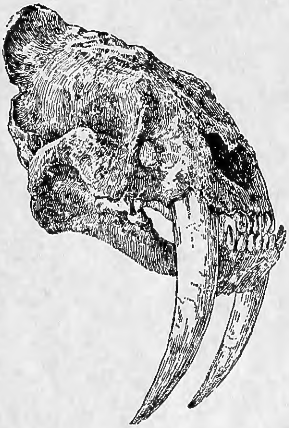
BULLETIN OF THE
# Southern California Academy of Sciences

LOS ANGELES, CALIFORNIA

Nostra tuebimur ipsi.



Vol. 61 January-March, 1962 Part 1

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Issued May 11, 1962

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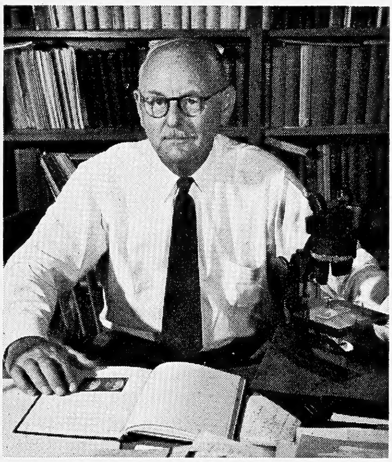

# A RESOLUTION

WHEREAS the Southern California Academy of Sciences has regretfully accepted the resignation of

DR. JOHN ADAMS COMSTOCK

as Editor of the BULLETIN

AND WHEREAS Dr. Comstock joined this Academy on June 23, 1919, was elected a member of the Publications Committee immediately thereafter, and has served continuously since then as Editor of the BULLETIN

AND WHEREAS he has long and loyally served this Academy in many other official capacities, to wit: Secretary, 1921-1926; President, 1926-1927; Treasurer, 1937-1939; Secretary-Treasurer, 1939-1948, and member of the Board of Directors since June 17, 1920

AND WHEREAS under his editorship the monographic series known as the Memoirs of the Academy was introduced in 1938, and six numbers have been published

AND WHEREAS he has contributed to the BULLETIN many outstanding scientific articles on the subject of Lepidoptera, accompanied by meticulously rendered illustrations of life histories drawn from life, all of which have enhanced the reputation of the BULLETIN as a scientific journal

AND WHEREAS he has led other scientists into active work for the Academy by his verbal eloquence, his congeniality, and his own example of devoted service

THEREFORE BE IT RESOLVED that the Southern California Academy of Sciences hereby expresses to Dr. Comstock the sincere thanks of all members and officers who have profited by his long, outstanding service as an eloquent literary spokesman in the promotion of scientific knowledge, and extends to him hearty wishes for his continuing good health and success in scientific achievement.

THEODORE DOWNS, *President*
GRETCHEN SIBLEY, *Secretary*

# LIFE HISTORY NOTES ON *EPIPLATYMETRA GROTEARIA* PACKARD

JOHN ADAMS COMSTOCK
Del Mar, California

During the summer field work of the Los Angeles County Museum group of entomologists in the Tonto Creek area of Gila County, Arizona, we were able to obtain eggs of *Epiplatymetra grotearia*, on July 1, 1956. These were reared to maturity, which made possible the following record of its life history, no portion of which has heretofore been published.

## EGG

Barrel-shaped, with rounded ends. Length, 1.1 mm. Width, 0.75 to 0.89 mm. The eggs were laid on their sides. In captivity they were placed in a single row.

The color is a delicate ivory-green when first laid, changing later to ivory-white, speckled with small brown dots and dashes, as shown on Figure 1. At first there appears to be a number of faint longitudinal lines on the surface of the egg, barely discernible under X 16 magnification. Later these lines become indistinguishable.

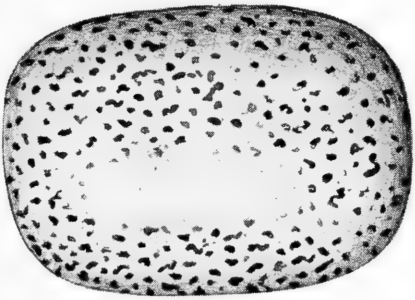

*Figure 1.* Egg of *Epiplatymetra grotearia.* Enlarged X 50.

There is apparently a cap-like micropyle at one end of the egg, but this is faintly indicated in only a few examples, and is absent in the others.

The 18 eggs in our original lot all hatched on July 14, 1956. The young larvae were tried on leaves of oak, peach, cherry, pine, raspberry and willow. They accepted the willow, and several were carried to maturity on it.

### FIRST INSTAR LARVA

The newly emerged larvae were long and cylindrical, of the characteristic "looper" type. They averaged 5. mm. in length. The head was wider than the first segment. The face and front were dull yellow, the mouth parts slightly darker, and the antennae black. The ocelli were prominent, and jet black.

*Body:* Ground color, translucent light yellow. There is a very narrow middorsal longitudinal yellow stripe, bordered by a very wide olive-green band. Below this, and on the ventral surface, the color is light yellow.

The legs are concolorous with the venter as are also the single pair of prolegs. No setae are distinguishable with a X 16 hand lens.

### LARVA OF 13 MM. LENGTH

Head, 0.9 mm. wide, which is also the average width of the body segments. The upper half of the head is light orange-yellow and the lower half white.

The body is regularly cylindrical throughout. The ground color is light yellow-green. The segmental junctures are yellow.

There is a middorsal longitudinal band of light green margined with yellow. Lateral to this is a narrow dull green stripe, on which there are minute black dots placed approximately one to a segment. Lateral and below this are several narrow longitudinal stripes, alternately green and yellow.

The infrastigmatal fold is yellow. The venter is striped as is the lateral surface. The spiracles are indistinguishable. The legs and prolegs are concolorous with the body.

On September 10, 1956 most of the larvae were mature, and a typical example was described as follows:

### MATURE LARVA

Length, 30. to 34. mm. Widest segment of body (7th) 2.5 mm. The shape is unusually elongate, and cylindrical.

Head width, 2. mm., very flat. Ground color, light tan. The adfrontal sutures are barely discernible as delicate brown lines.

The front is speckled with light brown, which is absent down the center, where the tan ground gives the appearance of a light stripe. Near the clypeal juncture there are two dark brown dots, one each side of the light middle area.

The cheeks are mottled with light brown dots and crossed longitudinally by two lines of blackish-brown dots, these lines ending on each cheek at the outer margin of the clypeus.

The mandibular area, including the clypeus, is of the same shade as the ground color, except for a darker shading medially.

The mandibles are tipped with black, the antennae are hyaline light tan, and the ocelli are black.

In the middorsal area of the body there is a longitudinal crenulated and partly discontinuous pair of stripes, occasionally accented with black dots. Lateral to this is a pair of crenulated black stripes which appear and disappear in an irregular manner. This line is an extension of the similar dark line on the cheeks, and it tends to become obsolescent near the cauda.

Below this the body is mottled with numerous light brown dashes, dots, and broken longitudinal stripes. There is a semblance of a wavy white longitudinal band substigmatally. This becomes well defined near the cauda, and is there edged superiorly with a dark brown line. On the first three segments this light substigmatal band is bordered inferiorly with a broad band made up of black dots.

The spiracles are conspicuous and are margined with black.

The venter is longitudinally marked in stripes of various shades of brown. The legs are concolorous with the body. The single pair of prolegs bear a whitish longitudinal band edged with dark dots, and the anal prolegs are marked somewhat similarly.

The crochets are dark brown. The few scattered setae are very short and inconspicuous. The larva is illustrated on Figure 2.

## PUPA

Length, 13 mm. Greatest width, 3.6 mm. The ground color is light tan on the cephalothorax and wing cases, and yellow-tan on the abdominal segments. The cremaster is deep blackish brown. The three middle segmental junctures of the abdomen are wide bands of deep brown, the remaining junctures being narrow.

The outer edges of the antennae are widely bordered with deep brown and the fronds are marked by well defined narrow brown lines.

The eyes are tan, with a marginal shading of light brown. The wing cases are striated over the venules.

On the third and fourth abdominal segments there are protruding papillae over the spiracles resting on large dark brown blotches. The remaining spiracles are small and deep brown.

A few broken blotches occur middorsally on the first five abdominal segments.

The cremaster terminates in a long cone, topped by two straight black shafts that are only slightly recurved at the tips. On each side of these there are three short yellow hooklets, markedly recurved.

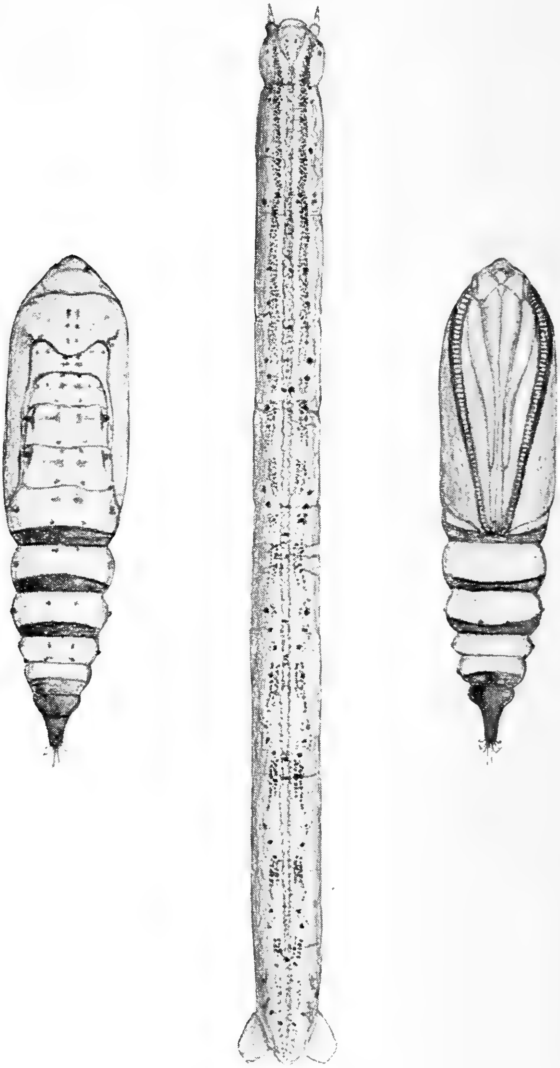

*Figure 2.* Larva and pupae of *Epiplatymetra grotearia.* Central, dorsal aspect of mature larva. Left, dorsal aspect of pupa. Right, ventral aspect of pupa. All figures enlarged X 4½. Reproduced from drawings by the author.

All of the structural features of the pupa are adequately shown on Figure 2. The first imago emerged September 27, 1956.

# THE SIGNIFICANCE OF THE PETROLIFEROUS NODULES OF OUR DESERT MOUNTAINS[1]

W. Dwight Pierce[2]
Los Angeles County Museum

In the last six or seven years there have come to notice multitudes of odd-shaped nodules containing beautiful silicified fossils and petroleum. Prior to 1954, they had been written off as pseudofossils.

The first collection of the nodules was made by W. F. Foshag of the U.S. National Museum, at the abandoned Town of Borate in the Calico Mountains of San Bernardino County, in the early 1930's. It was not then known that they contained fossils.

In January 1954, Dr. Allen M. Bassett of the U.S. Geological Survey, while studying boron deposits, broke open a nodule which contained a fossil dragonfly. He examined other nodules and called them to the attention of Dr. Allison Palmer, of the Survey in Washington. Palmer and Bassett collected from a number of sites opposite Camp Rock on Mule Canyon Drive; and by acid treatments Palmer found many interesting fossil insects.

I had the pleasure of seeing the Palmer collection in Washington in 1955, and shortly after, had a visit from Mr. and Mrs. John H. Rouse, amateur collectors, who had independently found insects in several nodules by cracking them open. They had seen a fossil fish skeleton in a nodule found by H. G. Kirkpatrick, and were in search of another fish when a dragonfly was disclosed.

The first Los Angeles County Museum party visited the Calico Mountains in May 1956, and we have had four expeditions with a total personnel of 51 persons, collecting 29,000 nodules (each one numbered and recorded by site, altitude, and collector). Other people have collected great numbers of nodules, and some very beautiful specimens have been extracted by them.

A total of 100 sites are now known to the writer. While the Calico Mountains in San Bernardino County was the original discovery area, we have now added the following as nodule sources: Tick Canyon, near Lang, in the San Gabriel Range of Los Angeles County; several sites

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[1] Read at the Annual Meeting of the Academy on May 19, 1961.

[2] Curator Emeritus.

on Mt. Pinos, in the Frazier Mountains, Ventura County; Skull Canyon, a branch of Horse Canyon in the Tehachapi Mountains, in Kern County; Lane Mountain, northeast of Barstow and northwest of the Calico Mountains, and also Lenwood Hill, south of Barstow; and the Horse Shoe Hills, east of the Calico Mountains, all in San Bernardino County; and finally Ryan, in Death Valley, Inyo County.

The significance of this distribution is that all of the sites are sources of borax, and are located on or close to andesitic volcanoes.

It makes an interesting pattern when we consider the triangle of the Mojave Desert, bounded on the north by the Garlock Fault, margining the Tehachapi Mountains, and with Death Valley at the northeastern tip; and on the southwest by the San Andreas Fault, margining the transverse mountain ranges of the San Gabriel and San Bernardino Mountains; with Tejon Pass at the junction, and Mt. Pinos the fulcrum of the great Mojave Squeeze. And then on the axis of the Squeeze are Lane Mountain, Lenwood, the Calico Mountains, and Horse Shoe Hills.

However, I expect more sites to be uncovered in the Panamints, and elsewhere in our desert volcanic areas.

One of the first significant features of these findings is that possibly by means of the insect and other fossils, we can correlate the various boron deposits of California.

All of the material so far found is of Miocene age; that is, from 20 to 25 million years old.

There are two series of fossil and petroleum bearing nodules in the Calico Mountains and the Frazier Mountains. The upper courses of nodules are bluish gray in color, while the older deposits contain only pale gray to whitish nodules. The nodules brought out from the borax mines are bluish. Inasmuch as all of the borax mines have been sealed off by the State, we have not been able to get much matrix material for the blue nodules. The white nodules are in lake bed deposits exposed by erosion in the Canyons.

From both series of nodules we obtain several kinds of fossils. When a new lot of nodules is brought in, each nodule is numbered and examined under lens for external specimens. Two percent of all the nodules examined have actual petrified insects, impressions, or moulds of insects, including many wings, visible on the outside.

Certain types of nodule invite cracking, and display cavities formerly occupied by dragonflies, other large insects, and even a beautiful beetle. Some of these nodules were actually formed by concretion around the insect. Many others, on cracking, display specimens and moulds of insects which have not been preserved, but the space they occupied is so clearly outlined that the original occupant can be readily determined. Most of this type are in the upper or blue layers, and silification did not always take place. The strontium or celestite fossils are all in these upper deposits.

The finest fossil material in both blue and white nodules is obtained by digestion of the nodules by acids which do not injure insect tissues, or the silicified replicas of insects. The acids so far effective are 20 percent solutions of formic, acetic, and hydrochloric acid, and a weaker solution of nitric acid. In the case of externally exposed fossils we use the slower hydrogen peroxide. The processes take from a day to weeks. When we find an impression we pour in latex and obtain a cast of the original occupant, so perfect that we can identify many of them.

To date, the findings in the nodules obtained by Dr. Palmer at Washington, Mrs. Ruth Kirkby at Riverside, Mr. John Gibron, Sr., at Campbell, and myself include specimens in 26 orders of invertebrates as follows, from the Calico Mountains, unless otherwise noted:

Turbellaria, or flat worms of three families, and also many strings of eggs, some showing embryos.
Mollusca.
Anostraca, or fairy shrimps, in various stages of growth, and multitudes of their coprolites, and even the eggs in the ovarium.
Ostracoda, from Calico Mountains, and also from Lenwood Hill.
Copepoda, from Lane Mountain.
Acarina, water mites, and their eggs, several species.
Arachnida, water spiders, several species.
Scorpionida, claw of a Scorpion.
Chelonethida, pseudoscorpion, several claws.
Myriapoda, a centipede.
Collembola, springtails.
Odonata, dragon flies and damsel flies.
Ephemerida, may flies, and clusters of eggs.
Plecoptera, Stone fly nymph.
Corrodentia, bark louse young.
Isoptera, five species of termite wings, and soldier head.
Thysanoptera, both suborders of thrips, several species.
Chermodea, jumping plant lice, adults, and wings.
Aphidodea, aphids.
Homoptera, several species of leafhoppers.
Hemiptera, several families of bugs, including egg of one.
Orthoptera, fragment of one grasshopper.

Coleoptera, several families of beetles, including larvae and adults. Also found in the Frazier Mountains.
Lepidoptera, crystallized aquatic moths, and impression of large moth.
Hymenoptera, a crystallized Braconid parasite, an ant, and impression of a wasp.
Diptera, several families of midges and flies, including eggs, larvae, pupae, adults. Also found in the Frazier Mountains.
Pisces, two fish skeletons.
Aves, crystallized feathers, and also feather impressions.
Mammalia, crystallized hairs of mammals.

In the plant kingdom:

Diatoms of several types.
Algae of many kinds.
Mosses of several types, stems and leaflets.
Pond weeds, entire plants.
Seeds of higher plants, also impression of a leaf.

One beetle had died and been filled with fungus, and then crystallized, and the masses of fungus protrude from the segments of the crystal skeleton.

Thus we have a good cross section of Miocene life in 3-dimensional preservation. The best of it is that in numerous specimens the internal structures, muscles, and nervous system have been preserved.

While crystal replication of insects and plants is absolutely new to Paleontology since 1954, we may also add as new records the finding of fossil Turbellaria, or flat worms, never before reported. Another first is the twenty or more kinds of fossil eggs. Dr. Hermann Weyland in Bavaria has, since our first announcement, reported insect eggs from lignite.

The beautiful fossils have another story to tell; that of sudden death and quick preservation. In proof of this are a may fly, which has an active life of one day, in front of her mass of eggs; several Heleid midges caught half way out of their pupa cases; a pair of bugs, and a pair of flat worms in copula; strings of eggs showing embryos in various stages of development; and fairy shrimps with eggs in the brood pouch. In fact, the multitude of insect larvae and pupae in perfect 3-dimensional preservation tell of rapid kill and preservation. There are other cases of decomposed bodies preserved in that condition. The tiny pond weed with corm, rootlets, and leaves in perfect form is a good example. Whatever the state of the biological material at the moment of catastrophe, that is the state that has been preserved for us.

The nodules are of several types. There are true concretions formed around dragonflies and other large insects; however, the insects in these are not silicified, sometimes strontium preserved. There are concretions formed by sudden solidification of boiling minerals, in which the formation is radial from a nucleus. These do not contain fossils. The commonest type are flat layered nodules, which were originally part of a layered bottom formation, and they almost uniformly display biological material.

I interpret from the nodules that life in the lake was normal often for many years, and then sudden catastrophe killed everything in the lake and preserved it. The fossils are not confined to nodules, for we find good specimens in matrix lake bed strata. In such matrix there is also petroleum. Such catastrophes occurred many times in the thousands of years represented by this lake bed series.

In addition to the deposit in the lake bed of volcanic gases, liquid and ash, there was violent earthquake tumbling of the rocks, and we see many evidences of upturned lake beds, of folding and twisting, and in the anticlines and synclines we find nodules in position in strata which had been flat when they rolled in.

My interpretation of the majority of the fossil bearing nodules is that the lake beds were uplifted and tilted by earthquakes, and then sunbaked, cracked, and broken, and the nodules thus formed fell back into the waters, rolled and tumbled and got their rounded form; and new deposits grew up around them, setting them in the matrix in which we now find them. Often a nodule was broken at the point of fold showing that the folding took place when the layers were soft. There are many evidences that the nodules are older than the matrix in which they now are, and it can be seen that the surrounding matrix was gradually built around them.

We also find matrix layers unbroken, containing the same kinds of insect remains. The matrix was laid down in two annual layers, which are of different colors; and in most areas these annual double bands measure 25 to the inch. At this rate the vertical wall of 88 feet in the southwest quarter of section 24, containing three great bands of nodule bearing strata could have taken up to 26,400 years to deposit. Thus we know that the lake existed either constantly or periodically for many thousands of years, and that there were many periods of volcanic disturbance.

The oldest bed, judging from its lowest position, contains more species of insects, and a greater diversity of species than the upper beds; and tentatively we might suggest that some species which originally existed in the lake or lakes, were extinguished, while only certain forms persisted through the centuries.

There are two peculiarities to the fossil deposits: one is that the biological material is crystallized either as silicate, or as strontium celestite. The other is that petroleum is present in practically every fossil bearing nodule.

The strontium preservation is commonest in the upper strata of blue nodules, or in the white concretions containing dragonflies. The silica preservation is in two states, crystal and colloidal. The colloidal silica fossils have perfectly clear lines, and are complete replications of the skeletons of the plants or insects, even to the hairs on the antennae and the septa in the compound eyes.

A replication like this requires a catalytic process of exchange of silica for chitin.

The petroleum phenomenon is unusual and I believe very important to us. The odor of petroleum in the mines and caves is so strong that one can hardly stand it. If you rub two nodules together you smell petroleum. If you dissolve the nodule in acid, the petroleum foams up in great quantities.

When you break a nodule you may find a great quantity of hardened petroleum in the heart of the nodule, and sometimes it is still liquid. Specimens containing insects may have a petroleum film surrounding the insect. The crystallized beetle with the fungus was full of petroleum, which came out when the specimen was put in xylol. Sometimes silicification has not taken place and the insect tissues are red; however, when dropped in xylol the entire specimen is dissolved. We solved this and saved the insect tissues by avoiding xylol and clearing in terpineol before mounting in balsam.

