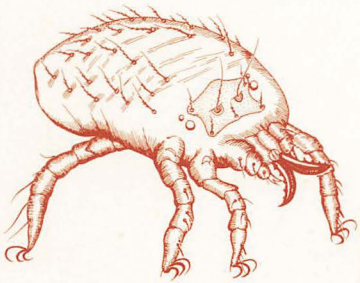
# Ectoparasites of Hawaiian Rodents



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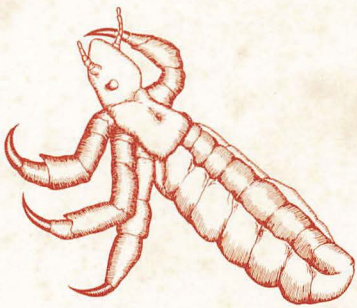

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# ECTOPARASITES OF HAWAIIAN RODENTS (SIPHONAPTERA, ANOPLURA AND ACARI)[1]

By **JoAnn M. Tenorio and M. Lee Goff**[2]

*Abstract.* Summary accounts, including host and distributional information, are provided for the ectoparasites of rodents in the Hawaiian Islands. Simplified keys illustrated with line drawings and photomicrographs are provided for identification of the 6 species of fleas (Siphonaptera), 2 species of sucking lice (Anoplura), and 14 species of ectoparasitic mites (Acari). Also presented are new host and geographic records within the Islands, including the first published records of rodent ectoparasites from Kaho'olawe Island.

The 4 species of rodents presently occurring in the Hawaiian Islands are *Rattus rattus* (Roof Rat or Black Rat), *R. norvegicus* (Norway Rat), *Rattus exulans hawaiiensis* (Polynesian Rat) and *Mus musculus* (House Mouse). The Polynesian Rat is thought to have arrived in Hawai'i with the early Polynesian colonizers, either as an accidental stowaway aboard their vessels or as an intentional introduction by the ancient Hawaiians for sport hunting with bows and arrows (Tomich 1969). The other 3 rodent species are of European or American stock and are widespread, commensal rodents introduced since the time of Captain Cook. Tomich (1969) provides an excellent synopsis and annotated bibliography of rodents and other mammals in Hawai'i.

Six species of fleas, 2 species of sucking lice, and 14 species of parasitic mites have been recorded and confirmed from Hawaiian rodents. Several other mite species that are normally predacious or associated with nests of rodents are frequently found on the bodies of rodents in Hawai'i. The purpose of this paper is to provide illustrated taxonomic keys for the identification of these species, as well as brief accounts on the hosts, distribution, and ecology of each species in the Hawaiian Islands. The keys are simplified and provided with references to figures to allow use by persons without specialized training in the systematics of these groups. Some parasites will require proper preparation to observe characters used in the keys. With practice, many of these rodent associates can be identified in alcohol without slide-mounting. The taxonomic keys should be viewed as aides in identifying the arthropod species; definitive identifications must be made by carefully checking reliably identified reference specimens, by referring to original or revised descriptions and illustrations, or by consulting with a specialist.

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TABLE 1. Distribution of Hawaiian rodent ectoparasites.*

| | Islands | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kure | Midway | Kaua'i | O'ahu | Mānana | Popoi'a | Moloka'i | Lāna'i | Maui | Kaho'olawe | Hawai'i |
| Fleas | | | | | | | | | | | |
| *Nosopsyllus fasciatus* | | | | X | | | | | X | | X |
| *Ctenocephalides felis felis* | | | X | X | X | | X | X | X | | X |
| *Leptopsylla segnis* | | | X | X | | | | | X | | X |
| *Echnidophaga gallinacea* | | | X | X | X | | X | | X | | X |
| *Xenopsylla cheopis* | | | X | X | X | | | | X | X* | X |
| *X. vexabilis* | | | X | X | | | | | X | | X |
| Lice | | | | | | | | | | | |
| *Hoplopleura pacifica* | X* | | | X | | X | | | X* | | X |
| *Polyplax spinulosa* | | X* | | X | | | | | X* | | X |
| Mites | | | | | | | | | | | |
| Actinedida | | | | | | | | | | | |
| *Neotrombicula megensi* | | X | | | | | | | | | |
| *Cheyletus eruditus*† | | | | ? | | | | | | | X* |
| *Paraspeleognathopsis bakeri* | | | | | | | | | | | X |
| *Speleorodeus derricki* | | | | | | | | | | | X |
| *Myobia musculi* | | X | | X | | | | | | X* | X |
| *Radfordia affinis* | | X | | X | | | | | | X* | X |
| *R. ensifera* | | X | | X | | | | | X* | | X |
| Acaridida | | | | | | | | | | | |
| *Myocoptes musculinus* | | X | | X | | | | | | X* | X |
| *Listrophoroides cucullatus* | | X | | X | | | | | | | X |
| *Afrolistrophorus musculus* | | X | | X | X | | | | | X* | X |
| Gamasida | | | | | | | | | | | |
| *Eulaelaps stabularis* | | | | | | | | | | | X |
| *Laelaps echidninus* | X* | X | X | X | | | | | X | | X |
| *L. nuttalli* | X* | | | X | | X | | | X | | X |
| *Androlaelaps hermaphrodita*† | | X* | | X | | | | | | X* | X* |
| *Echinonyssus butantanensis* | | | | | | | | | | | X |
| *Ornithonyssus bacoti* | | X | | X | X* | | | | | X* | X |

* New records are marked with an asterisk.
† Rodent associates not normally considered parasitic.

Several ecological studies of rodents and their ectoparasites have been carried out in Hawai'i [e.g., Cole & Koepke 1947 (mixed ectoparasites); Mitchell 1964a, b (mites); Haas 1965 (fleas)]. The most recent, and the first to concentrate on multiple habitats, was a 2-year study (October 1971 to September 1973) on the southeastern slope of Mauna Loa, Hawai'i, by Radovsky et al. (1979). That study was conducted along an altitudinal transect (840–2440 m) covering a broad range of vegetational

and climatic factors. Three of the 4 rodents present in Hawai'i were taken; *R. norvegicus* was not collected. Since the initial report on results of that project, further analyses of data have been carried out. Additional findings are presented here for the first time; to distinguish these from results already reported by Radovsky et al. (1979) and to indicate that the data derive from that project, these results are marked "Radovsky & Tenorio, unpubl." Other perspectives will appear in a forthcoming volume by Radovsky & Tenorio.

Recent surveys of rodent ectoparasites made on the island of Kaho'olawe represent the first collections of any parasites on that island. These are recorded here for the first time. Kaho'olawe is an arid island approximately 19 km by 10 km with a maximum elevation of 460 m. Prior to World War II, marginally successful attempts were made to establish sheep and cattle ranches on the island. With the advent of World War II, the island was converted to a target island for military bombing practice and this use has continued to the present. As a result of this bombing, vegetation is primarily restricted to the region immediately adjacent to the coastline and to gullies in the central portion of the island. Higher central portions of the island are completely denuded. Dominant vegetation consists of introduced kiawe (*Prosopis* sp.) and pili grass (*Heteropogon* sp.). No permanent water supply exists on the island and, due to the lack of vegetation and the nature of the soil, rainfall quickly drains to the ocean. In addition to feral cats and goats, Tomich (1969) listed 3 species of rodents from Kaho'olawe: *Rattus rattus, R. exulans* and *Mus musculus.* Rodent trapping was carried out by the junior author during November 1979 and February 1980 at 3 locations on the island: Beck's Cove, Hakioawa Point, and Smuggler's Cove. Only *M. musculus* was taken. Mice were quite numerous in 2 of the areas sampled, Hakioawa Point and Smuggler's Cove, and were observed foraging during the day. Populations at Beck's Cove were considerably lower. Ant activity at all 3 localities was high and any mice remaining in snap traps longer than 10 min following capture were destroyed. In several instances, ants, *Pheidole megacephala,* were observed feeding on live mice caught by the foot in traps. This high level of ant activity precluded any quantitative analysis of the ectoparasites reported from mice collected on Kaho'olawe.

Hosts recorded in species accounts are those known for the Hawaiian Islands. TABLE 1 gives the distribution of Hawaiian rodent ectoparasites and new island records. Discussions of parasites are in order of appearance in the keys. Photographs were taken using a Zeiss Normarski Differential Interference Contrast Microscope and Kodak Plus-X pan film.

## FLEAS (SIPHONAPTERA)

For a comprehensive review of the fleas known to occur in the Hawaiian Islands, refer to Haas et al. (1972). All the fleas treated here are introduced and are cosmopolitan or tropicopolitan.

### KEYS TO FLEAS ON HAWAIIAN RODENTS (♂ AND ♀)

1. Either pronotal comb (FIG. 3B) or both pronotal and genal combs present (FIG. 1, 2) ..... 2
   Neither pronotal nor genal comb present (FIG. 3A, 4B) ..... 4

2(1). Both pronotal and genal combs present ..... 3
Only pronotal comb present (FIG. 3B); ♂ penis rod long and coiled (FIG. 3D); ♀ spermatheca with hilla curled back over bulga (FIG. 3C) .. **Nosopsyllus fasciatus**

3(2). Eyes well developed; front margin of head without spiniform setae (FIG. 2A) ... ..... **Ctenocephalides felis felis**
Eyes apparently absent; 2 heavy spiniform setae on front margin of head (FIG. 2C) ..... **Leptopsylla segnis**

4(1). Anterior margin of head angular; combined length of thoracic terga shorter than 1st abdominal tergum (FIG. 3A) ..... **Echidnophaga gallinacea**
Anterior margin of head evenly rounded (FIG. 4B); combined thoracic terga longer than 1st abdominal tergum (FIG. 4A) ..... 5

5(4). ♀ spermatheca with base of hilla approximately on same line as lower margin of bulga (FIG. 5C, 6C); ♂ sternum IX (FIG. 5D, 6D) relatively straight, broad apically; process 1 (FIG. 5D) of ♂ clasper broad ..... **Xenopsylla cheopis**
♀ spermatheca with base of hilla extending well below level of lower margin of bulga (FIG. 5A, 6A); ♂ sternum IX curved, narrow apically (FIG. 5B, 6B); process 1 of ♂ clasper narrower (FIG. 5B) ..... **Xenopsylla vexabilis**

**Nosopsyllus fasciatus** (Bosc, 1800) northern rat flea FIG. 3B–D

*Distribution.* O'ahu, Maui, Hawai'i.

*Hosts. Mus musculus, R. exulans, R. novegicus, R. rattus, Herpestes auropunctatus* (Small Indian Mongoose).

The northern rat flea was first recorded from Hawai'i by Eskey in 1934. This flea is considered unimportant in the natural transmission of human plague but is a suspected vector of the rickettsia of murine typhus to man.

**Ctenocephalides felis felis** (Bouché, 1835) cat flea FIG. 1, 2A–B

*Distribution.* Kaua'i, O'ahu, Mānana, Moloka'i, Lāna'i, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus,* as well as cat, dog, *Herpestes auropunctatus,* domestic cattle, rabbit and man.

The cat flea was first recorded from Hawai'i on Hawai'i I by McCoy & Bowman in 1914. Early records by McCoy & Bowman in 1914 of the dog flea [*C. canis* (Curtis)] from rodents on Hawai'i I have not been confirmed (Haas et al. 1972) and it is possible that these may have resulted from misidentification of the cat flea. *C. f. felis* and *C. canis* may be separated by the shape of the head (short and rounded in *C. canis,* elongated and sloping in *C. felis*) and the 1st spine of the genal comb (about ½ as long as 2nd in *C. canis,* only slightly shorter than 2nd in *C. felis*).

*C. felis* is the most common flea found on dogs in Hawai'i. *C. canis* is only rarely taken on dogs, though the flea has undoubtedly been introduced repeatedly on imported dogs. Haas et al. (1972) questioned whether *C. canis* would be able to maintain a resident population in the lowlands of the Hawaiian Islands, since it is not a tropical or subtropical flea. They were able to confirm only 1 population locus, namely Humu'ula, Hawai'i I (elevation above 2000 m).

**Leptopsylla segnis** (Schonherr, 1811) mouse flea FIG. 2C–D

*Distribution.* Kaua'i, O'ahu, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus, Herpestes auropunctatus.*

The mouse flea was first recorded from Hawai'i by Ewing (1924a) from mice and rats on Hawai'i I. *M. musculus* is normally considered the primary host. Radovsky & Tenorio (unpubl.) found *L. segnis* on Hawai'i I to occur with moderate to high incidence on *R. exulans* and *R. rattus,* both at sample sites where *M. musculus* was abundant and at sites where mice were rare.

