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VOLUME 6, NO. 3

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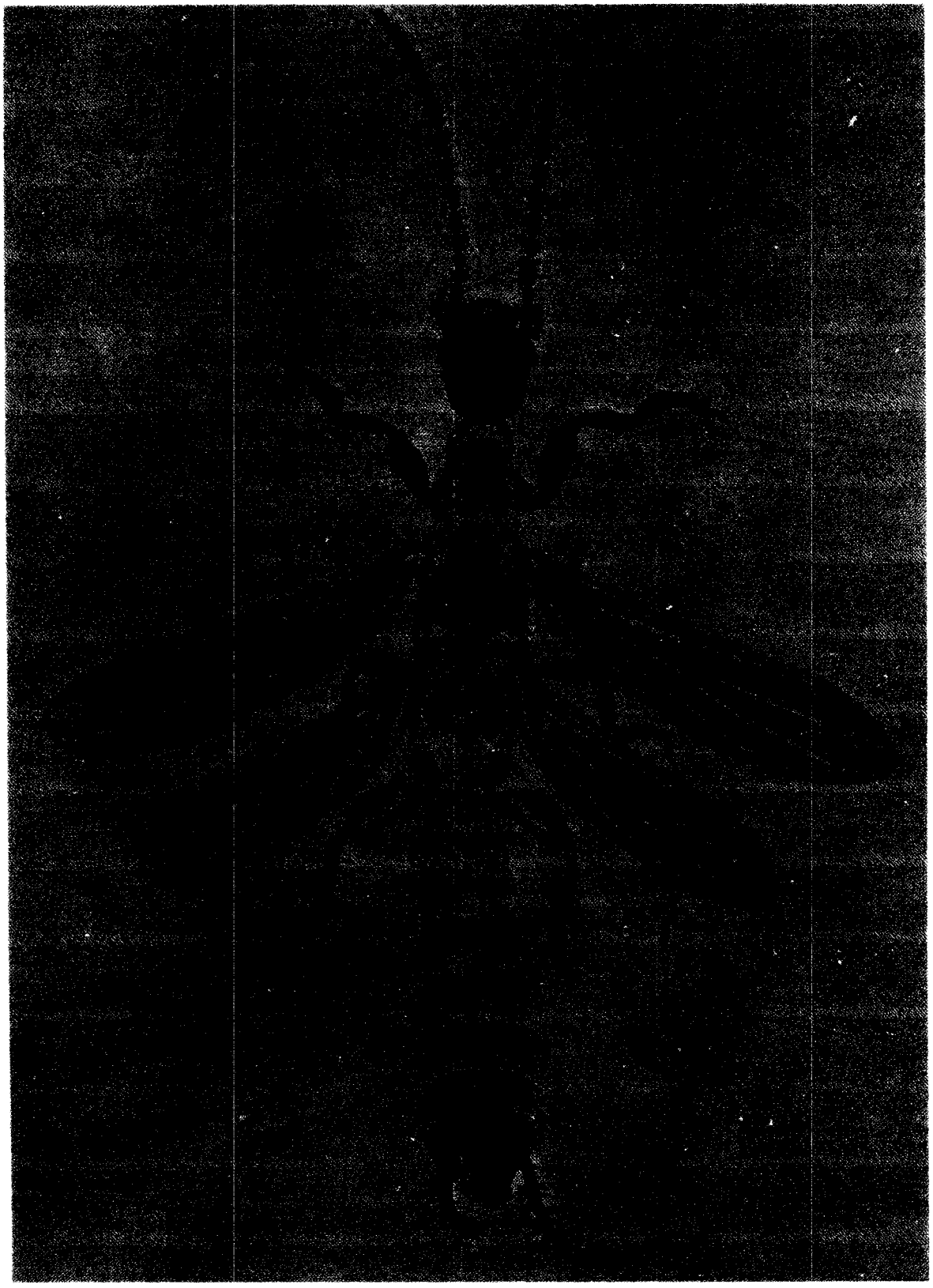

Chelicerca rubra (Ross), male. The only known endemic species of Embioptera occurring in California. KOH-cleared microscope slide preparation. Body length 6.5 mm.

