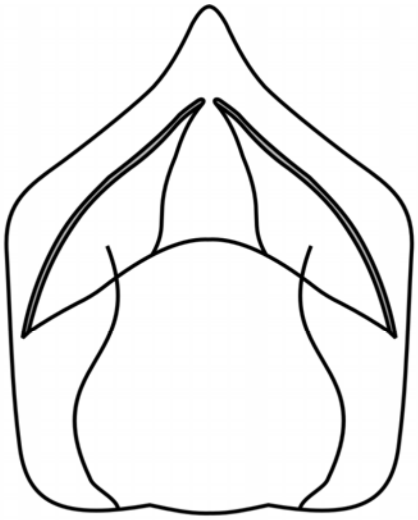

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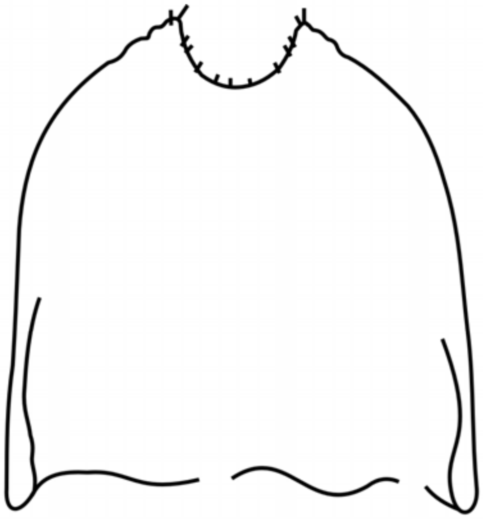

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Figure 6-25. Antenna of *C. randalli*.

Figure 6-26. Median lobe, dorsal view, of *C. randalli*.

Figure 6-27. Median lobe, lateral view, of *C. randalli*.

Figure 6-28. Basal plate, ventral view, of *C. randalli*.

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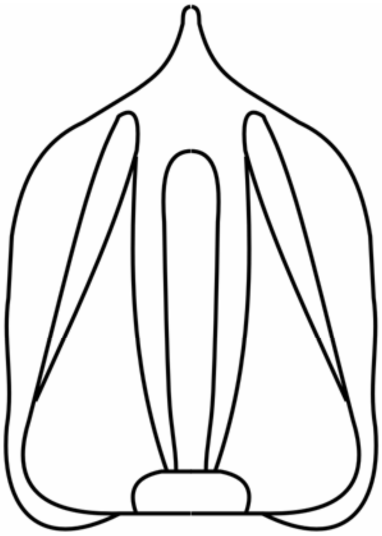

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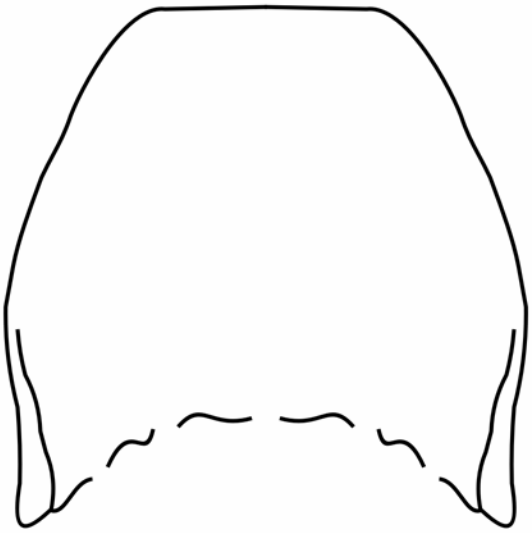

6-32

Figure 6-29. Antenna of *C. schwarzi*.

Figure 6-30. Median lobe, dorsal view, of *C. schwarzi*.

Figure 6-31. Median lobe, lateral view, of *C. schwarzi*.

Figure 6-32. Basal plate, ventral view, of *C. schwarzi*.

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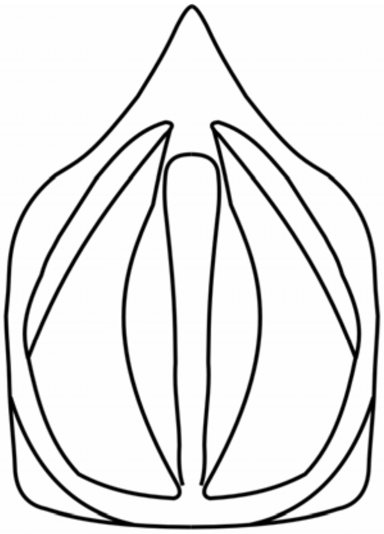

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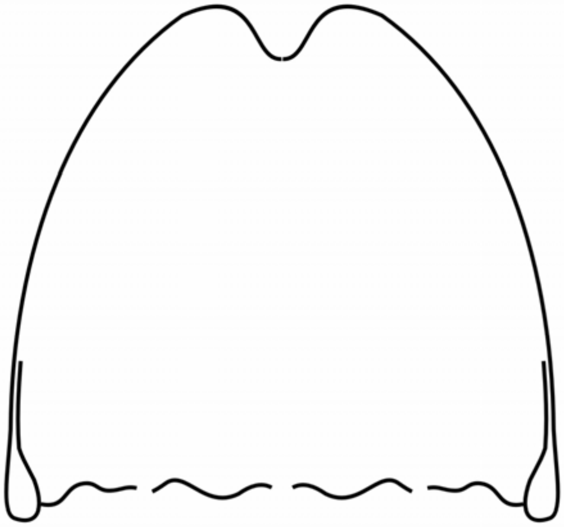

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Figure 6-33. Antenna of *Cybocephalus* new species 4. 6-33) antenna; 6-34) median lobe, dorsal view; 6-35) median lobe. lateral view; 6-36) basal plate, ventral view.