In the past it has been said that petroleum was formed from plant tissues and from diatoms. In this lake there were pond weeds, algae, diatoms, great layers of coprolites of fairy shrimp, and the animal life of the lake. I hold that all forms, plant and animal, which were converted into silica, contributed the substance which became petroleum.

In other words, there was another catalytic process: the formation of petroleum from the biological material freed by silicification, and even that which was not silicified. I have now concluded that the two catalytic actions were independent of each other, and there are cases where each process was incomplete. There are insects with half of the body silicified and half not.

It is well known that catalysis is brought about by the presence of a substance which does not itself enter into the final product. There was present at every site so far investigated, a well known catalyzer, boron. Boron is a primary volcanic product, and the primary deposits are those we must seek for our fossils. Borax is water soluble and has washed down from the volcanic primary sites to settle in brine basins as secondary boron, forming the dry lakes of the desert.

Boron is well known for its affinity with silicon, and boron silicate glass is one of the finest glasses known for laboratory work. Boron is also recently in the limelight as a catalyzer for the improvement of the quality of gasoline. Boron is volcanic, and has been mined at every site where the petroliferous fossil bearing nodules are found. Colloidal silicon replications of living creatures have never been found elsewhere than in the neighborhood of borax deposits on andesitic volcanoes. Because of these facts I reason that boron was the catalyzer responsible, when in highly heated condition, for the killing, preserving, and replicating of the insects and plants; and for the formation of the petroleum from their remains.

Since there is every evidence that the two catalytic processes were rapid, I reason that what happened once can happen again. Therefore, I challenge the chemical profession to produce in their retorts, petroleum from the waste biological material of our cities on a 24-hour basis. If I am right, the fuel supply of the future is assured us forever.

The problem may not be simple until we know all the ingredients and proportions. There is another factor that must not be overlooked. Many important chemical processes require a living, active agent at some step in the process. Some of the known agents in manufacture are bacteria, yeasts, fungi, and algae.

There were in these lakes algae and diatoms. The nodules yield beautiful silicified specimens of many types of algae, and often multitudes of diatoms.

Algae in lakes are known to take carbon dioxide from calcium bicarbonate and deposit the calcium carbonate as sediments. Likewise, algae have an affinity for silica in water, transforming it into colloidal silica. As long as I believed the two catalytic processes dependent one upon the other, I felt that perhaps the algae would be necessary to the commercial production of petroleum, and then the process might be slower. The latest findings indicate that petrolification was not dependent upon silification, and in that case colloidal silicon in the presence of boiling boron, might release the tissues for immediate conversion into petroleum. Of course our catalytic process will require the presence of certain gases; and we are certain that in volcanic gases there are hydrogen, carbon dioxide, and sulphur gases.

Strontium entered the picture only in a small part of the nodules; however, it must not be discounted.

Even if we prove that the petroleum in the volcanic mountain nodules was produced by boron catalysis, this does not necessarily mean that petroleum has not also been formed by other processes. We may have, however, pointed the way for solving the other types of formation.

It has long been thought that petroleum was formed in salt water; however, now we have evidence of its formation in fresh water into which volcanic salts came suddenly, and fresh water life continued in subsequent years.

Most reports on boron indicate that it is primarily volcanic; secondarily is leached into sinks and flat beds; and finally seeps into the ocean. May we not suspect that perhaps boron can still have catalytic powers in its secondary and tertiary phases?

# A NEW *PASIPHAEA* (CRUSTACEA, DECAPODA, NATANTIA) FROM SOUTHERN CALIFORNIAN WATERS[1]

John C. Yaldwyn[2]
Allan Hancock Foundation, University of Southern California

Since 1949, members of the Allan Hancock Foundation and of the Department of Biology, University of Southern California, have undertaken an increasingly intensive study of the fauna and ecology of the mid-waters of the deep basins, especially the San Pedro Basin, off the coast of Southern California. During the course of this work several new or unusual species of macrurous decapod Crustacea (shrimps and shrimp-like forms) have been obtained. The bulk of the collections made before September 1960 had already been examined and identified by Dr. John S. Garth of the Hancock Foundation, and specimens of the *Pasiphaea* described here had been sent to Dr. Fenner A. Chace, Jr., of the U.S. National Museum and had been recognized by him as a new species, though not described. Thus it has been my privilege, while working on these deep-water Crustacea during 1960-61, to describe this *Pasiphaea* in the first of a series of studies on this interesting material.

The San Pedro Basin, lying between San Pedro and Santa Catalina Island, has an area of about 655 square kilometres and a maximum depth of about 912 metres, while the sill depth (the depth of the lowest point on its rim) is about 737 metres. The new *Pasiphaea* has been taken as shallow as about 300 metres over this basin, as well as in nets that have touched the basin floor (actual depth of capture unknown), but it does occur in abundance, at least during daylight, at depths of about 550 to 700 metres. It has almost always been associated with *Sergestes similis* Hansen and appears to occur in a shallower zone than that in which the larger, more intensely pigmented, *Pasiphaea emarginata* Rathbun is usually taken.

Though occurring in numerous hauls in the San Pedro Basin, as well as in the deeper Catalina and San Nicolas Basins further offshore, the new *Pasiphaea* is recorded here from only four selected stations as its

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[1] Allan Hancock Foundation Contribution No. 245.

[2] On leave from the Dominion Museum, Wellington, New Zealand; visiting Fulbright Advanced Scholar supported by a grant from the National Science Foundation.

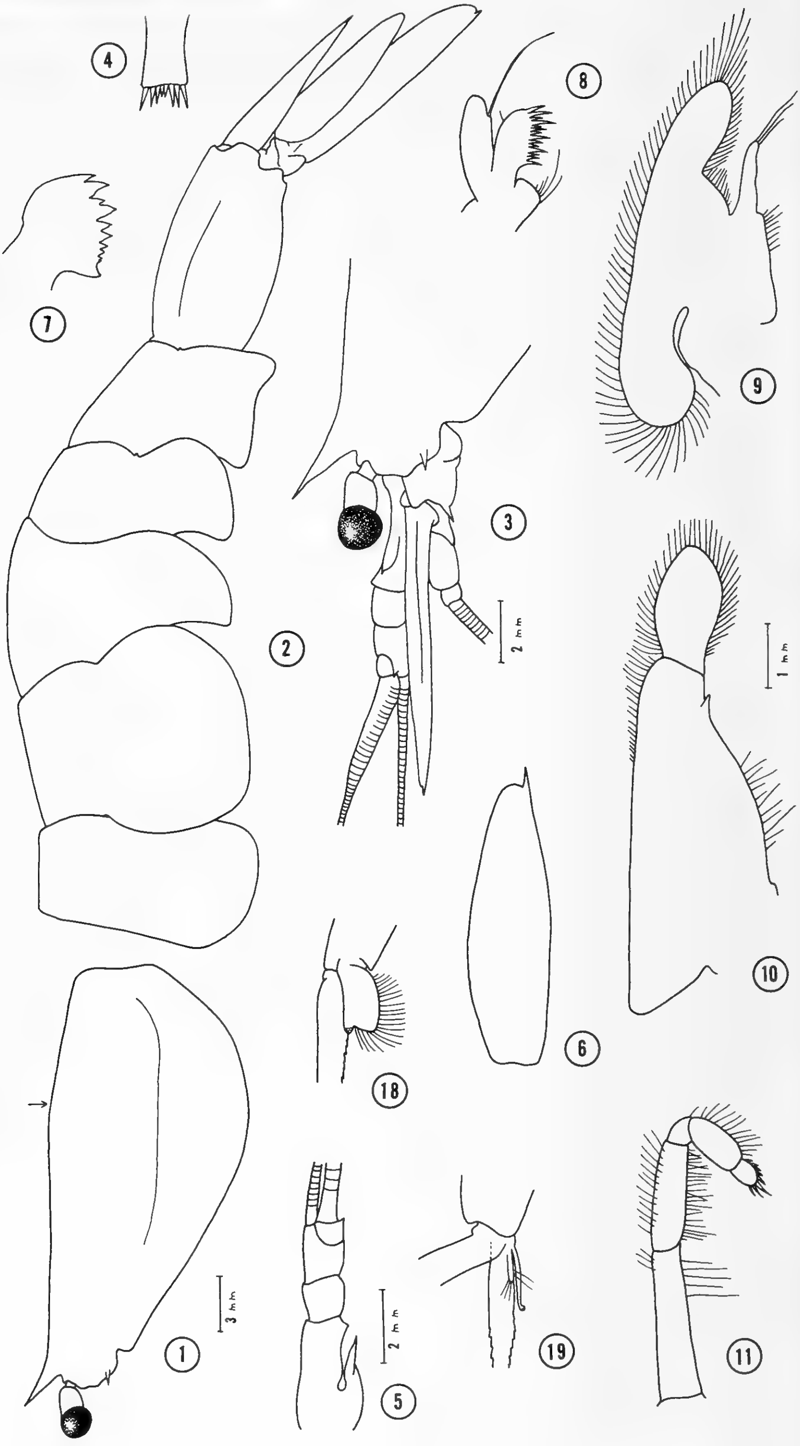
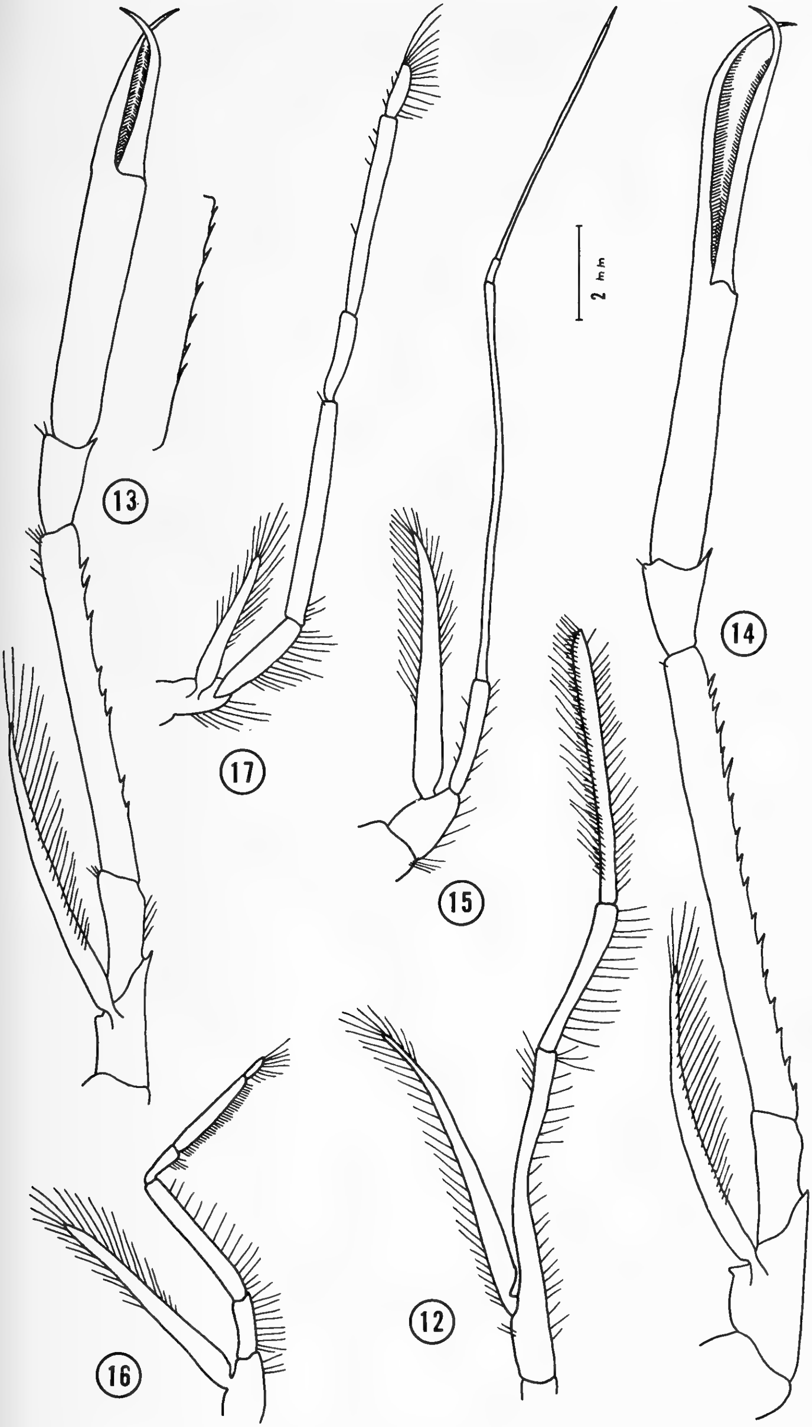


Fig. 1, lateral view carapace (arrow indicates extent of dorsal carina); fig. 2, lateral view abdomen; fig. 3, lateral view anterior part of carapace; fig. 4, dorsal view tip of telson; fig. 5, antennule; fig. 6, scaphocerite; fig. 7, mandible; fig. 8, 1st maxilla; fig. 9. 2nd maxilla; fig. 10. 1st maxilliped; fig. 11, 2nd maxilliped; fig. 12, 3rd maxilliped; fig. 13, 1st pereiopod; fig. 14, 2nd pereiopod; fig. 15, 3rd



pereiopod; fig. 16, 4th pereiopod; fig. 17, 5th pereiopod; fig. 18, male 1st pleopod; fig. 19, male 2nd pleopod. Figs. 1 to 17 from holotype, 18 and 19 from paratype, carapace length 17mm. Figs. 5 to 19 of right appendage. Figs. 1 and 2 to same scale; figs. 4, 7 to 11, 18 and 19 to same scale; figs. 5 and 6 to same scale; figs. 12 to 17 to same scale.

occurrence and bathymetric distribution will be discussed in detail in a future paper on the bathypelagic natant decapod Crustacea taken by the *Velero IV* off Southern California.

TABLE 1

Selected Allan Hancock Foundation stations in the San Pedro Basin from which *Pasiphaea chacei* n.sp. was obtained. All the specimens from these four stations are to be regarded as type material.

| | | *Net Down* | | | *Net Up* | | | |
|---|---|---|---|---|---|---|---|---|
| Sta. No. | Date | Position | Time | Fms | Position | Time | Fms | Remarks |
| 7186-60 | Oct. 28 1960 | 33-36-11<br>118-32-13 | 1035 | 475 | 33-30-52<br>118-22-48 | | | 2 metre net hit bottom during 1½ hours at depth. |
| 7221-60 | Dec. 9 1960 | 33-37-36<br>118-32-28 | 1008 | 463 | 33-27-13<br>118-17-24 | 1510 | 461 | Isaacs-Kidd Mid-Water Trawl at 1931 ft. by gauge; 4 hours at depth. |
| 7273-61 | Jan. 23 1961 | 33-39-07<br>118-31-02 | 1015 | 458 | 33-27-47<br>118-16-06 | 1503 | | IKMWT at 1986 ft. by gauge; 3½ hours at depth. |
| 7299-61 | Feb. 24 1961 | 33-38-03<br>118-32-39 | 1005 | 468 | 33-25-48<br>118-16-48 | 1510 | 458 | IKMWT at 2341 ft. by gauge; 4 hours at depth. |

## SECTION CARIDEA

### Family PASIPHAEIDAE

### Genus *Pasiphaea* Savigny, 1816

### **Pasiphaea chacei** new species

*Types:* Holotype, female, carapace length 19mm. from Station 7186-60 (Allan Hancock Foundation Catalogue No. 601). Paratypes, 1 female 11mm.[3] from Station 7186-60; 2 males 12 to 17mm., 30 females and immature 6 to 15mm., 2 ovigerous females 19mm., from Station 7221-60; 10 males 10.5 to 15mm., 24 females and immature 7.5 to 20mm.

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[3] The carapace length, in mm., is used as the standard length throughout.

(including 1 ovigerous 20mm.) from Station 7273-61, and 190 specimens, of which a sample of 50 consisted of 19 males 11.5 to 19.5mm. and 31 females 9.5 to 22mm. (3 ovigerous 19 to 21mm.), from Station 7299-61.

*Diagnosis:* Telson truncate distally. Carapace dorsally carinate, with a characteristic, slender, acute rostrum projecting anterodorsally at least as far as cornea. Abdomen smooth, not carinate. 1st pereiopod with 0 to 12 meral spines, 2nd with 6 to 23 meral spines. Fingers of 2nd pereiopod subequal with palm.

*Description:* Rostrum (gastric spine of some authors) prominent, relatively long and slender, acute, directed obliquely dorsally, without a curve, to extend anteriorly at least as far as cornea. Carapace with a distinct carina on anterior ⅔ of dorsal surface, posterior third smooth and rounded. Lateral surface of carapace with suprabranchial carina. Anterior margin produced dorsally into a blunt, convex lobe, not extending as far anteriorly as the broadly rounded lower orbital angle; this angle continuing ventrally into a weakly concave emargination, which in turn passes through a broadly rounded angle to trend obliquely posteroventrally into a concave emargination at level of branchiostegal spine, then into the deep branchiostegal sinus. Branchiostegal spine prominent, arising behind, and projecting beyond, anterior margin.

Abdomen smooth, all segments dorsally rounded and unarmed; 6th strongly compressed dorsally but not carinate. Pleura of 1st and 2nd broadly rounded; pleura of 3rd to 5th produced somewhat anteroventrally, 5th with concave ventral margin. 6th half as long again as 5th, with weak dorsolateral carina. Telson a little shorter than 6th segment, with a broad, longitudinal groove dorsally and a truncate distal margin armed with four pairs of spinules graded in size from a short median pair to a relatively long lateral pair.

Eyes well developed, cornea rounded, well-pigmented and broader than ocular peduncle.

Antennular peduncle with first segment reaching with less than ⅓ its length beyond eyes. Stylocerite narrow in dorsal view and relatively widely separated from first antennular segment proper; in lateral view dorsal margin forming an acute point distally which passes ventrally into the rounded anterior margin of the broad ventral portion of the stylocerite. Two antennular flagella present, dorsolateral flagella with about 13 enlarged basal segments in female, about 17 in male; enlarged basal section in male considerably broader and more abruptly passing into the flagellum proper than in the female; this character is especially useful for sexual differentiation. Antennal peduncle reaching to about midpoint of antennular peduncle, basal segment with strong, obliquely directed spine. Scaphocerite reaching distally beyond antennular peduncle to about last enlarged flagellar segment; outer margin weakly convex, produced into a strong distal tooth projecting full length beyond lamella, which is 3½ times as long as wide.

Mandible consisting of toothed incisor process only, palp absent. 1st maxilla with small, rounded proximal endite, strongly toothed distal endite and long, simple endopod armed with a single stout seta. 2nd maxilla with no endites visible, simple, well developed endopod and large scaphognathite. 1st maxilliped reduced to large elongate lamella, articulated distally. 2nd maxilliped simple, with distal segment articulated normally with penultimate, no epipod or exopod. 3rd maxilliped reaching a little beyond scaphocerite, ultimate segment long and slender, somewhat less than twice length of penultimate and shorter than antepenultimate, exopod well developed.

All pereiopods with well developed exopods, but no epipods. 1st pereiopod reaching with fingers and half palm beyond scaphocerite. Fingers slender, cutting edges toothed, tips curved and capable of crossing one another, ⅔ length of elongate, parallel-sided palm. Palm with medioventral row of about 5 to 7 slender, movable spines, as shown alongside fig. 13. Carpus ⅓ palm, armed with distoventral spine. Merus 5/4 palm, armed ventrally with from 0 to 12 (usually 2 to 9) unevenly sized and irregularly placed spines. Ischium about ⅓ length merus, unarmed. Basis with strong, distoventral spine. 2nd pereiopod reaching with fingers and half palm beyond scaphocerite. Fingers elongate, slender, cutting edge toothed, tips curved and capable of crossing one another, subequal in length to elongate palm, which is somewhat narrower distally than proximally. Carpus a little less than ⅓ palm, armed with strong distoventral spine. Merus 5/3 length palm, armed with from 6 to 23 (usually 14 to 21) unevenly sized spines spaced relatively evenly along entire ventral margin. Ischium about ¼ length of merus, unarmed. Basis with distoventral spine. 3rd pereiopod slender, attenuated, reaching to distal end of antennal peduncle, dactyl subequal to carpus and about 1/10 propodus which is ⅔ merus. Ischium a little less than ⅓ merus, all segments unarmed. 4th pereiopod short, reaching to basoischial articulation of 2nd pereiopod, dactyl ¼ propodus, carpus about ½ propodus, merus equal to carpus and propodus combined, ischium to ⅓ carpus, propodus and dactyl combined. 5th pereiopod distinctly longer than 4th, reaching a little beyond ischiomeral articulation of 1st pereiopod. Dactyl relatively broad, and rounded distally, a little more than ¼ propodus and a little more than ½ carpus, carpus subequal to ischium and 2/5 merus.

First pleopod male and female with broadly ovate endopod and short appendix interna bearing some hooks distally. 2nd to 5th pleopods male and female with slender appendix interna, 2nd pleopod male with in addition a slender and shorter appendix masculina. Uropods elongate, exopod longer than endopod, exopod with lateral margin produced into distal spine reaching beyond distal margin of lamella.

Eggs large and relatively few in number, measuring after preservation, 1.79 to 1.88 × 1.26 to 1.38 mm.

TABLE 2

Branchial Formula.

| | Maxillipeds | | | Pereiopods | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 1st | 2nd | 3rd | 4th | 5th |
| Pleurobranchiae | . | . | . | 1 | 1 | 1 | 1 | 1 |
| Arthrobranchiae | . | . | . | 1 | 1 | 1 | . | . |
| Podobranchiae | . | . | . | . | . | . | . | . |
| Epipodites | . | . | . | . | . | . | . | . |
| Exopodites | . | . | 1 | 1 | 1 | 1 | 1 | 1 |

*Color in Life:* The body and appendages are mainly transparent, while the eyes are dark golden brown. There is an irregular scattering of large, stellate, red chromatophores on the body and appendages, differing greatly in concentration with the size of the specimen. Small specimens are almost colorless, while in larger specimens the carapace at least appears pink, the fingers are very red with the curved tips grey-black in color. Eggs in an early stage of development are colorless. The viscera appears through the carapace as a dark mass anteriorly and yellow gonads posterodorsally (in mature specimens).