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EDWARD S. ROSS

INTRODUCTION

Embioptera are essentially tropical insects and, as in most other temperate regions, are very poorly represented in California. To date only three species have been found in the state, and it is unlikely that this number will increase except by the unintentional introduction of additional species by man.

Such introductions are quite possible because of the ease with which embiids travel in commerce in the shock-proof protection of their quickly established silken galleries. Embiids are commonly intercepted in plant quarantine, especially in shipments of orchid plants from the tropics. The fact that potential immigrants can occasionally slip through our borders was demonstrated by the collection by Dr. W. H. Lange of a live adult male of the pan-tropical species, *Oligotoma saundersii* (Westwood), on Hawaiian pineapples in a store in Berkeley, California, July, 1940. Eventually this species may become established (as it already is in Florida and Texas) in southern California, but no economic problems should arise as a result.

The most common of the three California species are two well-established Old World members of the family Oligotomidae which were early introduced in commerce. One of these is a parthenogenetic form of the Mediterranean *Haploembia solieri* (Rambur); the other is *Oligotoma nigra* Hagen, a species common in the Nile Valley and Middle East.

The third California species, *Chelicerca rubra* (Ross), is rarely seen by collectors. Its occurrence in the state is natural, but its taxonomic affinity is with a group (subgenus) of northwestern Mexican species as yet undescribed.

GENERAL BIONOMICS

The most singular feature of all Embioptera is an ability to produce sheet-silk by quick strokes of greatly swollen, gland-packed foretarsi. Both sexes and all developmental stages, even including the first instar, spin silk. The basal segment of the three-segmented foretarsus contains scores of silk glands. Each gland consists of a round lumen delimited by a layer of syncytial, silk-producing cells. The silk, still in a viscid state, is conducted from the lumen of each gland through a long duct which opens to the exterior at the apex of a hollow spinning seta on the plantar surfaces of the basal and medial tarsal segments. Many fine strands of silk are simultaneously spun with each stroke of the tarsus.

With these remarkable organs, embiids can rapidly construct highly protective silk tunnels wherever they go in search of food or in escape from adverse ecological conditions. The eggs are laid in a protected place in the tunnel system, and the gregarious, newly hatched young spin their own tunnel system which increases both in extent and tunnel diameter as the insects grow. In California, and other regions which experience prolonged dry seasons, these tunnel systems are generally spun under the protective cover of a stone, log, dry cattle dropping, or matted leaves. The tunnels, which give evidence of the presence of Embioptera at any season, generally follow soil cracks to depths where the insects retreat during the heat of the day or long hot dry periods.

Most of the anatomical and biological characteristics of embiids are adaptations to a life largely confined to silk tunnels. These are: (1) an elongate, supple body form with short legs and a high degree of prognathism; (2) an ability to run backward aided by highly developed hind tibial depressor muscles; (3) highly sensitive cerci to guide the backward movement; (4) universal apterism of the female through neoteny and a similar tendency (partial or complete) in males of many species; (5) development of wing flexibility in the male (an advantage during reverse movement in tunnels) and

a compensating wing stiffening for flight by blood pressure, principally in the wing's first radius vein.

Except for such specializations, Embioptera are rather generalized orthopteroid insects with a simple life history and unspecialized food habits. The diet is usually dead leaves, grass, bark flakes, lichens, and moss. At times Embioptera will nibble living plant tissue, especially grass at the edge of a stone. Wherever embiids choose to live on the basis of other ecological factors, there is almost certain to be a supply of food. Species representing highly divergent taxonomic groups from very distinct regions and ecological niches readily accept the same diet in laboratory cultures.

