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NIPAECOCCUS NIPAE (MASKELL) AND TWO APPARENTLY UNDESCRIBED SIBLING SPECIES (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE).

ABSTRACT

Nipaecoccus nipae (Maskell) and two apparently undescribed sibling species (Hemiptera: Coccoidea: Pseudococcidae).

This paper argues that there are at least two species belonging to the *Nipaecoccus nipae*-species complex in Hawaii, one with white wax and the other with buff wax. These two species differ in a number of features but perhaps the most important is that the encyrtid parasitoid *Pseudaphycus utilis* Timberlake is only known to parasitise the white-wax species. A brief history of the two species (and another in Florida) is outlined, followed by a discussion of the morphological reasons for believing them separate. The problems of nomenclature are then outlined and it is concluded that the buff-wax species is *Nipaecoccus nipae* (Maskell) and that *Nipaecoccus pseudonipae* (Cockerell) is a synonym. The two other species (i.e. the white-wax species from Hawaii and the species from Florida) are then described as *Nipaecoccus paranipae* **n.sp.** and *Nipaecoccus floridensis* **n.sp.** respectively.

Key words: coconut mealybug, neotropics, palms, *Pritchardia*, guava, *Psidium*, bisexual, morphology, nomenclature, types, key, Mexico.

INTRODUCTION

Nipaecoccus nipae (Maskell 1893), called the coconut mealybug in the USA, is a widely distributed species currently known from South America (type locality: Demerara, Guyana), Central America, California, Hawaii, Europe and Asia. It is almost certainly of Neotropical origin, from which region a number of closely related species have been described (Williams & Granara de Willink, 1992). Although these authors considerably increased the number of known species in the genus *Nipaecoccus*, they did not explain satisfactorily the apparent existence of unnamed sibling species that are morphologically very similar to *N. nipae*. Williams & Granara de Willink (1992) mentioned (p. 279) the existence in Hawaii of two "forms" of *N. nipae*: one with largely white external wax and the other with "yellow" wax, but stated that "in life the yellow and white forms are often found together." The implied conclusion is that they are not distinct species. It has been my experience that the two forms do not normally occur together in the field in Hawaii, and for reasons that are given below, they do appear to be distinct

species. In fact, as its wax is a dull yellowish-tan, the "yellow" species is perhaps better described as buff, while often the wax of the "white" species from Mexico and Hawaii is tinged faintly with canary yellow.

It appears, therefore, that *N. nipae*, as presently defined, is a species complex, one species of which has been dispersed widely, and a second of which is presently known from Mexico and Hawaii. In addition, a species previously identified as *N. nipae* in Florida (Merrill, 1953) is here considered to be a third species of that complex, as specimens that I have seen from there are not conspecific with the type. It seems likely that additional closely related but distinct and unnamed species exist in the Neotropical Region.

Short history:

A review of the history of these mealybugs in Hawaii will serve to illustrate this sibling species problem.

According to Zimmerman (1948), a mealybug believed to be *Dactylopius nipae* Maskell, was noted for the first time in Hawaii at Honolulu by R.C.L. Perkins in 1902. How long before that time it had been present there is unknown. Kirkaldy (1904) listed the species as *Trechocorys nipae* (Maskell) and stated that it was the cause of "considerable destruction to alligator pears, guava, etc." Crawford (1921) mentioned that avocado leaves were frequently encrusted with a "smut" fungus (sooty mould) due to the honeydew from this species. During 1922, several coccinellid beetle species and an encyrtid wasp (named *Pseudaphycus utilis* by Timberlake, 1923) were introduced into Hawaii from Mexico to combat this and other pestiferous mealybugs (Osborn, 1938). The encyrtid was reported as having become established in October 1922 (Fullaway, 1923), and later Timberlake (1927) stated that it had achieved "spectacular control" of the mealybug which "had been a bad pest of avocado, fig, mulberry, guava and banyan trees" for many years. Osborn considered the white-wax species to be true *nipae*, although he found the buff-wax species also present in Orizaba, Mexico, where he worked. The latter species also was determined for him as *nipae*, even though the parasitoid would not develop in it.