Figure 6-34. Median lobe, dorsal view, of *Cybocephalus* new species 4.

Figure 6-35. Median lobe, lateral view, of *Cybocephalus* new species 4.

Figure 6-36. Basal plate, ventral view, of *Cybocephalus* new species 4.

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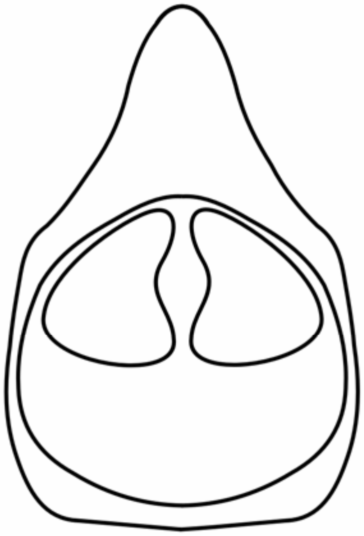

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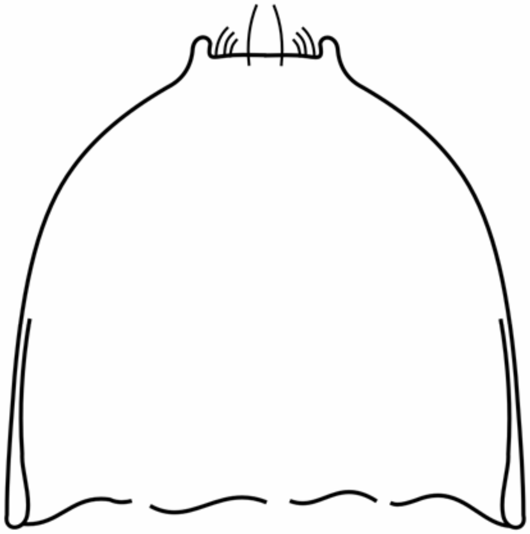

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Figure 6-37. Antenna of *P. metallicus*.

Figure 6-38. Median lobe, dorsal view, of *P. metallicus*.

Figure 6-39. Median lobe, lateral view, of *P. metallicus*.

Figure 6-40. Basal plate, ventral view, of *P. metallicus*.