*L. segnis* rarely bites man and its role in human plague outbreaks is negligible.

**Echidnophaga gallinacea** (Westwood, 1875) sticktight flea FIG. 3A

*Distribution.* Kaua'i, O'ahu, Mānana, Moloka'i, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus, Herpestes auropunctatus,* rabbit, pig, Nēnē (*Branta sandvicensis*), domestic chicken, House Sparrow and California Quail.

The sticktight flea was first recorded in Hawai'i by Illingworth in 1915 from O'ahu and was probably introduced on poultry from California (Haas et al. 1972). Though birds are usually considered primary hosts, this species also parasitizes many mammals.

**Xenopsylla cheopis** (Rothschild, 1903) Oriental rat flea FIG. 4A, 5C–D, 6C–D

*Distribution.* Kaua'i, O'ahu, Mānana, Maui, Kaho'olawe, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus.* Rarely taken on *Herpestes auropunctatus,* rabbit and dog.

First recorded from rodents on Hawai'i I by McCoy & Bowman in 1914, this flea probably arrived on *R. norvegicus* and *R. rattus* escaping from ocean vessels in 1899 and the early 1900's (Haas et al. 1972).

*X. cheopis* was very abundant on mice trapped in the recent survey of Kaho'olawe and was, in fact, the only flea recovered. Ths species reportedly thrives in extremely arid areas, from which *X. vexabilis* is precluded (Haas et al. 1972).

The Oriental rat flea is considered to be the principal vector of plague in the Old World. Though this disease was present in the Hawaiian Islands, with human cases during the 1st half of the 1900's, there have been no isolations of the plague organism from rodents or any other hosts since the late 1950's.

**Xenopsylla vexabilis** Jordan, 1925 Australian rat flea (Hawaiian rat flea) FIG. 4B, 5A–B, 6A–B

*Distribution.* Kaua'i, O'ahu, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus, Herpestes auropunctatus.*

*X. vexabilis* was probably the only flea present in the Hawaiian Islands in pre-Cook times, arriving on Polynesian sailing vessels on *R. exulans* (Haas et al. 1972). Owing to its external similarity to *X. cheopis,* it was misidentified in the early Hawaiian collections as that species.

In collections on Hawai'i I reported by Radovsky et al. (1979), only 6 specimens of *X. vexabilis* were taken in the 2-year period (Radovsky & Tenorio, unpubl.). All

were at the Kīpuka Nēnē site, a relatively dry open forest and grassland at 870 m. Hosts were *R. rattus, R. exulans,* and *Herpestes auropunctatus.*

Kartman et al. (1956) determined experimentally that *X. vexabilis* was about ½ as efficient as *X. cheopis* in transmission of plague. However, because it is a vector of plague among rats and because of its abundance in the field on *R. exulans,* this species was likely responsible for maintenance of plague along the Hāmākua Coast on Hawai'i I.

**Pulex irritans** Linnaeus, 1758 human flea

This flea was first recorded in Hawai'i by Bryan in 1915, though confirmed collections were not reported until later. Most confirmed records have been from dogs, which are the primary hosts of this flea. Eskey, in 1934, was the first to record the human flea from rats and a mongoose, but Haas et al. (1972) questioned these records because of lack of confirmatory specimens.

Of hundreds of specimens of *P. irritans* in the Bishop Museum collection, all are from the dog. In extensive collections made from rodents on Mauna Loa, Hawai'i I, from elevations 840 m to 2440 m and also at lower elevations, the human flea was never collected on the House Mouse or any of the 3 species of *Rattus* (Radovsky & Tenorio, unpubl.).

## Sucking lice (Anoplura)

Only 2 species of sucking lice have been recorded from rodents in Hawai'i. These may be readily distinguished in alcohol on the basis of gross characters. Nymphs are easily separated by their body shapes. Adults are similar in size and shape, but in *Hoplopleura,* the large lateral plates are darkened and prominent, the ventral and dorsal abdominal plates appear as narrow bands and the abdominal setae are very conspicuous; in *Polyplax,* the lateral plates are inconspicuous, the coloring is rather monochromatic and the abdominal setae blend in with the body and are difficult to pick out.

### Key to sucking lice on Hawaiian rodents

1. Adults (Fig. 7A, C) ..... 2
   Nymphs (Fig. 7B, D) ..... 3

2(1). 2nd abdominal ventral plate (sternite) with a lateral extension on each side that articulates with ventral (paratergal) plates (Fig. 8B); lateral plates large, emarginate posteriorly (Fig. 7C, 8B); dorsal and ventral plates of abdomen long and narrow (Fig. 8B) ..... **Hoplopleura pacifica**
   2nd abdominal ventral plate not as above (Fig. 8A); lateral plates smaller, subtriangular (Fig. 7A, 8A); dorsal and ventral plates of abdomen much wider (Fig. 8A) ..... **Polyplax spinulosa**

3(1). Abdomen heart-shaped; spiracles absent; abdomen without longitudinal rows of setae down center (Fig. 7D) ..... **Hoplopleura pacifica**
   Abdomen not heart-shaped, longer and more slender; spiracles present on lateral portions of abdomen; center of abdomen both dorsally and ventrally with 2 longitudinal, parallel rows of setae (Fig. 7B) ..... **Polyplax spinulosa**

**Hoplopleura pacifica** Ewing, 1924 tropical rat louse FIG. 7C–D, 8B

*Distribution.* Kure, O'ahu, Popoi'a, Maui, Hawai'i.

*Hosts. R. exulans, R. rattus.*

This louse was described by Ewing (1924b) from material from Popoi'a Islet ex *Rattus exulans* (=*R. hawaiiensis*). Because the original description did not provide characters to distinguish it from *H. oenomydis,* confusion ensued for years regarding the identity of *H. pacifica.* Following the synonymy by Ferris (1932) of *H. pacifica* with *H. oenomydis,* many authors reported this louse under the latter name. Johnson (1964, 1972) reviewed the history of the 2 names, pointed out morphological differences in adults and nymphs, and asserted that *pacifica* is a valid name. A lectotype from Ewing's cotype series in the Bishop Museum was designated and illustrated by Voss (1966).

*H. pacifica* is found on *R. exulans* in Asia and the Pacific Islands, and this rat is thought to be the primary host (Johnson 1972); in parts of the tropics and subtropics this louse also parasitizes *R. rattus* and *R. norvegicus.*

Mitchell (1964a) reported this louse from pooled hosts of the 3 *Rattus* spp. on O'ahu. Collections in Bishop Museum include specimens from O'ahu (ex *R. exulans, R. rattus*), Maui (Waiho'i and Kīpahulu Valleys: ex *R. exulans, R. rattus*) and Kure (ex *R. exulans*). In extensive collections from Hawai'i I, Radovsky & Tenorio (unpubl.) found *H. pacifica* to be generally restricted to *R. exulans,* occurring on 81% of *R. exulans* examined, with a mean of 37.8 lice per infested host. Cole & Koepke (1947) and Mitchell (1964a) also recorded this louse from rodents on O'ahu, but lice were not identified from specific rodent species. Collections in the Bishop Museum do not include specimens from *R. norvegicus.*

**Polyplax spinulosa** (Burmeister, 1839) spined rat louse FIG. 7A–B, 8A

*Distribution.* Midway, O'ahu, Maui, Hawai'i.

*Hosts. R. exulans, R. rattus, R. norvegicus.*

Zimmerman (1944) was the first to report this louse in Hawai'i, from "rats" in Honolulu. *P. spinulosa* was reported by Cole & Koepke (1947) on O'ahu on the 3 *Rattus* species, though apparently the louse was rare on *R. exulans.* The Bishop Museum collection includes specimens from Midway (*R. rattus*), and Maui and Hawai'i I (*R. exulans, R. rattus*).

Johnson (1964) stated that *R. rattus* and *R. norvegicus* are primary hosts of this cosmopolitan species and indicated a report of the spined rat louse from *R. exulans* in the Philippines. Both *R. exulans* and *R. rattus* on Hawai'i I were found infested to a considerable, approximately equal, extent (ca 69%) (Radovsky & Tenorio, unpubl.). A few specimens were taken on a relatively few mice in the same study and are thought to be the result of contamination or chance transfer from rats.

## MITES (ACARI)

The following section includes those mites parasitic on rodents or found frequently enough on the bodies of rodents to justify their inclusion. Many free-living species, predators, and nest associates (nidicoles) are occasionally found on rodents. Rodents that have been left dead in traps for long periods may be overrun by ants and other soil and litter inhabitants, such as Collembola (springtails) and Oribatida

(Cryptostigmata). Other postmortem or chance contaminants often recovered in rodent washing procedures include predatory mites such as the Ascidae, Rhodacaridae, Parasitidae, and Macrochelidae. Some nidicolous species are facultative ectoparasites, capable of feeding on blood from skin abrasions, tissue fluids, dead arthropods or other organic material. *Androlaelaps* and *Hypoaspis* in the family Laelapidae have nidicolous habits and are occasionally encountered in the pelage of rodents in Hawai'i, as are *Pseudoparasitus* and *Ololaelaps* in the same family. While these mites are generally considered to be nonparasitic, some *Androlaelaps* may penetrate the intact skin of young rodents to obtain blood. Among the nidicolous laelapids in Hawai'i, only *Androlaelaps hermaphrodita* is included in the key below. Although *Hypoaspis* spp. are not included in the key, the following species are worth noting here. *Hypoaspis miles* (Berlese) (=*Stratiolaelaps gurabensis*) (see Garrett & Haramoto 1967) and *Hypoaspis nidicorva* Evans & Till (FIG. 19D) (see Radovsky & Tenorio 1974) have been reported from Hawaiian rodents, but neither occurs frequently in collections of these animals, although *H. nidicorva* was found on 8.7% of *R. rattus* in the cool, wet Kīlauea Forest Reserve on Hawai'i I (Radovsky et al. 1979). *Hypoaspis sardoa* (Berlese) was reported for the first time from the Hawaiian Islands by Radovsky et al. (1979), who found it of relatively high incidence (ca 21%) on *R. rattus* but rare on *R. exulans* and *Mus musculus* in their Hawai'i I study (note: later recheck of analyses revealed incidence on *R. exulans* not to be "about the same rate" as on *R. rattus,* as reported by Radovsky et al., but rather only about 2.7% on *R. exulans*—unpubl. records).

Hypopodes (FIG. 17C) of the Acaridida are sometimes found in rodent washings and were particularly abundant in Kaho'olawe I mouse collections reported in this paper. These small to tiny ovoid mites represent the 2nd nymphal stage, which secures rides on passing animals by attaching with ventral suckers or claspers. Hypopodes are primarily phoretic and lack functional mouthparts.

The reader should refer to Garrett & Haramoto (1967) for references to the early Hawaiian literature that are cited below but not included in the Selected References.