Some entomologists in Hawaii in the early part of this century also expressed the opinion that more than one species was being confused under the name *Nipaecoccus nipae*. Zimmerman (1948) discussed the problem and stated that "some considered the yellow form, occurring principally on palms, to be *Pseudococcus pseudonipae* (Cockerell) (1897: 302), whereas the white form has been known here as *nipae*." Ferris (1950) also discussed the problem, but concluded that there were no demonstrable differences between the yellowish and the white forms, and treated *pseudonipae* as a junior synonym of *nipae*.

However, biological evidence suggests that there are two species present in Hawaii. Despite Zimmerman's statement (1948) that "Several local observers say that they have not seen white *nipae* in many years", both forms still exist in Hawaii, and I have collected the white species on Oahu and on Molokai on several occasions since about 1960, although it is much less common than the species with buff-coloured wax. In some areas (e.g., Bird Park, Hawaii Volcanoes National Park), the latter has at times been very abundant.

BIOLOGICAL DIFFERENCES

Strong biological evidence for the distinctness of the two "*nipae*-complex" species present in Hawaii is provided by the behaviour of the introduced encyrtid parasitoid *Pseudaphycus utilis*. Wherever I have found the white-wax species, I have reared this parasitoid from the confined mealybugs. However, I have never found any evidence of this or any other parasitoid attacking the buff-wax species. The failure of *P. utilis* to parasitize *N. nipae* in southern California, where apparently only the buff-wax species occurs, also has been noted (Flanders, personal communication).

Zimmerman (1948) stated that the specific name *pseudonipae* was generally applied in Hawaii to the "yellow forms occurring principally on palms", whereas *nipae* was applied to the white forms. When I first became interested in the *nipae*-sibling species problem during the 1960's, I established colonies of both species on potted palms (*Pritchardia* sp.) in the laboratory, and found that both would develop equally well on these palms and on guava (*Psidium guajava*), indicating that the host separation suggested by Zimmerman was untrue. This finding was also supported by host data from field collections.

Both the white- and the buff-wax species in Hawaii are bisexual, and a study of the adult males revealed that there is a consistent difference in the length of the tarsal claws of males from the two populations (Fig. 2). The claws of the buff-wax species are ca. 40μm long, greater than one-half the length of the distal tarsomere. Those of the white-wax species are ca. 32μm long; one-half, or slightly less, as long as the distal tarsomere. Approximately 25 males of each species were examined. This difference, coupled with the difference in the colour of the external wax of the females and the failure of the parasitoid of the white-wax form to develop in the buff-wax form, provides strong evidence that these two forms represent two distinct species.

Other minor morphological differences that were noted in both sexes of these two forms in Hawaii include apparent differences in the structure of the external wax coverings and the distribution of the multilocular disc-pores on the females, but these may prove not to be significant characters when populations from other areas are studied.

NOMENCLATURE

The problem of the proper application of the names *Dactylopius nipae* Maskell and *Dactylopius pseudonipae* Cockerell required the examination of the appropriate type material for resolution. In 1974, I arranged the loan of Maskell's unmounted type-lot material of *D. nipae* from the collection of the DSIRO, Auckland, New Zealand. This material, from nipa palm, included a few mealybugs and, from these, it was possible to determine that the colour of the external wax covering was apparently buff (yellowish). Furthermore, the length of the tarsal claw on a somewhat fragmentary adult male also matched that of the males associated with the buff-wax species in Hawaii. I therefore concluded that the name *Dactylopius nipae* Maskell should be applied to the buff-wax species present in Hawaii and southern California, and probably also to other buff-wax populations outside of tropical America, although males of these are unknown to me.