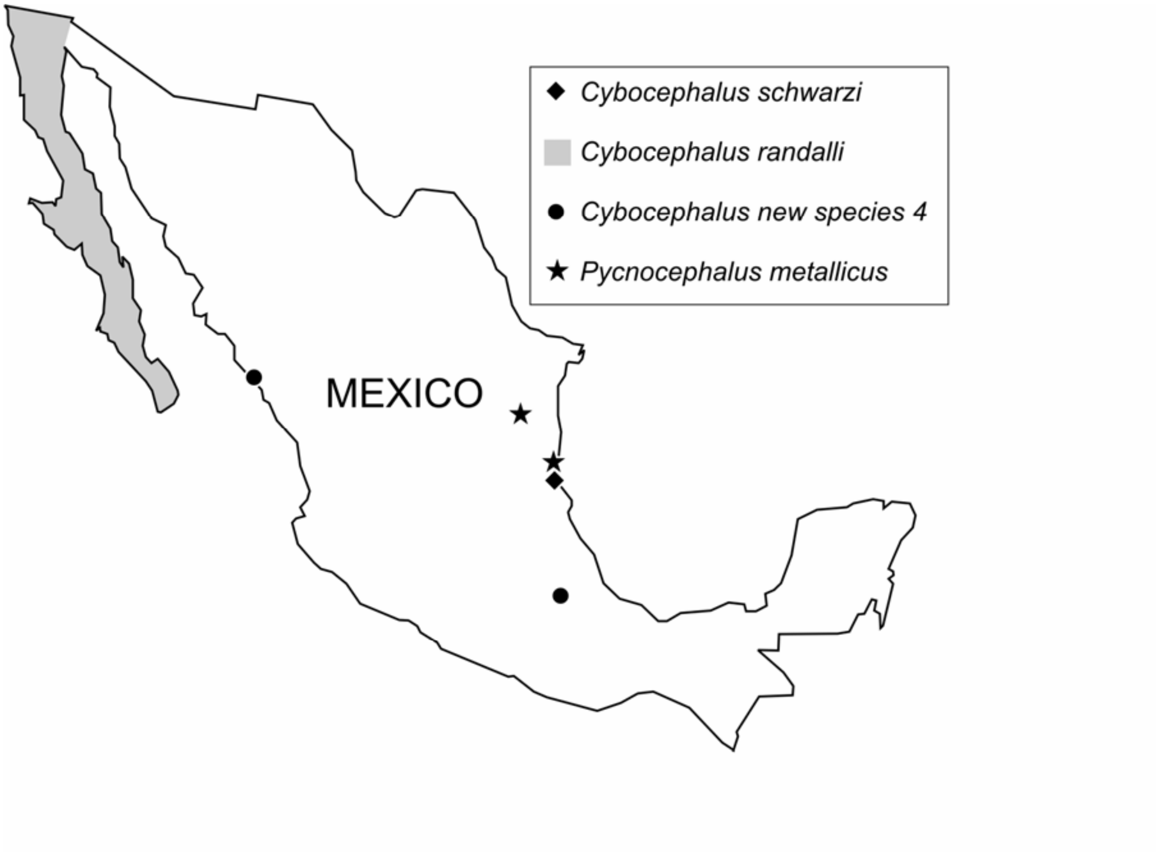

Figure 6-41. Collection localities of *Cybocephalus randalli*, *Cybocephalus schwarzi*, *Cybocephalus* new species 4 and *Pycnocephalus metallicus* in Mexico.

LIST OF 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. Entomol. Res. 60: 5-16.

Alvarez, J. M., and R. van Driesche. 1998a. Biology of *Cybocephalus* sp. nr. *nipponicus*(Coleoptera: Cybocephalidae), a natural enemy of euonymus scale (Homoptera: Diaspididae). Environ. Entomol. 27: 130-136.

Alvarez, J. M., and R. van Driesche. 1998b. Effect of prey, sex, density, and age on oviposition of *Cybocephalus* sp. nr. *nipponicus* (Coleoptera: Cybocephalidae), a natural enemy of euonymus scale (Homoptera: Diaspididae). Florida Entomol. 81: 429-436.

Anonymous. 1998. Insects: *Cycas* under scale attack, can the Thai beetle be the solution? Landscape and Nursery Digest. January: 1-5.

Anonymous. 2003. Scale Destroyers, *Rhyzobius lophanthae*. IPM of Alaska. http://ipmofalaska.homestead.com/files/Rhyzobius.html (January 2006).

Arnett, R. H. Jr. 1960. The beetles of the United States (a manual for identification). TheCatholic University. Amer. Press., Washington. 1112 pp.

Atkinson, P. R. 1983. Environmental factors associated with fluctuations in the numbers of natural enemies of a population of citrus red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae). Bull. Entomol. Res. 73: 417-426.

Ben-Dov, Y. 1990. Classification of diaspidoid and related Coccoidea. Pp. 97-128. D. Rosen, [ed] Armored scale insects, their biology, natural enemies and control, Vol. A. Elsevier, Amsterdam. 384 pp.

Ben-Dov, Y., 1993. A systematic catalogue of the soft scale insects of the world. Flora and Fauna Handbook No. 9. Sandhill Crane Press, Inc. Gainesville, FL, xxviii +536 pp.

Ben-Dov, Y., D. R. Miller, and G. A. P. Gibson. 2003. Scalenet, distribution query. http://www.sel.barc.usda.gov/scalenet/query.htm (July 2005).

Blumberg, D. 1973. Field studies of *Cybocephalus nigriceps nigriceps* (J. Sahlberg) (Coleoptera: Cybocephalidae) in Israel. J. Nat. Hist. 7: 567-571.

Blumberg, D. 1976. Adult diapause of *Cybocephalus nigriceps nigriceps* (Col.: Cybocephalidae). Entomophaga 21: 131-139.

Blumberg, D., and E. Swirski. 1974a. Prey consumption and preying ability of *Cybocephalus* (Coleoptera: Cybocephalidae). Phytoparasitica 2(1): 3-11.

Blumberg, D., and E. Swirski. 1974b. The development and reproduction of cybocephalid beetles on various foods. Entomophaga 19: 437-443.

Blumberg, D., and E. Swirski. 1982. Comparative studies of two species of predatory beetles of the genus *Cybocephalus* (Col: Cybocephalidae). Entomophaga 27:67-76.

Borror, D. J., C. A. Triplehorn and N. F. Johnson, 1989. An Introduction to the Study of Insects. Sanders Publishing, Ft. Worth. 512 pp.

Bøving, A. G., and F. C. Graighead. 1931. An illustrated synopsis of the principal larval forms of the order Coleoptera. Entomol. Americana, (N. S.) 11: 1-351.

Bréthes, J. 1922. Descripción de varios coleópteros de Buenos Aires. Anal. Soc. Cient. Argentina 94: 263-305.

Champion, C. 1913. Notes on various Central American Coleoptera, with descriptions of new genera and species. Trans. Entomol. Soc. London, 58-169.

Champion, G. C. 1923. Some Indian Coleoptera. Entomol. Mon. Mag. 59: 77-78.

Chandra, J., and P. N. Avasthy. 1978. First record of *Cybocephalus* sp. predacious on whitefly, *Neomaskellia bergii* Signoret. Indian J. Entomol. 40: 445-446.

Cividanes, F. J., and A. P. Gutierrez. 1996. Modeling the age-specific per capita growth and reproduction of *R. lophanthae* (Coleoptera: Coccinellidae). Entomophaga 41: 257-266.

Clausen, C. P. 1940. Entomophagous insects. McGraw-Hill Book Co., Inc. New York and London. 688 pp.

