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DELTAMYSIS HOLMQUISTAE, A NEW GENUS AND SPECIES OF MYSIDACEA FROM THE SACRAMENTO-SAN JOAQUIN ESTUARY OF CALIFORNIA (MYSIDAE: MYSINAE: HETEROMYSINI)

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Abstract.—*Deltamysis holmquistae* is described from the Sacramento-San Joaquin estuary of central California. Its sparsity in plankton net samples suggests that its supposed habitat has not been sampled adequately. Limited sampling in tule beds failed to take specimens. *Deltamysis holmquistae* may be an introduced species; it was not found until 1977 despite sampling for Mysidacea in the estuary since 1963. Characteristics of the tribe Heteromysini are redefined to include *Deltamysis*. The new definition allows the addition of *Burrimysis* and the transfer of *Mysidetes* from the Leptomysini to the Heteromysini. A new key to the Heteromysini is given which includes the subgenera of *Heteromysis*.

W. M. Tattersall (1932) identified the following five species of Mysidacea taken on the 1912–1913 *Albatross* survey of San Francisco and San Pablo Bays: *Neomysis mercedis* Holmes, 1897; *Neomysis franciscorum* Holmes, 1900 (current name *N. rayi* (Murdoch, 1885)); *Neomysis kadiakensis* Ortmann, 1908; *Neomysis costata* (Holmes, 1900) (misidentification of species currently named *Exacanthomysis davisi* (Banner, 1948)); *Neomysis macropsis* Tattersall, 1932 (current name *Alienacanthomysis macropsis* (Tattersall, 1932)).

Most numerous of these species is *N. mercedis*, which is usually most abundant in Suisun Bay and the Sacramento-San Joaquin River delta upstream from San Pablo Bay (Orsi & Knutson 1979). The new species described below occurs in the same area as *N. mercedis*.

Methods

The California Department of Fish and Game has conducted a continuous monitoring survey of zooplankton since June 1968. Mysids were collected in a 0.505 mm mesh plankton net, 1.48 m long and 29 cm in diameter. Diagonal 10-minute bottom to surface tows were made at fixed stations in Suisun Bay, the Delta and, during periods of high river outflow, downstream into San Pablo Bay (Fig. 1). Sampling was done twice a month from April to November and monthly in March and November. Year-round sampling was done prior to 1984. Surface and bottom electrical conductivity, surface temperature, chlorophyll *a*, and Secchi disc measurements were made at the beginning of each tow.

Heteromysini Hansen 1910

Deltamysis, new genus

Scale of antenna 2 with transverse suture separating short distal segment. Pereopod 2 (endopod of thoracopod 3) not stouter than other pereopods. Pleopods rudimentary in both sexes. Endopod of uropod without spines near statocyst or on medial margin. Penis of moderate size, reaching distal margin of basipod of pereopod 7. Telson entire,

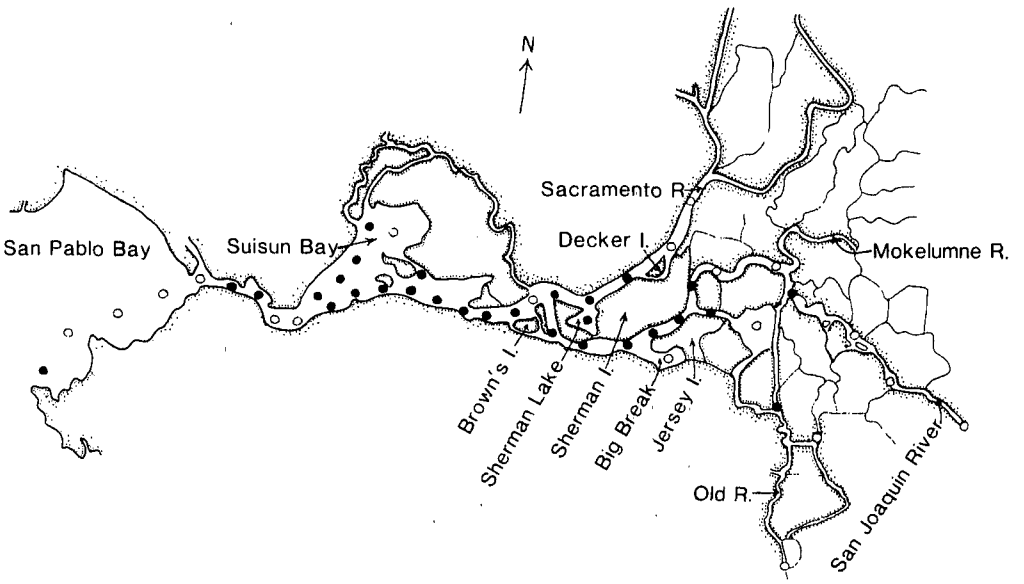

Fig. 1. Sacramento-San Joaquin Estuary. Zooplankton stations of California Department of Fish and Game indicated by circles. Stations where *Deltamysis holmquistae* has been collected indicated by solid circles.

apex with pair of short central spines flanked by 3 pairs of longer spines.