The possibility that *D. pseudonipae* Cockerell might be a valid species in this complex necessitated an examination of the type material of that species. Cockerell's (1896) brief, unillustrated description of *pseudonipae* did not specify a type locality, but he did state that originally he saw specimens from a "Michigan hothouse" which he at first assigned to *nipae*, but later, after receipt of additional specimens from California, he changed his mind and named it as a new species, *pseudonipae*. Ferris (1950), after consulting with Harold Morrison (who stated that specimens collected in a California greenhouse and sent to Cockerell by Alexander Craw "do not exist in the National Collection and specimens from another source have been erroneously indicated as the types"), apparently assumed that California was the type locality. However, the "specimens from another source" that Morrison referred to are in fact labelled "*Dact. pseudonipae* / Palm. / Agr. College Mich. / July 30 '94 / (Davis)" and "Type." The label originally read "*Dact. nipae*", but someone, in the same handwriting (?Cockerell) inserted "*pseudo-*" above the line. This suggests to me that these slides contain the original Michigan hothouse material that Cockerell first identified as *nipae* but

which he later changed to *pseudonipae* and are, therefore, the true cotypes of *D. pseudonipae* Cockerell. Eight female specimens on three slides that were part of this material were remounted, one specimen to a slide. One specimen was designated as a lectotype and the remainder paralectotypes of *Dactylopius pseudonipae* Cockerell. The slides, except one paralectotype retained by the writer, were returned to the U.S. National Collection.

On the basis of the described wax colour and female morphology (Cockerell's material included no males), these specimens appear to be conspecific with *D. nipae* Maskell, and Ferris's placement of *D. pseudonipae* as a junior synonym of *D. nipae* appears to be valid.

Although I am not entirely satisfied with the extent of the data available, I doubt that I will be able to do further work on the resolution of the *N. nipae* species complex, and wish to place on record the information that I now possess. I believe that, in the future, the application of molecular techniques will confirm the existence of a complex of sibling species, but I do not possess the resources needed to accomplish this.

TENTATIVE KEY TO SOME SPECIES OF THE *NIPAECOCCUS NIPAE* COMPLEX

1. Female with ca. 100 or more multilocular disc-pores; conical setae on all abdominal cerarii relatively close together, their bases separated by less than a seta length; circulus relatively large, ca. 125µm long, more or less dumb-bell shaped; Florida. ..... *floridensis* n. sp.

- Female with 10-50 multilocular disc-pores; conical setae on anterior abdominal cerarii relatively widely separated, the distance between their bases greater than the length of one seta; circulus smaller, usually less than 80µm long, usually circular or nearly so 2

2. Adult male with middle and hind tarsal claws ca. 40µm long; adult female with buff-coloured external wax; widespread.....*nipae* (Maskell)

- Adult male with middle and hind tarsal claws ca. 32µm long; adult female with largely white external wax; Mexico, Hawaii .....*paranipae* n. sp.

Note: although *N. floridensis* runs to *N. nipae* in the key of Williams & Granara de Willink, it appears to differ markedly from the other species here placed in the *nipae*-complex, and may not be very closely related to true *nipae*.

DESCRIPTIONS

Nipaecoccus floridensis Beardsley, n. sp. (Fig. l).

ADULT FEMALE.

Mounted material: oval; ca. 1.4mm long; anal lobes moderately well developed, each with an apical seta ca. 160µm long. Antenna ca. 270-280µm long, 7-segmented. Legs well developed, hind trochanter + femur ca. 200µm long; hind tibia + tarsus ca 200µm long; hind tarsal claw ca. 25µm long. Hind coxa with numerous, fairly large translucent micropores, these absent on all other segments. Labium ca. 105µm long; distinctly shorter than clypeo-labial shield. Circulus conspicuous, about 110-120µm long by 110-115µm maximum width, constricted medially at intersegmental boundary, unsclerotized. Two pairs of dorsal ostioles present, rims not sclerotized. Anal ring ca. 70-75µm wide, with 6 ring setae 80-100µm long.

Anal lobe cerarii each with 2 conical setae ca. 20-26µm long, several auxillary setae, a few trilocular pores and 1-3 circular discoidal pores slightly larger than triloculars, on margin of a irregular sclerotized area that extends onto venter but is confined to apical part of lobe. Anterior abdominal cerarii each with 2 or 3 conical setae, often as long as anal lobe pair or nearly so, with bases separated by less than length of one seta; plus a few trilocular pores; usually with a few auxillary setae; surrounding derm unsclerotized. Metathoracic cerarii similar, with 2 or 3 conical setae; but anterior cerarii represented by more or less irregularly scattered marginal conical setae. Interantennal cerarii fairly well-defined, each containing a loose group of 4 or 5 conical setae.