## KEY TO MITES COMMONLY ASSOCIATED WITH RODENTS IN THE HAWAIIAN ISLANDS, BASED PRIMARILY UPON ♀

1. Body generally oval, well sclerotized, with discrete dorsal and ventral plates; with lateral stigmata, usually associated with elongated peritremes; tritosternum present (FIG. 9) . . . Gamasida (Mesostigmata) ..... 11
   Body generally more weakly sclerotized, with or without plates; without lateral stigmata and peritremes, tritosternum absent ..... 2
2(1). Empodia of legs II–III padlike (FIG. 14A), rayed (FIG. 10D), clawlike (FIG. 12) or apparently absent (FIG. 10A, B); stigmata present, opening on or near gnathosoma (if stigmata absent, with only 3 pairs of legs, family Trombiculidae); palpi with 3–5 free segments; coxal apodemes not obvious . . . Actinedida (Prostigmata) ..... 3
   Empodia suckerlike (FIG. 10C); stigmata absent; palpi with 2 free segments; coxal apodemes strongly sclerotized (FIG. 11A) . . . Acaridida (Astigmata) .. 9

3(2). Three pairs of legs; body broadly oval in shape; stigmata absent; with a single anterodorsal plate (FIG. 12) . . . Trombiculidae . . . . . **Neotrombicula megensi**
Four pairs of legs; body more elongate; stigmata present; plates absent or, if present, with more than 1 plate . . . . . 4

4(3). 1st pair of legs shortened and thickened (FIG. 16A–C), modified for clasping hair of host; soft-bodied, without plates . . . Myobiidae . . . . . 7
All legs of similar structure . . . . . 5

5(4). Palpi modified for grasping prey, with large distal claws and comblike or sicklelike setae (FIG. 13); legs lacking netlike ornamentation . . . . **Cheyletus eruditus**
Palpi not as above, claws and comblike or sicklelike setae absent; legs with netlike ornamentation (FIG. 14A); in nasal passages . . . . . 6

6(4). Sensilla with short setules and a few subterminal elongate setules (FIG. 14C) . . . . . **Paraspeleognathopsis bakeri**
Sensilla with only short setules (FIG. 14B) . . . . . **Speleorodeus derricki**

7(4). Tarsus II with 2 claws (FIG. 10B) . . . . . 8
Tarsus II with 1 claw (FIG. 10A) . . . . . **Myobia musculi**

8(7). Setae on posterior portion of dorsum not broader than remainder of setae (FIG. 15B) . . . . . **Radfordia affinis**
Three pairs of setae on posterior of dorsum much expanded, foliate (FIG. 15A) . . . . . **Radfordia ensifera**

9(2). Legs III and IV thickened, highly modified for clasping host hairs; body more oval in shape (FIG. 16D) . . . . . **Myocoptes musculinus**
Legs III and IV not modified as above; body more elongate in shape (FIG. 17D, E) . . . . . 10

10(9). Body flattened dorsoventrally; legs I and II modified; body with 3 dorsal plates separated only by a narrow furrow, covering whole width and nearly whole length of body (FIG. 17E) . . . . . **Listrophoroides cucullatus**
Body cylindrical, cigar-shaped; legs I–IV all of similar form; body with 2 distinct dorsal plates (prodorsal and propodosomal plates fused); body extensively transversely striated between plates (FIG. 17D) . . . . . **Afrolistrophorus musculus**

11(1). Very large, heavily sclerotized mites, about 1 mm long; genital plate broadly expanded behind coxae IV, separated from anal plate by thin strip of integument . . . . . 12
Smaller mites, not so heavily sclerotized; ventral plates not as above . . . . . 13

12(11). Metapodal plates large, triangular; genital plate with about 50 setae; posterior margin of genital plate and anterior margin of anal plate straight (FIG. 18C) . . . . . **Eulaelaps stabularis**
Metapodal plates small; genital plate with 4 pairs of setae; posterior margin of genital plate concave, fitting closely around convex anterior margin of anal plate (FIG. 18A) . . . . . **Laelaps echidninus**

13(11). Elongate oval mites; genital plate with 1 pair of setae; coxae without spinose setae . . . . . 14
Broadly oval mites; genital plate with 4 pairs of setae; coxae with spinose setae (FIG. 9, 18B) . . . . . **Laelaps nuttalli**

14(13). Spinelike setae present ventrally on femur, genu and tibia of leg II (FIG. 11B); sternal plate about as long as wide (FIG. 18D); chelae with several well-developed teeth (chelate-dentate) . . . . . **Androlaelaps hermaphrodita**
Leg II lacking spinelike setae; sternal plate much wider than long; chelae without teeth (edentate) . . . . . 15

15(14). Coxae II and III each with a strong, acute, backwards-directed spur ventrally (FIG. 11C); genital plate broadly rounded on posterior margin, tongue-shaped (FIG. 19C) ..... **Echinonyssus butantanensis**
Coxae without spurs; genital plate strongly tapering posteriorly, more or less pointed posteriorly (FIG. 19B) ..... **Ornithonyssus bacoti**

## ACTINEDIDA (PROSTIGMATA)

### TROMBICULIDAE

**Neotrombicula megensi** Goff, 1975 FIG. 12

*Distribution.* Midway.
*Hosts. R. rattus.*
This chigger was described from 3 larvae ex *R. rattus* on Eastern I, Midway Is. It is known only from the type collection.

### CHEYLETIDAE

**Cheyletus eruditus** (Schrank, 1781) FIG. 10D, 13, 17A, B

*Distribution.* O'ahu (?), Hawai'i.
*Hosts. R. rattus.*
Cheyletid mites are frequently recovered from birds and mammals, where they exist as predators of ectoparasitic arthropods sharing the same habitat. All specimens of *C. eruditus* examined from Hawai'i were from *R. rattus* collected on the island of Hawai'i in the Kīlauea Forest Reserve. Examination of specimens collected from litter on O'ahu and the nest of an 'I'iwi, *Vestiaria coccinea,* on Kaua'i, which had previously been identified as *C. eruditus,* revealed that these specimens represented another, closely related undescribed species. Specimens reported by Garrett & Haramoto (1967) as *C. eruditus* from chicken feed on O'ahu could not be located, but there is a strong possibility that these may have represented the undescribed species.
Summers & Price in 1970 reported *C. eruditus* from litter in barns and tree bark in California.

### EREYNETIDAE

Only 2 species of rodent nasal mites have been reported from Hawai'i (Radovsky et al. 1979). These tiny white mites are normally recovered in numbers only in nasal flushings or dissection of the nares, but sometimes occur in small numbers in body washings, where they easily escape observation because of their small size.

**Paraspeleognathopsis bakeri** (Fain, 1955) FIG. 14C

*Distribution.* Hawai'i.
*Hosts. M. musculus.*

**Speleorodeus derricki** (Womersley, 1954) FIG. 14A, B

*Distribution.* Hawai'i.
*Hosts. R. exulans, R. rattus.*

MYOBIIDAE

**Myobia musculi** (Schrank, 1781) FIG. 10A, 15C, 16B

*Distribution.* Midway, O'ahu, Kaho'olawe, Hawai'i.

*Hosts. M. musculus.*

Found worldwide on the House Mouse, this fur mite was first reported from O'ahu by Zimmerman in 1956 and subsequently from Midway by Goff (1975) and Hawai'i I by Radovsky et al. (1979). In the last study, the overall incidence of *M. musculi* on *M. musculus* for the 2 years of sampling was 47.8% (intensity, i.e., no. specimens per infested host, 2.7), very close to the incidence (46.1%, intensity 2.4) for *Radfordia affinis* on the same host (Radovsky & Tenorio, unpubl.).

*M. musculi* was recovered from Kaho'olawe mice in recent collections.

**Radfordia affinis** (Poppe, 1896) FIG. 15B, 16A, C

*Distribution.* Midway, O'ahu, Kaho'olawe, Hawai'i.

*Hosts. M. musculus.*

Cosmopolitan on the House Mouse, this fur mite species was recorded first in the "Hawaiian Islands" by Joyce in 1957, and later recorded from O'ahu by Garrett & Haramoto (1967). *R. affinis* was subsequently taken on Midway by Goff (1975, reported in error as *R. ensifera* ex *M. musculus*) and most recently on mice from Hawai'i I (Radovsky et al. 1979) and Kaho'olawe.

**Radfordia ensifera** (Poppe, 1896) FIG. 15A

*Distribution.* Midway, O'ahu, Maui, Hawai'i.

*Hosts. R. exulans, R. rattus, R. norvegicus.*

This fur mite of rats is found throughout the world on commensal *Rattus*. The first record in Hawaii was by Joyce in 1958 ex "rat," with no island specified. Subsequent reports were by Mitchell (1964a) from O'ahu *R. exulans, R. rattus* and *R. norvegicus* and by Goff (1975) from Midway *R. rattus* (reported in error as ex *M. musculus*). Radovsky et al. (1979) collected this mite from both *R. exulans* and *R. rattus* on Hawai'i I, where the overall incidence on both hosts was about 34% (Radovsky & Tenorio, unpubl.).

The Bishop Museum collection includes specimens from Maui (Waiho'i Valley) from *R. exulans* and *R. rattus*.

ACARIDIDA (ASTIGMATA)

MYOCOPTIDAE

**Myocoptes musculinus** (Koch, 1884) FIG. 10C, 16D

*Distribution.* Midway, O'ahu, Kaho'olawe, Hawai'i.

*Hosts. M. musculus.*

This pelage-inhabiting mite of the House Mouse is also cosmopolitan. First report in the islands was by Joyce in 1957 (island unstated) and later records were by Garrett & Haramoto (1967) from O'ahu, Goff (1975) from Midway and Radovsky et al. (1979) from Hawai'i I. In the last study, *M. musculinus* was found to have a lower incidence of infestation (37.2%) on mice than *M. musculi* (47.8%) and *R.*

*affinis* (46.1%), but many more *M. musculinus* (8.1) occurred per infested host as compared to *M. musculi* (2.7) and *R. affinis* (2.4) (Radovsky & Tenorio, unpubl.).

This species was recovered also in recent collections on Kaho'olawe.

ATOPOMELIDAE

**Listrophoroides cucullatus** (Trouessart, 1893) FIG. 17E

*Distribution.* Midway, O'ahu, Hawai'i.

*Hosts. R. exulans, R. rattus, R. norvegicus.*

This is a common parasite of *R. rattus* and *R. norvegicus* in the tropics and subtropics. It was first reported on O'ahu as *Listrophoroides expansus* Ferris by Mitchell (1964a) from all 3 of the Hawaiian *Rattus* species. Fain in 1972 synonymized *L. expansus* with *L. cucullatus*. Goff (1975) found the species on Midway *R. rattus*. Radovsky et al. (1979) collected this fur mite on *R. exulans* and *R. rattus* on Hawai'i I, where they found it abruptly limited by altitude (i.e., temperatures below 16 °C), occurring in moderate to high numbers on both hosts below 1220 m, but absent on rats above 1220 m.

LISTROPHORIDAE

**Afrolistrophorus musculus** (Wilson & Lawrence, 1967) FIG. 17D

*Distribution.* Midway, O'ahu, Mānana, Kaho'olawe, Hawai'i.

*Hosts. M. musculus.*

First reported on O'ahu as *Listrophorus* sp. by Joyce in 1959, this fur mite was later described as a new species of *Listrophorus* by Wilson & Lawrence in 1967, who also reported specimens from Hawai'i I, O'ahu, and Mānana. Fain in 1970 transferred the species to *Afrolistrophorus*. This mite has been reported elsewhere only from Puerto Rico (Tamsitt & Fox 1970). On Hawai'i I, Radovsky et al. (1979) found *A. musculus* on the House Mouse to have a similar abrupt restriction by altitude as was found for *L. cucullatus* on *R. rattus* and *R. exulans*.

Kaho'olawe mice were found heavily infested with *A. musculus* in recent collections.

GAMASIDA (MESOSTIGMATA)

HAEMOGAMASIDAE

**Eulaelaps stabularis** (Koch, 1836) FIG. 18C

*Distribution.* Hawai'i.

*Hosts. M. musculus, R. exulans, R. rattus.*

Cosmopolitan in nests and on bodies of rodents and insectivores and in nests of birds, this species was first reported by Garrett & Haramoto (1967) ex *M. musculus* and *R. exulans* on Hawai'i I. Radovsky et al. (1979) collected only 22 specimens, mostly females, in their 2-year Mauna Loa (Hawai'i I) study and the species was restricted to *R. rattus* at the study sites, with all but 1 specimen occurring in the wet Kīlauea Forest Reserve (Radovsky & Tenorio, unpubl.).

Uchikawa & Rack (1978) recently discussed the *E. stabularis* complex, suggested that several species have been included under the name *stabularis* and redescribed

what they considered to be the true *stabularis*. Pending further study of this complex, we continue to use *E. stabularis* in the broad sense for the Hawaiian form.

LAELAPIDAE

**Laelaps echidninus** Berlese, 1887 spiny rat mite FIG. 18A

*Distribution.* Kure, Midway, Kaua'i, O'ahu, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus.*

The spiny rat mite is common in both north temperate and tropical zones on the Norway Rat and sometimes as a parasite of other wild rodents. It was first reported in Hawaii ("Hawaiian Islands") ex "rats" by Pemberton in 1943 and, since then, has been recorded from all 3 species of *Rattus,* as well as *M. musculus,* on all major islands except Moloka'i and Lāna'i (see Garrett & Haramoto 1967) and on Midway *R. rattus* (Goff 1975).

In a study by Mitchell (1964b) in Mānoa Valley, O'ahu, *L. echidninus* showed a distinct preference for *R. exulans* (incidence 68%, intensity 6.0) over *R. rattus* (incidence 56%, intensity 2.6). Radovsky et al. (1979) reported the reverse preference for *R. rattus* in their Hawai'i I study, but later analyses of the data (unpubl.) revealed an incidence of 21% (intensity 9.0) on *R. exulans* and only 12% (intensity 2.7) on *R. rattus,* thus agreeing with the relative abundance on these 2 hosts observed by Mitchell in his lower-altitude study. Mitchell (1964a) found a lower incidence (44%) and intensity (0.8) on *R. norvegicus* than on the other 2 hosts at the same O'ahu study site.