Clausen, C. P., and P. A. Berry. 1932. The citrus blackfly in Asia, and the importation of its natural enemies into tropical America. U. S. Dep. Agric.Tech. Bull. No. 320: 58 pp.

Collins, F. A., and W. H. Whitcomb. 1975. Natural enemies of the white peach scale, *Pseudaulacaspis pentagona* (Homoptera: Coccidae), in Florida. Florida Entomol. 58: 15-21.

Deepak, M., G. C. Hamilton, M. G. Hughes, and J. H. Lashomb. 2003. Distribution of natural enemies of euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae), in New Jersey. Biol. Control 32: 602-607.

Dekle, G. W. 1976. Florida armored scale insects. Gainesville, Florida Dept. Agr. and Consumer Serv., Div. Plant Industry, Gainesville, Florida 345 pp.

De Marzo, L. 1995. Some remarks on the presence of *Cybocephalus rufifrons* Reitt. In South Italy (Coleoptera: Cybocephalidae). Entomologica, Bari 29: 135-147.

Drea, J. J., and R. M. Carlson. 1988. Establishment of *Cybocephalus* sp. (Coleoptera: Nitidulidae) from Korea on *Unaspis euonymi* (Homoptera: Diaspididae) in the Eastern United States. Proc. Entomol. Soc. Washington 90: 307-309.

Drea, J. J., and R. M. Hendrickson Jr. 1988. Exotic predators: Two Asian beetles may provide the answer to controlling euonymous scale. American Nurseryman, October, 15: 66-71.

Emshousen, C., and C. Mannion. 2004. Taming Asian cycad scale (*Aulacaspis yasumatsui*). The Cycad Newsletter 27(1): 8-10.

Endrödy-Younga, S. 1962a. Neue Cybocephaliden Gattungen aus der aethiopischen region (Coleoptera, Cybocephalidae). Ann. Historico-Naturales Musei Nationalis Hung. Pars Zool. 54: 271-277.

Endrödy-Younga, S. 1962b. Die äthiopischen Arten der Gattung *Cybocephalus* Er. (Coleoptera, Cybocephalidae). Acta Zool. Acad. Sci. Hung. 8: 284-335.

Endrödy-Younga, S. 1963. Cybocephalidae (Coleoptera, Clavicornia). Exploration Parc National de la Garamba, 41(3): 31-81.

Endrödy-Younga, S. 1964a. Die Cybocephalus-Arten von den Mascarenen und Seychellen (Coleoptera, Cybocephalidae). Acta Zool. Acad. Sci. Hung. 10: 61-84.

Endrödy-Younga, S. 1964b. Cybocephalidae (Coleoptera, Clavicornia). Exploration de la Parc National de l'Upemba, 68(4): 61-64.

Endrödy-Younga, S. 1965. Eine neue mitteleuropaeische Art der Gattung *Cybocephalus* Er. (Coleoptera, Cybocephalidae). Nachrichtenbl. Bayer. Entomol. 14: 41-43.

Endrödy-Younga, S. 1967a. Coleoptera: Cybocephalidae. *In*: B. Hanström, P. Brink & G. Rudebeck (eds.), South African animal life, results of the Lund University expedition in 1950-1951. Vol. 13. Almqvist and Wiksell, Stockholm, 38-44.

Endrödy-Younga, S. 1967b. 5. Familie Cybocephalidae. *In*: Freude, Harde, Lohse: Die Käfer Mitteleuropas 7: 77-79.

Endrödy-Younga, S. 1968. Monographie der Paläarktischen Arten der Familie Cybocephalidae (Coleoptera: Clavicornia). Acta Zool. Acad. Sci. Hung. 14: 27-115.

Endrödy-Younga, S. 1969. Cybocephalidae (Coleoptera, Clavicornia). *In*: The scientific results of the Hungarian soil zoological expeditions to the Brassaville-Congo. Opusc. Zool. Budapest 9: 259-272.

Endrödy-Younga, S. 1971a. Neue Ergebnisse bei der Bearbeitung der paläarktischen und orientalischen Cybocephalidae (Coleoptera: Clavicornia). Acta Zool. Acad. Sci. Hung. 17: 243-249.

Endrödy-Younga, S. 1971b. Cybocephalidae, Coleoptera. Insects of Micronesia 16: 281-285.

Endrödy-Younga, S. 1976. Some new Aethiopian species of the family Cybocephalidae [Col. Clavicornia]. Ann. Soc. Entomol. France (N. S.), 12 (1): 113-122.

Endrödy-Younga, S. 1979. Insects of Saudi Arabia Coleoptera: Fam. Cybocephalidae. *In*: Wittmer W., Buettiker W. (eds.): Fauna of Saudi Arabia I. Basel, Natural History Museum and Ciba Geigy, 228-231.

Endrödy-Younga, S. 1982. Cybocephalids of Réunion and Mauritius Islands (Coleoptera: Cybocephalidae). Ann. Transvaal Mus. 33(13): 261-264.

Endrödy-Younga, S. 1984. A new species of *Cybocephalus* (Coleoptera, Cucujoidea, Cybocephalidae) from Israel. Isr. J. Entomol. 18: 1-2.

Erichson, W. F. 1844. Cybocephalus. Z. Entomol. 5: 441-445.