In comparison with *Pasiphaea emarginata*, taken in the same area, *P. chacei* is considerably less pigmented, especially on the carapace, the pereiopods and the anterior segments of the abdomen.

*Maturity and Sexual Differentiation:* The smallest ovigerous female examined in the material available had a carapace length of 19mm., however, some females at a carapace length of 15mm. had a small, but quite distinct, ovary, containing ova, clearly visible posterodorsally through the transparent cuticle of the carapace. Males with a carapace length of 15mm. or less had an extremely small appendix masculina, which at a carapace length of 12mm. and below was usually not discernible. The difference in width of the enlarged basal segments of the antennular flagella, as described above, is, however, a clear sexual distinction at all sizes down to at least a carapace length of 10mm., and in larger specimens can be easily used for "in hand" sexing without magnification.

The size at maturity then is a carapace length of about 15 to 16mm., with all males above this size bearing a well developed appendix masculina and all females above this size with a clearly visible, developing ovary.

*Variation in Meral Spinulation:* The number of spines on the meri of the 1st and 2nd pereiopods has been widely used in this genus as a systematic character. Considerable variation within a species has been recorded previously (e.g. in *Pasiphaea sivado* by Stephensen, 1923), but the extent of this variation both within a species and between the right and left members of a pair of limbs in the same individual is often not fully appreciated. Fifty specimens selected at random from Station 7299-61 gave the following figures. (Data for 2nd pereiopods in parenthesis.)

The spines on the merus of the 1st pereiopod (2nd pereiopod) varied from 0 to 12 (6 to 23), with 90% (80%) of the sample having from 2 to 9 (14 to 21) on the right member. Sexually mature specimens tended to have more than immature specimens. Thus the variation in the 23 mature specimens was from 2 to 12 (15 to 23) with an average of a little more than 6 (18), while in the 27 immatures the variation was from 0 to 9 (6 to 19) with an average of a little more than 3 (a little less than 14). The difference in the number of spines between the right and left member of the 1st pereiopods (2nd pereiopods) varied from 0 to 3 with an exceptional 5 (0 to 4); in 38% (28%) there was no difference between the right and left member, in 40% (38%) there was a difference of one, and in 18% (18%) a difference of 2, one specimen had a difference of 3 and one of 5 (five specimens had a difference of 3 and three a difference of 4).

In a general way the greater the number of spines on the 1st pereiopod the greater the number on the 2nd. The ratio of the number of meral spines on the right 1st to the number on the right 2nd in the sample varied from 1:1.6 to 1:9 (96%) with one at 1:12 and one at 1:16. The difference between the number of spines on the right 1st and the number on the right 2nd varied from 4 to 17 with 76% between 10 and 14 and the average at a little over 11.

Finally it should be stated that there is a great variation in the size of the meral spines present, and that all recognizable spines have been counted no matter how small. Sexual significance in variation was tested for, but no correlation could be made.

*Systematic Position:* The carinate carapace, the smooth abdomen and the distally truncate telson clearly distinguish this species from all but five of the approximately 34 described and recognized species and forms of the genus *Pasiphaea*. These five species are as follows: *P. sivado* (Risso, 1816) from the North Atlantic, Mediterranean and Indo-West Pacific; *P. unispinosa* Wood-Mason, 1893, from the Indian Ocean; *P. magna* of Rathbun, 1904 (only questionably identified by Rathbun as *P. magna* Faxon, 1893) from Californian waters; *P. flagellata* Rathbun, 1906, from Hawaiian waters, and *Pasiphaea* sp. oc. de Man, 1920, from Indonesian waters.

*Pasiphaea chacei* differs from *P. sivado* (first adequately described by Zariquiey, 1957) in that the latter has the carapace compressed but not actually carinate and a small but distinct spine posterodorsally on the 6th abdominal segment (personal observation from Mediterranean material); it differs from *P. unispina* in which the condition of the abdomen is undescribed, in the number of spines on the meri of the 1st and 2nd pereiopods, only 0 and 1 respectively in the latter species; it differs from *P. magna* of Rathbun (which I am convinced is conspecific with *P. magna* Faxon) in that Rathbun's specimens have the 2nd to 5th addominal segments carinate (personal observation from Rathbun's original material); it differs from *P. flagellata*, in which the condition of the dorsal surface of the carapace is undescribed in the literature, in that the carapace is non-carinate in the latter (personal observation from Rathbun's original material), and finally *P. chacei* differs from *Pasiphaea* sp. oc of de Man in that the carapace in the latter is compressed, but not actually carinate dorsally, and the number of spines on the meri of the 1st and 2nd pereiopods is, as in *P. unispina*, 0 and 1 respectively. In addition to the above differences the characteristic, slender, prominent rostrum, extending beyond the anterodorsal margin of the carapace, clearly distinguishes *P. chacei* at a glance from these and other similar species.

*Comparison with* Pasiphaea emarginata *Rathbun:* The only other species of *Pasiphaea* taken commonly in the San Pedro Basin is *P. emarginata* Rathbun (*P. pacifica* Rathbun, with a deeply forked telson, occurs very rarely). Though *P. emarginata* has a carinate abdomen and a weakly, but distinctly, distally-emarginate telson in adult stages, in juveniles these features are not at all apparent and may, especially in damaged material, be impossible to make out. It has been found, however, that in juvenile *P. emarginata* (at carapace lengths of less than 11 mm.), though the telson may be apparently distally truncate, there are always at least 5 pairs of spines on the distal margin of the telson and often a small medial spine as well, while in *P. chacei* (juveniles and adults) there are almost always only 4 pairs of distal spines. In the rare cases where more than 4 pairs are present, identification must be made from rostral shape, strength of branchiostegal spine and depth of branchiostegal sinus.

In general *P. emarginata*, in contrast to *P. chacei*, is usually bigger, specimens with a carapace length up to about 45mm. are quite common from San Pedro Basin (compared to a maximum of about 22mm. in *P. chacei*), and more brightly colored; in *P. emarginata* the carapace appears deeper anteriorly as the posterior margin of the branchiostegal sinus is longer; the front (the anterodorsal margin of the carapace) is more prominent and reaches as far as the suborbital angle; the rostrum does not extend up to the front and is separated from the front (in lateral view) by a much less acute angle or more often a smooth curve (in juveniles the rostrum may extend almost vertically); the branchiostegal spine is considerably shorter and does not extend much beyond the anterolateral margin of the carapace; there is a distinct, submarginal, low carina around the dorsal portion of the branchiostegal sinus; the dorsal carina of the carapace extends nearly to the posterior margin and the 2nd to 5th abdominal somites are distinctly carinate.

*Remarks:* It gives me great pleasure to name this species for Dr. Fenner A. Chace, Jr., whose work on Crustacea, especially Western Atlantic Caridea, is so well known, and to memorialize his name, along with those of other eminent carcinologists—Alcock, Doflein, Faxon and Rathbun—in the wide-ranging and typically bathypelagic genus. *Pasiphaea.*

I wish to thank Dr. John S. Garth for suggesting and aiding this study, and for permission to examine these specimens, and also the Allan Hancock Foundation for the use of laboratory space and equipment.

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# NONMARINE MOLLUSCS FROM RECENT SEDIMENTS NEAR VERNON, APACHE COUNTY, ARIZONA

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## INTRODUCTION

Mr. James Schoenwetter, of the Geochronology Laboratories of the University of Arizona, had in 1960 worked out a B. C. 1500 to A. D. 1300 pollen sequence for the Vernon area as part of studies on postglacial climatic and resulting cultural changes for northern Arizona. In the summer of 1961, Mr. R. H. Hevly continued work in the region, concentrating on the pre-B. C. 1500 time. Mr. M. E. Cooley of the U. S. Geological Survey collaborated in stratigraphic field studies of the Recent geology.

In connection with gathering material for C-14 dating, samples for pollen analysis were also taken; invertebrate remains also discovered were turned over for checks on the preliminary paleo-environmental implications shown by pollen and lithologic work. In order to put on record findings from stratigraphy and malacology for the immediate area, the following description is presented.

## UNITS IV & III

Six miles north of the town of Vernon lies old Laguna Salada with an associated series of beach deposits with archaeological materials of early man and later puebloid affinities. It is in T. 11 N., R. 25 E. A large arroyo drains southeasterly into the northwest end of Laguna Salada; the elevation is ca. 6,300 feet. Messrs. Helvy and Cooley took samples from the arroyo wall in fluviatile and/or lacustrine deposits. Four stratigraphic units were in sequence in the arroyo; their approximate ages were determined. In the top two units (IV & III) invertebrate remains were collected with matrix. For the molluscs, mostly freshwater, the return was low and only genus-level determinations are presented at this time.

Unit IV.—Rust stained sand and gravel; with Cretaceous (?) brachiopod shells, apparently of one kind.

Sample No. LS-3, 13-F:
(Grey sand and gravel.)

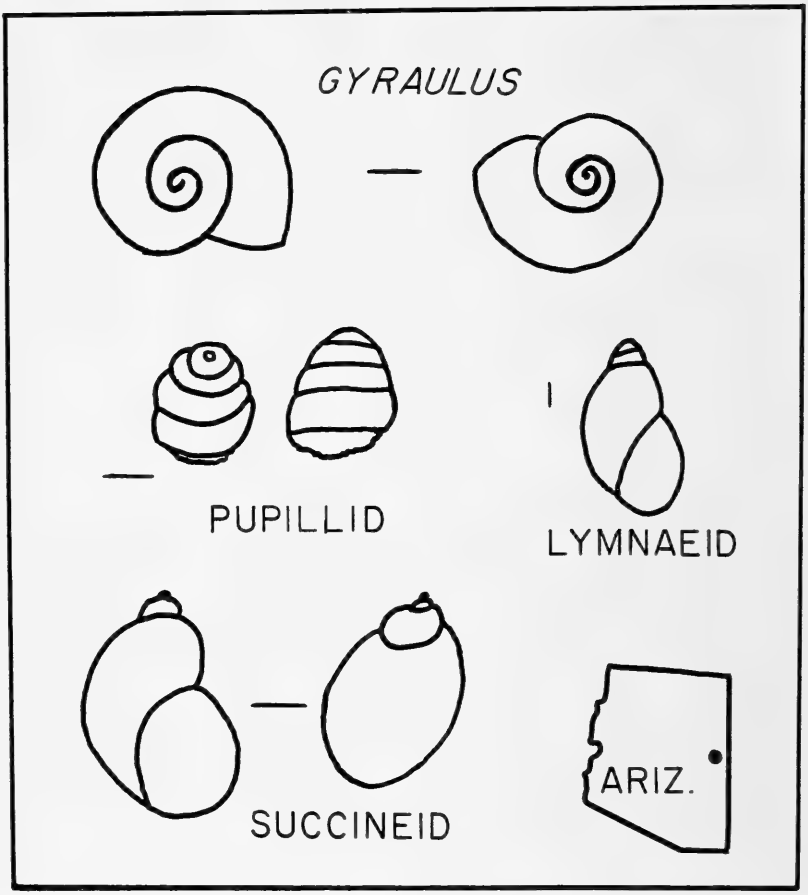

*Figure 1.* Commonly occurring nonmarine molluscan remains in Recent deposits near Vernon, Arizona. Scale lines = 1 mm.

*Gyraulus*, rare in comparison to Unit III samples. Fragments of brachiopod shells or a Cretaceous (?) oyster-like bivalve.

Unit III.—Clays, sands, and gravels.

Sample No. LS-3, 12F-"B" [superior position]:

(Dark brown clay.)

1 lymnaeid freshwater snail shell; illustrated in Figure 1. Abundant Cretaceous (?) foraminifera; large, some up to 1.5 x 7.0 mm and illustrated in Figure 2. 1 framentary *Gyraulus*, a freshwater

snail shell. Fragments of the body whorl of a large snail; possibly freshwater, and a lymnaeid.

Sample No. LS-3, 12-F:

(Dark brown clay.)

Numerous succineid terrestrial, [?amphibious], snail shells; example illustrated in Figure 1. Foraminifera; same kind as in previous sample. Fragments of Cretaceous (?) brachiopod shells. Many *Gyraulus*. Fragments of body whorls of freshwater snails or succineids or both.

Sample No. LS-3, 11-F:

(Grey sand and gravel.)

Many *Gyraulus;* example illustrated in Figure 1. 1 fragmentary terrestrial pupillid snail shell; illustrated in Figure 1.

[Yellow brown clay. No invertebrate remains discovered.]

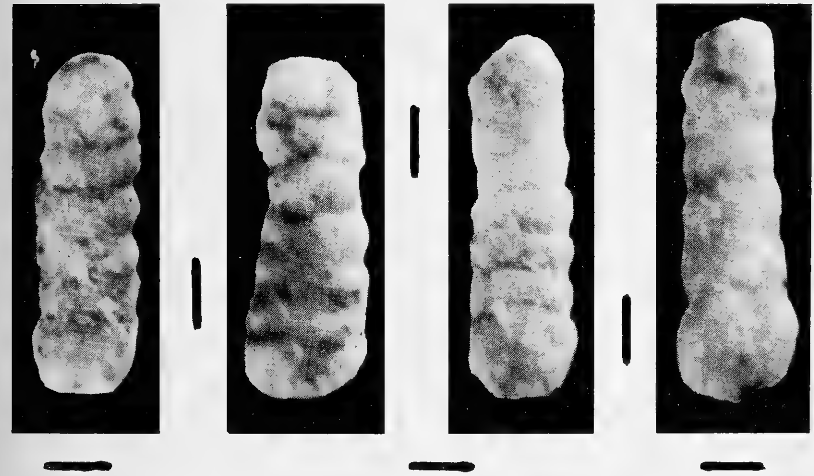

*Figure 2.* Examples of Cretaceous (?) foraminifera occurring in Unit III of reported Recent sediments near Vernon, Arizona. Scale lines = 1 mm.

## Discussion

In Pleistocene and Recent alluvial deposits in the Southwest, it is sometimes suspected that redeposition has occurred. In many areas where the Recent geology has been little studied, it cannot be readily known if often present terrestrial and freshwater molluscan fossils are *in situ* or not. Therefore, the presence of Cretaceous (?) brachiopods and foraminifera with Pleistocene or Recent snail shells in the old Laguna Salada area is phenomenal.

## SUMMARY

The presence, by very evident redeposition of much older organic fossils, Cretaceous (?) brachiopods and foraminifera, in beds of Units IV & III points to the existence in the immediate region of a marker for possible future value to correlation. Additional interdisciplinary studies are needed to determine the extent in time and space of the particular alluviation pattern depositing sediments in Units IV and III.

## ACKNOWLEDGMENTS

I am grateful to Mr. Hevly and Mr. Cooley, also to Dr. P. S. Martin of the Chicago Natural History Museum for the opportunity to study the material and situation. Drs. W. H. Mathews, V. J. Okulitch, and A. E. Cockbain of my University kindly examined the unusual forams. This report constitutes partial results of research supported by Grant NSF-18472 from the Anthropology Program of the National Science Foundation, 1961-1962.

# RECORDS OF SNAKES FROM JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA[1]

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The following preliminary report represents the compilation of records of snakes obtained in or near Joshua Tree National Monument from August, 1959 through 1960. These specimens were taken in connection with detailed studies of the flora and fauna being conducted by the authors and others at Long Beach State College, with the generous aid of the Monument staff.

The records listed below include those which fill certain distributional gaps, represent range extensions and in most cases represent the first published account of the species within the Monument.

Fifteen species of snakes were taken within the Monument. A total of 150 snakes are listed below, including 125 records from the Monument. Most of the snakes were found on the roads, either dead (DOR) or alive (AOR). Some identified examples were not saved either because of their poor condition or when alive, because of adequate samples available from the area.

Examination of the seasonal data reveals that most of the snakes were taken between late March and the first of July (130 of 150 records). This coincides in part with the amount of collecting since the reduction of snakes obtained per night discouraged additional trips. However, collecting trips were conducted in and around the Monument in every month of the year, and the Monument staff picked up specimens when possible. A summary of the records is as follows:

Jan.—0, Feb.—0, March—24, April—38, May—46, June—23, July—5, August—5, Sept.—3, Oct.—6, Nov.—0, Dec.—0.

## Acknowledgments

We wish to thank the following persons who have aided in the assembly of specimens and observations: Dr. Dennis G. Rainey, Dr. Elbert L. Sleeper, Mr. South Van Hoose, Mr. Julius C. Geest, Mr. Kenneth D.

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[1] Contribution No. 3 from the Biological Sciences Department, Long Beach State College, California.

Peyton and others, all from Long Beach State College; Superintendent William R. Supernaugh, Mr. James R. Youse, Park Naturalist and others on the staff of Joshua Tree National Monument. To Mr. Supernaugh and to the National Park Service, we extend our appreciation for permission to study the flora and fauna and to collect specimens in the Monument. Investigations in the field were supported (in part) by a research grant (E-3407) from the National Institutes of Health, Public Health Service.

## Accounts of the Species

The records of the snakes (15 species, 150 records, 108 specimens) are listed from southwest to northwest, in the Monument and adjacent to the Monument (to the north). Unless otherwise indicated, all localities are within the Monument and the dates are for the year 1960.

Several localities mentioned below are not on the map in the folder for Joshua Tree National Monument, or on other maps usually available. These are as follows, with their position from well known points: Cottonwood Spring Y (= 1 mi. NW Cottonwood Spring), Pinto Y (= 9 mi. S Monument Headquarters in Twentynine Palms) and Lower Covington Flat Camp, in Riverside County, 0.5 mi. S of San Bernardino County line (= 8 mi. S of the town of Joshua Tree).

The 108 specimens indicated in parentheses are in the Herpetological Collection of Long Beach State College.

### *Lichanura roseofusca gracia* Klauber
### Desert Rosy Boa

*Specimens examined.*—Total 5, as follows: *Riverside County:* 3.5 mi. S Cottonwood Spring Y, AOR, 13 May (1); 3.2 mi. N Cottonwood Spring Y, AOR, 16 June (1); Road W of Hidden Valley at junction of Stokes Road, 4000′, 2 May (1); *San Bernardino County:* Indian Cove Camp No. 4, 3300′, 21 May (1). ADJACENT TO MONUMENT, *San Bernardino County:* 0.3 mi. N Monument Entrance, Lower Covington Flat, 4100′, 7 Oct. (1).

*Additional Record.*—Total 1, as follows: ADJACENT TO MONUMENT, *San Bernardino County:* La Contenta Road, 2 mi. S of Twentynine Palms Highway (3 mi. N of Monument Entrance), AOR, 11 April (Sight record, E. L. Sleeper).

All of the Rosy Boas examined were similar in coloration, being typical of the desert subspecies to which they are assigned. The northwestern examples have more irregular (serrated) edges to the reddish body stripes than do those from near Cottonwood Spring.

### *Arizona elegans eburnata* Klauber
### Desert Glossy Snake

*Specimens examined.*—Total 12, as follows (AOR, unless otherwise noted): *Riverside County:* 1.1 to 1.5 mi. S Cottonwood Spring Y, DOR, 15 May (1), 16 June (1); 2.7 mi. NW Cholla Cactus Garden, 15 June (1); 0.2 mi. W Pinto Y, 24 June (1); 6.8 mi. W Pinto Y, 4400′, 9 Aug. (1); Lower Covington Flat Camp, 4700′, Can Trap, 11 June (1), 17 July (1). *San Bernardino County:* 7 mi. S Monument Headquarters, Twentynine Palms, 3200′ (2.8 mi. S Monument Entrance), 2 April (1); 1.8 mi. N Lower Covington Flat Camp, 6 Sept. (1); 4.6 mi. N Lower Covington Flat Camp, 23 July (1). ADJACENT TO MONUMENT, *San Bernardino County:* 1 mi. W of Joshua Tree, 2900′, 9 Aug. (1); 0.5 mi. S, 4 mi. W town of Joshua Tree, La Contenta Road, 14 May (1).

The Glossy Snake is widely distributed throughout the Monument, having been taken as high as 4700 feet. It was the most abundant nocturnal snake at higher elevations.

### *Chionactis occipitalis occipitalis* (Hallowell)
### Mojave Shovel-nosed Snake

*Specimens examined.*—Total 2, as follows: *Riverside County:* 2 mi. NW Old Dale Junction, 2200′, AOR, 15 May (1). ADJACENT TO MONUMENT, *San Bernardino County:* Twentynine Palms, 2000′, 15 May (1).

### *Hypsiglena torquata deserticola* Tanner
### Desert Night Snake

*Specimens examined.*—Total 5, as follows: *Riverside County:* 0.5 mi. N Old Dale Junction, 2500′, AOR, 14 May (1); 1 mi. S Old Dale Junction, DOR, 21 May (1); 1 mi. N White Tank Campground, 3800′, AOR, 29 May (1); Lower Covington Flat Camp, both in can trap, 4700′, 16 June (1), 23 June (1).

The specimen from White Tank seems to possess certain characteristics of the coastal subspecies, *H. t. klauberi.* Additional specimens are needed to determine if this represents intergradation between the two subspecies, or retention of characters of the coastal form as it is being submerged by the desert subspecies.

### *Lampropeltis getulus californiae* (Blainville)
### California Kingsnake

*Specimens examined.*—Total 2, as follows: *Riverside County:* 3.1 mi. N Cottonwood Spring Y, AOR, 15 June (1). ADJACENT TO MONUMENT, *San Bernardino County:* 1 mi. E Joshua Tree, 2800′ DOR, 15 May (1).