Although the silken tunnels must be highly efficient protection from predators, especially by providing prearranged escape routes, embiids must regularly fall prey to beetles, spiders, ants, and the like. In regions of endemicity each species is also attacked by specific parasites. The eggs are parasitized by tiny wasps of the family Scelionidae, and the embiid bodies are attacked by ectophagous wasp larvae of the bethyloid family Sclerogibbidae and larvae of midges of the family Itonidae. Other kinds of specific parasites and predators thrive on embiids in certain regions. New taxonomic categories will be added to the California insect list when the parasites of the endemic *Chelicera rubra* are reared. The two nonendemic species probably owe much of their biological success to freedom from attacks of their specific parasites.

None of the Embioptera of California—in fact of any region of the world—can be classed as economic pests. It is possible, however, that a pest control operator may at times be called to answer inquiries concerning Embioptera colonies about the house or garden, but the chances of real horticultural or household damage is practically nil because of vegetable-scavenger food habits of the insects.

Acknowledgments

I am indebted to the various collectors and museum officials cited in the accompanying records for their contributions and assistance. The collections referred to by symbol are: C.A.S., California Academy of Sciences, San Francisco; C.I.S., California Insect Survey, University of California, Berkeley; C.D.A., California State Department of Agriculture, Sacramento; C.U., Cornell University, Ithaca, N.Y.; L.A.M., Los Angeles County Museum; K.U., University of Kansas, Lawrence; U.C.D., University of California, Davis; U.C.L.A., University of California, Los Angeles; U.C.R., University of California, Riverside.

Key to California Species of Embioptera (any instar)

1. Hind basitarsus with a medial, membranous sole-bladder in addition to the usual terminal terminal bladder (fig. 2). Parthenogenetic species . . . . . *Haploembia solieri* (Rambur)
   Hind basitarsus without a medial sole-bladder (fig. 1). Bisexual species 2
2. Small species (adults less than 8.0 mm. in length). Juveniles pale reddish-brown; adult female brick-red; adult male red with terminalia and head black. Left cercus of male one-segmented, long arcuate (fig. 3). . . . . *Chelicerca rubra* (Ross)
   Larger species (adults at least 9.0 mm. in length. Juveniles pale tan; adult female blackish-brown; adult male uniformly medium to dark brown. Left cercus of male two-segmented, segments straight (fig. 4) . . . . . *Oligotoma nigra* Hagen

Family Anisembiidae

Genus *Chelicerca* Ross

Chelicerca (Dactylocerca) rubra (Ross)

(Frontis.; fig. 3)

Anisembia (Dactylocerca) rubra Ross, Ann. Ent. Soc. Amer., 33:659. Type locality: Rosarito Beach, Baja California, C.A.S.