*L. echidninus* was not taken on *M. musculus* by Radovsky et al. (1979).

The Bishop Museum collection has 1 ♀ ex *R. exulans* from Kure.

**Laelaps nuttalli** Hirst, 1915 domestic rat mite FIG. 18B

*Distribution.* Kure, O'ahu, Popoi'a, Maui, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus.*

The domestic rat mite is a widely distributed parasite, primarily of *Rattus* spp., occurring most frequently in tropical and warm temperate areas. It was first reported from the Hawaiian Is by Ewing (1924b), who described it as a new species, *Laelaps hawaiiensis,* from *R. exulans* from Popoi'a Islet. *L. hawaiiensis* was later synonymized with *L. nuttalli* by Fox (1946). The mite was subsequently reported from all 3 *Rattus* spp. and from Hawai'i I, Maui (ex "Rattus") and O'ahu.

The Bishop Museum has 9 specimens ex *R. exulans* from Kure and a long series from Waiho'i Valley, Maui, ex *R. exulans* and *R. rattus,* as well as 1 Waiho'i Valley specimen ex *M. musculus.*

Radovsky et al. (1979) reported on collections from Hawai'i I. Like *L. echidninus, L. nuttalli* occurred on a higher proportion of *R. exulans* (73%) than on *R. rattus* (53%), but incidence and intensity of *L. nuttalli* on those hosts was higher than those of *L. echidninus*; incidence on *M. musculus* was only 4% (Radovsky & Tenorio, unpubl.).

*L. nuttalli* decreased in both incidence and intensity with altitude on Hawai'i I (Radovsky et al. 1979). This species appears to be limited in distribution on Mauna Loa by temperature. Its occurrence in cool temperate regions elsewhere may be

the result of the artificially protected harborages offered by the nests of its domiciliated rodent hosts.

Mitchell (1964b) found the incidence of *L. nuttalli* in Mānoa Valley, O'ahu, on *R. exulans* to be 100% and on *R. rattus,* 97%; only 1.1% of the *R. norvegicus* at the same site harbored this mite (Mitchell 1964a).

**Androlaelaps hermaphrodita** (Berlese, 1903) FIG. 18D

*Distribution.* Midway, O'ahu, Kaho'olawe, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus.*

This cosmopolitan species described by Berlese from Rome from plant material was first recorded in Hawai'i in 1962 by Joyce as *Androlaelaps setosus* Fox, a junior synonym of *A. hermaphrodita* (from O'ahu ex *R. exulans, R. norvegicus* and *M. musculus*). Mitchell (1964a) added *R. rattus* to the host list on O'ahu.

The Bishop Museum collection includes specimens from O'ahu and Hawai'i I from all hosts except *R. norvegicus,* in addition to 1 ♀ from Midway ex *M. musculus.*

A few females of *A. hermaphrodita* were taken on Kaho'olawe mice.

**Echinonyssus butantanensis** (Fonseca, 1932) FIG. 19C

*Distribution.* Hawai'i.

*Hosts. M. musculus, R. exulans, R. rattus.*

This is a widely distributed parasite of rodents, particularly commensal *Mus* and *Rattus. E. butantanensis* was first recorded in Hawai'i by Garrett & Haramoto (1967) from Hawai'i I ex *R. exulans* as *Hirstionyssus latiscutatus,* a junior synonym of *E. butantanensis* (see Herrin 1974). The genus *Hirstionyssus* was synonymized with *Echinonyssus* by Tenorio & Radovsky in 1979.

*E. butantanensis* was recorded from Hawai'i I by Radovsky et al. (1979) on *R. rattus* and *M. musculus,* but not from *R. exulans.* All records were from the wetter sites and the authors concluded that high moisture appears to be a requisite for this mite. *R. rattus* seemed to be a more optimal host than *M. musculus* under the conditions of the study site.

MACRONYSSIDAE

**Ornithonyssus bacoti** (Hirst, 1913) tropical rat mite FIG. 19A–B

*Distribution.* Midway, O'ahu, Mānana, Kaho'olawe, Hawai'i.

*Hosts. M. musculus, R. exulans, R. norvegicus, R. rattus.*

This bloodsucking mite is associated with rats and other rodents, chickens, other birds, and wild carnivores worldwide. It readily bites man in the absence of its preferred hosts and may produce irritation or dermatitis. Experimentally *O. bacoti* is capable of harboring certain pathogens, such as the bacilli of plague and tularemia, for long periods, although it has not been implicated in the natural transmission of any human disease.

The tropical rat mite was first reported from O'ahu by Cole & Koepke (1947) ex *R. exulans, R. norvegicus* and *R. rattus.* It was found on Midway by Goff (1975) ex *R. rattus.*

Radovsky et al. (1979) on Hawai'i I took *O. bacoti* only at the dry lower-altitude sites and did not collect it above 840 m. It was found only on *M. musculus* (31%

infested of 123 collected) and was not recovered from *R. rattus* and *R. exulans* at the same sites. These authors postulated that *O. bacoti* might be naturally excluded from localities with high moisture levels. This contrasts with the study of Mitchell (1964a), who found the mite on all 3 *Rattus* spp. (17.2% incidence on *R. rattus* of 64 hosts examined, 11.1% on *R. norvegicus* of 9 examined, 4.0% on *R. rattus* of 25 examined) in the fairly wet Mānoa Valley site on O'ahu. *Mus* was apparently not taken in Mitchell's studies.

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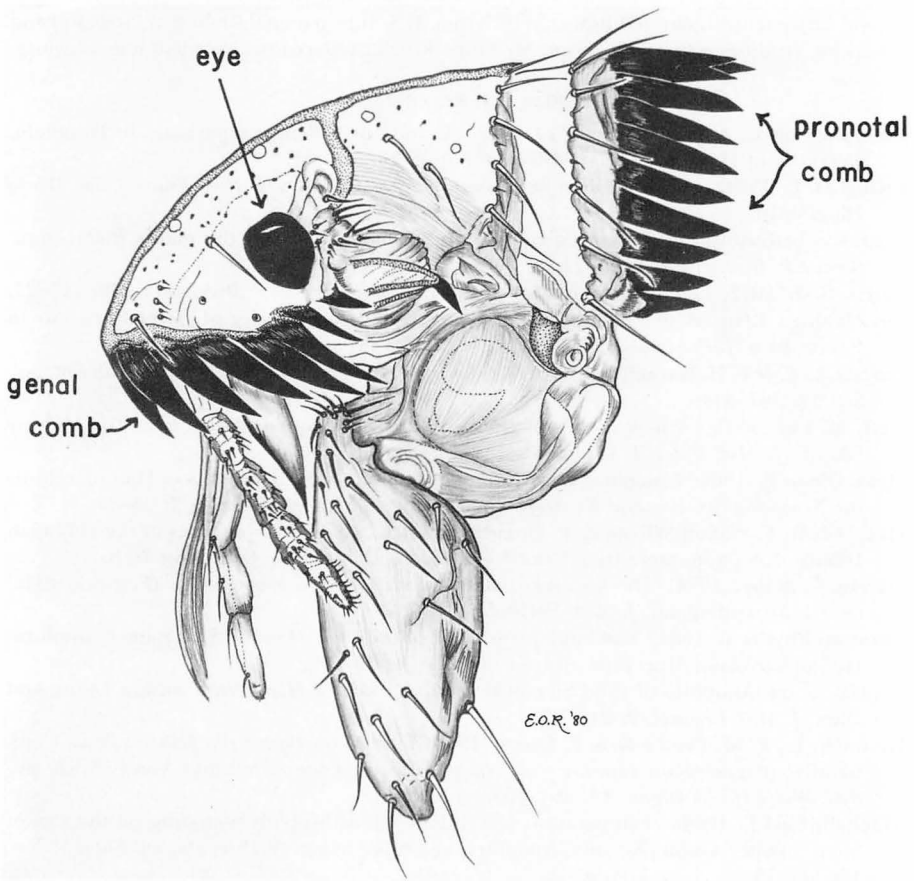


FIG. 1. *Ctenocephalides felis felis* ♀. Head, prothorax and fore coxa.

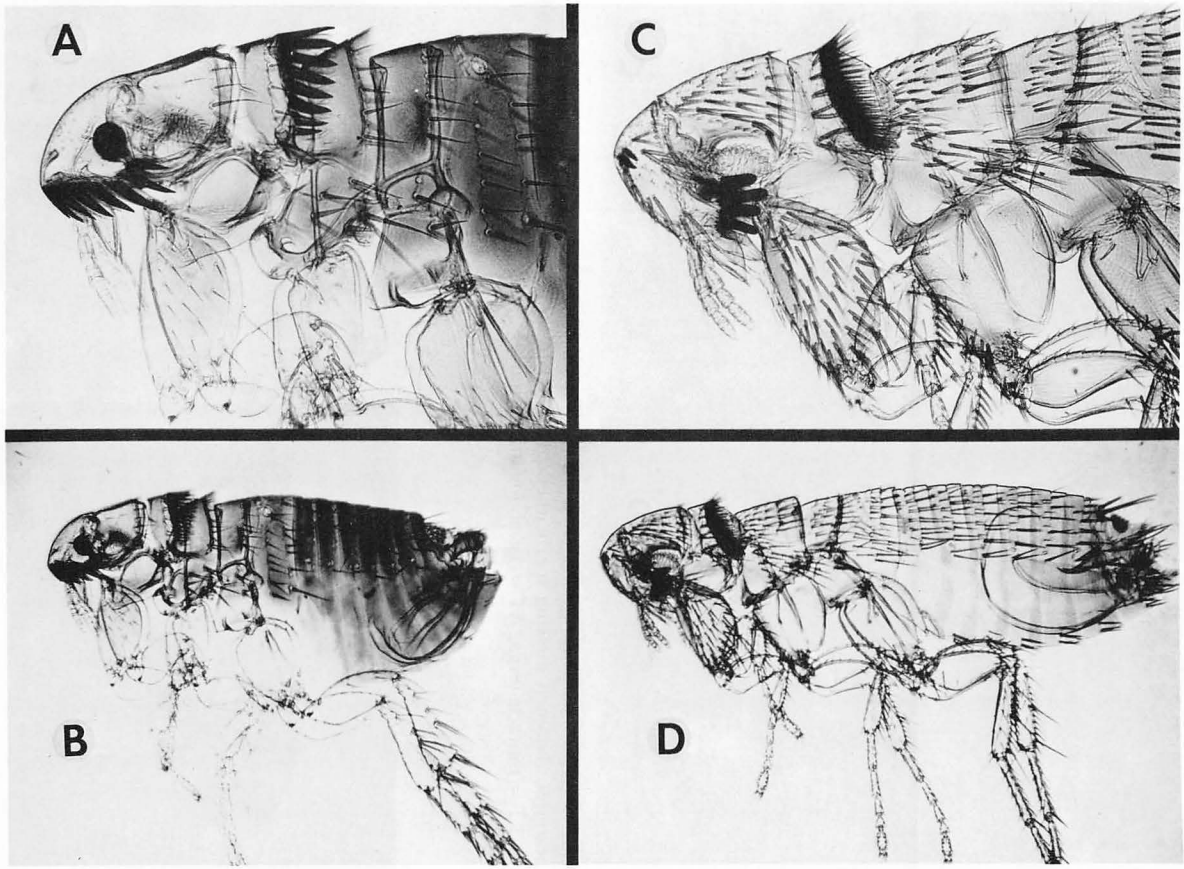


FIG. 2. A–B, *Ctenocephalides felis felis* ♂. C–D, *Leptopsylla segnis* ♂.