Dorsal surface of most abdominal segments each with a transverse mesal row of 3 conical setae of variable size, mostly ca. 15-20µm long, a few such setae scattered on dorsum of head and thorax; small, spiniform setae, 10-14µm long, scattered sparsely on dorsum. Trilocular pores scattered evenly over dorsum; no dorsal ducts discernible.

Venter of abdominal segments behind circulus with 100 or more multilocular disc-pores, arranged in bands near posterior segment margins as illustrated; no such disc-pores noted anterior to circulus, on lateral margins or on dorsum. Ventral setae sparsely scattered, slender, more elongate than dorsal setae, up to ca. 30µm long on head and around vulva. Trilocular pores sparsely scattered on venter; 20-30 very small tubular ducts, without discernible rims or collars, present on venter between legs; small discoidal pores, most slightly larger than triloculars, very sparsely scattered on venter.

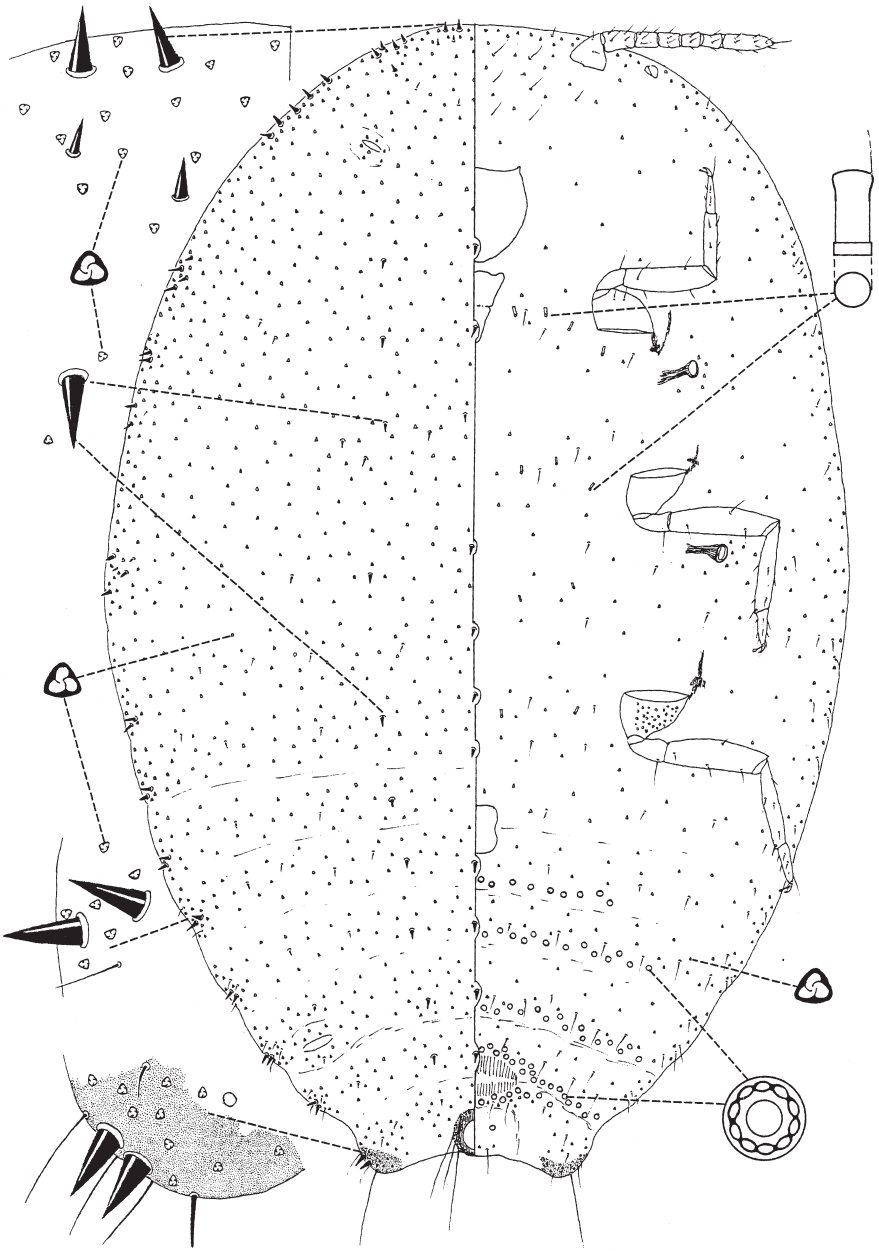

Figure l. *Nipaecoccus floridensis* **n.sp**., dorsal and ventral aspects and details.