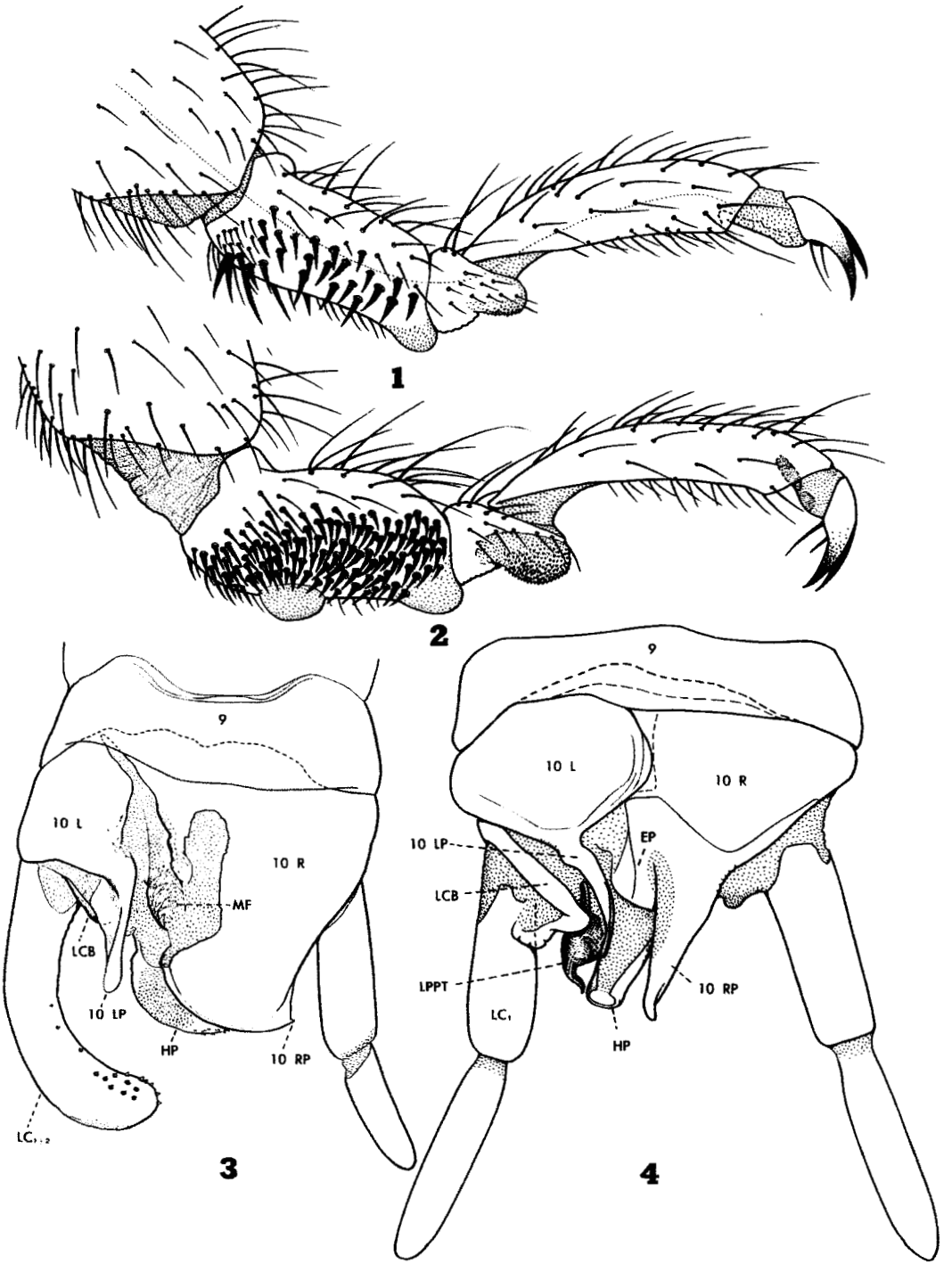
Geographic range:

Arizona, Baja California, Sonora (probable), Mexico; California, New Mexico, and Utah.

California records:

Kern Co.: 5 mi. w. Tehachapi, colonies under stones mixed with those of *Haploembia solieri* (Rambur), males mature VI-49 (E. S. Ross, C.A.S.); Randsburg, late instar juveniles, IV-6-48 (J. W. MacSwain, C.I.S.).

Riverside Co.: Banning, penult. male under stone in desert (D. W. Pierce, L.A.M.); Palm Canyon, male in flight, IV-16-37 (G. E. and R. M. Bohart, C.A.S.); Palm Canyon, colonies under stones and skirts of fan palms, IV-15-39 (E. S. Ross, C. A.S.); Piñon Flat, San Jacinto Mts., 2 males in sweepings, V-24 and 27-39 (E. G. Linsley and J. G. Shanefelt, C.A.S.); same locality, colonies under stones, IV-8-54 (E. S. Ross, C.A.S.).



Figs. 1-4. Key characters of California Embioptera: Fig. 1. Hind tarsus adult female *Oligotoma nigra* Hagen, showing single (apical) sole-bladder. Fig. 2. Hind tarsus of *Haploembia solieri* (Rambur), showing two basitarsal sole-bladders. Fig. 3. *Chelicerca rubra* (Ross), abdominal terminalia of male. Fig. 4. *Oligotoma nigra* Hagen, abdominal terminalia of male.