### *Masticophis flagellum piceus* (Cope)
### Red Racer

*Specimens examined.*—Total 11, as follows: *Riverside County:* 0.2 mi. NE Hidden Valley Entrance, DOR, 24 April (1); 1.5 mi. W Pinto Y, DOR, 9 April (1). *San Bernardino County:* 5 to 7 mi. S Monument Headquarters, Twentynine Palms, DOR, 8 May (1), 6 September (1); 2.9 mi. N Lower Covington Flat Camp, 29 May (1). ADJACENT TO MONUMENT, *San Bernardino County:* Twentynine Palms, 31 August 1959 (1); 2 to 3.6 mi. N Monument Boundary, La Contenta Road (1 to 3 mi. S, 4 mi. W town of Joshua Tree), March (3), AOR, 8 May (1), AOR, 23 June (1).

This is another widespread species, probably being present throughout the Monument. It is more abundant at elevations over 2800 feet.

### *Masticophis lateralis lateralis* (Hallowell)
### California Striped Racer

*Specimens examined.*—Total 4, as follows: *Riverside County:* 1 mi. N Salton View, DOR, 8 April (1); 1 mi. N Hidden Valley, DOR, 9 April (1); Lower Covington Flat Camp, 4700′, 26 March (1). *San Bernardino County:* Lower Covington Flat, 2.5 mi S Monument Entrance, 4300′, AOR, 2 April (1).

*Additional records.*—Total 2, as follows: *Riverside County:* Eureka Point, 2 mi. W Lower Covington Flat Camp, 5300′, 7 August 1959 (1, dead, not saved); Lower Covington Flat Camp, 4700′, 30 April (Sight record, E. L. Sleeper).

The striped racer is found in the Pinon-Juniper association at elevations above 4000 feet. The example from San Bernardino County regurgitated an adult *Eumeces gilberti.* The easternmost record (Hidden Valley) represents a range extension of approximately 26 miles to the east of the nearest records from the San Bernardino Mountains.

### *Phyllorhynchus decurtatus perkinsi* Klauber
### Western Leaf-nosed Snake

*Specimens examined.*—Total 20, as follows (AOR, unless otherwise noted): *Riverside County:* 1.6 to 5 mi. S Cottonwood Spring Y, 13 May (2), 14 May (2), 21 May (1), 28 May (1); 1.4 mi. SW Old Dale Junction, DOR, 21 May (1); 0.4 to 4.3 mi. NW Old Dale Junction, 13 April (1), 14 May (4), 15 May (1); Cholla Cactus Garden, 2 April (1); 2 to 4.2 mi. NW Cholla Cactus Garden, 15 April (1), 16 June (1); 2 mi. SE White Tank, 29 May (1); White Tank, 3800′, 15 June (1). *San Bernardino County:* 4 mi. S Monument Headquarters, Twentynine Palms, DOR, 13 April (1), 3 June (1).

*Additional records.*—Total 10, as follows (all AOR and released): *Riverside County:* 0.5 to 2 mi. S Cottonwood Spring Y, 21 May (2), 3 June (1); Old Dale Junction, and 0.3 to 4.3 mi. NW, 21 May (3), 29 May (1); Cholla Cactus Garden and 2.5 mi. NW, 3 June (2); 2.8 mi. SE White Tank, 26 June (1).

This is perhaps the most abundant snake in the Monument although it seems to be restricted to the lower elevations, rarely above 3000 feet although one record is from 3800 feet. Most of the records (19 of 30) are from the month of May.

### *Pituophis melanoleucus deserticola* Stejneger
### Great Basin Gopher Snake

*Specimens examined.*—Total 9, as follows (DOR, unless otherwise noted): *Riverside County:* 0.5 mi. N Pinto Y, 25 March (1). *San Bernardino County:* 1 mi. N Pinto Y, AOR, 23 June (1); 4 mi. S Monument Headquarters, Twentynine Palms (0.1 mi. S Monument Entrance), 3000′, AOR, 22 May (1), 12 April (1). ADJACENT TO MONUMENT, *San Bernardino County:* 3 to 3.5 mi. S Monument Headquarters, Twentynine Palms, AOR, 5 March (1), 24 April (1), 25 April (1); 1 mi. W Indian Cove turnoff (7 mi. W Twentynine Palms), 21 May (1); 1 mi. E town of Joshua Tree, 15 May (1).

This subspecies seems to be restricted to the northern edge of the Monument. No examples of the Gopher Snake were taken in the southern half of the Monument where the subspecies *affinis* is to be expected.

### *Rhinocheilus lecontei lecontei* Baird and Girard
### Western Long-nosed Snake

*Specimens examined.*—Total 5, as follows: *Riverside County:* 1.8 mi. N Cottonwood Spring Y, AOR, 22 October (1); 0.3 mi. S Old Dale Junction, DOR, 12 April (1) and 12 July (1). *San Bernardino County:* 6 mi. S Monument Headquarters, Twentynine Palms, DOR, 11 April (1). ADJACENT TO MONUMENT, *San Bernardino County:* Road to Indian Cove, 1 mi. N Monument Entrance, DOR, 23 April (1).

All of the specimens possess the desert pattern usually referred to as the subspecies *Rhinocheilus lecontei clarus* Klauber. All of the localities are below 3000 feet in elevation.

### *Salvadora hexalepis* (Cope)
### Western Patch-nosed Snake

*Specimens examined.*—Total 14, as follows (DOR, unless otherwise noted): *Riverside County:* 4 mi. S Cottonwood Spring Y, 2500′, 14 May (1); 1.5 mi. S Old Dale Junction, 27 March (1); 2 mi. S Pinto Y (White Tank) 3800′, 12 April (1); 0.5 mi. S to 0.5 mi. N Pinto Y, 26 March (1), 2 April (2); 1.5 W Pinto Y, 21 Oct. 1959 (1); Entrance to Hidden Valley, 23 April (1). Lower Covington Flat Camp, 4700′, caught near camp, 12 April (1). *San Bernardino County:* 1.5 mi. N Lower Covington Flat Camp, AOR, 10 April (1). ADJACENT TO MONUMENT, *San Bernardino County:* 1.5 to 2.5 mi. S Monument Headquarters, Twentynine Palms, 28 Oct. 1959 (1), 13 April (1); 1.5 mi. N Monument Entrance, Lower Covington Flat, AOR, 23 April (1); 0.5 mi. S, 4 mi. W town of Joshua Tree, 9 Oct. (1).

*Additional records.*—Total 2, as follows: *Riverside County:* Cholla Cactus Garden, 3 June (1, DOR, not saved); 4 mi. SE Pinto Y, 21 May (1, DOR, not saved).

No subspecific determination has been made of the specimens of patch-nosed snakes from the Monument. The two specimens from the south edge of the Monument (near Cottonwood Spring Y and Old Dale Junction) seem to represent typical examples of *S. h. hexalepis* (Cope), whereas those specimens at the northern edge of the Monument exhibit characters of both *S. h. hexalepis* and *S. h. mojavensis* Bogert. Additional specimens are needed to determine the subspecies present, the ranges of each and the areas of intergradation.

### *Trimorphodon vandenburghi* Klauber
### California Lyre Snake

*Specimen examined.*—Total 1, as follows: *Riverside County:* 1.9 mi. NW Cholla Cactus Garden, 2800′, DOR, 5 September 1959 (1).

This represents a slight range extension to the east from the west side of the Little San Bernardino Mountains.

### *Crotalus cerastes* Hallowell
### Sidewinder

*Specimens examined.*—Total 26, as follows (AOR, unless otherwise noted): *Riverside County:* Cottonwood Spring Y, 12 July (1); 2.6 mi.

S to 7 mi. NW Old Dale Junction, 1900′ to 2700′, 12 March (1), 25 March (7), 26 March (1), 15 April (1), 14 May (1), 15 June (1), 22 Oct. (1); 3 mi. NNE Old Dale Junction, 12 July (1); 1 mi. SE to 3 mi. NW Cholla Cactus Garden, 25 March (1), 27 March (1), 9 April (2), 13 April (1), 15 April (1), 15 June (1); 0.5 mi. S Belle Campground, 3800′, 9 May, DOR (1), 14 May (1). *San Bernardino County:* 5 mi. S Monument Headquarters, Twentynine Palms, 26 March (1); ADJACENT TO MONUMENT, 1.2 mi. S Monument Headquarters, 2400′, 9 August (1).

*Additional records.*—Total 4, as follows: *Riverside County:* Old Dale Junction, 26 March (1, AOR and released); 4.3 to 5 mi. NW Old Dale Junction, 26 March (1, AOR and released), 29 May (1, AOR and released); 4 mi. NW Cholla Cactus Garden, 26 March (1, DOR, not saved).

Determination to subspecies was not made for these specimens. Klauber (1944:102) indicated that the area of intergradation between *C. c. cerastes* and *C. c. laterorepens* Klauber is to be expected along the Riverside-San Bernardino County line. Specimens from the northern edge of the Monument seem to be *C. c. cerastes*. Most of the specimens were taken below 3000 feet, although one adult was taken alive at dusk on the road at 3800 feet near Belle Campground.

### *Crotalus mitchelli pyrrhus* (Cope)
### Southwestern Speckled Rattlesnake

*Specimens examined.*—Total 12, as follows: *Riverside County:* 2.5 mi. NW Old Dale Junction, DOR, 23 April (1); 5.4 mi. NW Old Dale Junction, 27 March (1); 1.5 mi. SE Cholla Cactus Garden, AOR, 13 April (1); Cholla Cactus Garden, 2300′, AOR, 15 May (1); 0.2 mi. S Eureka Point, 2 mi. W Lower Covington Flat, 5200′, 12 June (1). *San Bernardino County:* 8 mi. SE town of Joshua Tree (3 mi. SE Monument Entrance), AOR, 15 June (1); Lower Covington Flat, 0.3 to 3 mi. SE Monument Entrance, AOR, 29 April (1), AOR, 15 May (1), DOR, 29 May (1), AOR, 11 June (1). ADJACENT TO MONUMENT, *San Bernardino County:* 3.5 mi. S Monument Headquarters, Twentynine Palms (0.5 mi. N Monument Entrance), 15 May (1); 1 mi. N Monument Entrance, Lower Covington Flat, AOR, 15 May (1)

The Speckled Rattlesnake has been found throughout the Monument in rock habitats. Several specimens were taken in areas some distance from conspicuous rock outcrops, but they usually were in higher elevations.

### *Crotalus viridis helleri* Meek
### Southern Pacific Rattlesnake

*Specimens examined.*—Total 3, as follows: *Riverside County:* Lower Covington Flat Camp, 4700′, 11 April (1), 30 April (1); Jumbo Rocks, 4000′, 11 mi. S Twentynine Palms, DOR, 5 August 1959 (1).

*Additional record.*—Total 1, as follows: *Riverside County:* Lower Covington Flat Camp, 4700′, 23 May (Sight record, E. L. Sleeper).

These localities represent a range extension of more than 30 miles to the east for the southern subspecies which has been reported from the San Bernardino Mountains.

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# MONARCHISTIC DOMINANCE IN SMALL GROUPS OF CAPTIVE MALE MOSQUITOFISH, *GAMBUSIA AFFINIS PATRUELIS*

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Dominance-subordinance interrelations among vertebrates have received considerable attention in recent years. Allee (1952) summarized the literature dealing with the more commonly reported of these, the peck-right or peck-dominance hierarchy, which has been described for all classes of recent vertebrates. A less frequently reported social order (also discussed, briefly, in the same paper by Allee) is that in which the despot not only dominates all of its associates, but also inhibits any interaction between the remaining members of the group. Collias (1944: 90) used the term "monarchistic" for this type of social organization.

Such a monarchistic dominance has been reported for captive male albino laboratory mice (Uhrich, 1938), for captive male domestic cats (Winslow, 1938), by Cooper (1942) for captive African lions (males over males and females), and possibly for captive male American chameleons (Evans, 1936). Allee (1952) mentioned that it is known to occur in fishes, but did not cite a specific species.

We now report the finding of monarchistic dominance behavior in captive male mosquitofish, *Gambusia affinis patruelis* Baird and Girard. Monarchistic was the usual dominance behavior demonstrated by the groups studied, in March and April, although one group of four fish for a time demonstrated a peck-right (or thrust-right) dominance of sorts in which three of the four interacted (the fourth neither chased nor was chased). This display of different types of dominance in mosquitofish is thus similar to the variations in types of social orders shown for the laboratory mouse (Uhrich, 1938). Although the fish were not actually measured, our notes indicate that in each of the dominance relations established during this study, the largest fish was the despot. This was true in the case of the American chameleons studied by Evans (1936), but was not true for the domestic cats reported on by Winslow (1938).

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## MATERIALS

Male *Gambusia affinis patruelis* were collected from a stream running through the botany garden on the University of California campus at Westwood Village, Los Angeles, California, and were identified using keys provided by Hubbs (1926).

## PROCEDURE

Under varying conditions, up to four male *Gambusia* were integrated in a five-gallon aquarium and the water level reduced to one gallon, to reduce the area of confinement. Although in this series of observations there were many forms of aggressive behavior, possibly including some nipping or biting, thrust was taken as the most clear-cut demonstration. The thrust is usually directed at the victim's flank. Aside from thrust, preliminary dorsal fin erection forms a major part of the aggressive pattern.

Fighting, on the other hand, is carried out by the fishes making an "S" shape of their bodies and giving a sharp flip to the caudal fin. This propels a current of water against the opponent. On one occasion, two *Gambusia* fought continuously for 15 minutes using these "tail blows" (such as those described for other species of fishes by Tinbergen, 1958: 25), with intermittent thrusts at each other's flanks, before the dominant individual was established.

This dominant individual, or despot, roams freely throughout the tank. Once beaten, the subdued individual usually flees from the agressor. Submission is indicated by holding quite still, or by swimming very slowly. The body is held parallel to the bottom of the tank. Fast swimming almost invariably brings on an attack by the despot. On occasion, a submissive individual will elude observation by the despot by sinking down into the aquarium where it seems to attract less attention.

Marking.—100 grams of Alizarin Red S dye were dissolved in 100 cc. of distilled water, and between 0.1 and 0.2 cc. were injected intramuscularly either in the caudal region, in the dorsal fin region, or both. This method allows for three separate markings and for one unmarked control.

In a series of 15 markings or remarkings, between April 12 and April 21, death was caused twice. Death was immediate, and mechanical marking injury was considered responsible. At no time was further ill effect noticed from this freshly-made solution. It should be noted that old Alizarin Red S solution is toxic to fish. On one occasion a solution 30 days old was used to mark eight males. Six died immediately (apparently not from mechanical injury), one showed distress, and one showed no apparent ill effect.

Specimens retained their stain for varying lengths of time (two to seven days) and remarking did not interfere with the experiments.

## RESULTS

### *Experiment 1 (13 March)*

In a preliminary observation, definite aggression was shown by one of the larger males and in the space of one hour no interaction was noted between the other three. The aggressive individual thrust at the other three, who would flee from it. The agressive actions by the despot were almost continuous.

### *Experiment 2 (21 March)*

In this experiment the despot (which suppressed interaction between the remaining fish) was removed as soon as its dominance was established (in less than 30 minutes). There was an occasional interaction between submissive fish (three such interactions were noted in one hour), but this was rare once dominance was established. As the despot established himself, he was removed from the aquarium and placed in a container marked A. Interaction by the remaining three fish was begun almost immediately, and when another became dominant (after four to five minutes) he was transferred to a container marked B. Before his removal, he suppressed interaction between the remaining two fish. When one of these remaining two fish became dominant (after one to two minutes), he was placed in a container marked C. The fourth individual was placed in a container marked D.

### *Experiment 3 (11 April)*

Four fish were starved for four days and then were integrated. A piece of shrimp was introduced and two of the fish carried out a 15-minute battle directly above the shrimp. During the fight, both of the other fish came under and fed. Once both fish stopped fighting to chase off a feeding fish, but immediately resumed their fight. After a dominant alpha individual was established, he curtailed interaction among the other individuals by (1) chasing any fast-moving fish in the aquarium—this could be either a chasing or a chased individual, or both, but his presence would stop the interaction, and (2) by juxtaposing his body (on two occasions) between an aggressor and his victim. In this latter instance, all three individuals held quite still.

### *Experiment 4 (12 April)*

In this series of experiments, times of establishment of successive dominance were noted and the individuals were placed in separate tanks marked A, B, C, and D in their successive order of rank when the preceeding despot was removed. The time required for A to become despot was not noted, but after his removal, B became despot in 10 minutes, and after his removal C became despot in four minutes. A was marked in the caudal region, B was left unmarked, C was marked in the region below the dorsal fin, and D was marked in both the caudal and dorsal regions.

### *Experiment 5 (12 April)*

One hour after Experiment 4, the fish were integrated again and the same successive ranking manifested itself as each despot was removed. A was despot within ten minutes. After A was removed, B became dominant over C and D within four minutes, and after the removal of

TABLE 1

Number of thrusts in 30-minute periods in Dominance-Subordinance relationships of the mosquitofish, *Gambusia affinis patruelis*, after monarchial hierarchy established. *Upper*, four fish; *Middle*, after *A* removed, three fish remaining; *Lower*, after *A* and then *B* removed, two fish remaining.

*(Submissive individual on top of table, aggressive individual on side)*

| | A | B | C | D |
|---|---|---|---|---|
| A | - | 8 | 2 | 2 |
| B | 1 | - | 0 | 1 |
| C | 0 | 0 | - | 3 |
| D | 0 | 0 | 0 | - |

| | B | C | D |
|---|---|---|---|
| B | - | 11 | 8 |
| C | 0 | - | 0 |
| D | 0 | 0 | - |

| | C | D |
|---|---|---|
| C | - | 8 |
| D | 0 | - |

B, C, became dominant over D in four minutes. This was the same succession of monarchy as shown before marking.

### *Experiments 6 and 7 (13 and 14 April)*

Experiment 4 was repeated twice within the next two days, with the same succession of monarchy resulting, using the same four individuals. In Experiment 6, the successive times in which the despot assumed his position were three, five and ten minutes. Times were not recorded in Experiment 7. In both of these experiments, the fish were well fed before they were integrated, after being kept in separate containers for nearly 24 hours.

During Experiments 6 and 7 the number of thrusts made by each individual was tabulated. Table 1 shows these data and clearly indicates that interactions among individuals below the despot were infrequent. It should be stated that they occurred early in the experiment, though this is not indicated in the table. In addition, thrust frequency is not very stable. Various factors seemed to influence the number of thrusts: (1) The existing despot varies as to degree of aggressiveness, and (2) The existing submissive individuals vary as to degree of submissiveness. If the submissive individual flees easily, he is harassed more than one that does not—as fleeing almost always stimulates chasing and thrusting. Also, if the submissive individual remains quiet, rather than moving around, he is usually ignored.

### *Experiment 8 (20 April)*

In order to observe the effect of prior residence, B of Experiment 4 was placed in the aquarium and A was removed to a separate container for five days. Then A was returned to the aquarium. B thrust at A who did not flee, but could be edged around in a circle by B for the first ten minutes. For the second ten minutes, the fish usually avoided each other. Then A thrust at B twice within the next ten minutes, after which A became completely dominant. The pattern of A's thrusts at B after 50 minutes was as follows: Over a ten-minute period; five thrusts, rest, search, rest, six thrusts, rest, seven thrusts, rest, seven thrusts, rest, eight thrusts, rest, two thrusts, rest, five thrusts, rest. During this time, the submissive individual, B, would try to avoid contact if approached by the despot, A, or would hold very still. B fled quickly if thrust at.

### *Experiment 9 (21 April)*

In the last experiment of this series, the effect of hunger on the dominance order of the fishes from Experiment 4 was studied. Individuals C and D were separated and starved for seven days. Individuals A and B, also separated, were well fed. The four fish were then integrated and food was introduced. For the first six minutes, D (the omega individual in the succession of monarchy) thrust, chased, and inflicted tail blows at A, B, and C. The following four minutes, C was dominant, engaging in the same aggressive actions against the other three fish. A then engaged B. During this period, C and D were intermittently feeding when not fighting. For a period of three hours and 20 minutes there was no continuing despot, and fighting occurred between all individuals. After this period, A reestablished himself as the alpha despot. Therefore, hunger, like prior residence, played a disrupting role in the dominance order, but did not have a permanent effect.

## Summary

There is definite dominance and subordination in small groups of captive male *Gambusia affinis patruelis* in which:

1. The dominance-subordination relationship is not affected by the marking methods employed during the study.
2. Usually, instead of a descending peck-order or thrust-order within a group, a single individual is dominant and represses aggression by other members of the group. This may be termed monarchistic dominance.
3. Within a short while after removal of a despot, a new despot manifests himself.
4. The order of succession of monarchy shows constancy over a period of time.
5. Dominance order is disrupted for a brief period of time by prior residence of a usually submissive individual, and for a much greater length of time by starvation of a usually submissive individual. In each case, the usually submissive individual becomes despot for a brief period.
6. A peck-right or thrust-right of sorts is sometimes demonstrated.

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G. W. HORN'S LAND GASTROPOD LOCALITY IN ARIZONA. Camp Grant in southern Arizona is the designated type locality for several species of vertebrates and invertebrates. It is where George H. Horn (Ewan 1955: 52), the coelopterist, collected terrestrial molluscs in the 1860's; he later gave them to William M. Gabb in Philadelphia. Three kinds were described as new by Gabb (1866).

E. L. Cockrum (1960), in commenting upon the collecting spot for the type material of *Onychomys torridus torridus* (Coues), a grasshopper mouse, has given a history for changes of name and localities for long deactivated Camp Grant. His summary was necessitated by the mammal locality being considered in some recent publications to be in Graham County instead of at the junction of Aravaipa Creek and San Pedro River in Pinal County (2160 feet elevation, T. 7 S., R. 16 E., 8 mi. N. & 5 mi. W. of Mammoth). In Gabb's paper and H. A. Pilsbry's monograph (1940, 1948), the confluence of the streams was indicated; the molluscan type material was probably from stream *rejectamenta* as Pilsbry has noted.