Erkiliç L. B., and N. Uygun. 1997. Studies on the effects of some pesticides on white peach scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Homoptera: Diaspididae) and its side-effects on two common scale insect predators. Crop Protection 16: 69-72.

Evans, G. A., P. Dessart, and H. Glenn. 2005. Two new *Aphanogmus* (Hymenoptera: Ceraphronidae) of economic importance reared from *Cybocephalus nipponicus* (Coleoptera: Cybocephalidae). Zootaxa 1018: 47-54.

Flanders, S. E. 1934. The life histories of three newly imported predators of the red scale. J. Econ. Entomol. 27: 723-724.

Frank, J. H., and E. D. McCoy. 1994. Commercial importation into Florida of invertebrate animals as biological control agents. Florida Entomol. 77: 1-20.

Giddy, C. 1990. Conservation through cultivation. Memoirs of the New York Botanical Garden 57: 89-93.

Greathead, D. J. 1973. A review of introductions of *Lindorus lophanthae* (Blaisd.) (Col.: Coccinellidae) against hard scales (Diaspididae). Technical Bulletin of the Commonwealth Institute of Biological Control 16: 29-33.

Grouvelle, A. 1908. Coléoptères de la region indienne. Ann. Soc. Entomol. France 78: 394.

Grouvelle, A. 1913. Nitidulidae. *In*: the Percy, Sladen, Trust Expedition to the Indian Ocean in 1905. Trans. Linn. Soc. London 16(2): 93-110.

Habeck, D. H. 2002. Nitidulidae Latreille 1802. *In* R. H. Arnett Jr., M. C. Thomas, P. E. Skelley, and J. H. Frank (eds.), American beetles Volume 2. CRC Press, Boca Raton, pp. 311-315.

Hamon, A. 2000. Cycad aulacaspis scale, *Aulacaspis yasumatsui*. http://www.doacs.state.fl.us/~pi/enpplemtolaulacaspis.html.

Hara, A. H., R. Y. Niino-DuPonte, C. M. Jacobsen, S. Chun, W. T. Nagamine, R. A. Heu,and N. M. Nagata. 2004. What's killing my sago palm? Cycad Scale *Aulacaspis yasumatsui*. Hawaii Dept. Agr.

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

HDA (Hawaii Department of Agriculture). 2004. Distribution and host records of agricultural pests and other organisms of Hawaii. http://www.hear.org/starr/insects/ (August 2005).

Heintz, C. 2001. Update of the pest management evaluation for the almond industry. Almond Board of California. California Dept. Pesticide Reg. 37 pp.

Heu, R. A. and, M. E. Chun. 2000. Sago palm scale *Aulacaspis yasumatsui* Takagi (Homoptera: Diaspididae). Hawaii Dept. Agr. New Pest Advisory no. 99-01.

Heu, R. A., M. E. Chun, W. T. Nagamine. 2003. Sago palm scale *Aulacaspis yasumatsui* Takagi (Homoptera: Diaspididae). New Pest Advisory no. 99-01. Rev. Sept. 2003. http://www.hawaiiag.org/hdoa/npa/npa99-01-spalmscale2%20.PDF (March 2005)

Hill, K. 2004. The cycad pages. http://plantnet.rbgsyd.gov.au/PlantNet/cycad/index.html (March 2005).

Hodges, G. S., F. W. Howard, and E. A. Buss. 2003. Update on management methods for cycad aulacaspis scale. Florida Coop. Ext. Service, IFAS, University of Florida. ENY-680. http://edis.ifas.ufl.edu (January 2005).

Hodgson, C., and J. H. Martin. 2001. Three noteworthy scale insects (Hemiptera: Coccoidea) from Hong Kong and Singapore, including *Cribropulvinaria tailungensis*, new genus and species (Coccidae), and the status of the cycad-feeding *Aulacaspis yasumatsui* (Diaspididae). Raffles Bull. Zool. 49:227-250.

Honda, J. Y., and R. F. Luck. 1995. Scale morphology effects on feeding behavior and biological control potential of *Rhyzobius lophanthae* (Coleoptera: Coccinellidae).Ann. Entomol. Soc. America 88: 441-450.

Horn, G. H. 1879. Revision of the Nitidulidae of the United States. Trans. Am. Entomol. Soc. 8: 267- 341.

Howard, F. W. 1997. CRIS Report, Project FLA-FTL-03607. Progress 1996/10/01 to 1997/09/30.

Howard, F. W., A. Hamon, M. McLaughlin, and T. J Weissling. 1999. *Aulacaspis yasumatsui* (Homoptera: Sternorrhyncha: Diaspididae), a scale insect pest of cycads recently introduced into Florida. Florida Entomol. 82: 14-27.

Howard, F. W., and T. J. Weissling. 1999. Questions and answers about the cycad aulacaspis scale insect. Proc. Florida State Hortic. Soc. 112: 243-245.

Howard, F. W., T. Weissling, and D. Hull. 1996. New armored scale insect introduction in Miami area. [eds.] A. W. Meerow and C. T. Stephens. Tropicline 9(2).