Explanation of symbols: 9 = ninth abdominal tergite; 10 L and 10 R = left and right hemitergites of tenth segment; 10 LP and 10 RP = processes of 10 L and 10 R; MF = median flap of 10 R; EP = epiproct; HP = hypandrium process; LPPT = left paraproct; LCB = left cercus-basipodite; LC_{1+2} = composite two-segmented left cercus. Terminalia figures omit setae except micro-setae or echinulations of LC_{1+2}. Stippling represents membrane.

San Diego Co.: Borrego State Park, juveniles, IV-25-55 (R.O. Schuster, C.I.S.); San Ysidro, mature female under stone, IV-2-39 (E. S. Ross, C.A.S.).

Discussion:

This small, native, reddish species has an extensive range from the warm shores of the Pacific Ocean near San Diego to Great Basin localities in southern Utah and a Rocky Mountain locality of south central New Mexico. It is possible that a study of more extensive samples of the eastern populations will prove the existence of a subspecies complex. The geographic distribution indicates that winter cold may not be as limiting a distributional factor as the need for optimum soil moisture occurring in seasonal conbination with proper temperature.

The typical environment of *rubra* appears to be under stones on rocky, well-drained, grassy hillsides often with scattered cactus and other xerophytes. The tunnels are small and extend inconspicuously among the bases of grass growing at the edge of the cover. The colonies are scattered and small and consist of a single female and her brood. The species appears to have but one annual generation with mature males and females present in California from mid-April to June. After mating, the males apparently soon die and, with the drying of the niche, the females retreat down tunnels in soil cracks where the eggs are laid. The young probably hatch within a few days and begin feeding on vegetative debris in the soil adjacent to the tunnels or go to the grass-surrounded surface tunnels to feed during more humid periods of the night or early morning. The species probably overwinters as juveniles which are inactive during long cold periods. With the coming of warm early spring days of February, March, and April, activities increase and development is completed.

The strong red and black pigmentation of the male and the fact that these winged forms have been collected in the sweep net, suggests that the male of the species disperses diurnally. The males in a given area probably mature about the same time and crawl up on the grass and other low vegetation and take flight in their peculiar termitelike manner. Although many of these colony-free males may succumb to the hazards of the outside environment, such dispersal tends to lessen the chances of developing distinguishable isolated populations. In Mexico, where males of many species of *Chelicerca* are apterous, a great complex of species has developed within relatively small geographic areas.

We may expect to find *rubra* in the proper niches along the coast, possibly from Santa Barbara on the north southward well into Baja California. Inland, it should extend northward from proper zones in the San Pedro Martir Mountains, Baja California, along the eastern slopes of the mountains of southern California, thence possibly into the basin ranges of Inyo County.

Family Oligotomidae

Genus *Oligotoma* Westwood

Oligotoma nigra Hagen

(Figs. 1, 4)

Oligotoma nigra Hagen, 1885, Canad. Ent., 17:174. Type locality: Cairo, Egypt. M.C.Z.

Synonyms: *Embia californica* Banks (1906), *Oligotoma mesopotamica* Esben-Petersen (1929).

Region of endemicity: Probably western and/or northwestern India (related species are concentrated in India).

Man-extended Old World distribution:

Tigris-Euphrates valleys, Israel, and Nile Valley from Upper Sudan to Cairo. Undoubtedly found in intervening areas, especially in warm irrigated regions.[1] Range probably extended in ancient as well as modern commerce.

Man-created New World distribution:

Warm regions of California, Nevada, Arizona, and Texas (one record). Probably also in Rio Grande Valley of New Mexico, northern Sonora and Baja California, Mexico.

California records:

Imperial Co.: El Centro (R. H. Beamer, K. U.); El Centro, IV-1939 young in bark of Canary Island palm in city park (Ross and Michener, C.A.S.); Holtville, VI-23-46, male at light (E. C. Van Dyke, C.A.S.); Laguna Dam, Colorado River, 2 males, XII-30-51 (R. L. Usinger, C.A.S.).