Although Gabb described three species of minute pulmonates from the locality, two remain valid. The *Pupa (Modicella) arizonensis* was shown (Pilsbry 1948: 921) to be *Pupoides albilabris* (C. B. Adams). *Pupoides hordaceus* (Gabb) [=*Pupa hordeacea* Gabb, 1866] is now represented by only one worn shell from the type lot (Pilsbry 1948: 924-5). *Helix hornii* Gabb 1866 has become *Thysanophora horni* (Pilsbry 1940: 986).—Robert J. Drake, University of British Columbia.

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# DEPENDENCE ON TEMPERATURE OF Ca/Mg RATIO OF SKELETAL STRUCTURES OF ORGANISMS AND DIRECT CHEMICAL PRECIPITATES OUT OF SEA WATER

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## Relationship between Ca/Mg Ratio of Skeletal Structures of Organisms and Temperature

As shown by Chilingar (1953: 206) and Chave (1954), there is an inverse ("hyperbolic") relationship between the Ca/Mg ratio in the skeletons of organisms and the temperature of the water in which they live. Figures 2 through 11 show the relationship between the mean yearly temperature of sea water and the Ca/Mg ratio[1] of various groups of organisms, arranged in the order of increasing phylogenetic complexity. Sixty two per cent of the data plotted in these graphs are based on the analyses by Clark and Wheeler (1922) and 23 per cent on the results obtained by the writer. Although many analyses of organisms by Clark and Wheeler are not accompanied by temperature data, the exact description of location and depth enables one to determine the temperature from oceanographic literature. Additional data (15 per cent) were obtained from Chave (1954), who plotted $MgCO_3$ content of skeletons versus temperature of sea water. The "Ca/Mg ratio versus temperature" curves generally have a "hyperbolic" shape. The average Ca/Mg ratios of various groups of organisms, however, are different, and there is very little relationship between the average Ca/Mg ratio and the phylogenetic level (Figure 1).

Some scattering of the points in Figure 3 can be explained by the fact that samples of *Foraminifera* analyzed contained both benthonic and pelagic forms, whereas the temperature recorded is that of the bottom water.

Very high Ca/Mg ratios of the skeletons of madreporarian corals (Figure 5) are due to the fact that aragonitic organisms contain very small amounts of magnesium. Chave (1954) demonstrated that aragonitic organisms seldom contain over 1 per cent magnesium carbonate. The Ca/Mg ratio, therefore, largely depends on the mineralogic form of the carbonate. For example, in the case of gastropods and pelecypods

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[1] Weight ratios. The Ca and Mg contents were determined by the writer by using wet chemical technique with double precipitation.

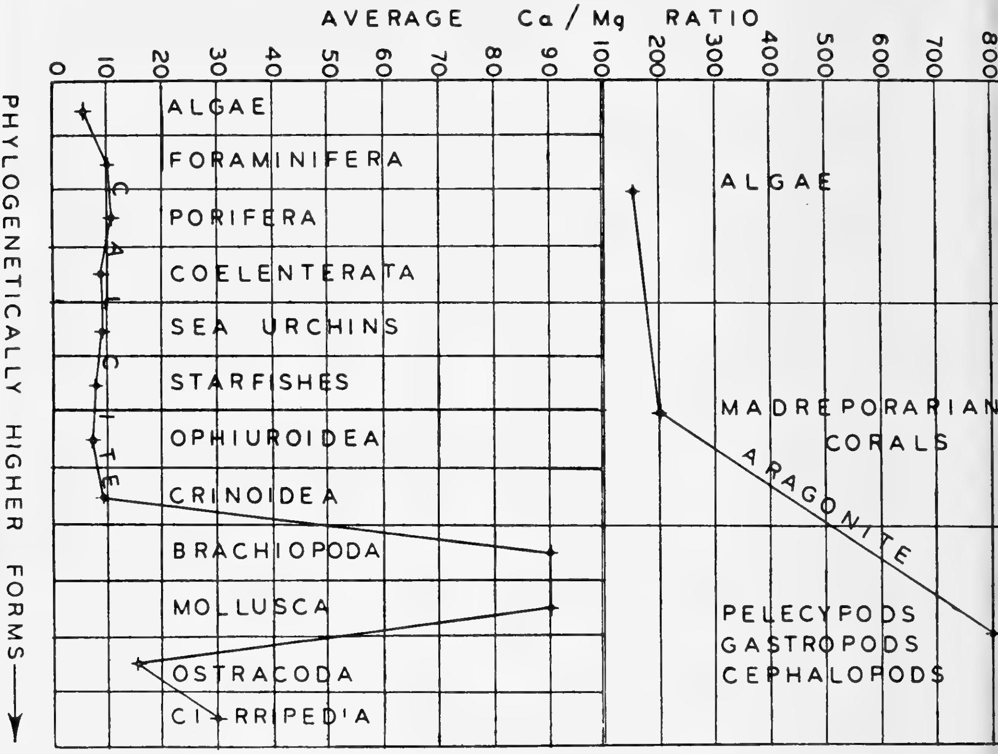


*Figure 1.* Relationship between Ca/Mg ratio and the phylogenetic level of organisms.

the presence of a few per cent of calcite causes a marked decrease in the Ca/Mg ratio.

The X-ray analysis conducted by the writer showed that madreporarian corals do not contain calcite, whereas the organisms plotted in Figures 2, 3, 4, 6, 7, 8, 9, 10, and 11 are devoid of aragonite.

Even small variations in temperature are reflected in the Ca/Mg ratios of organisms. For example, *Rhipidogorgia flabellum* Linné at 24.5° and 25° C. had Ca/Mg ratios of 9.04:1 and 8.3:1, respectively (Figure 4). The spines of *Tripneustes ventricosus* (Lamarck) have a Ca/Mg ratio of 14.3:1 at 24.5° C. and 12.1:1 at 26° C.

## Effect of Temperature on Ca/Mg Ratios of Chemical Precipitates from Sea Water

Mixtures of $CaCO_3$ and $MgCO_3$ have been precipitated from 500 cc. samples of sea water on adding 300 cc. of saturated solutions of $Ca(HCO_3)_2$. Figure 12 shows inverse relationship between the temperature and Ca/Mg ratios of precipitates obtained at the end of 48 hours. The "hyperbolic" shape of "Ca/Mg ratio versus temperature" curve is possibly due to the rapid rate of precipitation of $CaCO_3$ at higher temperatures, which enables $CaCO_3$ to trap more $MgCO_3$.

In another set of experiments, 300 cc. of saturated solutions of $Ca(HCO_3)_2$ were added to 500 cc. samples of sea water with enough $Na_2CO_3$ to bring the solution to the verge of clouding. The higher magnesium content of the precipitates in these experiments (Figure 13) was possibly due to the precipitation of magnesium as $Mg(OH)_2$, because the solubility product of $Mg(OH)_2$ is exceeded at a pH of around 9.49.

## Discussion

The similarity in shape of "Ca/Mg ratio versus temperature" curves of primitive invertebrates and direct chemical precipitates suggests that the Ca/Mg ratios of these organisms are either controlled to some extent by the conditions in the surrounding environment (namely, variation of the solubility products of $CaCO_3$, $MgCO_3$, $Mg(OH)_2$, etc. at different temperatures), or that the internal processes somewhat resemble the external processes. The former explanation becomes even more plausible when one remembers that primitive invertebrates do not have autonomous blood systems (open to outside environment) and their tissues are transfused by sea water.

Different organisms have different Ca/Mg ratios; hence, the chemical composition of protective and skeletal structures is not entirely controlled by the physical-chemical properties of the surrounding environment. Inasmuch as different organisms possibly attain different pH within their tissues, the Ca/Mg ratios of their skeletons is probably also related to this pH. The writer (1956a: 32) had previously shown that the Ca/Mg ratio of direct precipitates decreases with higher pH. Examination of Figures 12 and 13 also suggests that the "Ca/Mg versus temperature" curves of organisms, which could attain high pH ($\backsim\geqslant 9.49$) within their tissues and precipitate magnesium as $Mg(OH)_2$, might approach a straight line.

It is also interesting to note that the writer (Chilingar, 1956b: 211) proved that the Ca/Mg ratios of *Strongylocentrotus purpuratus* (Stimp-

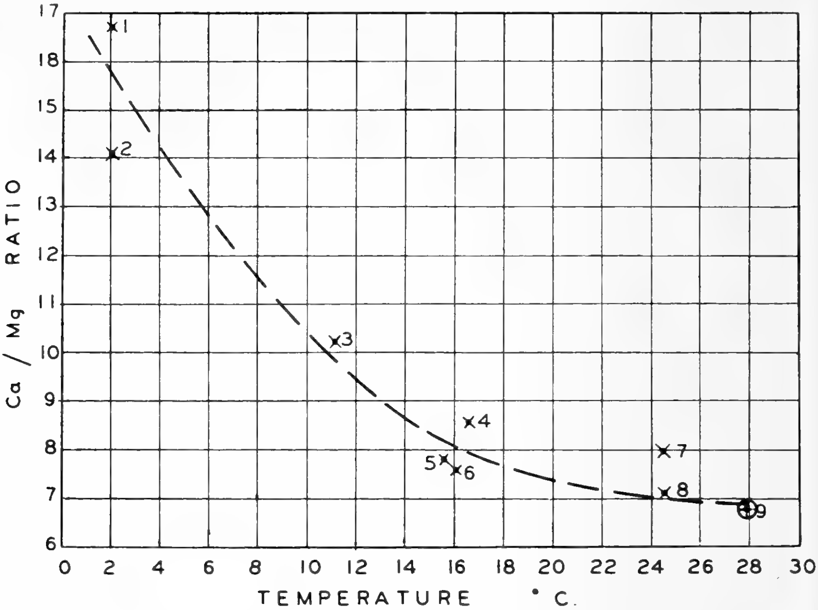


*Figure* 2. Relationship between the Ca/Mg ratio of *Lithothamnium* skeletons and temperature. Analyses by Chave (1954, p. 273): 1, 2—*Lithothamnium* sp., Alaska; 3—*Lithothamnium* sp., Maine; 4—*Lithothamnium* sp., California; 5, 6—*Lithothamnium* sp., Japan; 7-8—*Lithothamnium* sp., Bermuda. Analysis by Chilingar: 9—*Lithothamnium* sp., Guam.

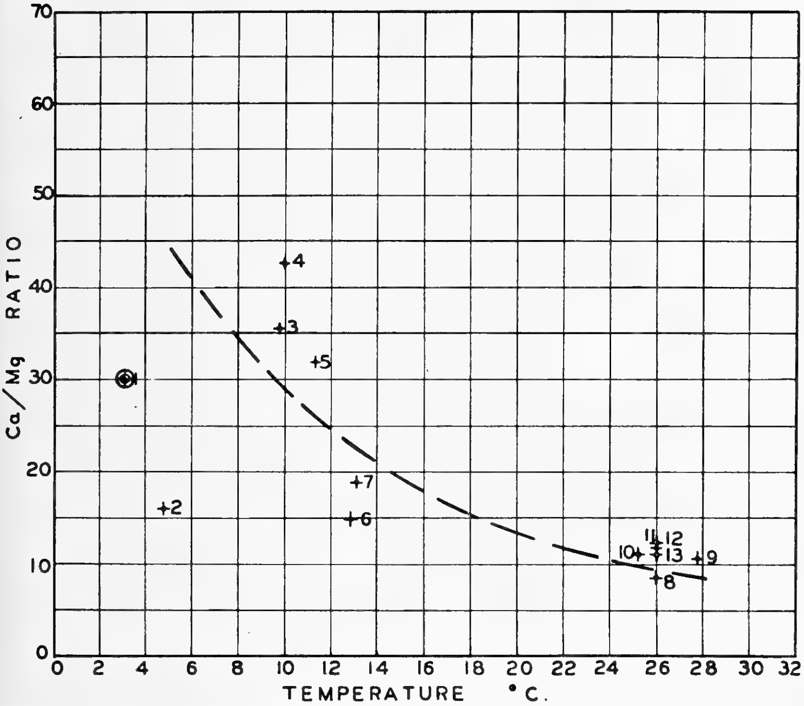


*Figure 3.* Relation between Ca/Mg ratio in skeletons of *Foraminifera* and temperature. Analysis by Clarke and Wheeler (1922, p. 2): 1—*Globorotalia menardii* d'Orbigny. Analyses by Chilingar: 2—*Foraminifera* sample No. 7, off San Diego, California, depth of 2560 feet (Bandy, 1953); 3—*Foraminifera* sample No. 4, off San Diego, California, depth of 380 feet (Bandy, 1953); 4—*Foraminifera* sample No. 1261, off San Diego, California, depth of 375 feet (Bandy, 1953); 5—*Foraminifera* sample No. 960, off San Diego, California, depth of 260 feet (Bandy, 1953); 6—*Foraminifera* sample No. 345, off San Diego, California, depth of 200 feet (Bandy, 1953); 7—*Foraminifera* sample off Louisiana, Gulf of Mexico, depth of 102 feet; 8—*Sorites* sp., South of Tortugas, Florida; 9—Sample of *Foraminifera* from Bikini; 10—*Miniacina alba* Linné, Bahamas; 11—*Quinqueloculina auberiana d'Orbigny*, south of Tortugas, Florida; 12—*Archaias adunca* Fichtel and Moll, Key West, Florida; 13—*Sorites marginalis* Lamarck, south of Tortugas, Florida, depth of 29.3 meters.

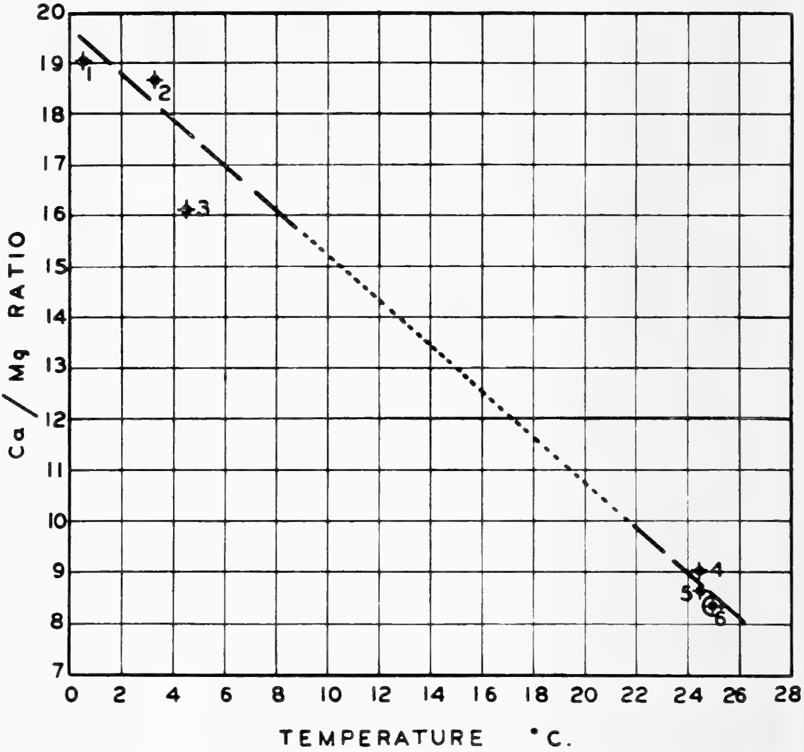


*Figure 4.* Relation between Ca/Mg ratio in skeletons of Alcyonarian corals and temperature. Analyses by Clarke and Wheeler (1922, p. 9): 1—*Alcyonium carneum* L. Agassiz, 2—*Lepidisis caryophyllia* Verrill, 3—*Pennatula aculeata* Dana, 4—*Rhipidogorgia flabellum* Linné. 5—*Gorgonia acerosa*, Pallas, Florida. Analysis by Chilingar: 6—*Rhipidogorgia flabellum* Linné, Bahamas.

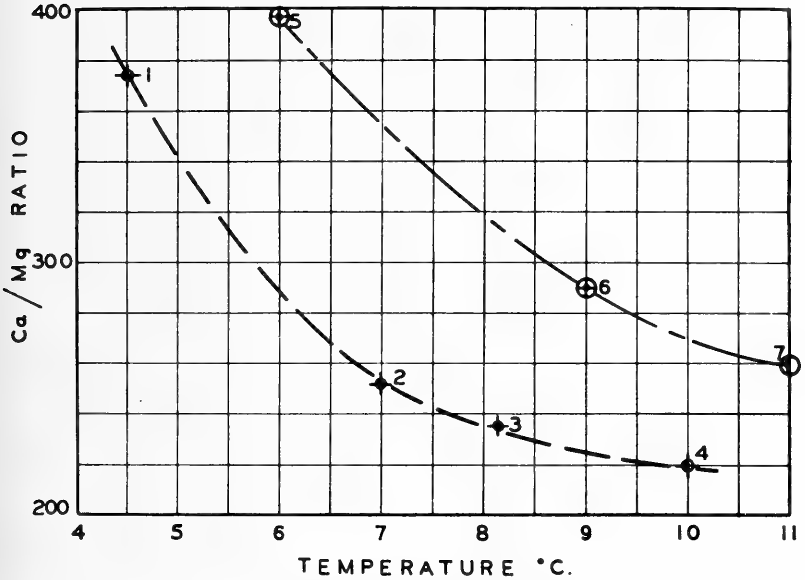
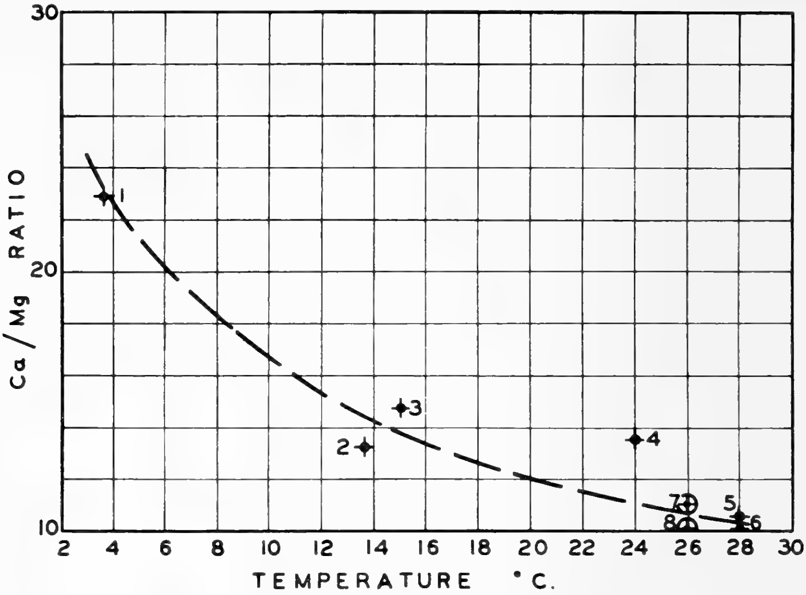


*Figure* 5. Relation between Ca/Mg ratio in skeletons of Madreporarian corals and temperature. Analyses by Clarke and Wheeler (1922, p. 6): 1—*Flabellum alabastrum* Moseley, 2—*Deltocyathus italicus* Michelotti, 3—*Desmophyllum ingens* Moseley, 4—*Dasmosmilia lymani* Pourtales. Analyses by Chilingar: 5—*Madrepora* sp., 6—*Madracis* sp., 7—*Dendrophyllia* sp.



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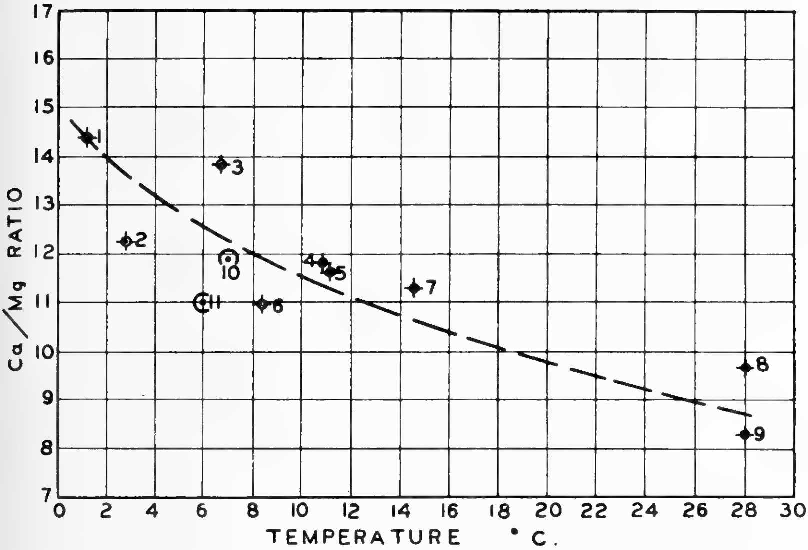

*Figure 7.* Relation between Ca/Mg ratio in skeletons of Star Fishes and temperature. Analyses by Clarke and Wheeler (1922, p. 26): 1—*Ctenodiscus crispatus* Retzius, 2—*Benthopecten spinosus* Verrill, 3—*Plutonaster agassizii* Verrill, 4—*Leptasterias compta* Stimpson, 5—*Odontaster hispidus* Verrill, 6—*Ctenodiscus procurator* Staden, 7—*Orthasterias tanneri* Verrill, 8—*Asterina minuta* Gray, 9—*Linckia guildingii* Gray. Analyses by Schmelck (1901): 10, 11—*Arcaster tenuispinus* (Düben and Koren).