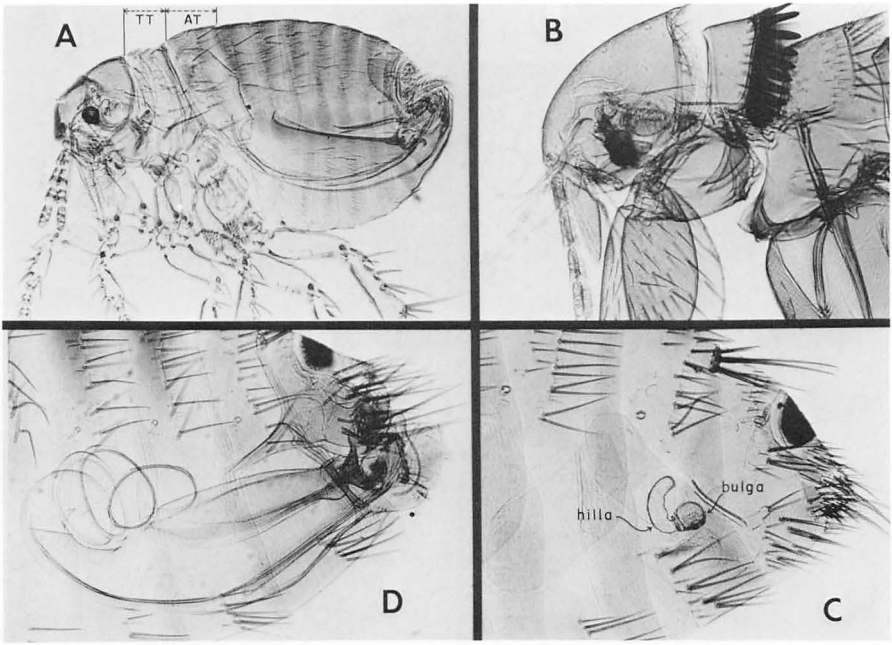


FIG. 3. A, *Echidnophaga gallinacea*. B–D, *Nosopsyllus fasciatus*: B, ♀ anterior portion; C, ♀ posterior abdomen showing spermatheca; D, ♂ posterior abdomen showing coiled penis rods. TT = thoracic terga, AT = 1st abdominal tergum.

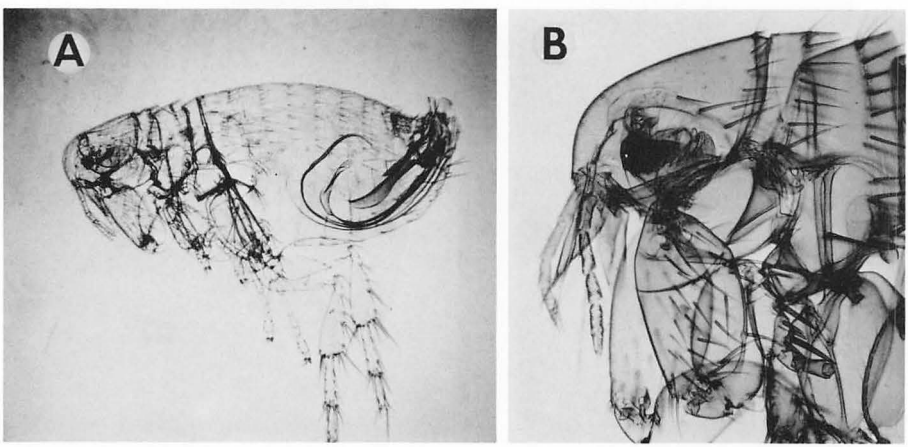


FIG. 4. *Xenopsylla* spp. A, *cheopis* ♂; B, *vexabilis* ♀.

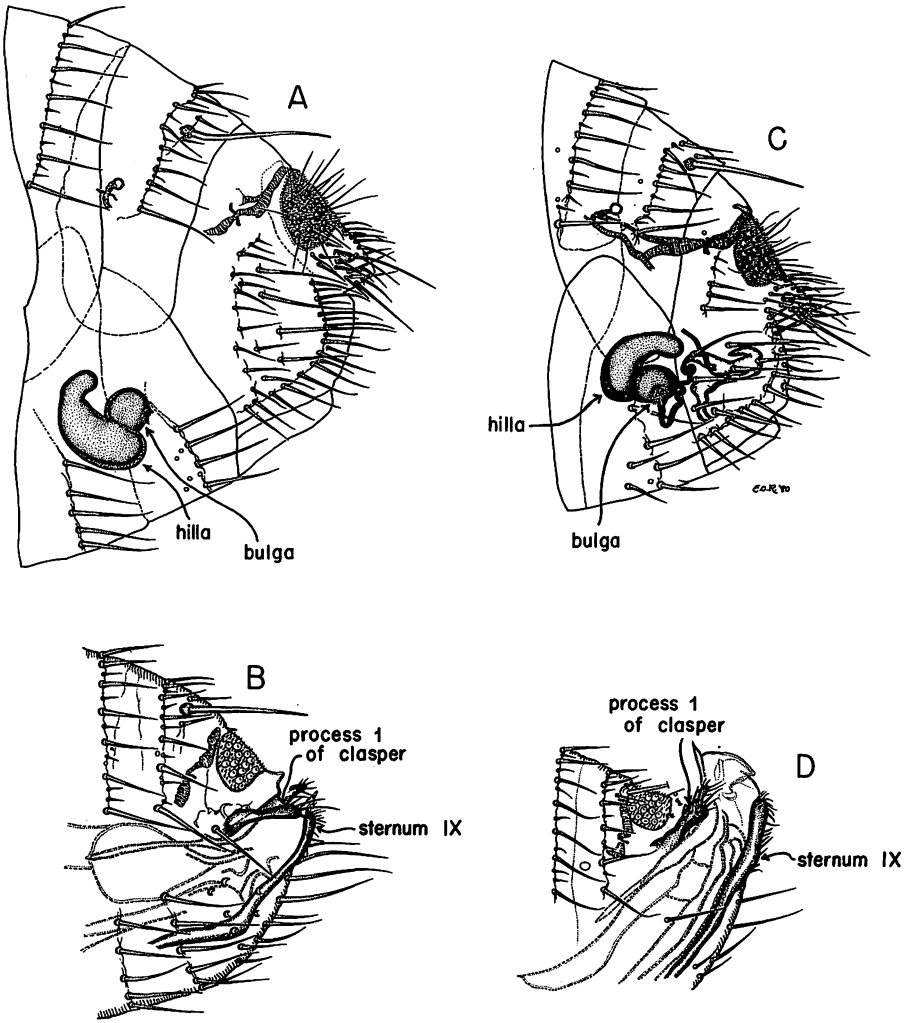


FIG. 5. *Xenopsylla* spp., posterior abdomen: A, *vexabilis* ♀; B, *vexabilis* ♂; C, *cheopis* ♀; D, *cheopis* ♂.

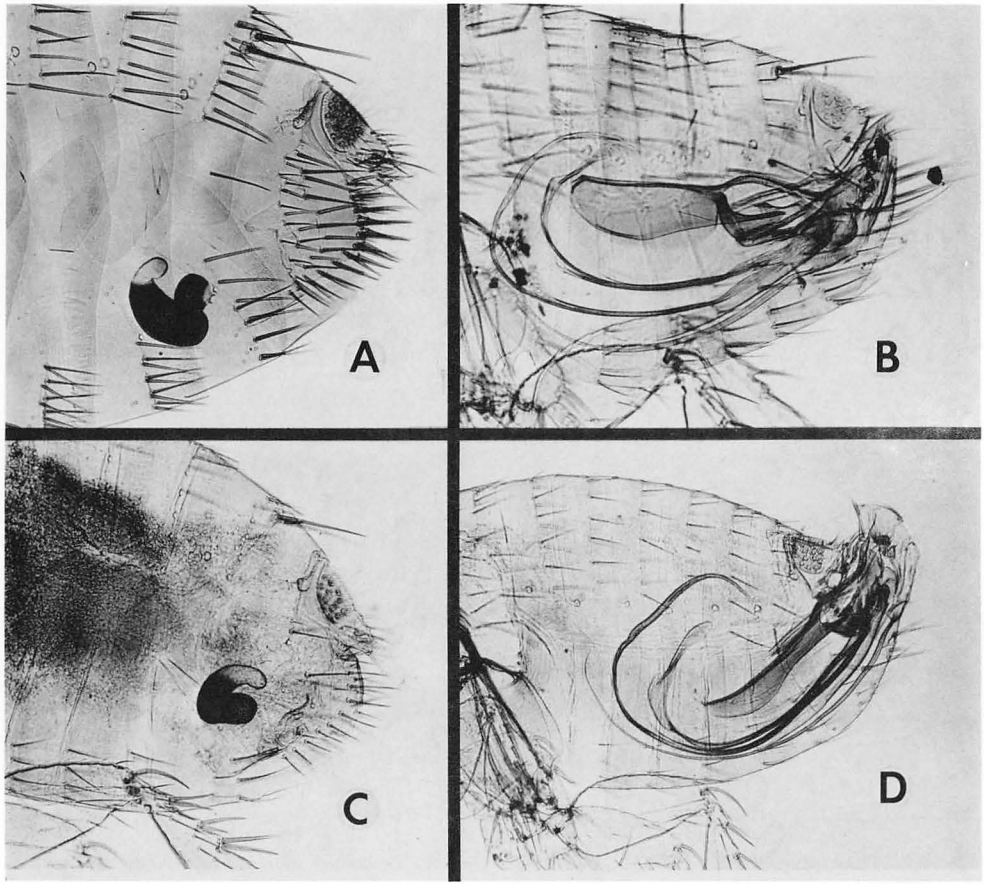


FIG. 6. *Xenopsylla* spp., posterior abdomen: A, *vexabilis* ♀; B, *vexabilis* ♂; C, *cheopis* ♀; D, *cheopis* ♂.

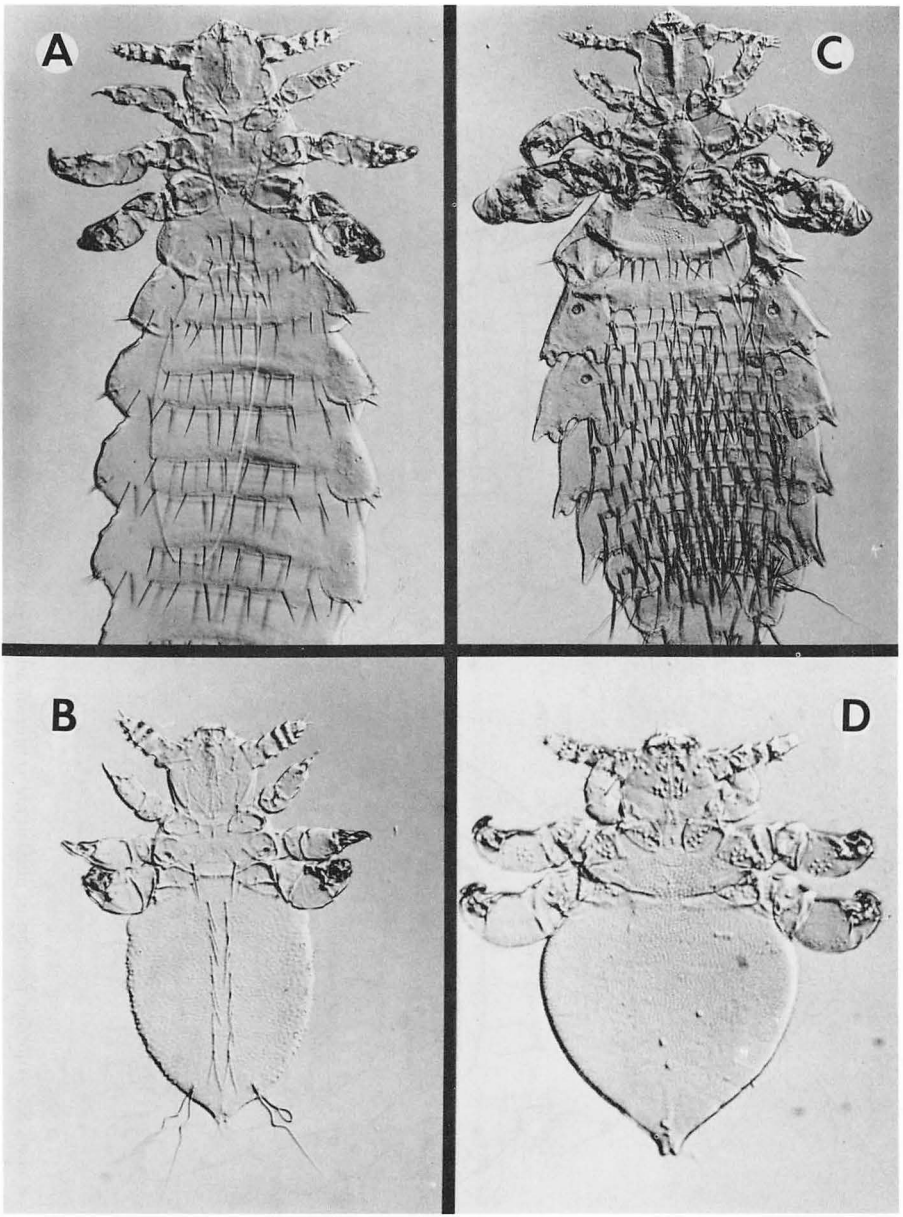


FIG. 7. A–B, *Polyplax spinulosa*: A, adult ♀; B, nymph; C–D, *Hoplopleura pacifica*: C, adult ♀; D, nymph.