Inyo Co.: CCC Camp, Death Valley, 1 male at light, III-20-51 (M. L. Seibert, C.A.S.); Furnace Creek, Death Valley, 2 males at light, III-13-41 (E. C. Van Dyke and T. Aitken, C.A.S.).

Los Angeles Co.: Pacific Palisades, 2 males at light during heat wave, IX-2/7-55 (W. A. McDonald, U.C.L.A., C.A.S.).

Riverside Co.: Blythe, 2 males at light, VII-14-38 (P. H. Timberlake, U.C.R., C.A.S.); Blythe, male at light, VII-14-38 (P.H. Timberlake, U.C.R. and C.A.S.); Blythe, 2 males at light, VI-21-46 (J. W. MacSwain, C.I.S.); Blythe, 1 mature female, VIII-20-47 (J. W. MacSwain, C.I.S.); Blythel, 1 male, VI-22-45 (E. G. Linsley and R. F. Smith, C.I.S.); Blythe, 2 males at light, VII-16-50 (B. Adelson, C.I.S.); Blythe, numerous juveniles in colony on underside of drawing board on cement

[1] Specimens recently received from New South Wales indicate an extension into Australia.

floor, VI-25-47, (R. F. Smith, C.I.S.); Indio, juveniles in bark of date palm, IV-1939, (E. S. Ross and C. D. Michener, C.A.S.); Mecca juveniles in date palm (D. W. Pierce, L.A.M.); Palm Springs, numerous males on walls under lights at night, VI-1-39 (E. S. Ross, C.A.S.); Riverside, male at light (O. L. Brawner, U.C.R.).

San Diego Co.: La Jolla, colonies under stones and palm logs, 2 mature males IV-25-40 (E. S. Ross, C.A.S.); San Ysidro, colonies under stones, 2 mature males present, IV-3-6-39 (E. S. Ross, C.A.S.).

Tulare Co.: Ducor, 1 male in grain conveyor XII-16-55 (R. P. Allen, C.D.A.).

Discussion:

As can be gained from the above records, this Old World species is now thoroughly established in California as well as in other regions of southwestern United States and probably northwestern Mexico. It is almost certain that it was introduced into the New World in the late 1880's or 1890's in date palm cuttings from Egypt and the Persian Gulf regions where the species is common. Further evidence of this mode of entry is the fact that *nigra* commonly inhabits the trunks and basal offshoots of date palms both in the Old and New World. It is by no means restricted to such habitats, however. Furthermore, Dr. T. D. A. Cockerell informed me that he and Nathan Banks years ago collected live Embioptera and many other insects in Old World date palm cuttings being held for inspection in Washington, D.C., before their dispatch to the Southwest for propagation.

In spite of its early introduction and subsequent increased spread and population growth, this species remained incorrectly identified until recently (Ross, 1940). The synonym, *Embia californica* Banks, was not only long applied to the species but also to the more common *Haploembia solieri* (Rambur) (*vide infra*).

It is probable that *nigra* will gradually extend its range northward along the California coast and interior valley. The extension will be limited only by low temperature and perhaps excessive moisture, but not by an absence of niches and food.

Males of *nigra* are easily recognized because they are winged, relatively large, and rather uniformly brownish or blackish in color. Any winged male embiopteron taken at light in California is almost certain to be *nigra*. The only other male embiids in California are those of the much smaller and rarer *Chelicerca rubra*. Such males can be immediately distinguished by their bright reddish body with contrastingly blackish head and abdominal terminalia. Males of *rubra* have never been collected at light.

Adult females of *nigra* may be distinguished by their rather uniformly blackish-brown color and absence of maculation. They may be also distinguished from those of *Haploembia*, which is pale and maculate, by their lack of a second (medial) sole-bladder on the hind basitarsus. The latter character can be used for distinguishing all stages of the two species.