Type species.—*Deltamysis holmquistae,* new species.

Etymology.—From the Sacramento-San Joaquin *Delta* + *mysis.*

Deltamysis holmquistae, new species
Figs. 2–4

Material.—All from the Sacramento-San Joaquin Estuary, collected between Brown's Island and Jersey Island (Fig. 1) and deposited in the Division of Crustacea, Smithsonian Institution. Holotype ♂, USNM 251607. Allotype ♀, USNM 251608. Paratypes: USNM 251609, 5; USNM 251610, 7; (exact locations and dates of collection unknown for USNM 251607-251610). USNM 251611, Sta. 78, between Sherman I. and Jersey I., 2 Sep 1977, 1 ♀; USNM 251612, Sta. 78, 26 Aug 1977, 2; USNM 251613, Sta. D-11, Sherman Lake, 18 Aug 1977, 2; USNM 251614, Sta. 76, W of Jersey I., 26 Aug 1977, 2; USNM 251615, Sta. 74, S of Sherman Lake, 2 Sep 1977, 1; USNM 251616, Sta. 62, N of Sherman Lake, 1 Sep 1977, 1; USNM 251617, Sta. D-15, between Sherman I. and Jersey I., 26 Aug 1977, 2; USNM 251618, Sta. 56, N of Brown's I., date unknown, 9.

Etymology.—Named for the distinguished Swedish zoologist, Charlotte Holmquist, in recognition of her important contributions to the systematics of Mysidacea of the North American Pacific coast.

Description.—Length of adult (rostrum-telson) 3–5 mm. Carapace emarginate posteriorly, exposing pereonite 7. Rostrum short, rounded in dorsal view, pointed in lateral view. Eyestalks short, about as long as eye, which is about 1.5× as wide as long and born obliquely laterad on stalk. Telson about 1.2× as long as width at base, entire, with 7 pairs of marginal spines as follows: 4–5 lateral pairs increasing in length posteriorly, 2 long subapical pairs, and 1 short apical pair less than half length of subapical spines.