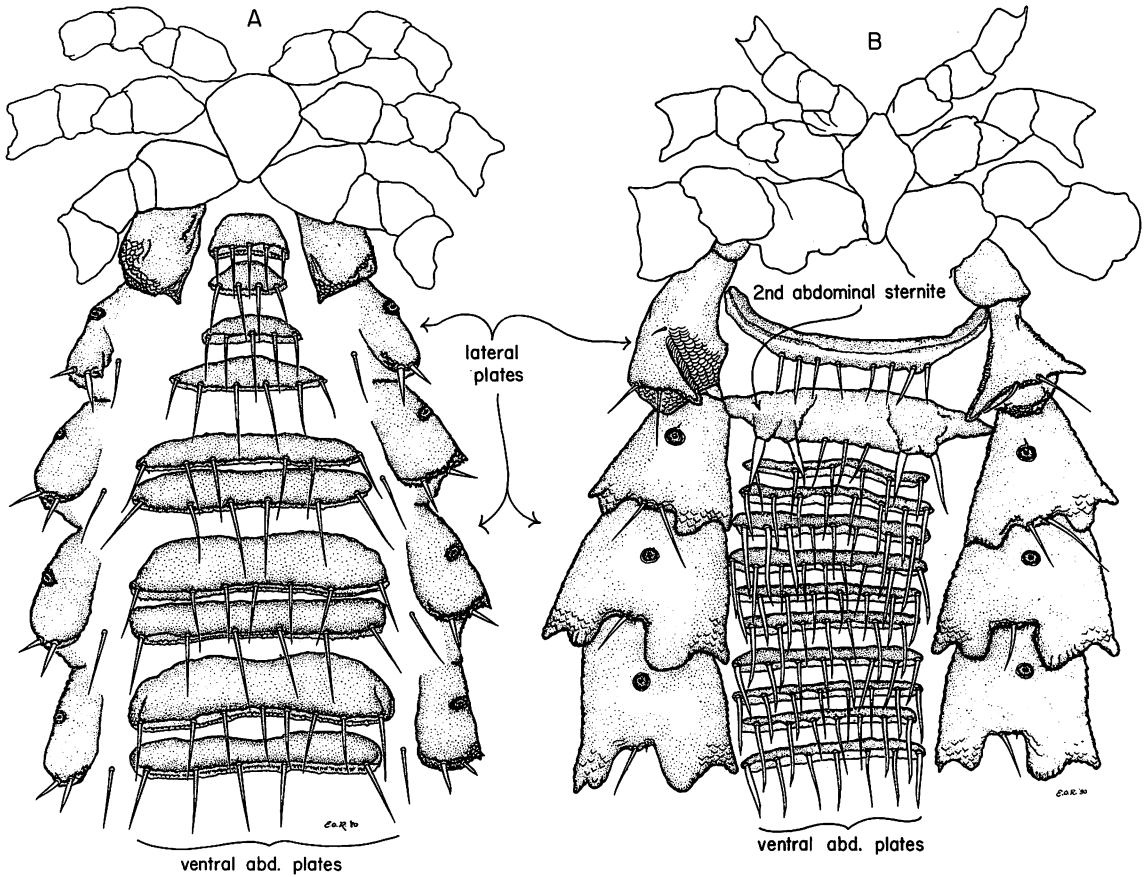


FIG. 8. Anterior portion of abdominal venter of adult ♀. A, *Polyplax spinulosa*; B, *Hoplopleura pacifica*.

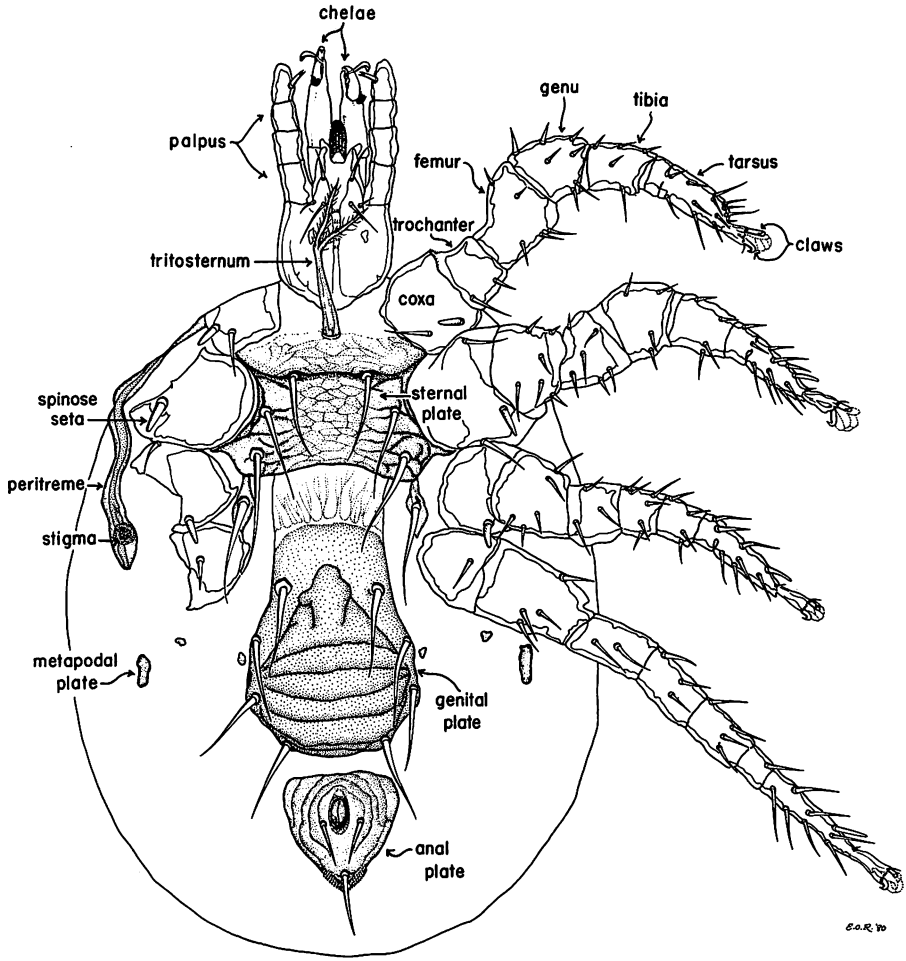


FIG. 9. *Laelaps nuttalli,* representing generalized Gamasida mite venter.

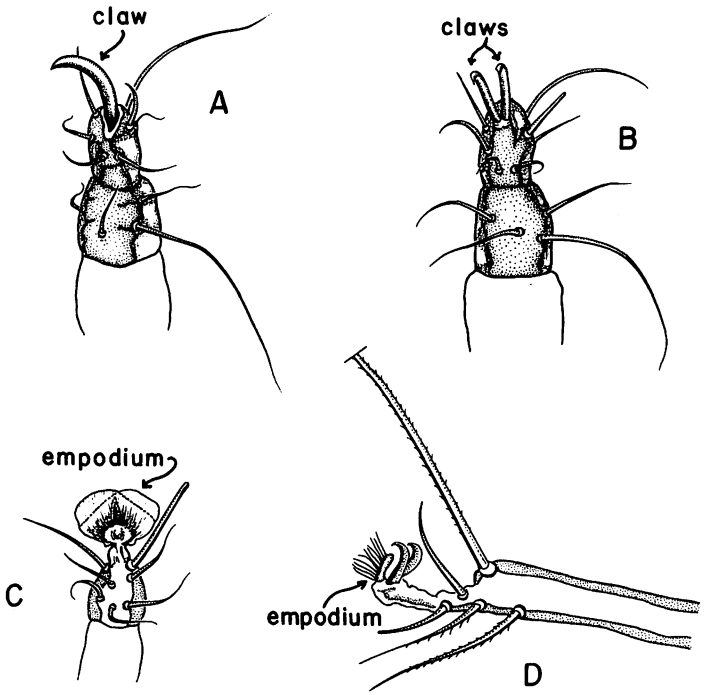


FIG. 10. Terminal portion of legs: A, *Myobia musculi,* tibia and tarsus II; B, *Radfordia* spp., tibia and tarsus II; C, *Myocoptes musculinus,* tarsus I; D, *Cheyletus eruditus,* distal portion.

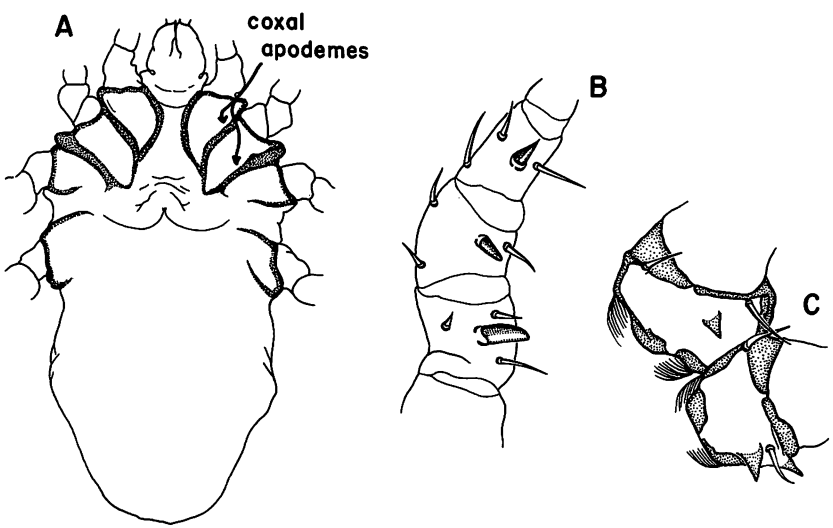


FIG. 11. A, generalized venter of Acaridida mite showing coxal apodemes; B, femur, genu and tibia II of *Androlaelaps hermaphrodita*; C, venter of coxa II and III of *Echinonyssus butantanensis.*

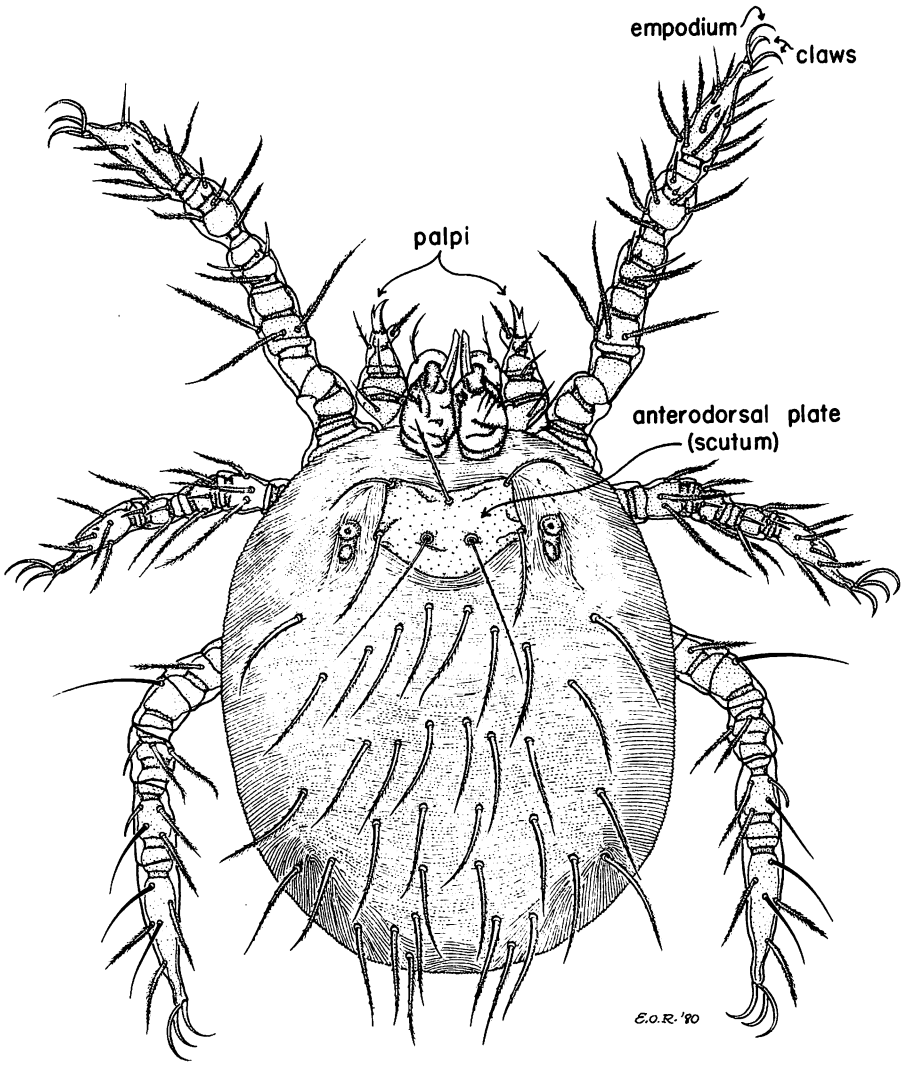


FIG. 12. *Neotrombicula megensi*, dorsal.