Nigra is a vigorous weed species, occupying a great variety of ecological niches. It probably develops continuously, with any stage or sex present at any time of the year. During cold periods, however, its activities may cease temporarily. Like so many xerophilous creatures, the males disperse nocturnally and are attracted to light. Such males are a common sight at lights on warm summer nights in the Coachella and Imperial valleys as well as in Arizona.

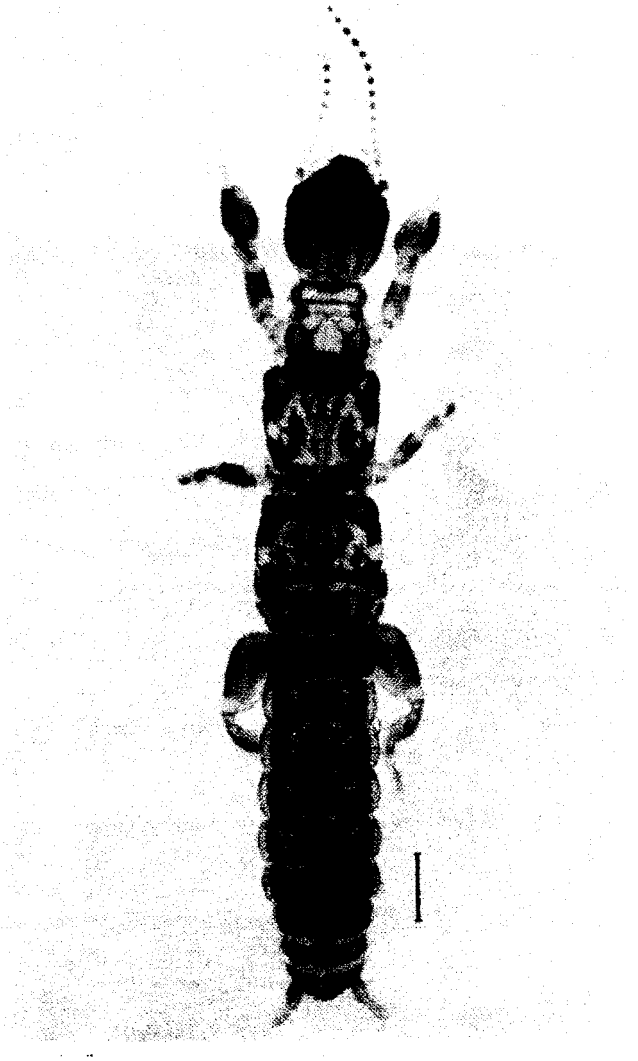


Fig. 5. *Haploembia solieri* (Rambur), adult female exhibiting characteristic maculation.

Genus *Haploembia* Verhoeff

Haploembia solieri (Rambur)

(Parthenogenetic form)
(Figs. 2, 5, 6, 7)

Embia solieri Rambur, 1842, Hist. Nat. Insectes Neuropteres, Paris, p. 313. Type locality: near Marseille, France, deposited in Inst. Royal Sci. Nat. Belg., Brussels.

Synonyms: *Embia taurica* Kusnezov (1903); *Embia (Haploembia) grassii* Friederichs (1906); *Embia cephalotes* Navás (1908); *Haploembia codinae* Navás (1922); *Gynembia tarsalis* Ross (1940).

Geographic range:

Bisexual form: certain shores and islands of the Mediterranean and Black seas; Atlantic coast of Portugal and Morocco. Parthenogenetic form: Sardinia, Corsica, and adjacent islands; Canary Island, northern Baja California (Mexico), California, Arizona, and Texas (one record).

On the basis of numerous records and observations, it is concluded that this species occurs, or can occur, throughout the grass-oak or Mediterranean life zones of California. It thus occurs throughout the Coast Range, from at least Clear Lake on the north, southward into northern Baja California. In the interior of the state it probably encircles the foothill regions surrounding the Central Valley. In altitude it ranges through the zone of digger pines and well into the ponderosa pine level. Its range also extends into suitable grassy zones facing the Mojave Desert. The most northerly record in the state is Red Bluff, Tehama County.