Howard, F. W., T. J. Weissling and M. McLaughlin. 1997. Progress in controlling cycad scale in Miami, April 1997, http://flrec.ifas.ufl.edu/entomo/Ornamental_Pests/cycad.htm (March 2005)

Hudson, W., T. Scudder, T. Dorsey, G. Robbins, and M. Mayer. 2000. Biological control of the euonymus scale *Unaspis euonymi* (Homoptera: Diaspididae) using *Cybocephalus nipponicus* (Coleoptera: Nitidulidae). Annual report 2000. Philip Alampi Beneficial Insect Laboratory, www.state.nj.us/agriculture/plant/euonymus%202000.pdf (January 2005).

Jacquelin du Val, P. N. C. 1858. Genera des coléoptères d'Europe. A. Deyrolle, Paris, France, 225 pp.

Jefferson, D. K., P. B. Schultz, and M. D. Bryan. 1995. Distribution of euonymus scale, *Unaspis euonymi* (Comstock), in Virginia. J. Entomol. Sci. 30: 273-278.

Kajita, H., I. M. Samudra, and A. Naito. 1991. Discovery of the spiraling whitefly *Aleuriducus disperses* Russell (Homoptera: Aleyrodidae) from Indonesia, with notes on its host plants and natural enemies. Appl. Entomol. Zool. 26: 397-400.

Kapadia, M. N., and S. N. Puri. 1993. New records of natural enemies of castor whitefly. J. Maharashtra Agric. Univ. 18: 339.

Kartman, L. 1946. A new host for *Cybocephalus* sp. a predator of diaspine Coccidae. J. Econ. Entomol. 39: 814.

Katsoyannos, P. 1984. Notes on life history and field efficiency of *Cybocephalus fodori* predator of *Quadraspidiotus perniciosus* in northern Greece. Entomol. Hell. 2: 35-40.

Kehat, M., E. Swirski, D. Blumberg, and S. Greenberg. 1974. Integrated control of date palm pests in Israel. Phytoparasitica 2: 141-149.

Kirejtshuk, A. G. 1997. Volume 28. Nitidulidae (Coleoptera) of the Himalayas and northern Indochina. Part I: Subfamily Epuraeinae. Koeltz Scientific Books, Königstein, Germany, 347 pp.

Kirejtshuk, A. G., D. G. James, and R. Heffer. 1997. Description and biology of a new species of *Cybocephalus* Erichson (Coleoptera: Nitidulidae), a predator of Australian citrus whitefly. Australia J. Entomol. 36: 81-86.

Kuznetsov, V. N. 1997. Lady Beetles of the Russian far east. Memoir No. 1. Center for Systematic Entomology. The Sandhill Crane Press, Gainesville, Florida, 248 pp.

Labuschange, T. I., M. S. Daneel, and M. DeBeer. 1996. Establishment of *Aphytis* sp. (Hymenoptera: Aphelinidae) and *Cybocephalus binotatus* Grouvelle (Coleoptera: Nitidulidae) in mango orchards in South Africa for control of mango scale, *Aulacaspis tubercularis* Newstead (Homoptera: Diaspididae). Yearbook South African Mango Growers' Association 16: 20-22.

LeConte, J. L. 1863. New Species of North American Coleoptera. Prepared for the Smithsonian Institution. Smithsonian Miscellaneous Collections No. 167 6:1-86. [pp. 87-177 were published in 1866.]

Lupi, D. 2003. Contribution to the knowledge of Cybocephalid beetles. Biology and ethology of *Cybocephalus freyi* Endrödy-Younga. Bull. Zool. Agr. Bachic. Ser. II. 35: 45-54.

Moretti, A. 1990. Cytotaxonomy of cycads. Memoirs of the New York Botanical Garden57: 114-122.

Murray, A., 1864. Monograph of the family of Nitidulidae. Trans. Linn. Soc. London (I) 24: 211-414.

Nohara, J., and M. Iwata. 1988. Biological study of *Cybocephalus gibbulus* (Erichson),(Coleoptera: Cybocephalidae), a predator of the scale insect in the citrus orchards. Proc. Fac. Agric. Kyushu Tokai University 7: 25-31.

Nakao, S-I, K. Nohara, and A. Nagatomi. 1985. Effect of insecticide treatments on the fauna of a natural growth of citrus of Japan. Mushi 50(5): 91-114.

Parker, H. L. 1951. Notes on *Pycnocephalus argentinus* Brèthes, parasitic on *Ceroplastes* sp. in Uruguay. Proc. Entomol. Soc. Wash. 53: 35-41.

Parsons, C. T. 1943. A revision of Nearctic Nitidulidae (Coleoptera). Bull. Comp. Zool. 92: 121-248.

Plapp, F. W. Jr. 1971. Insecticide resistance in *Heliothis:* Tolerance in larvae of *H. virescens* as compared with *H. zea* to organophospate insecticides. J. Econ. Entomol. 64: 999-1002.

Ramani, S. 2000. Fortuitous introduction of an aphelinid parasitoid of the spiraling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) into the Lakshadweep islands with notes on host plants and other natural enemies. J. Biol. Control 14: 55-60.

Reitter, E. 1874. Diagnoses der bekannten *Cybocephalus*-Arten. Verh. Naturf. Ver. Brünn 12(2): 1-10.