Antenna 1 peduncle segments 1 and 3 subequal in length, about 2× as long as seg-

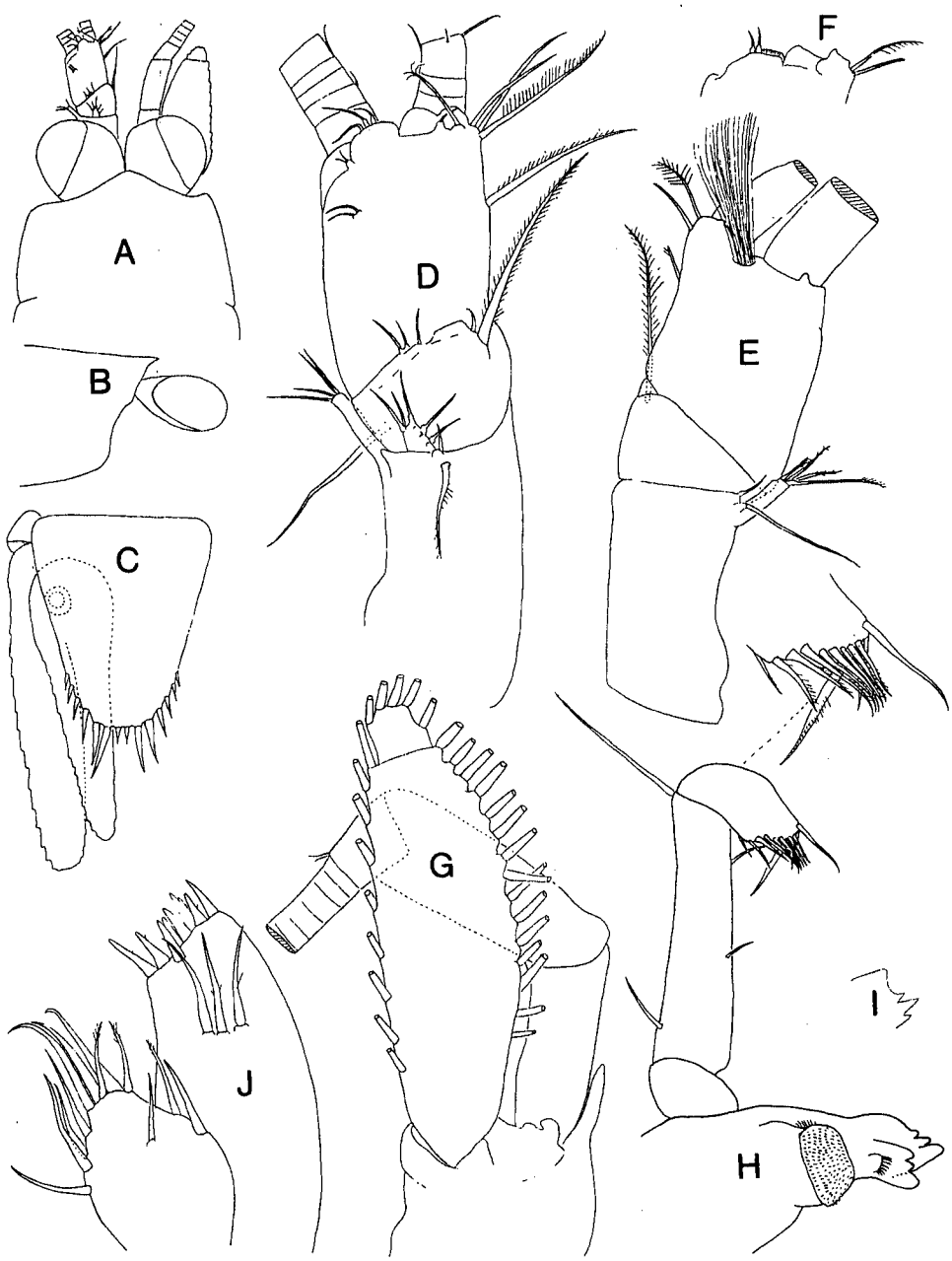

Fig. 2. *Deltamysis holmquistae*: A, Anterior body, dorsal, ♀; B, Same, lateral; C, Telson and uropod, dorsal, ♂; D, Left antenna 1, dorsal, ♀; E, Left antenna 1, ventral, ♂; F, Antenna 1, distal part of segment 3, dorsal, ♂; G, Left antenna 2, dorsal, ♂; H, Left mandible, anterior, ♂; I, incisor of right mandible, ♂; J, Left maxilla 1, posterior, ♂.

Fig. 3. *Deltamysis holmquistae*: A, Left maxilla 2, anterior, ♂; B, Left maxilliped, anterior, ♂; C, Left pereopod 1, ♀; D, Pereopod 3; E, Pereopod 7, ♀; F, Pereopod 7 basipod and 1st segment of exopod, ♂, with penis at base.