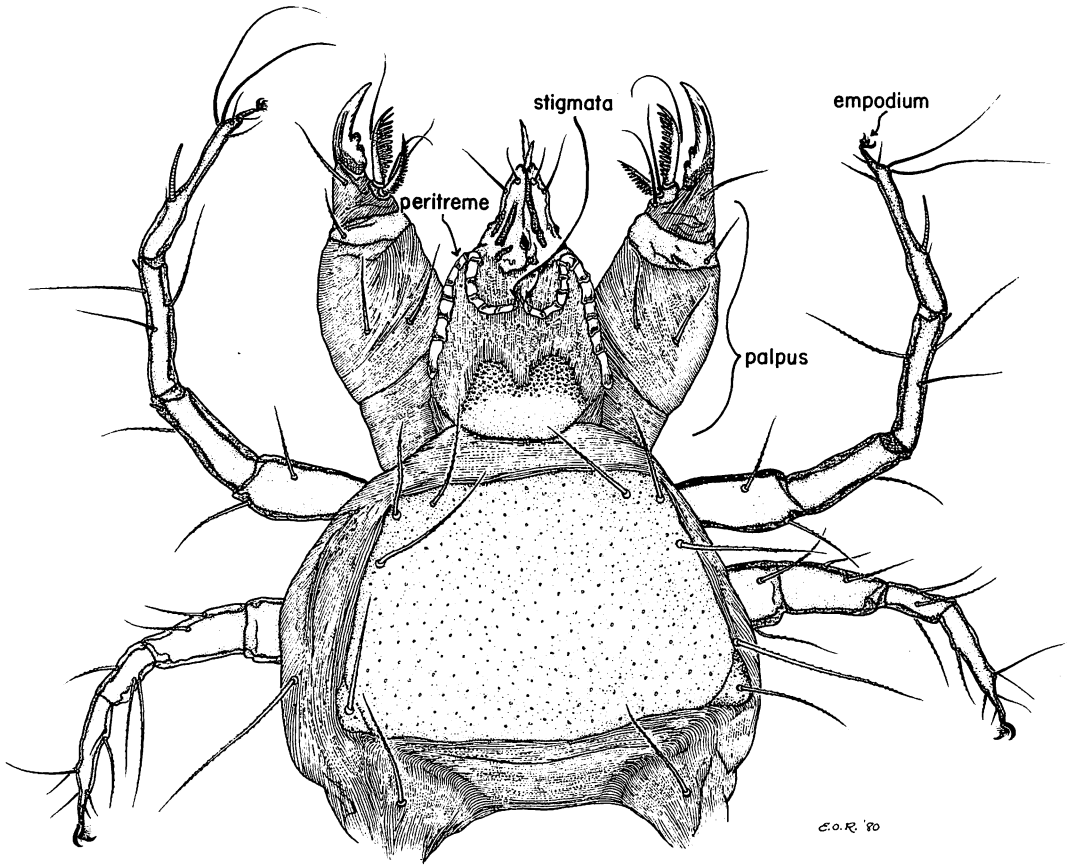


FIG. 13. *Cheyletus eruditus*, anterodorsal portion.

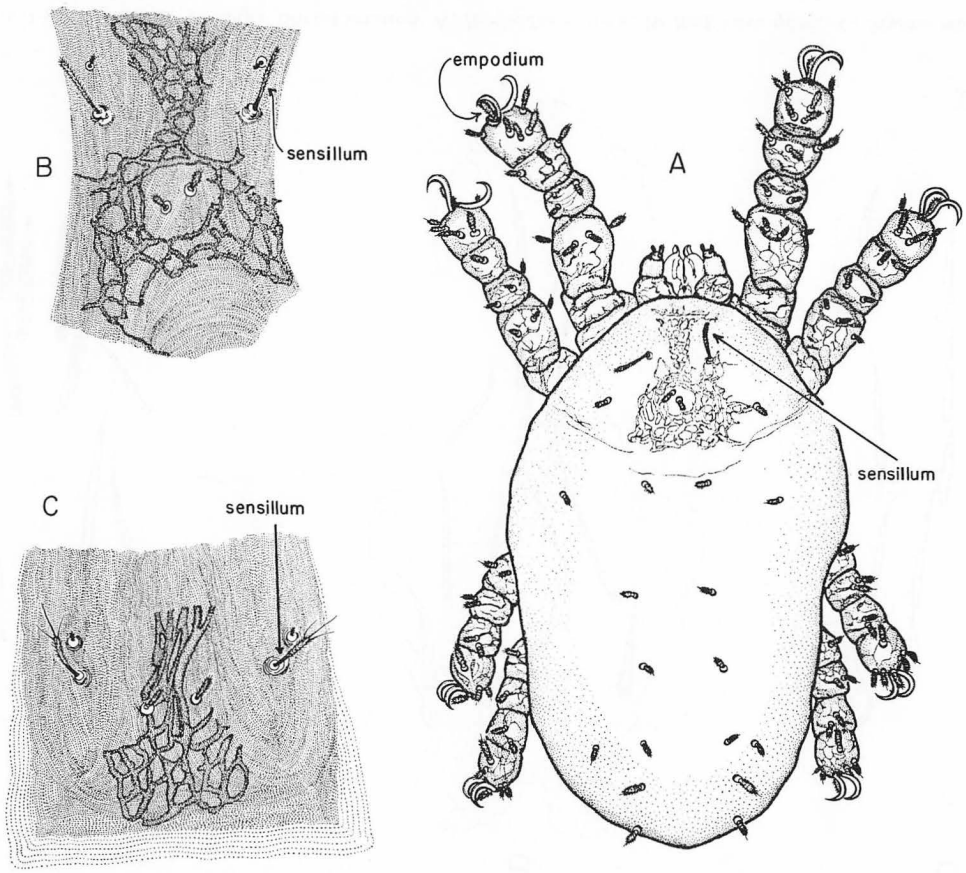


FIG. 14. A–B, *Speleorodeus derricki*: A, dorsal; B, anterodorsal portion showing sensilla; C, *Paraspeleognathopsis bakeri,* sensilla.

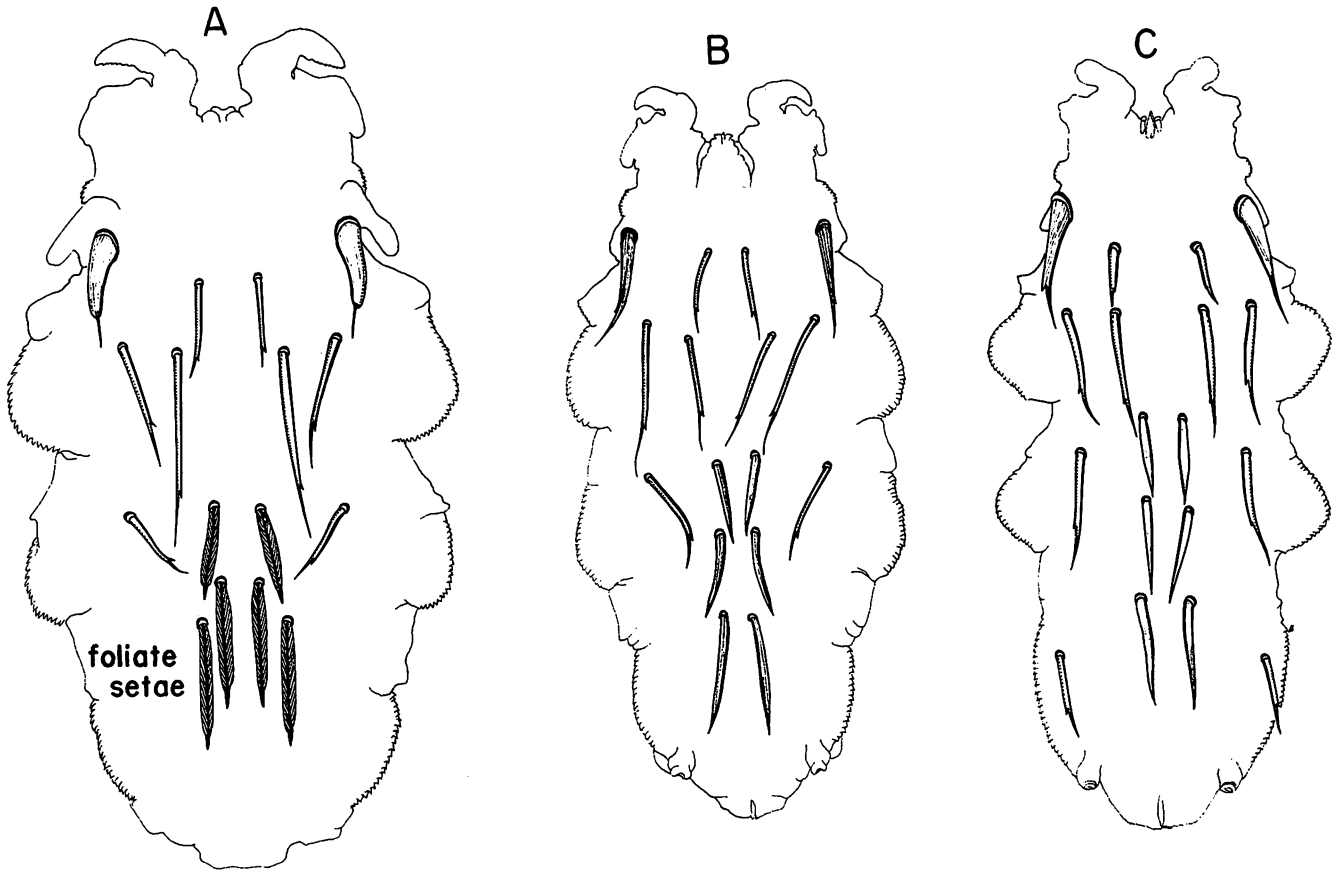


FIG. 15. Myobiidae ♀, major dorsal setation: A, *Radfordia ensifera*; B, *Radfordia affinis*; C, *Myobia musculi*.