Material examined: Holotype ♀ and allotype ♂ on one slide: Florida, Daytona Beach, 20.IV.1967, John N. Pott, coll., on *Acoelorrhaphe wrightii* (saw palmetto) (Palmae) (USNM). One ♀ paratype and one ♂ paratype on one slide: data as holotype (USNM).

Remarks: Females of *N. floridensis* run to *N. nipae* in all available keys, including that of Williams & Granara de Willink (1992). It differs from *N. nipae* in possessing: (i) a much larger number of ventral multilocular disc-pores, (ii) a larger circulus, and (iii) the conical setae of the abdominal cerarii all with their bases relatively close together.

Adult males associated with the females described above have relatively short tarsal claws, ca. 32µm long, and are similar to *N. paranipae* n. sp. from Hawaii.

I have not seen *in situ* material of this species, and do not know the colour or form of the external wax covering.

Nipaecoccus paranipae Beardsley, ***n. sp.*** (Fig. 2).

ADULT FEMALE.

Mounted material: virtually identical to females of *N. nipae*, except in distribution of ventral multilocular disc-pores, with at least 2 to 4 such disc-pores present near posterior margin of abdominal segment IV (segment bearing posterior half of circulus) (multilocular disc-pores are usually absent on this segment on *N. nipae*, although a few specimens have one or two).

Adult male mounted on microscope slide very similar to that of *N. nipae*, but with tarsal claws ca. 32µm long (vs. ca. 40µm long in *N. nipae*).

Material examined: holotype ♀, allotype ♂ and paratype ♂ on one slide: Hawaiian Is., Oahu I., Punahou, Honolulu, 31.iii,1966, S. H. Au, coll., on *Areca* sp., prob. *lutescens* (Palmae) (USNM). Twenty ♀♀ and 30 ♂♂ paratypes mounted on 11 slides: data as holotype (USNM; Bishop Museum, Honolulu).

Remarks: the slide-mounted females of *N. nipae* and *N. paranipae* are almost indistinguishable, and the slight difference in the distribution of the multilocular disc-pores noted in Hawaiian populations may not hold when additional extra-Hawaiian populations are studied. In the field, the two species are easily recognized by the colour of the external wax covering, as discussed previously. The obvious difference in the lengths of the tarsal claws of the adult males appears to be the best morphological character available to separate slide-mounted specimens of these two species.

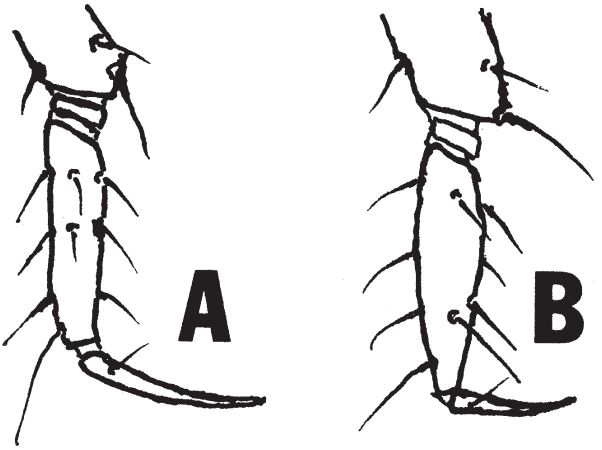

Figure 2. Middle tarsus and tarsal claw of adult male: A, *Nipaecoccus nipae* (Maskell) (specimen from San Diego, California); B, *Nipaecoccus paranipae* **n.sp**. (specimen from Honolulu, Hawaii).

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