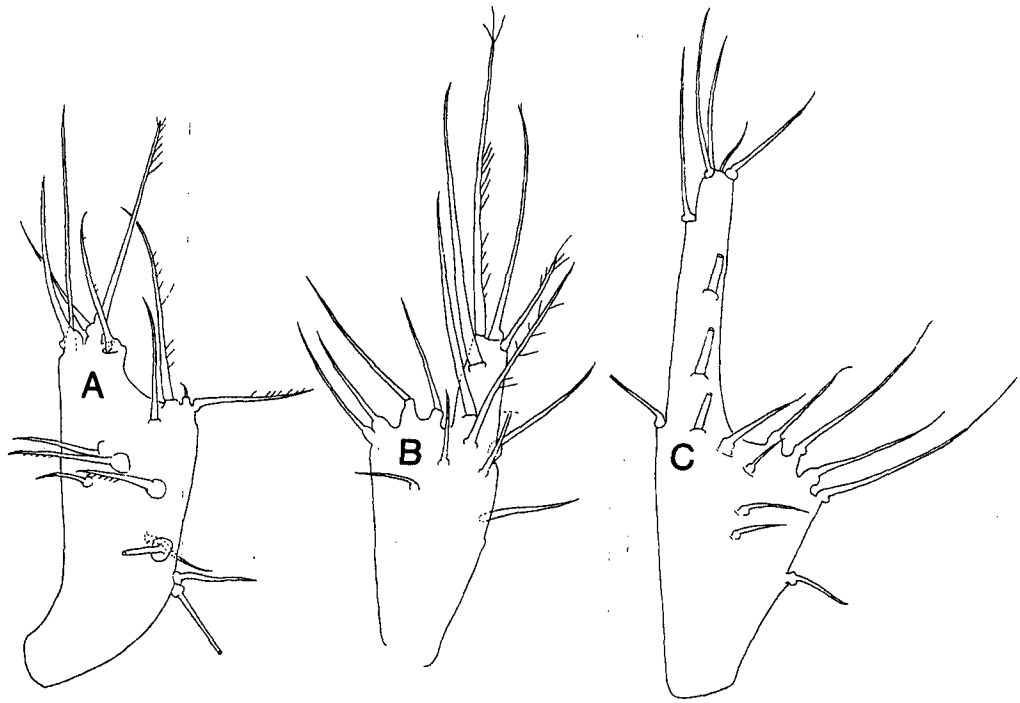

Fig. 4. *Deltamysis holmquistae*: A, Left pleopod 1, anterior, ♂; B, Left pleopod 4, posterior, ♂; C, Right pleopod 5, anterior, ♂.

ment 2. Segment 1 with long middorsal seta near distal margin, subtriangular process distally slightly lateral to seta bearing several bulbous-based setae, and narrow rectangular process at distolateral corner bearing 4 apical setae. Segment 2 with dorsal distomedial seta reaching almost to distal end of segment 3. Segment 3 with several rounded setose lobes dorsally at distal end; male antennular brush inserted directly on ventral surface, male lobe not developed.

Antenna 2 peduncle reaching distal end of scale; segment 1 produced at distomedial corner into lanceolate process. Scale about 3× as long as wide; distal segment about 0.1× scale length.

Left mandible with 3-cuspate incisor and lacinia; right mandible with 4-cuspate incisor and no lacinia. Spine-row represented by 8 slender spines on a rounded boss. Molar with broad elliptical grinding surface. Palp segment 2 about twice length of segment 3, with seta on distolateral corner more than half length of segment; segment 3 with oblique distal margin armed with row of setae of uniform length and 2 longer setae.

Maxilla 1 outer ramus with 9 apical spines and 3 surface setae. Inner ramus with 11 marginal setae and 1 surface seta.

Maxilla 2 protopod inner margin completely covered with setae. Endites densely setose apically. Endopod proximal segment less than 0.25× as long as distal segment; latter almost 2× as long as wide, densely setose at and near apex. Exopod not reaching proximal margin of segment 1 of endopod, armed only with 2 apical setae.

Maxilliped (endopod of thoracopod 1) endite of basis nearly reaching distal margin of ischium. Medial margin of all segments except propus densely setose; latter with 3 setae on medial part of distal margin and 3 broom setae on lateral margin.

Pereopod 1, merus with 5 long setae on

anterior margin; carpus with 2 shorter setae on anterior margin; propus with 6 long setae on or near distal margin and 3 on lateral surface; dactyl about 0.8 × length of propus, with 15 marginal setae. Pereopods 2–3, "tarsus" of 3 segments. Pereopods 4–7, "tarsus" of 4 segments.

Penis cylindrical, about 5 × as long as wide, reaching slightly beyond basis of pereopod 7, unarmed.

Pleopods of both sexes in form of unsegmented plates. Proximal part bearing bulbous-based setae; pseudobranchial lobe also bearing bulbous-based setae. Distal part short in pleopods 1–4, in pleopod 5 longer and armed with long setae on anterior surface and at apex.

Uropod about 1.7 × length of telson. Exopod slightly longer than endopod.

Relationships.—Definitions of the Heteromysini, e.g., that of Tattersall & Tattersall (1951), emphasize the enlarged pereopod 2, the rudimentary condition of the pleopods in both sexes, the long penes, and the reduction in size of the male lobe of antenna 1 and in the number of setae borne by this lobe.

However, in the genus *Harmelinella* Ledoyer (1989), recently described and assigned to the Heteromysini, pereopod 2 is not enlarged. In other features *Harmelinella* conforms to the Heteromysini except for the very long male pleopod 3, comparable in length to the long pleopod 4 characteristic of members of the tribe Mysini. If *Harmelinella* is accepted in the Heteromysini, enlargement of pereopod 2 is no longer a requirement for membership in this tribe, and *Deltamysis* can be included in it without difficulty, as can *Burrimysis* Jaume & Garcia (1992), which also lacks an enlarged pereopod 2.