Reitter, E. 1875. Diagnosen neuer Cybocephalus-Arten als Nachtrag zu der gleichnamigen Abhandlung in den Verhandlungen des Naturhistorischen Vereins in Brünn 1873, pgs. 55-56. *In* E. v. Harold (ed.), Coleopterologische Hefte: Herausgegeben unter Mitwirkung mehrerer Fachgenossen, 13.

Riley, C. V. 1882. General note. Am. Nat. 16: 514.

Rosen, D. 1990. Armored scale insects: Their biology, natural enemies and control. Vol. B. Elsevier, New York, USA, 688 pp.

Rosen, D., and P. DeBach. 1978. Diaspididae, p. 78-128. *In:* C. P. Clausen (ed.), Introduced Parasites and Predators of Arthropod Pests and Weeds: A world review. Agric. Handbk. 480, U. S. Dept. Agric., Washington, D. C.

Rubstov, I. A. 1952. *Lindorus* - An effective predator of diaspine scales. Entomol. Obozr.32: 96-106 [in Russian].

SAS Institute. 2001. SAS/STAT user's guide, version 8.1. SAS Institute, Cary, NC.

Sharp, D. 1891. Biologia Centrali-Americana, Insecta. Nitidulidae. 2(1): 372-373.

Smirnoff, W. 1950. Sur la biologie au Maroc de *Rhyzobius (Lindorus) lophanthae* Blaisd.(Col.Coccinellidae). Rev. Pathol. Veg. Entomol. Agric. Fr. 29: 190-194.

Smirnoff, W. 1954. Les *Cybocephalus* (Col. Cybocephalidae) D'Afrique du nord, predateurs de *Parlatoria blanchardi* Targ. (Homoptera, Coccoidea) parasite du palmier-dattier. Rev. Pathol. Veget. Entomol. Agric. Fr. 33: 84-101.

Smith, T. R., and R. D. Cave. 2006a. The Cybocephalidae (Coleoptera) of America north of Mexico. Ann. Entomol. Soc. America 99: 776-792.

Smith, T. R., and R. D. Cave. 2006b. The life history of *Cybocephalus nipponicus* a predator of the cycad aulacaspis scale, *Aulacaspis yasumatsui* (Homoptera: Diaspididae). Proc. Entomol. Soc. Washington 108: (in press).

Smith, T. R., and R. D. Cave. 2007. The Cybocephalidae (Coleoptera) of the West Indies and Trinidad. Ann. Entomol. Soc. America, in press.

Snodgrass, G. L. 1996. Glass-vial bioassay to estimate insecticide resistance in adult tarnished plant bugs (Heteroptera: Miridae). J. Econ. Entomol. 89: 1053-1059.

Snodgrass, G. L., J. J. Adamczyk, Jr., And J. Gore. 2005. Toxicity of insecticides in a glass-vial bioassay to adult brown, green, and southern green stink bugs (Heteroptera: Pentatomidae). J. Econ. Entomol. 98: 177-181.

Spichiger, S-E. 2004. The Pennsylvania Department of Conservation and Natural Resources. Forestry. 2004. Forest Pest Management News. 22(1).

Stathas, G. J. 2000. The effect of temperature on the development of predator *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) and its phenology in Greece. Biocontrol 45: 439-451.

Stathas, G. J. 2001. Ecological data on predators of *Parlatoria pergandii* on sour orange trees in southern Greece. Phytoparasitica 29: 207-214.

Stathas, G. L., P. A. Eliopoulos, D. C. Kontodimas and D. Th. Siamos. 2002. Adult morphology and life cycle under constant temperatures of the predator *Rhyzobius lophanthae* Blaisdell (Col., Coccinellidae). Anz. F. Schädlingsk. (J. Pest Sci.) 74: 57-59.

Swirski, E., and M. Wysoki. 1995. Avocado pests in Israel. Proc. World Avocodo Congress III. 419-428.

Stathas, G. J. 2000. The effect of temperature on the development of predator *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) and its phenology in Greece. BioControl 45: 439-451.

Stathas, G. J. 2001. Studies on morphology and biology of immature stages of the Predator *Rhyzobius lophanthae* Blaisdell (Col.: Coccinellidae). J. Pest Sci. 74:113-116.

Swirski, E., D. Blumberg, M. Wysoki, and Y. Izhar. 1987. Biological control of the Japenese bayberry whitefly, *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae), in Israel. Isr. J. Entomol. 21: 11-18.

Tachikawa, T. 1974. Natural enemies of *Quadraspidiotus macroporanus* Takagi (Homoptera: Diaspididae). Trans. Shikoku Entomol. Soc. 12: 31-32.

Takagi, S. 1977. A new species of *Aulacaspis* associated with a cycad in Thailand (Homoptera: Coccoidea). Insecta Matsumurana, N. S. 11: 63-72.

Tanaka, M., and K. Inoue. 1980. Biology of *Cybocephalus nipponicus* Endrödy-Younga (Cybocephalidae) and their role as a predator of citrus red mites, *Panonychus citri* (McGregor). Bull. Fruit Trees Res. Stn. Ser D 2: 91-110.

Tang, W., S-L Yang and P. Vatcharakorn. 1997. Cycads of Thailand: Nong Nooch Tropical Garden and the Cycad Conservation Company, Bangkok. 34 pp.