Fig. 6. *Haploembia solieri* (Rambur), eggs.

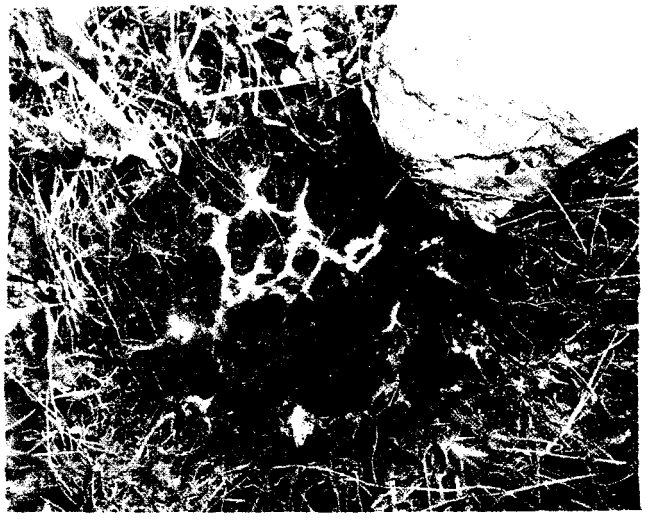


Fig. 7. *Haploembia solieri* (Rambur), typical small colony under stone in grassland. Silk tunnels extend down soil crevices.

Discussion:

This is the embiopteron most frequently encountered in California. The complete absence of males, so vital in the taxonomic study of Embioptera, caused considerable difficulty in establishing the identity of the species. For many years it was referred to as *Embia* or *Oligotoma californica* Banks (= *Oligotoma nigra* Hagen), and recently (Ross, 1940) it was placed as a distinct genus and species of uncertain position in the order. More recently (Ross, 1944) it was suspected to be assignable to the Mediterranean genus *Haploembia*. With the discovery of parthenogenetic *Haploembia solieri* on Sardinia (Stefani, 1953), and a comparison of specimens from California and Sardinia, it is now concluded that the California population was introduced by man from the Mediteranean region or the Canary Islands. In view of the extensive distribution of the California population, such an introduction must have occurred at a very early date, perhaps in the Spanish colonial period.

The kind of taxonomic category represented by this parthenogenetic form is still open to question.

According to Stefani, females of the parthenogenetic form differ from those of the bisexual type in their slightly paler coloration and in having the rim of the egg's operculum not elevated. There is also geographic and complete sexual isolation. Stefani found that the parthenogenic females repulse males of *solieri,* and it is unlikely that mating could occur and thus interrupt the parthenogenetic mode of reproduction.

BIOLOGY

The preferred environment of *solieri* is a warm, sunny, well-drained grassy slope. Another requirement is a type of soil, such as adobe or serpentine, which will crack and thus provide access to moist cool depths during the long dry season. The occurrence of *solieri* in such places is limited, however, by the need of stones for cover. In addition to stone cover, the species will utilize dry cattle droppings (the embiid tunnels ramify through abandoned coprophagous insect burrows), logs, matted leaves, bark at the bases of oak trees, boards, and the like. In many places it is conceivable that the species could exist without more cover than matted leaves or grass as long as soil cracks exist or open at the proper season to provide escape from desiccation and heat.

Solieri has but one generation annually. Females mature in May or June and lay eggs in protected places in the lower tunnel system. These hatch a few days after oviposition, and the young begin development during the summer months. With approaching cold weather, development slows and then ceases during prolonged winter cold periods. At such times the embiids completely enclose themselves in dense silk cocoons "uberwinterungnesten." The species has been found in zones of the Sierra Nevada which experience appreciable snowfall. In the spring, development resumes, and the females come to maturity. Males of this species have never been found in California and probably never will unless bisexual stock is introduced. Considerable information on parthenogenesis in this species has been presented by Stefani (1956).

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