The genus *Mysidetes* Holt & Tattersall (1906) does not have an enlarged pereopod 2, but the pleopods of both sexes are rudimentary, and the penes are very long, in some species extending anterior to the rostrum. The male lobe varies from small to well developed. *Mysidetes* is now placed in the tribe Leptomysini, in which it is the only genus with rudimentary pleopods in both sexes. If the definition of the Heteromysini is expanded to accommodate *Harmelinella* and *Deltamysis,* then *Mysidetes* must be transferred from the Leptomysini to the Heteromysini.

Some characters of *Mysidella* Sars (1872) fit the revised definition of *Heteromysis* given below, including the rudimentary pleopods of both sexes and the long penes. However, the form of the labrum, mandible, and maxilla 2 of *Mysidella* are so unusual that it is generally assigned to its own subfamily, *Mysidellinae* Czerniavsky, 1882.

Within the expanded Heteromysini *Deltamysis* is most similar to the recently described *Burrimysis* Jaume & Garcia (1992), from an anchialine lake in a cave of the island of Cabrera, Balearic Islands. Whether or not the features that distinguish *Burrimysis* from *Deltamysis* are of generic value is debatable, but for now we prefer to recognize both genera pending further evidence. *Burrimysis* differs from *Deltamysis* in having a telson with an apical cleft lined with denticles, a uropodal endopod with a spine on the medial margin near the statocyst and a row of spines on the lateral margin, and an unsegmented antennal scale.

An alternative to expanding the limits of the Heteromysini would be to resurrect Holt & Tattersall's (1906) subfamily Mysidetinae, but with tribal rank, Mysidetini, to include *Mysidetes, Harmelinella, Deltamysis,* and *Burrimysis.* Hansen (1910) rejected "the subfamily Mysidetinae which I cannot accept" without a word of explanation of his reasons for doing so, and assigned *Mysidetes* to the Leptomysini. All subsequent authors, including Tattersall (1955) have followed Hansen in placing *Mysidetes* in the Leptomysini.

Although a plausible case can be made for recognizing the Mysidetini, we choose

for the time being to expand the definition of the Heteromysini and to postpone consideration of the validity of the Mysidetini.

We offer the following revised diagnosis of the Heteromysini and key to the genera and subgenera assigned to it. The section of the key dealing with the subgenera of *Heteromysis* is modified from Băcescu (1968).

Tribe *Heteromysini* Norman, 1892

Male lobe of antenna 1 usually reduced. Antenna 2 scale setose all around. Pereopod 2 sometimes enlarged and robust. Propus (=carpopropodus of Hansen and others) of pereopods 3–7 divided into subsegments. Pleopods of both sexes rudimentary, except long pleopod 3 of male *Harmelinella*. Penes long, cylindrical. Telson with or without apical cleft.

Key to the Genera and Subgenera of Heteromysini

1. Pereopod 2, some of distal segments enlarged 2
– Pereopod 2 without enlarged distal segments 4
2. Body isopod-like, dorsoventrally flattened. Pleonites with well developed pleurae ..... *Platymysis* Brattegard, 1980
– Body not dorsoventrally flattened. Pleonites without well developed pleurae 3
3. Eye reduced, restricted to distolateral part of eyestalk ..... *Heteromysoides* Băcescu, 1968
– Eye well developed, occupying full width of distal part of eyestalk ..... *Heteromysis* Smith, 1873
   a. Pereopod 2 very robust, greatly inflated; merus enlarged, dentate; exopod reduced. Endopod of uropod longer than exopod ..... *H.* (*Gnathomysis*) Bonnier & Pérèz, 1902
   – Pereopod 2 only moderately robust. Endopod of uropod shorter than exopod ..... b
   b. Pleopods not sexually dimorphic. Pleon with median sternal processes ..... *H.* (*Heteromysis*) Smith, 1873
   – Pleopod 4 sexually dimorphic. Pleon without median sternal processes c
   c. Antenna 1 with pair of modified setae on distomedial corner of segment 3; medial seta linguiform with subterminal flagellum; lateral seta simple, very long, directed laterally ..... *H.* (*Olivemysis*) Băcescu, 1968
   – Antenna 1 with 2 pairs of simple setae on distomedial corner of segment 3, pairs diverging from each other. Pleopod 4 with 2 apical setae longer than pleonite 4 *H.* (*Neoheteromysis*) Băcescu, 1976
4. ♂ pleopod 3 very long, 2-segmented ..... *Harmelinella* Ledoyer, 1989
– ♂ pleopod 3 rudimentary, unsegmented 5
5. Telson with apex truncate, not cleft ..... *Deltamysis,* new genus
– Telson with apical cleft lined with denticles 6
6. Endopod of uropod with row of spines on medial margin (except *M. hanseni* Zimmer, 1914). Antennal scale with small distal segment separated by transverse suture (except *M. halope* O'Brien, 1986) ..... *Mysidetes* Holt & Tattersall, 1906
– Endopod of uropod without row of spines on medial margin. Antennal scale without suture ..... *Burrimysis* Jaume & Garcia, 1992