Tian, M. 1995. Description of one new species of genus *Cybocephalus* from China (Coleoptera: Cybocephalidae). J. S. China Agric. Univ. 16(2): 42-43.

Tian, M. 1996. A new species of the genus *Cybocephalus* from Dinghushan Natural Reserve, Guangdong, China (Coleoptera: Cybocephalidae). Acta Zootaxon. Sinica 21: 92-94.

Tian, M. 2000. Two new species of Cybocephalidae (Coleoptera) from northwest China. Entomol. Sinica 7(2): 127-131.

Tian, M., and H. Pang. 1994. A new species of *Cybocephalus* (Coleoptera: Cybocephalidae) from Taiwan. Chin. J. Entomol. 14: 401-403.

Tian, M., and Z. Peng. 1997. Notes on the genus *Cybocephalus* Erichson from Hainan Island, China (Coleoptera: Cybocephalidae). J. S. China Agric. Univ. 18: 34-38.

Tian, M., and S. Ramani. 2003. Description of a new species of *Cybocephalus* Erichson (Coleoptera: Cybocephalidae) from India feeding on the spiraling whitefly, with notes on its biology. Entomon 28: 21-25.

Tian, M., and G. Yu. 1994. Two new species of the genus *Cybocephalus* from China(Coleoptera: Cybocephalidae). Entomol. Sinica 1: 209-213.

Thieret, J. W. 1958. Economic botany of the cycads. Econ. Bot. 12: 3-41.

Vinson, J. 1959. The genus *Cybocephalus* Erichson in the Mascarene Islands (Coleoptera: Nitidulidae). Proc. R. Soc. London B Biol. Sci. 28: 7-18.

Van Driesche, R. G. and T. S. Bellows Jr. 1993. Steps in classical arthropod biological control. Thomas Say Publications In Entomology: Proc. Entomol. Soc. America, Lanham, Maryland, 88 pp.

Van Driesche, R. G., K. Idoine, M. Rose, and M. Bryan. 1998. Release, establishment and spread of Asian natural enemies of euonymus scale (Homoptera: Diaspididae) in New England. Florida Entomol. 81:1-9.

Vinson, J. 1959. The genus *Cybocephalus* Erichson in the Mascarene Islands (Coleoptera: Nitidulidae). Proc. R. Soc. London B Biol. Sci. 28: 7-18.

Waterhouse, C. O. 1877. Account of the zoological collection made during the visit of H. M. S. ‘Peterel’ to the Galapagos Islands. In: Günther, Proc. Zool. Soc. London, 77-82.

Weissling, T. J., F. W. Howard, and A. B. Hamon, 1999. Cycad aulacaspis scale, *Aulacaspi yasumatsui* Takagi (Insecta: Homoptera: Sternorrhyncha: Diaspididae. Florida Coop. Ext. Service, IFAS, University of Florida. EENY-096. http://edis.ifas.ufl.edu.

Whitelock, L. M. 2002. The Cycads. Timber Press. Portland, Oregon. 532 pp.

Whiting, M. G. 1963. Toxicity of cycads. Econ. Bot. 17: 271-301.

Williams, J. R., and D. J. Greathead. 1973. The sugarcane scale insect *Aulacaspis tegalensis* (Zhnt.) and its biological control in Mauritius and East Africa. PANS 19: 353-367.

Yu, G. 1994. Three new species of Cybocephalidae (Coleoptera) from China. Zool. Res.15(3): 13-17.

Yu, G. 1995a. Two new species of Cybocephalidae (Coleoptera) from Guangdong, China. Entomotaxonomia 17(1): 31-34.

Yu, G. 1995b. Two new species of Cybocephalidae (Coleoptera) from China. Entomotaxonomia 17(4): 277-280.

Yu, G. and M. Tian. 1995. Notes on the genus *Cybocephalus* Erichson from China (Coleoptera: Cybocephalidae). Entomol. Sinica 2(1): 35-38.

Yu, G. 1995a. Two new species of Cybocephalidae (Coleoptera) from Guangdong, China. Entomotaxonomia 17(1): 31-34.

Yu, G. 1995b. Two new species of Cybocephalidae (Coleoptera) from China. Entomotaxonomia 17(4): 277-280.

Yus, R. 1973. On the presence in the Iberian Peninsula of *Rhyzobius lophanthae* (Blaisdell, 1892) (Col. Coccinellidae). Graellsia 29: 111-115.

Yasuda. S. 1981. Natural enemies of *Pseudaulacaspis pentagona* Targioni (Hemiptera: Diaspididae) and their seasonal prevalence. Jap. J. Appl. Ent. Zool. 25: 236-243.

BIOGRAPHICAL SKETCH

Trevor Randall Smith was born on February 3, 1977, in Tampa, Florida. The son of an avid outdoorsman, his earliest memories are of hunting, fishing, and hiking in the unique ecosystems of Florida. In December 2000, he graduated from the University of Central Florida with a Bachelor of Science degree in biology under the guidance of Stuart Fullerton. Trevor was offered an assistantship to study entomology at the University of Florida in Summer 2001 and worked with Dr. John Capinera. Upon receiving a Master of Science degree in December 2003, Trevor was again offered an assistantship to pursue his Doctor of Philosophy degree at the University of Florida, this time with advisor Dr. Ronald Cave.