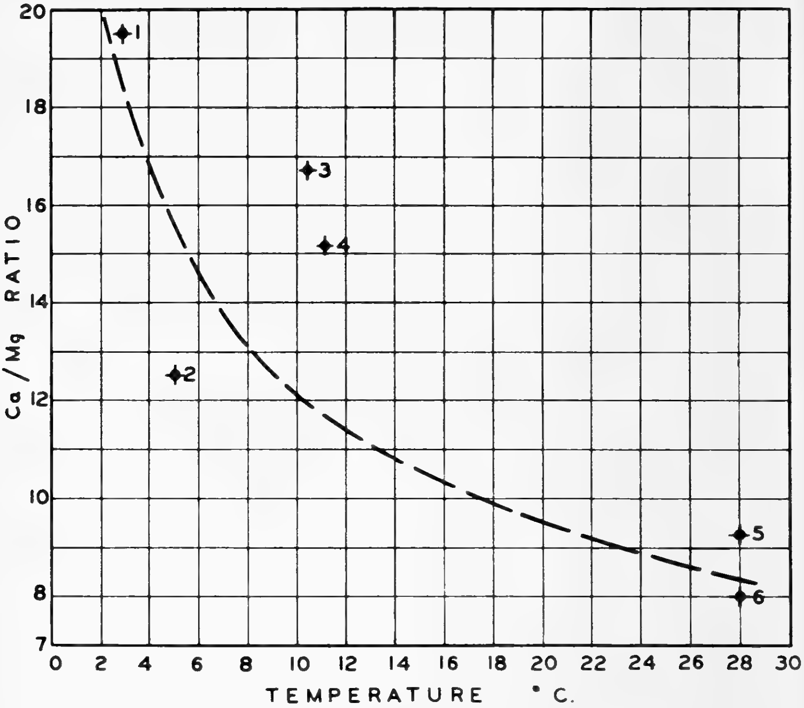

*Figure 8.* Relation between Ca/Mg ratio in skeletons of Ophiurans and temperature. Analyses by Clarke and Wheeler (1922. p. 29): 1—*Ophiomusium lymani* W. Thomson, 2—*Ophioglypha sarsii* Lütken, 3—*Ophiocamax fasciculata* Lyman, 4—*Ophioglypha lymani* (Ljungman), 5—*Ophiocoma pumila* Lütken, 6—*Ophiomyxa flaccida* Say.

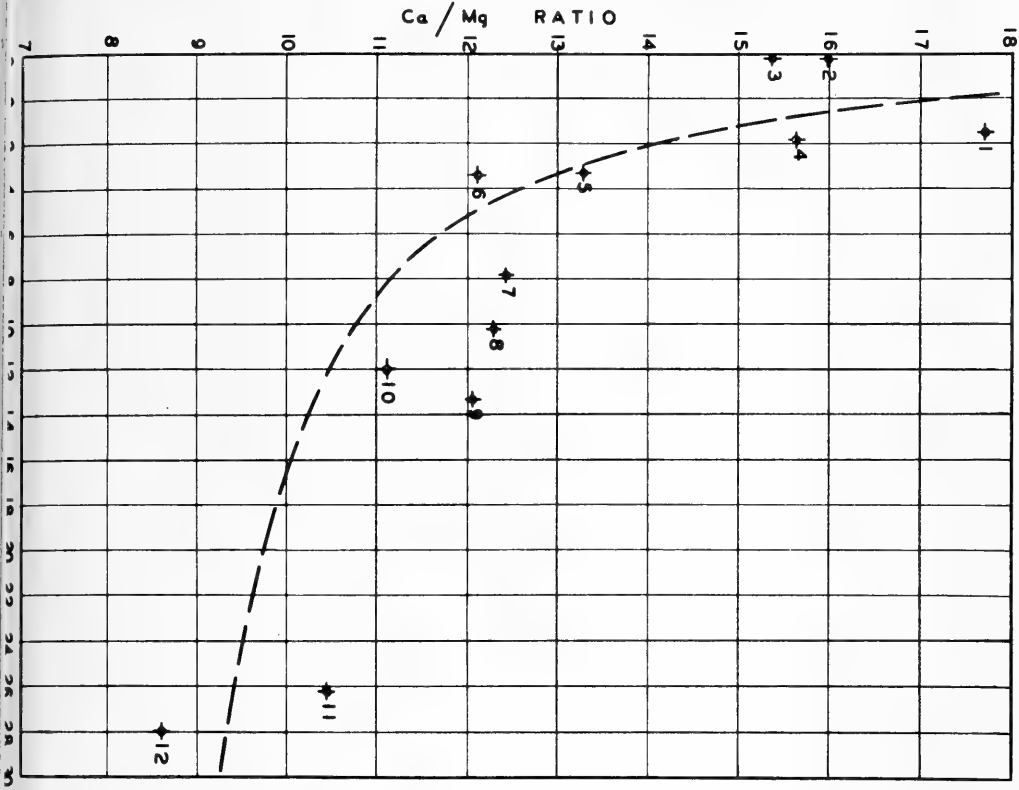

*Figure 9.* Relation between Ca/Mg ratio in Crinoid skeletons and temperature. Analyses by Clarke and Wheeler (1922, p. 17): 1—*Heliometra glacialis* (Leach) var. *maxima* (A. H. Clark), 2—*Promachocrinus kerguelensis* Carpenter, 3—*Anthometra adriani* Bell, 4—*Ptilocrinus pinnatus* Clark, 5—*Florometra asperrima* Clark, 6—*Pentametrocrinus japonicus* Carpenter, 7—*Hathrometra dentata* Say, 8—*Hypalocrinus naresianus* Carpenter, 9—*Metacrinus rotundus* Clark, 10—*Parametra granulata* Clark, 11—*Crinometra concinna* Clark, 12—*Tropiometra carinata* Lamarck.

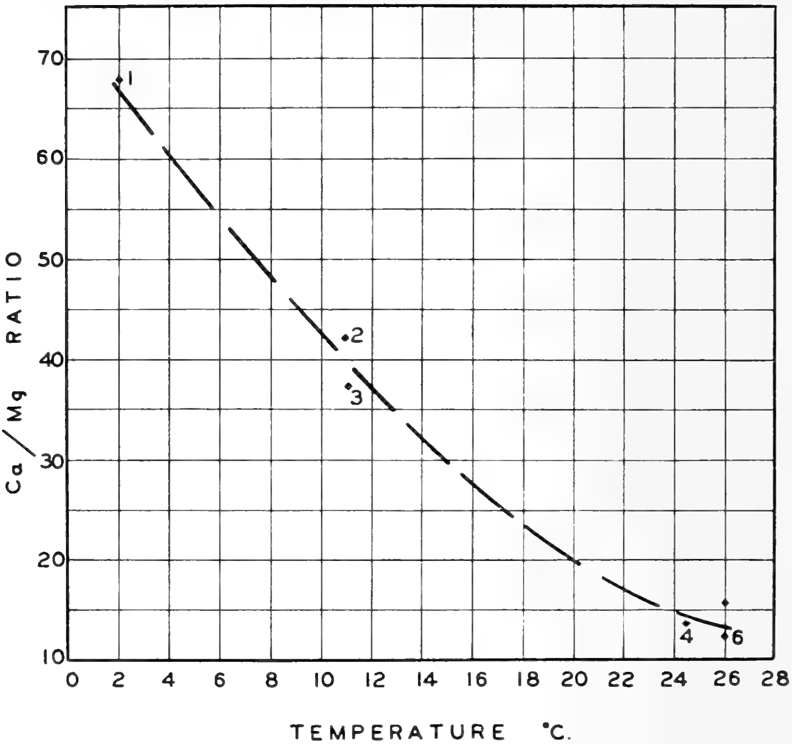

*Figure 10.* Relationship between temperature and Ca/Mg ratio in skeletons of Ostracods (analyses by Chave, 1954, p. 273).

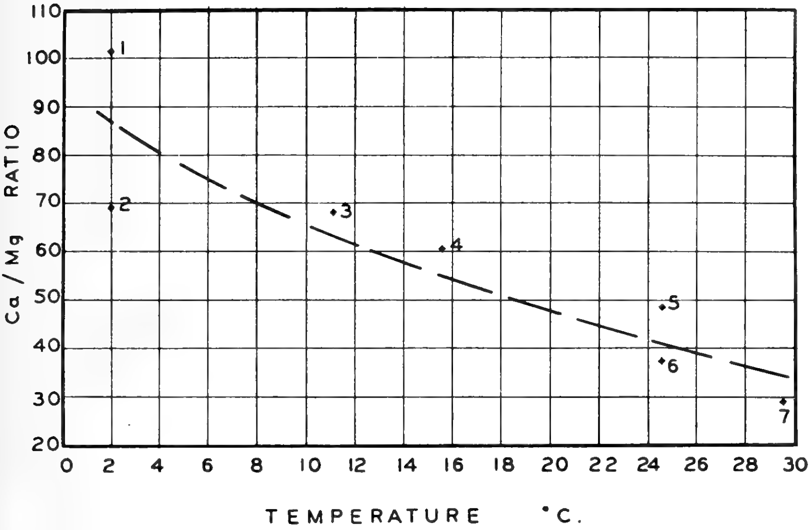

*Figure 11.* Relationship between Ca/Mg ratio in skeletons of Barnacles and temperature (analyses by Chave, 1954, p. 273).

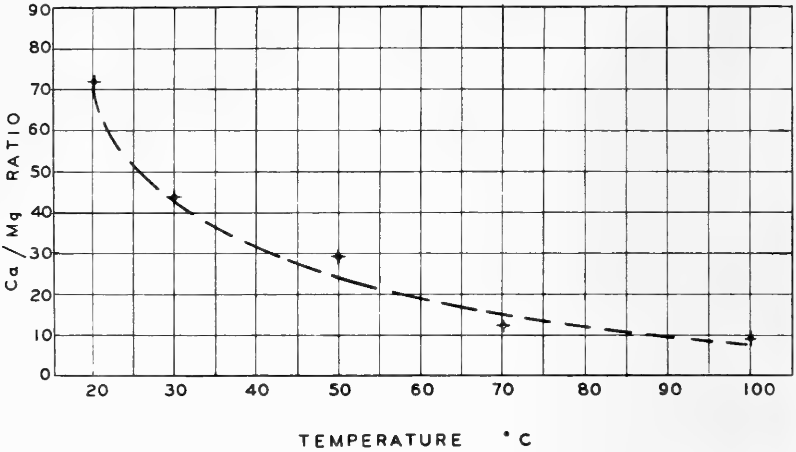

*Figure 12.* Relationship between temperature and Ca/Mg ratio of direct chemical precipitates from sea water on adding saturated solutions of $Ca(HCO_3)_2$.

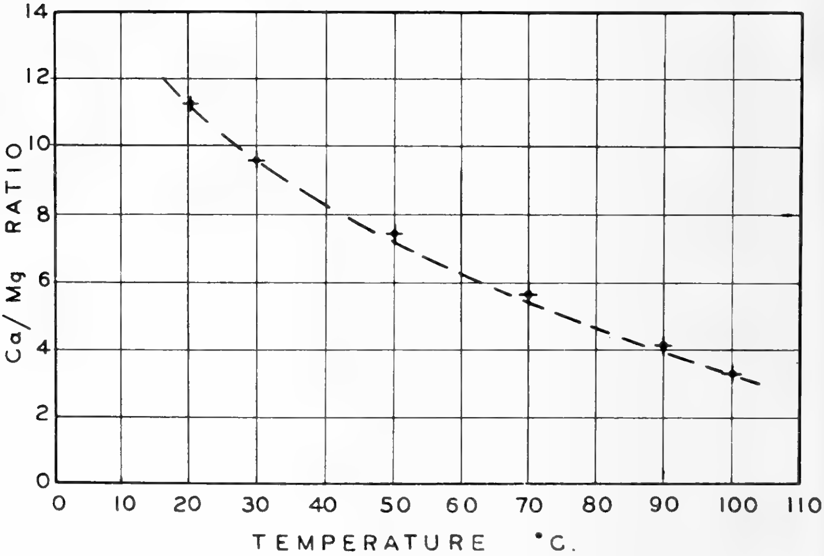

*Figure 13.* Relationship between temperature and Ca/Mg ratios of direct chemical precipitates from sea water on adding saturated solutions of $Ca(HCO_3)_2$ with $Na_2CO_3$.

son) and *Mytilus californianus* Conrad are proportional to the Ca/Mg ratio of sea water in the aquarium. This finding suggested that possibly other invertebrates also assimilate more magnesium in the environment having a higher concentration of magnesium.

## CONCLUSIONS

The findings of the present study can be summarized as follows:

1. There is an inverse ("hyperbolic") relationship between the Ca/Mg ratio in the skeletons of organisms and the temperature of the water in which they live.

2. Different organisms have different Ca/Mg ratios and there is very little relationship between the Ca/Mg ratios and the phylogenetic level of organisms.

3. Inverse relationship exists between the Ca/Mg ratios of direct chemical precipitates out of sea water and the temperature.

4. The Ca/Mg ratios of direct chemical precipitates out of sea water are also controlled by the pH of the medium of deposition.

5. The similarity in shape of "Ca/Mg ratio versus temperature" curves of invertebrates and direct chemical precipitates suggests that the Ca/Mg ratios of these organisms are controlled to some extent by the effect of temperature on solubility products of $CaCO_3$, $MgCO_3$, $Mg(OH)_2$, etc. The differences in magnitude of Ca/Mg ratio in different organisms may be related to the growth mechanism and composition and pH of the body fluids.

The future line of research suggested by this work is to make a detailed study of the variation in the Ca/Mg ratios of skeletal and protective structures of organisms on varying the pH and chemical composition of the sea water.

## ACKNOWLEDGMENTS

This author is greatly indebted to Drs. T. Clements, W. H. Easton, K. O. Emery, O. L. Bandy, C. M. Beeson, and R. H. Merriam of the University of Southern California, whose help and critical advice were invaluable in carrying the present study to completion.

The investigator would also like to express his appreciation to G. P. Kanakoff of the Los Angeles County Museum and A. H. Clark of the Smithsonian Institution for supplying numerous skeletal and protective structures of organisms.

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REPORT OF A SCYPHOZOAN *STEPHANOSCYPHUS SIMPLEX* KIRKPATRICK FROM THE ARCTIC OCEAN. The scyphozoan *Stephanoscyphus simplex* Kirkpatrick has recently been collected from drifting stations in the Beaufort and Chukchi Seas. The specimens agree with the description of Kramp (1959) in both internal and external characteristics.

The following data are available for the two collecting stations:

| | | *Station Number* | |
|---|---|---|---|
| | | 204 | 411 |
| *location* | | | |
| | longitude (W) | 144° 55′ | 165° 48′ |
| | latitude (N) | 71° 45′ | 74° 54′ |
| *date* | | December 24, 1959 | January 30, 1961 |
| *water depth (meters)* | | 1540 | 471 |
| *collecting device* | | orange peel bucket | orange peel bucket |
| *collector* | | Roger W. Lewis | John Tibbs |

The colony collected from station 411 contained thirty-two individuals clustered on a rock, whereas a single loose specimen was collected from station 204. Water temperatures at the bottom were not recorded from these locations but from readings taken at about the same depth and location approximate temperatures can be extrapolated: —0.4°C for station 204 (Muguruma 1961) and +0.5°C for station 411 (Church 1961).

*Stephanoscyphus simplex* has previously been reported from several localities in the Atlantic Ocean, the Mediterranean Ocean, the Indian Ocean, the waters of the Malayan Archipelago, the Gulf of Panama, the Kermadec Trench, the Tasman Sea, and the Antarctic Ocean with depths ranging from 430 to 7000 meters. Temperatures had previously ranged from 0° to 11°C. This report extends the range of distribution and temperature tolerance.

These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Southern California, NR 107-567. We also gratefully acknowledge the use of the laboratory facilities of the Allan Hancock Foundation and the technical assistance of Yuk Maan Leung for sectioning the specimens.—Carolyn Brahm and John L. Mohr, Biology Department, University of Southern California, Los Angeles 7.

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# ANALYSIS OF THE HABITAT, WEB DESIGN, COCOON AND EGG SACS OF THE TUBE WEAVING SPIDER *DIGUETIA CANITIES* (McCOOK). (ARANEA, DIGUETIDAE)

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The spider family Diguetidae, also known as tube and net weavers, is endemic to North America where it occurs in southwestern United States and northern Mexico. It is represented by a single genus, *Diguetia,* which contains five species (Gertsch, 1949) of which *Diguetia canities* (McCook) is the most common and widespread. It has been recorded from west Texas, Arizona, southern Utah, southeastern California (Gertsch, 1935:6) and is now known to be abundant in at least two areas on the eastern side of the Chiricahua Mountains, Cochise County, Arizona. The family is one of four archaic types known to persist in the southwest (Gertsch, 1949:265).

The present studies were started on December 20, 1960, when a number of cocoons were brought into the laboratory from a thorn shrub area located 1.5 miles N.E. of Portal at an elevation of 4600 feet. No adult *D. canities* were found at this time so the cocoons, egg sacs and parasites were cultured, worked over in a preliminary fashion and set aside awaiting the capture of the spider for verification of the determination. This was accomplished on October 31, 1961, when many cocoons were collected in the same area and most fresh ones were found to have the female in the entrance to the cocoon. Two cocoons were each found to contain an immature specimen of *Phidippus formosus* Peckham and Peckham and one had an immature specimen of *Chiracanthium inclusum* (Hentz). In 1960, one cocoon contained an immature female of the latter species along with the eggs, deutova and spiderlings of *D. canities.* These two species apparently occupy deserted or old cocoons of *D. canities* for purposes of overwintering but might also feed on the spiderlings of the latter as they emerge from the egg sacs and enter the passageway.

## Habitats

When it was discovered that the spiders were selecting primarily one species of plant in which to hang their cocoons in the Portal area, three other areas each with different dominating vegetation cover were either

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surveyed or studied. From two to three miles N.E. of Portal the principal cover plant is *Flourensia cernua* (Tar bush) intermixed with *Ephedra trifurca* (Joint-fir), *Parthenium incanum* (Mariola), *Yucca elata* (Yucca) and a few species of perennial and annual herbs. Several hundred plants were examined on November 28 and December 1 but no cocoons were found. In an area from five to six miles N.E. of Portal the dominant plant is *Larrea tridentata* (Creosote bush) sparsely intermixed with *Flourensia cernua* (Tar bush) and *Parthenium incanum* (Mariola). An examination of hundreds of plants again gave negative results. Chew (1961:8) studying the "Ecology of the Spiders of a Desert Community" and working on a plot six miles N.E. of Portal, collected one specimen of *D. canities* on "Larrea divericata" in 817 spiders swept from the above mentioned three plant species. The fourth area, dominated by *Opuntia*, *Fouquieria* and *Agave*, gave positive results which will be discussed along with the account of the Portal plot.

Although the female *D. canities*, when out of her natural environment (Fig. 1), is seen to be strikingly marked with white hairs and bands on the abdomen and cephalothorax, and with black rings on her long legs, she is seldom seen unless prodded out of her hiding place in the entrance to the cocoon. When disturbed from her normal venter-up position under the cocoon she blends with the background of the foliage or the cocoon to a remarkable degree. Most of the nest and web building activity takes place at night and although much of the feeding activity probably occurs during the day it would consist of a brief dash onto the web to capture the prey and take it back to the cocoon entrance to be eaten. Although sometimes difficult, it is easier to look for the cocoon and capture her at the entrance where she is guarding the egg sacs rather than looking for the spider.

## PORTAL HABITAT

In the study area near Portal the cocoons were found suspended in various species of small leafy shrubs and herbs, beautifully camouflaged to match their surroundings (Figs. 2, 3, and 4). Even though they are fairly common they are easily missed because of their secretive position in the plants and the nature of the materials used in the construction of the cocoon. The effectiveness of this camouflage is lost only after the leaves have fallen or the plants have dried up for the winter, at which time, some of the cocoons have also fallen to the ground and are almost indistinguishable from the debris beneath the plants.

The principal shrubs or small trees in this area are *Prosopis juliflora* (mesquite), *Mimosa biuncifera* (wait-a-minute), *Acacia constricta* (white-thorn), *Acacia gregii* (catclaw), and *Chilopsis linearis* (desert willow). Intermixed with these are perennial herbs such as *Gutierrezia microcephala* (snake-weed), *Solanum eleagnifolium* (horse-nettle) and many annual herbs including *Salsola kali* (Russian thistle), *Eriogonum abertianum* (buck-wheat), *Tidestromia lanuginosa*, *Amaranthus palmeri* (pig-weed), and *A. fimbriatus* (Kearney and Peebles, 1951). Many species of grasses are also represented and most of these plants figure prominently in the cocoon making activities of *D. canities* at lease in this locality. According to Gertsch (1949:234) "Cocoon retreats from different areas differ markedly in color, texture and general composition." The preferred plant was found to be *Acacia constricta* and most of the cocoons were in young plants from one to three feet in height and were suspended from four inches to two feet from the ground. In some instances the sheet webbing beneath the cocoon was in touch with the ground and anchored to it. Other plants used in the order of frequency were *P. juliflora*, *G. microcephala*, *S. kali*, *M. biuncifera* and *T. lanuginosa*. The cocoons are suspended in small openings in the plants by means of guy lines to adjacent leaves and twigs attached to the top half or two-thirds of the cocoon (Fig. 5). In the immediate vicinity of the cocoon many tangle lines are irregularly attached to the guy lines and to the various objects making up the cocoon. From the lower half or one-third to the edge of the bottom there is an area free of supporting lines extending around the cocoon. From the edge of the opening at the bottom other guy lines extend radially outward and slightly downward to the adjacent vegetation, each connected to the other by a loose sheet web. Near the edge of the cocoon there are one or more openings in this sheet web which allows the spider access to the top surface to gather in prey that fall upon it or in the tangle lines around the upper portion of the cocoon. They also have access to the bottom of the sheet but whether or not they pull prey through it as do the sheet web weavers isn't known. In a number of instances a second sheet is suspended beneath the first and is attached to the lower edge of the cocoon by one or more lines that probably act as trap lines similar to those constructed by the orb weavers to detect the presence of prey in the web. This second sheet may also serve to protect the spider from attack from beneath as it apparently does in the sheet web weavers (Gertsch, 1949:170).