Occurrence of *Deltamysis holmquistae*

Although there has been continuous sampling for zooplankton in the estuary since June 1968 and earlier sampling from 1963–

1965 (Turner & Heubach 1966, Heubach 1969), *Deltamysis* was not found until August 1977. It has been collected every year since 1977, but in low numbers, from one specimen in 1984 to 39 in 1987. Specimens have been taken from western San Pablo Bay (one specimen during the high spring outflow of 1983) to Decker Island in the Sacramento River, in the San Joaquin River to the mouth of the Mokelumna River, and in the southern delta from the Old River (Fig. 1). The salinities where it was found ranged from fresh water to 18.7‰. Most specimens have been taken in salinities of 1.1–2.2‰, which is at the upstream edge of the entrapment or null zone, a region of high turbidity, long water residence time, and high concentrations of phytoplankton and zooplankton.

Heteromysini are epibenthic or commensal rather than planktonic, and plankton tows collect them neither efficiently nor quantitatively. Commensal species, summarized by Mauchline (1980), are associated with sponges, sea anemones, gastropod shells of hermit crabs, and brittle stars. Almost nothing is known about the habits of species of Heteromysini that have not been found to be commensal. In the living coral reef exhibit at the National Museum of Natural History, Smithsonian Institution, a population of *Heteromysis mayana* Brattegard (1970) lives in the lagoon part of the exhibit. Individuals swim constantly among the sea grass plants at the bottom, alighting briefly on the grass leaves from time to time, but not swimming into the water column above the leaves. If *Deltamysis holmquistae* behaves like *Heteromysis mayana,* plankton tows would capture few of them, and the low numbers in the Department of Fish and Game samples are the result of a sampling method that is inefficient for this species. Sampling with a net mounted on a sled would produce better information on the distribution and abundance of *D. holmquistae.*

We have considered the possibility that *Deltamysis* lives in the extensive tule marshes of the estuary. These are marshes dominated by the large sedges *Scirpus lacustris* and *S. acutus.* These marshes are of two kinds, seasonally flooded and permanently flooded. The extensive marshes north of Suisun Bay fall in the first category. These marshes are owned either by the state of California or by private hunting clubs which flood them, usually in September, to attract waterfowl. No aquatic animals can survive year-round in these marshes because they are drained in the spring.

The tule marshes that are permanently underwater are more limited in area. The largest are on Brown's Island and at the submerged western end of Sherman Island around Sherman Lake. Sampling on Brown's Island with a dip net failed to catch mysids. Sherman Lake has a regular sampling station, but only one *Deltamysis* specimen has been caught there in all the years of sampling. At another station surrounded by submerged tule marsh in Big Break, no *Deltamysis* specimens have ever been taken.

Origin of *Deltamysis*

Deltamysis holmquistae could be native to the Sacramento-San Joaquin Delta and overlooked until recently because of inadequate sampling techniques. Or it could be an addition to the growing list of species considered to have been introduced through human activity (e.g., Orsi et al. 1983, Ferrari & Orsi 1984, Orsi & Walter 1991). San Francisco Bay is young, formed in the late Pleistocene (Atwater et al. 1977), hence there has been insufficient time for endemic species to evolve in its estuarine habitats. These habitats have been available since the arrival of Spanish ships in 1776 for colonization by non-endemic species, many of which were introduced during the last century (Carlton 1979).

If *D. holmquistae* is an introduced species, there is no evidence of its possible origin, since no mysid species closely resem-

bling it is known elsewhere. Since several copepods introduced into the Sacramento-San Joaquin estuary are considered to be native to the Far East, that is the obvious geographical region in which to begin to search for *Deltamysis*.

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