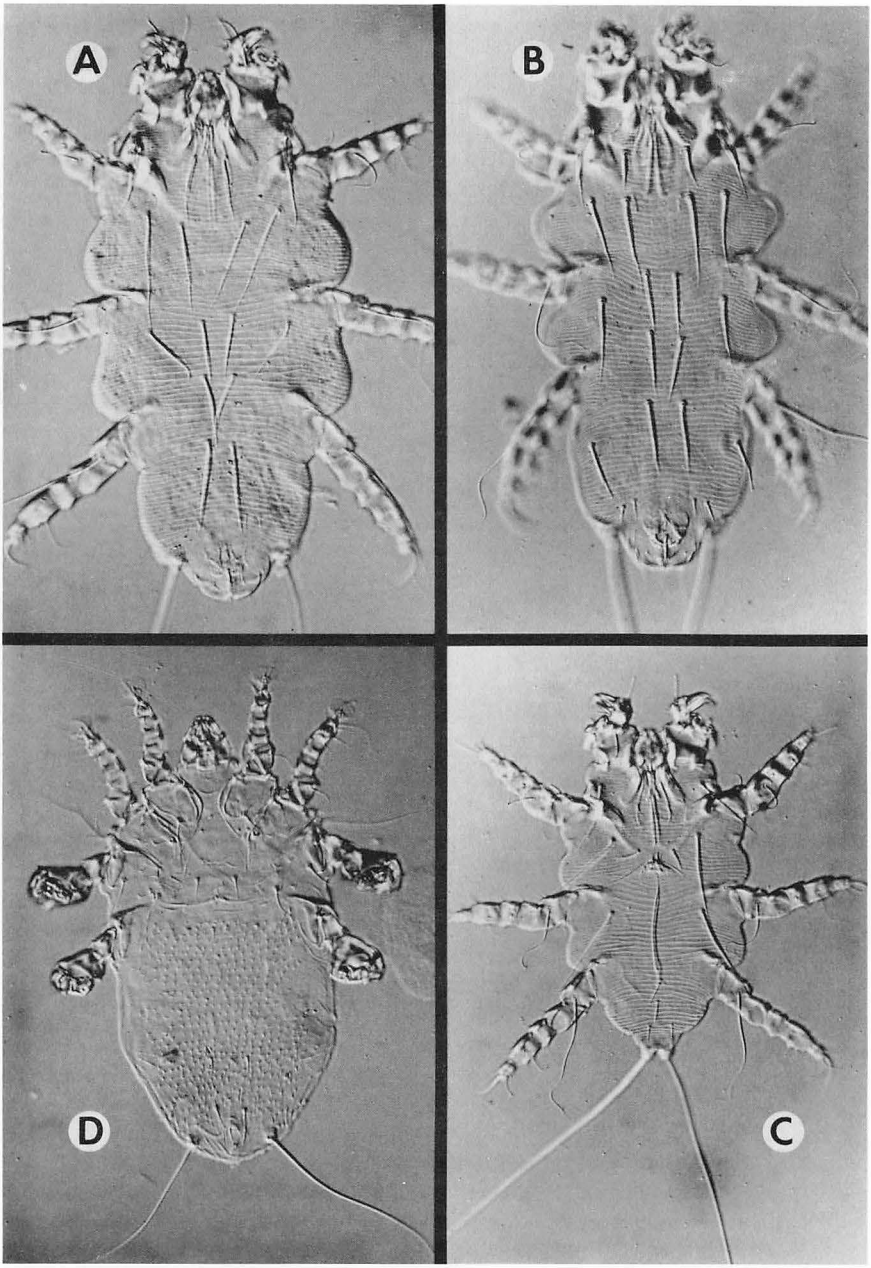


FIG. 16. A, *Radfordia affinis* ♀, dorsal; B, *Myobia musculi* ♀, dorsal; C, *Radfordia affinis* ♂, dorsal; D, *Myocoptes musculinus* ♀, ventral.

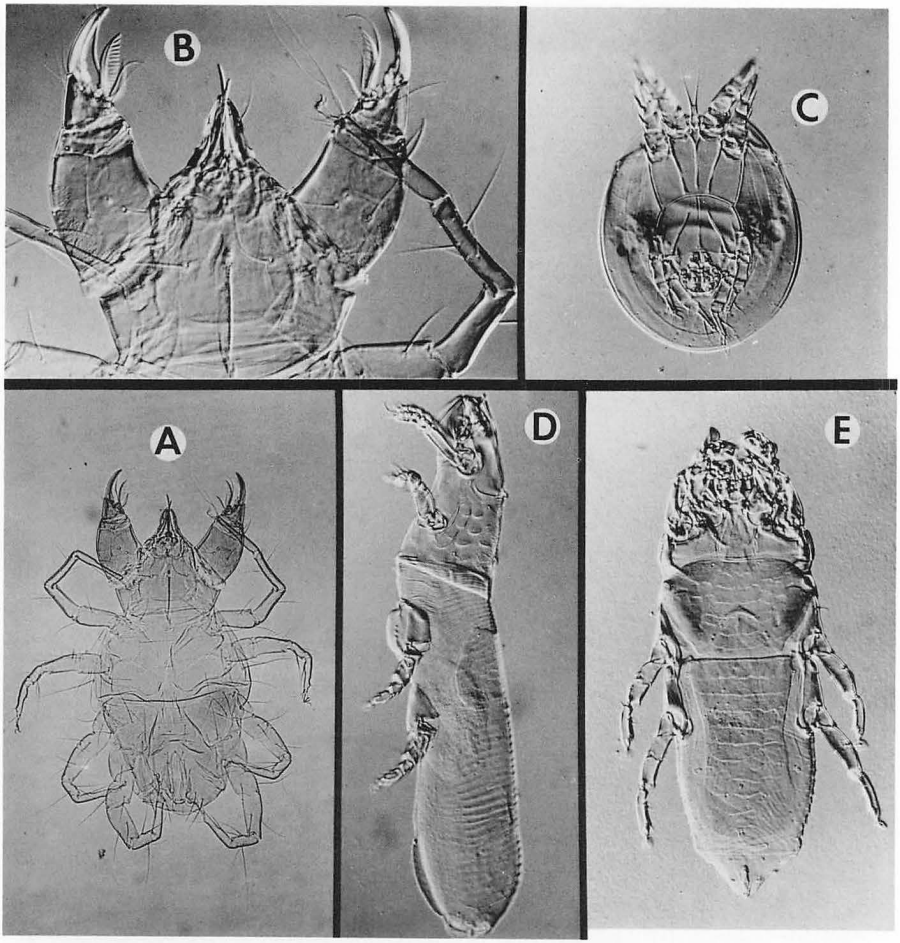


FIG. 17. A, *Cheyletus eruditus*; B, *C. eruditus,* gnathosoma; C, hypopus of an acarid mite; D, *Afrolistrophorus musculus* ♀, lateral; E, *Listrophoroides cucullatus* ♀, dorsal.

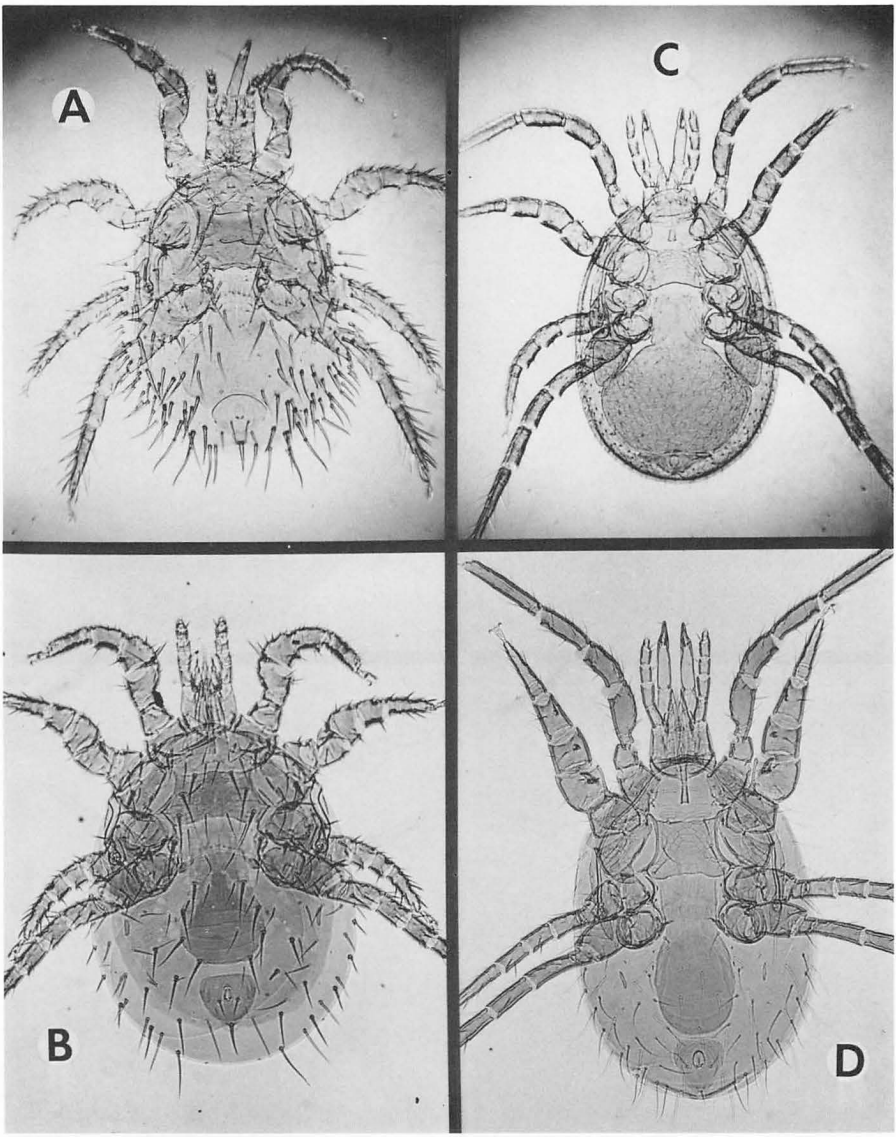


FIG. 18. Gamasida ♀, venter: A, *Laelaps echidninus*; B, *Laelaps nuttalli*; C, *Eulaelaps stabularis*; D, *Androlaelaps hermaphrodita.*

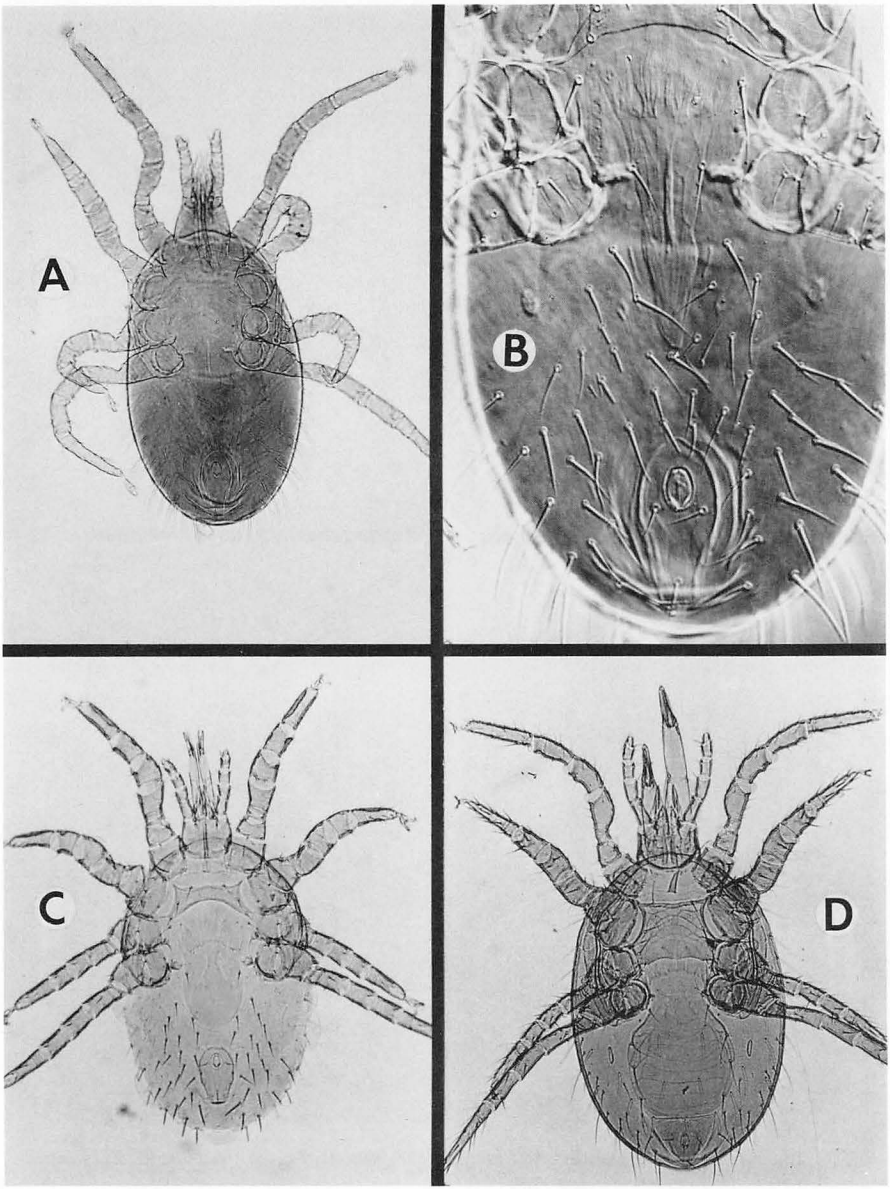


FIG. 19. Gamasida ♀, venter: A–B, *Ornithonyssus bacoti*; C, *Echinonyssus butantanensis*; D, *Hypoaspis nidicorva*.

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