## Cocoons

Incomplete or small cocoons tend to be trumpet shaped, narrowing gradually from bottom to top, whereas complete or large ones are elongate or oval with a narrow constriction at the top and are nearly parallel sided to the bottom opening. The narrower, loosely closed end is always at the top and the bottom opening is slightly flared and enlarged so as to accommodate the female. On the side of the opening opposite to the side on which the egg sacs are placed, a few leaves or other debris are woven in to form a small protruding lip. In case of threat the female may pull this over the opening to protect herself and block entry to the passageway extending upward over the egg sacs for the length of the cocoon. It may also be used as support while she is completing the last egg sac which is very near the opening. These cocoons have been reported to be three or more inches in length (Gertsch, 1949:234) but in the Portal area they ranged from 20-45 mm., average 31 mm., in length and 11-18 mm., average 14 mm. in width. In 1960, one 85 mm. long cocoon was found but appeared to have been torn and another 65 mm. long contained 19 normally arranged egg sacs. None this large has been seen since.

The cocoon is a rather loosely but strongly woven conglomeration of materials found in the immediate vicinity (Fig. 6) and also contains the bodies of various prey consumed by the female which have been incorporated into the cocoon especially around the open end. The following table gives the identifiable contents of 25 cocoons and the total number of cocoons in which each type of material was found.

| *Materials* | *Number Cocoons* |
|---|---|
| Plants | |
| Eriogonum abertianum, seeds | 25 |
| Acacia constricta, leaves and twigs | 21 |
| Tidestromia lanuginosa, leaves and flowers | 20 |
| Gramineacea, seeds and stems | 20 |
| Amaranthus palmeri, seeds | 18 |
| Amaranthus fimbriatus, seeds | 12 |
| Gutierrezia microcephala, flowers | 8 |
| Solanum eleagnifolium, leaves | 7 |
| Prosopis juliflora, leaves and stems | 6 |
| Mimosa biuncifera, leaves and stems | 1 |
| Salsola kali, leaves | 1 |
| Twigs, miscellaneous | 25 |
| Pebbles and dirt | 25 |

| *Materials (continued)* | | | | | *Number Cocoons* |
|---|---|---|---|---|---|
| Excrement | | | | | |
| Mouse | | | | | 13 |
| Rabbit | | | | | 15 |
| Caterpillar | | | | | 3 |
| Arachnida | | | | | |
| Salticidae | | | | | 1 |
| Insecta | | | | | |
| Coleoptera | | | | | 12 |
| | Carabidae | 2 | Chrysomelidae | 3 | |
| | Anthicidae | 2 | Staphylinidae | 2 | |
| | Malachidae | 1 | Melyridae | 1 | |
| | Scarabaeidae | 2 | Cleridae | 1 | |
| Hymenoptera | | | | | 22 |
| | Formicidae | 18 | Apidae | 1 | |
| | Chalcidae | 1 | Small parasitic wasps | 19 | |
| Homoptera | | | | | 25 |
| | Cicadellidae | 25 | Chermidae | 12 | |
| | Membracidae | 1 | Fulgoridae | 1 | |
| Hemiptera | | | | | 15 |
| | Miridae | 4 | Anthocoridae | 11 | |
| | Lygaeidae | 7 | Tingidae | 1 | |
| Diptera | | | | | 15 |
| | Muscidae | 15 | Chironomidae? | 1 | |
| Thysanoptera | | | | | 1 |
| Lepidoptera | | | | | 14 |
| | Gelechiidae, larval cocoons | 11 | Small moths | 7 | |
| | | | Caterpillars | 1 | |

The exterior of the cocoons consists primarily of small twigs, leaves, seeds, pebbles and excrement, tied together with a maze of silk. Cocoon building, although not observed, probably begins in June or early July and judging from the number of seeds represented, continues into late fall. A number of cocoons collected on October 31, 1961, contained fresh green leaves of *Acacia constricta*, fresh flowers of *Tidestromia lanuginosa*, seeds of *Amaranthus palmeri* and *A. fimbriatus* in the loose outer covering which would indicate building activity in September and October. By November the females are content to rest in the cocoon opening (Fig. 7) and there was no indication of recent construction or egg laying activities in the field. Two females, that were brought into the laboratory and kept with their cocoons in petri dishes, each spun an additional egg sac and laid a few eggs in them around the middle of November. Since the females had no building materials available, the sacs protruded from the cocoon entrances and were out of line with the other sacs because the cocoons were lying on their sides. In 1960, by December 20 all the females had died or at least departed from the cocoons.

## PREY

If the remains of prey incorporated in the cocoons is indicative of the dietary preferences of *D. canities*, irrespective of relative abundance, they feed primarily on *Cicadellids* (leafhoppers), small wasps of many species, *Formicidae* (ants), *Chermidae* (Psyliids or jumping plant lice), Diptera (flies), and *Anthocoridae* (flower bugs or minute pirate bugs). However, all the above plus many more insects are common inhabitants of the plants in which the spiders occur and it would seem that the size of the prey rather than quality governs the selection. With only one exception (Scarabaeidae–*Diplotaxis*) all the prey was small. Although the larval cocoons of the *Gelechiidae* are listed above with the prey, it is not at all certain that they don't represent building materials rather than food. These larval cocoons of *Gelechia aulaea* Clarke (det. by Lloyd Martin) are common in *Acacia constricta* from midsummer through the winter months and are occupied by the caterpillars until October and November when they drop to the ground to pupate. Eleven cocoons of *D. canities* were found to contain from one to six of these *Gelechia* cocoons and since the latter are firmly attached to the plants and seldom drop to the ground during the spider's period of activity, it is assumed that some, if not all, were collected on the plants and therefore might have contained caterpillars. The remains of a caterpillar were found in one *D. canities* cocoon.

## HABITAT, 7.8 MILES N.E. OF PORTAL

Another population of *D. canities* was located 7.8 miles N.E. of Portal on an east facing limestone hillside where the vegetation cover was entirely different from that on the adjacent valley floor and at 1.5 miles northeast of Portal. The principal plants in the order of their abundance were as follows: *Fouquieria splendens* (Ocotillo), *Opuntia phaeacantha*, *Opuntia engelmanni*, *Ferocactus wislizeni* (Barrel cactus), *Acacia gregii* (Catclaw), *Parthenium incanum* (Mariola), *Calliandra* sp. (False mesquite), *Larrea tridentata* (Creosote bush), *Agave* *schottii* (Century plant), *Flourensia cernua* (Tar bush), *Gutierrezia microcephala* and a number of small herbs. The dominant vegetation along the base of the hill and extending on out into the valley was *L. tridentata* (Creosote bush) and *F. cernua* (Tar bush). Both plants were also represented on the hillside although outnumbered by the first seven species listed above.

On November 29, 1961, 25 cocoons were collected in an area roughly 100 yards square, all plants being examined. Fourteen were suspended between the leaves of *Opuntia phaecantha* which is a low growing nopal that usually has grass, *Calliandra* sp. or other vegetation growing around it, seven were well camouflaged in *Parthenium incanum*, three were suspended between low leaves of the taller growing *Opuntia engelmanii* and one was exposed in a dead *Gutierrezia microcephala* plant. Even though Creosote bush and Tar bush were intermixed with the above plants no cocoons were found on them which was also true of two other areas examined in which they were the dominant species. Neither of these plants are represented on the Portal plot where *D. canities* is known to be present.

## COCOONS

The cocoons that were suspended in *Opuntia* (Fig. 8) were made up primarily of materials from underlying or adjacent plants and only three out of 17 contained recognizable pieces, spines (5), from the cactus. Most of the leaves that were used were from *Calliandra* sp. Those suspended in *Parthenium* were made up primarily of materials from this plant with a liberal use of leaves especially on the outer covering. The cocoon on *Gutierrezia* was an old one but appeared to consist mostly of materials from this plant with the addition of pebbles and grass stems. All were found within a foot of the ground. The insect remains incorporated in the cocoons were in almost the same relative numbers and kinds as in the Portal plot. In the 25 cocoons there were three live and two dead *D. canities*, one live *Chiricanthium inclusum* and one dead *Phidippus* sp. which represents a considerable reduction in adult population of *D. canities* in a month's time between the two collecting dates—October 31 and November 29.

In *D. canities* the cocoons appear to serve in three capacities for the benefit and survival of the species. (1) As a protective covering for the egg sacs; (2) As a centralized protective and feeding retreat for the female; (3) As a central anchor for the sheet web that spreads out beneath it for trapping prey. For what is probably its primary function, that of protecting the egg sacs against the climatic elements, predators and parasites, it has a number of advantageous features but unfortunately these are not entirely infallible. Its camouflaged construction, the space at the entrance and habit of the female to repose there probably have a deterring effect on predators and parasites but some of these have found ways of getting around these protective features. The construction of the cocoon and arrangement of the egg sacs appear to afford the best protection against the climatic elements and probably developed as such because the species overwinters in three vulnerable stages—eggs, deutova and spiderlings.

## Egg Sacs

In many spiders the female lays a mass of eggs, covers them with a silken sheet and then molds the mass into the egg sac characteristic of her species (Gertsch, 1949: 33). Others use viscid secretions or fine silk lines to hold the eggs together. *D. canities* apparently uses neither of these techniques as the eggs are loose in the sac, the sac is only about half to three-quarters filled and its surfaces do not bear the imprints of the enclosed eggs. The fact that the eggs are laid loose or at most with a temporary adhesive probably accounts for why the sacs are only partially filled. Egg sac construction and egg laying have not been observed.

The spinning of the egg sacs and laying of the eggs begins at the top of the cocoon since the contents of the upper sacs are more advanced in development than those at the lower end, at least by the end of October. The sacs are spun on one side of the hollow interior of the cocoon, they are shingled one on top of the other, with the inner edges elevated above the outer edge at about a 45° angle to the long axis of the cocoon (Fig. 9). The first sac is located a short distance in from the narrowed upper end of the cocoon and the last is immediately inside the cocoon entrance with its lower outer edge almost flush with the edge of the opening (Fig. 10). When the female is inside the opening (Fig. 7) she is covering this last egg sac. The passageway through the cocoon narrows down immediately in front of the last egg sac and while it would allow for movement of the spiderlings it appears to be too small for the female to move through. Each sac is individually surrounded by a network of pale yellow silk attaching it to the margin of the cocoon and to the adjacent sacs. A heavier layer of silk, extending from side to side on the cocoon, covers all the sacs (Fig. 11). The opposite wall of the cocoon is also covered with silk but not as densely.

Each egg sac is lenticular or discus shaped, from 5 to 6 mm. in diameter, and is made of pale yellowish silk woven so tightly as to give them a parchment-like appearance. The edges of the two halves are rather loosely silked together, probably to enable the spiderlings to escape readily (Fig. 12). In 54 cocoons gathered near Portal in 1961, the number of egg sacs in each varied from 2-10 with an average of 4.6. In 25 cocoons taken in 1961, at 7.8 miles N.E. of Portal, they varied from 1-8 egg sacs in each with an average of 3.9 per cocoon. The shingled and angled arrangement of these sacs would be a definite advantage during wet weather if moisture seeped in at the top of the cocoon. The first sac would direct it downward and outward, thus protecting the remaining sacs beneath it.

## EGGS

The eggs are opaque, white, cylindrical and vary from .75-.80 mm. in diameter (Fig. 13). They are laid free in the sacs, never completely fill it and there is no impression of the eggs on the side wall of the sac. The deutova (Fig. 14) vary from .80-.95 mm. in lengths, the cephalothorax and legs are white, the eyes are black and the abdomen is a pale brown. The first molt spiderlings vary from 1.0-1.5 mm. in length and the color is the same as in the deutova. In 50 egg sacs taken at random the number of eggs or deutova in each varied from 41-164 with an average of 113. Since there is an average of 4.6 and 3.9 sacs per cocoon this would give an average reproductive potential of 520 offspring per female at Portal and 441 at 7.8 miles N.E. of Portal. However, as pointed out by Gertsch (1949:35) spiders that lay many more eggs than *D. canities* have a survival average of only one pair per female. This figure seems inordinately low for the maintenance of the poulation and it would be expected that more would survive under favorable environmental conditions and there would therefore be a fluctuation in the population from year to year.

When multiple egg sacs are spun by a single female, the number of eggs tends to decrease in the later ones (Gertsch, 1949:35). In *D. canities* there is some irregularity in individual cocoons, for example, one had the following number of eggs in the order laid: 117, 150, 137, 141, 109; and another 101, 147, 133, 130, 111, 94. However, if the average number is taken for the last five sacs in 25 cocoons in the order laid it is 135, 132, 121, 114, 86 or a gradual decrease as is known to occur in some other species. When the cocoons were collected near Portal on October 31, 1961, all but one of the last sacs laid contained eggs, the other had deutova; in the next to last, 21 contained eggs, four had deutova; and in the third from the last, 11 contained eggs, eight had deutova, four contained both eggs and deutova, one had a predaceous larva and the last a parasite larva. In the cocoon that had ten egg sacs, the first four laid contained 1st molt spiderlings, the next three deutova, the eighth had 100 deutova and eight eggs and the last two were still in the egg stage. Out of the 25 cocoons only five had spiderlings in a total of ten egg sacs.

In the 25 collected at 7.8 miles N.E. of Portal on November 29, 18 of the last sacs laid contained eggs, two deutova, three were empty because of predator activity and two had parasite larvae and pupae. In the 22 next to last sacs laid, 13 contained eggs, three deutova, one eggs and deutova, three a predaceous larva and two parasites. In 19 third from the last sacs, six contained eggs, eight deutova, three a predaceous larva, one parasite, one eggs and deutova. Predatism and parasitism appears to be higher in this location than at Portal and might be due to the more exposed position of the cocoons on the *Opuntia* plants (Fig. 8). No parasites or predators were found in the seven cocoons on *P. incanum* which were well camouflaged (Fig. 15).

## PREDATISM AND PARASITISM

Predatism and parasitism are both operating against the early stages of *D. canities*. One predaceous larva will feed on the contents of as many as three egg sacs, thus destroying around 340 potential spiders and a single parasite larva working in one sac will destroy an average of 113 eggs or deutova to complete its development. So far as known no parasites of *D. canities* have previously been recorded and although two wasp parasites have been reared, the true association has been established for only one of these, *Arachnophaga picea* (Riley). This wasp (Figs. 16 and 17) is ant-like in appearance and behavior, belongs in the family *Eupelmidae* and has previously been recorded as a parasite of *Chrysopa californica*, *Argiope argentata*, *A.* sp., *Epeira* sp., and *Phidippus opifex* (Muesebeck, Krombein and Townes, 1951:512). The manner in which the egg is deposited in the egg sac of *D. canities* has not been ascertained but apparently the female lays only one per sac as only one larva is found in each (Fig. 18). As early as October 31 these larvae are ready to pupate but in 1960 on December 20 both larvae and pupae were found in the sacs and the adults emerged in the laboratory between January 8 and February 3, 1961. Pupation takes place in the sac (Fig. 19) after all the *D. canities* eggs and deutova have either been eaten or destroyed. On November 29 one larva of *A. picea* was found with an ectoparasitic larva on its anterior end which killed it, but thus far we have been unable to rear the adult for determination.

*Figure 1.* Adult female of *Diguetia canities* (McCook). Photo by Mortenson.

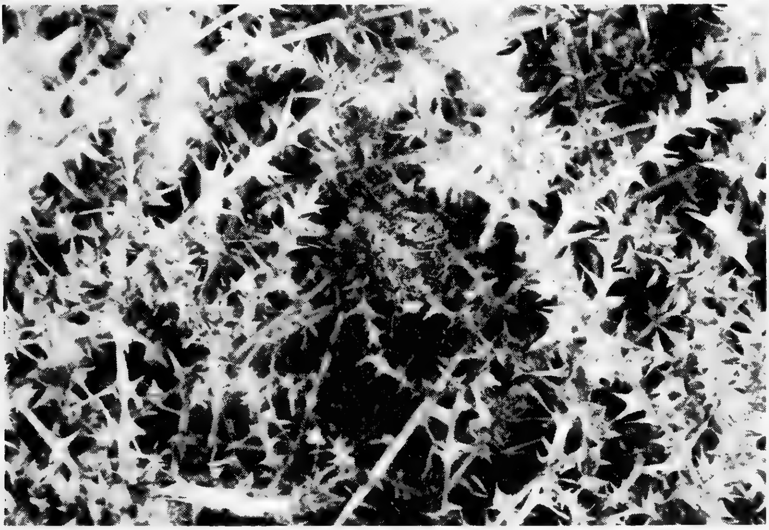

*Figure 2.* Suspended cocoon of *Diguetia canities* (McCook) in *Salsola kali* L. Photo by Mortenson.

*Figure 3.* Suspended cocoon of *Diguetia canities* (McCook) in *Acacia constricta* Benth. Photo by Mortenson.

*Figure 4.* Top view of *Diguetia canities* (McCook) cocoon suspended in *Acacia constricta* Benth. Photo by Mortenson.

*Figure 5*. Cocoon of *Diguetia canities* (McCook) showing guy lines, tangle lines and sheet web. Photo by Mortenson.

*Figure 6*. Cocoon of *Diguetia canities* (McCook) showing composition. Photo by Mortenson.

*Figure 7*. Entrance to cocoon of *Diguetia canities* (McCook) showing female in opening. Photo by Mortenson.

*Figure 8*. Cocoon of *Diguetia canities* (McCook) suspended in *Opuntia phaeacantha*. Photo by Mortenson.

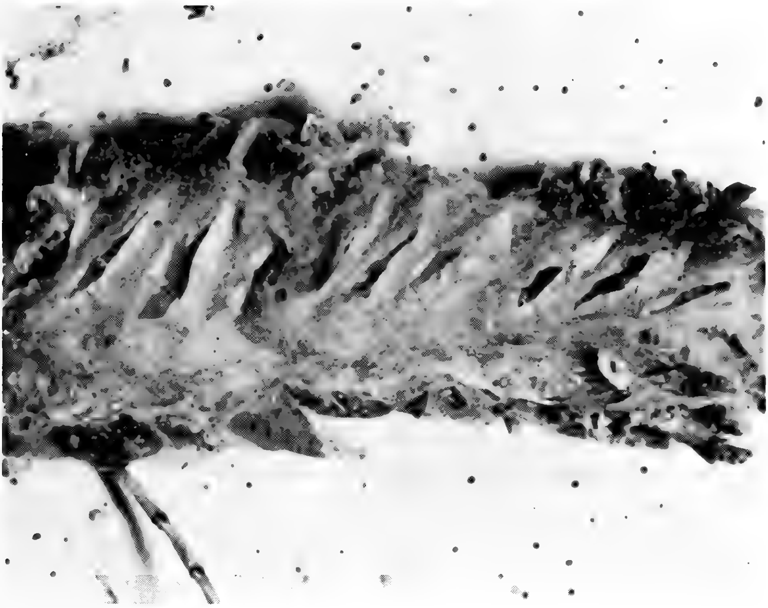

*Figure 9.* Cross section of cocoon *of Diguetia canities* (McCook) showing covering over egg sacs and angle at which they lay. Photo by Mortenson.

*Figure 10.* Entrance to cocoon of *Diguetia canities* (McCook) showing position of last egg sac and flap made of two rabbit droppings. Photo by Mortenson.

*Figure 11.* Cross section of cocoon of *Diguetia canities* (McCook) showing covering over egg sacs on bottom of passageway. Photo by Statham.

*Figure 12.* Cross section of cocoon *of Diguetia canities* (McCook) with silk cover removed and egg sacs opened. Photo by Statham.

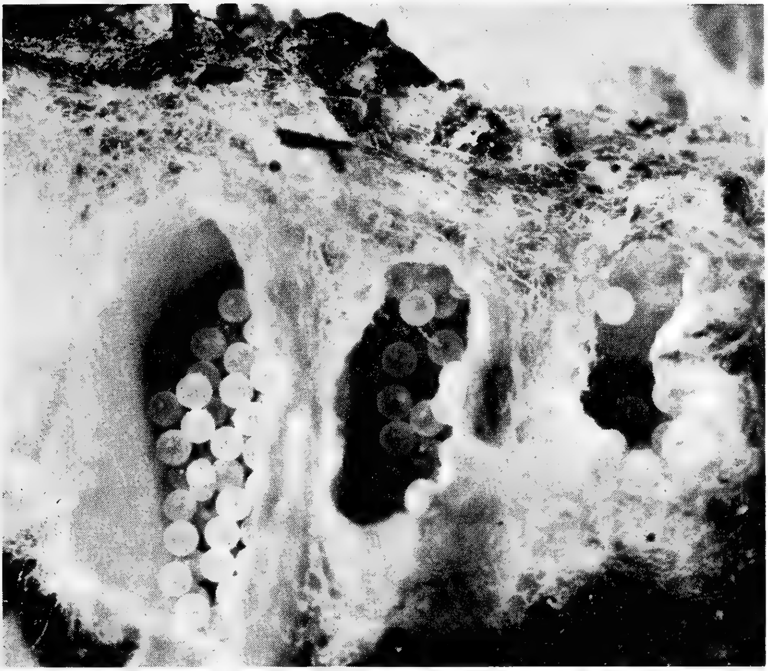

*Figure 13*. Eggs of *Diguetia canities* (McCook) in egg sacs. Photo by Mortenson.

*Figure 14.* Deutova and shed corions of the eggs in the egg sac of *Diguetia canities* (McCook). Photo by Mortenson.

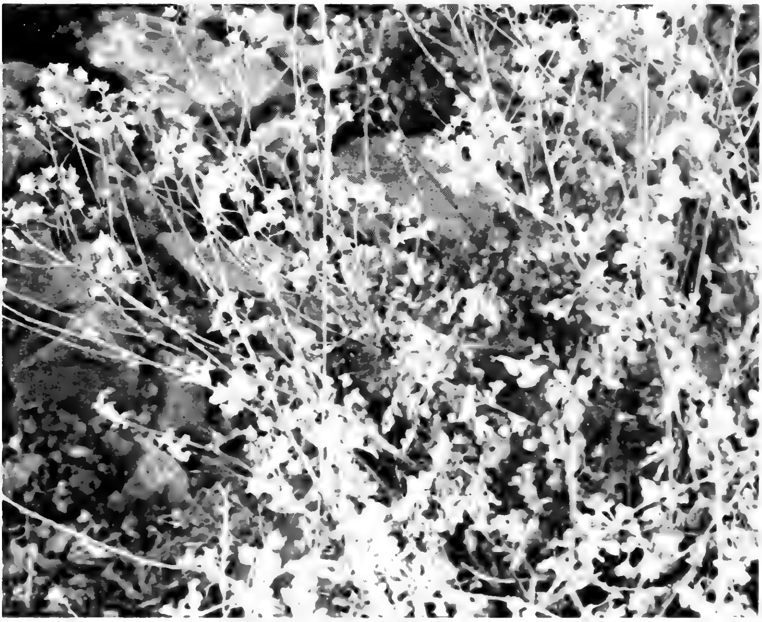

*Figure 15.* Cocoon of *Diguetia canities* (McCook) suspended in *Parthenium incanum*. Photo by Mortenson.

*Figure 16.* Adult (dorsal view) of *Arachnophaga picea* (Riley). Photo by Mortenson.

*Figure 17.* Adult (lateral view) of *Arachnophaga picea* (Riley). Photo by Mortenson.

*Figure 18.* Mature larva of *Arachnophaga picea* (Riley) in egg sac of *Diguetia canities* (McCook). Photo by Statham.

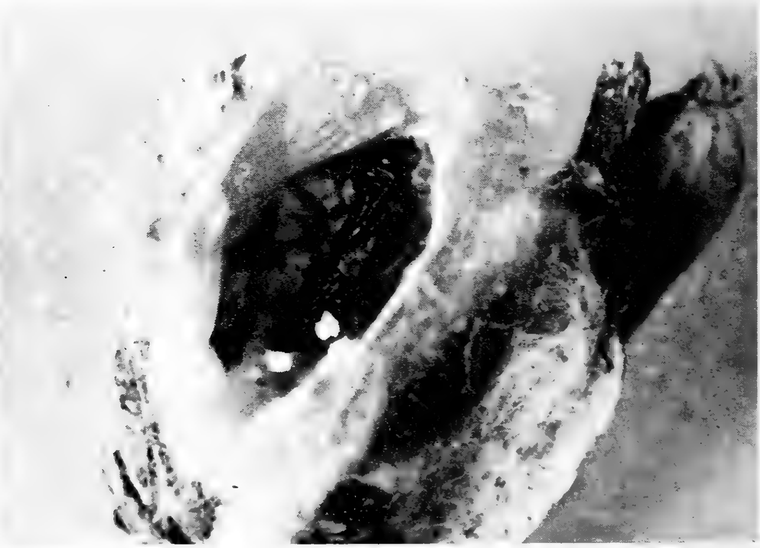

*Figure 19.* Pupa of *Arachnophaga picea* (Riley) in egg sac of *Diguetia canities* (McCook). Photo by Mortenson.

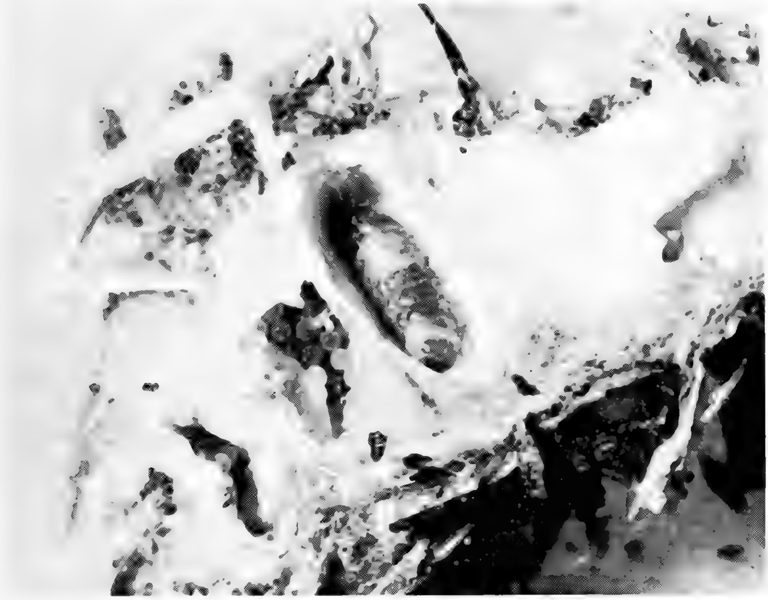

*Figure 20.* Larva of *Cymatodera* sp. in egg sac of *Diguetia canities* (McCook). Photo by Mortenson.

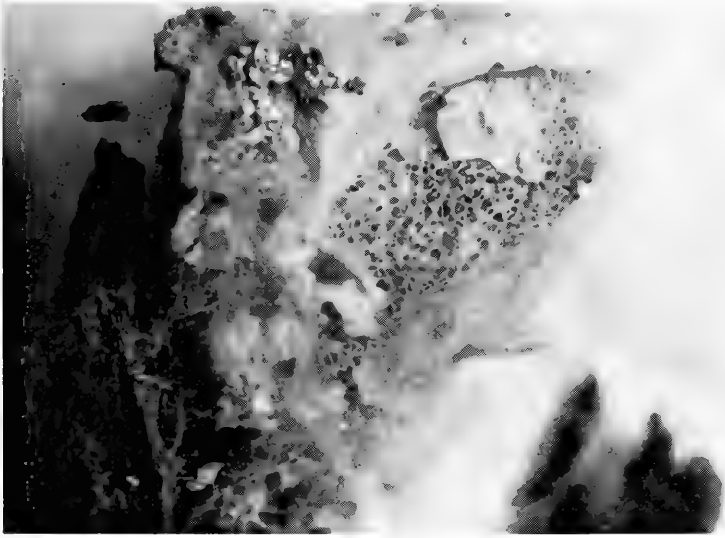

*Figure 21.* Pupal cell of *Cymatodera* sp. in egg sac of *Diguetia canities* (Mccook). Photo by Mortenson.

In 1960 no predaceous larvae or signs of their work were encountered in any of the egg sacs examined at the Portal plot. In 1961 they were found to be not uncommon in this location and at 7.8 miles N.E. of Portal were even more abundant and had destroyed the contents of a number of egg sacs. Although none have been reared as of this writing they belong to the beetle family *Cleridae* and probably to the genus *Cymatodera* (Fig. 20). Entry into the egg sac is made through the bottom or sides where small holes are cut by the larva. The adult beetle probably lays her eggs on or nearby the cocoon from where the larvae work their way into the egg sacs. As many as three larvae were found in some of the larger cocoons but the usual number was one. Each larva consumes the contents of from one to three egg sacs and usually pupates within one of the sacs although one pupal cell was found just outside and another could not be found even though three sacs had been destroyed. They move from sac to sac by cutting holes in the parchment-like side walls near the bottom and are thus concealed from view from above.

The pupal cell (Fig. 21) is constructed of coarse white strands, silk-like in appearance, on the outside which are firmly anchored to the spider silk and egg sac walls and an inner layer of finer strands which line the cell. These layers harden and give the cell a fairly rigid outer covering. This substance is probably the oral exudate which is used by many Clerids in the construction of their pupal cells (Balduf, 1935: 110). The larvae of *Cymatodera* have previously been reported as predators of many kinds of wood boring beetles, larvae of various hymenoptera and moth caterpillars (Balduf, 1935:107-111) but this appears to be their first recorded invasion of the *Aranea.*

## Discussion and Summary

It is known that in many desert areas these spiders prefer various species of cactus for their nest building sites. However, with a species as widespread as *D. canities* such plants are not always available and it is no surprise that their distribution is neither limited by nor confined to regions where such succulent vegetation dominates. In an area roughly eight miles in extent along the eastern foothills of the Chiricahuas between Portal and Harris Mountain there are four adjacent but distinct types of vegetative cover, two of which are occupied by *D. canities.*

At 1.5 miles N.E. of Portal the dominant shrubs in this thorn shrub area are *Acacia constricta* and *Prosopis juliflora* which accur in about equal numbers but the spiders are found mostly on the former. In the next and adjacent area extending from two to three miles N.E. of Portal the dominant plant is *Flourensia cernua* in which no *D. canities* were located. It is doubtful that this represents a sampling or survey error since hundreds of plants were examined closely on two different occasions. Their absence might better be explained by the fact that the plant is resinous, has a hop-like odor and there are not as many small insect prey in this type of vegetative cover as in the thorn shrub area. The next area surveyed was from three to six miles N.E. of Portal in which the dominant plant was *Larrea tridentata* sparsely intermixed with *Flourensia cernua.* Here again no spiders or their cocoons were found even though the same area was covered where Chew found one specimen on *Larrea.* This one may have been moving around from adjacent *Parthenium incanum* plants in which it is now known they construct their cocoons. The characteristic open growth at the base of the *Larrea* plants, the paucity of subsidiary growth beneath them and their strong characteristic odor might be the determining factors inhibiting or preventing the establishment of colonies of *D. canities* in this type of vegetative cover. *Larrea* also has a limited insect fauna as compared with many other plants.

Since both of these plants were absent from the Portal plot there was no way of checking on them in this known *D. canities* colony. However, at 7.8 miles N.E. of Portal the spiders were found in an area dominated by two species of *Opuntia*, the low-growing *O. phaecantha* being preferred, and even though both *Larrea* and *Flourensia* were intermixed and in close contact neither contained cocoons. *Parthenium incanum* which when growing in *Larrea* or *Flourensia* contained no cocoons, had them when in association with *Opuntia.*

When the female *D. canities* constructs her cocoon in herbaceous or woody plants, she utilizes materials from these as well as from adjacent plants and material found on the ground. When they are suspended in succulents such as *Opuntia*, practically all of the building materials are obtained from the plants growing beneath or around these plants.

The cocoons are usually suspended in openings within two feet of the ground and each has one and sometimes two sheet webs beneath for capturing prey which consists primarily of ants, small parasitic wasps and leafhoppers. The cocoons contain an average of from 3.9 to 4.6 egg sacs and each of these has an average of 113 eggs. There is an overall decrease in the number of eggs laid between the first and last egg sacs and the upper sac is the first one constructed.

One parasite, *Arachnophaga picea* (Riley) a wasp belonging to the family *Eupelmidae*, has been reared from the egg sacs of *Diguetia* *canities* and it has an ectoparasite on its larva which has not as yet been reared. The primary predator of the immature stages is a beetle belonging to the family *Cleridae* and probably to the genus *Cymatodera.*

## ACKNOWLEDGMENTS

Our appreciation is expressed to Dr. Willis J. Gertsch of the American Museum of Natural History for identifying the spiders, to Dr. B. D. Burks of the U. S. National Museum for the name of the parasite and to Miss Marjorie Statham of the American Museum of Natural History for supplying some of the photographs.

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# STUDIES IN NEARCTIC DESERT SAND DUNE ORTHOPTERA

## PART VI

## A NEW GENUS AND THREE NEW SPECIES OF LARGE SAND-TREADER CAMEL CRICKETS FROM THE COLORADO DESERT WITH KEYS AND NOTES

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This is another treatise on the Sand Dune Fauna completed under a grant from the National Science Foundation.

For quite some years now, especially during the course of four summers of extensive exploration and intensive study on the sand dune biotae of the North American Deserts and with the accumulation of considerable materials representing well over a dozen new species, it has been increasingly apparent that the sand-treader camel cricket genus *Ammobaenetes* Hubbell 1936, is not a congeneric one.

The genotype of *Ammobaenetes* is *Daihinia phrixocnemoides* Caudell 1907, a small Rhaphidophorid possessing, in the apical half of its straight caudal tibiae, a closely packed group of 5 to 6 pairs of long aciculate spurs forming a "sand basket" by which it jumps and digs readily in loose drifting sand and from which it derives both its scientific and common names. The female has a rather long, straight, slender ovipositor whose length is approximately one-half that of the body length and with which she oviposits rather deeply in the loose sand.

Restricted to, and existing on, the sand dunes of the Colorado Desert and dune areas peripheral to it but pertaining to the Gila Desert, both eremological components of the Great Sonoran Desert, is a group of much larger sand-treaders whose body size is two to three times that of members of true *Ammobaenetes* as based on the genotype. The large males of this group possess strongly arched or bowed caudal tibiae and the ovipositor of the female is very short and heavy, its length about one-sixth body length, or approximately the length of the pronotum. All species of this sand-treader complex have these important features. Their habits and life zones differ from those of the genus *Ammobaenetes* and it is obvious that here, contained in the genus *Ammobaenetes*, is a generic entity quite distinct from that genus. It is the purpose of this paper to describe this generic entity and the various species representing it.

To facilitate the student, a provisional key is here presented.

## PROVISIONAL GENERIC KEY TO THE SAND-TREADER CAMEL CRICKETS AND ALLIES

1. Mesotibiae with 3 to 5 pairs of dorsal spines( sometimes irregularly placed) exclusive of the calcars . . . . . . . . . . . . . . . . . . . . . . . . . . 3

   Mesotibiae with 2 pairs of dorsal spurs (sometimes only 3) exclusive of the calcars . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

2. Sand basket present and formed by crowding apically of 4 pairs of long aciculate spurs. Ovipositor equal to the pronotal length . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Rhachocnemis* Caudell

   Sand basket absent. Ovipositor exceeding the length of the pronotum . . . . . . *Ceuthophilus*, *Pristoceuthophilus*, *Udeopsylla*, *Styracosceles*

3. Sand basket formed of 4 to 6 pairs of long aciculate spurs, somewhat flattened on their inner faces and crowded apically on the caudal tibiae . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5

   Sand basket absent . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4

4. Caudal tarsomeres—3, their distoventral angles well rounded. Ovipositor 1.5 to 2.0 times their pronotal length . . . *Daihinia* Haldeman

   Caudal tarsomeres—4, their distoventral angles strongly acute. Ovipositor equal to pronotal length . . . . . . . . . . . . *Daihiniodes* Hebard

5. Size small; external inferior keel of caudal femora untoothed or with a few minute teeth. Caudal tibiae straight. Ovipositor long, slender, about one-half body length or twice pronotal length . . . . . . . . . . . . 7

   Size medium to very large; external inferior keel of caudal femora bearing strong teeth. Caudal tibiae straight or strongly arched. Ovipositor short and heavy, its length about the pronotal length . . . . . 6

6. Size medium to medium large. Caudal tibiae strongly arched in the male, female straight. External inferior keel of caudal femora with row of uniform strong teeth; internal keel also dentate. Tarsomere ratio 3-4-4, the distoventral angles spinose or acute . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Macrobaenetes* n. gen.

   Size medium to very large. Caudal tibiae straight in both sexes. External inferior keel of caudal femora with 2 to 4 very large spike-like teeth centrally situated on the keel, preceded and followed by smaller teeth. Tarsomere ratio 3-4-4, the distocentral angles spinose or acute . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Daihinibaenetes* Tinkham

7. Tarsomere ratio 3-4-4, their distoventral angles well rounded . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Daihiniella* Hubbell

Tarsomere ratio 3-4-3; their distoventral angles spined or acute . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Ammobaenetes* Hubbell

## **Macrobaenetes** NEW GENUS

The new genus *Macrobaenetes* is amply distinguished from *Ammobaenetes* Hubbell by many characters as: much larger size, the strongly arched or bowed caudal tibiae of the male, the dentition on dorsal ridge and inferior keels of the caudal femora which in *Ammobaenetes* is nondentate; by the tarsomere ratio of 3-4-4 instead of 3-4-3 as in *Ammobaenetes;* by the long first caudal tarsomere which in *Ammobaenetes* is very short; by the short ovipositor being about half the length observed in *Ammobaenetes* in relation to body length and by other minor features as well.

The males of *Macrobaenetes* are distinguished from all other large sand-treaders by the strongly arched caudal tibiae; the female separated from *Daihinibaenetes* Tinkham by the fine teeth on the external inferior keel of the caudal femora and by the same character from *Daihinia* and *Daihiniodes* which do not possess sand baskets, that is, at least 5 pairs of long aciculate spurs, somewhat flattened internally and crowded apically and without any small teeth intervening between these long spurs.

*Description:* Form typical of the heavier-bodied Rhaphidophorids. Maxillary palpi with all segments slender and elongate, the apical palpomere broadened and recurved in the distal two-thirds, its ventral surface sunken or excavate to leave a sensitized periphery; labial palpi with segments elongate, the apical segment enlarged in distal half. Pronotum with foremargin slightly concavely emarginate; lobes of all thoracic notites with slight narrowly reflexed margins. Leg spination as follows: forefemora unspined dorsally, ventrally unspined except for single tooth on internal keel. Foretibiae unspined dorsally except for small uniform pair of calcars; ventrally with 4 pairs of long tapering spurs plus the apical calcars, the external row much the larger. Foretarsi trimerous, segments 1 and 2 very short, segment 3 twice their combined length; distoventral angles of 1 and 2 lobate, of 3 acute. Middle legs with meso femora unspined dorsally and ventrally except for a tooth on each lower genicular lobe. Mesotibiae dorsally with 3 to 4 pairs spines plus apical calcars; ventrally with 3 pairs smaller spurs, spaced as dorsally, plus apical calcars. Mesotarsomeres 4, segments 2 and 3 very short, 1 equal to 4 and each twice length of 2 and 3, distoventral angles acutely rounded in 1 and 4, acutely lobate in 2 and 3, that of 2 much the largest. Hind legs with semiappressed teeth on the dorsal ridge; external inferior keel with 16 to 18 large heavy teeth and internal inferior keel with 14-16 much smaller ones. Teeth in the female much smaller. Caudal tibiae of male strongly arched; the ventral keel unspined except for median appressed subapical tooth and pair of small attingent calcars; the dorsal keels with 7 evenly paired spurs, 5 pairs of which form the sand basket in the apical quarter plus the long apical calcars which are also part of the sand basket. Caudal tarsomeres—4, segments 2 and 3 very short, segment 4 twice the length of 2 and 3, segment 1 about one and one-third times the length of 4; distoventral angles similar to those of mesotarsus. Genitalia with supra-anal plate roundly triangular, deflexed; cerci long, acuminate, hirsute; subgenital plate with rather strong forcipate arms. Ovipositor short, its length slightly less than the pronotal length; dorsal valvulae terminating in acute tooth; ventral valvulae bearing 4 uncinate apical hooks.

Genotype: *Macrobaenetes kelsoensis* new genus and new species.

The generic name refers to the large size of these sand treaders which distinguished them from *Ammobaenetes* Hubbell which are of much smaller size, some species being rather minute.

A key to males of this new genus, based on some of the more important taxonomic features, is presented below.

## KEY TO THE MALES OF **Macrobaenetes** NEW GENUS

1. Size very large. Caudal femora with basal portion of the lower genicular lobes armed with 2 or 3, rarely 1 tooth; dorsal teeth confined to ridge; usually 16-18, sometimes 15-22 teeth on external inferior keel. Sides of mesonotum nontuberculate. . . . *valgum* (Strohecker)

   Size large. Caudal femora with basal portions of lower genicular lobes armed with 1, rarely 2 teeth; dorsal teeth confined or not confined to dorsal ridge; 8-20 teeth on the external inferior keel. Sides of mesonotum tuberculate or nontuberculate . . . . . . . . . . . . . . . . 2

2. Dorsal mesotibial spurs—3 pairs. Caudal femora with dorsal teeth confined to ridge; external inferior keel with 14-20, usually 16-18 large closely spaced teeth. Sides of mesonotum nontuberculate . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *kelsoensis* n. sp.

Dorsal mesotibial spurs—4 to 5 pairs. Caudal femora with dorsal teeth running in oblique rows exteriorly onto upper portion of outer pagina; external inferior keel with 9 to 18 teeth. Sides of mesonotum with dentate tubercles . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3

3. Usually five pairs of dorsal mesotibial spurs. Abdominal notites sparsely tuberculate; metanotum sparsely tuberculate. External inferior keel of caudal femora with usually 8-10, sometimes 8-13 large, widely spaced teeth . . . . . . . . . . . . . . . . . . . . . . *algodonensis* n. sp.

Usually 4 pairs of dorsal mesotibial spurs. Abdominal notites and metanotum with sides heavily tuberculate. External inferior keels of caudal femora with usually 13-14, sometimes 9 to 18 large, strong, less widely spaced teeth . . . . . . . . . . . . . . . . . . . *sierrapintae* n. sp.

### **Macrobaenetes kelsoensis** NEW SPECIES

FIGURE 1

Differs from *valgum* (Strohecker), *algodonensis* n. sp. and *sierrapintae* n. sp. by possessing only 3 pairs of dorsal mesotibial spurs, instead of 4 or four and ½ or 5 pairs; from *algodonesis* n. sp. and *sierrapintae* n. sp. by the lack of dentate tuberculation on the flanks of the mesonotum; by the confinement of the dorsal teeth to the dorsal ridge in the caudal femora and by the greater number of large strong teeth on the external inferior keel of the caudal femora; from *valgum* (Stroh.) by possessing only 1 instead of 2 or 3 teeth at the base of the inferior genicular lobes of the caudal femora. These characters plus others in the spination and spuration of the caudal tibiae offer ample means to the serious student for their separation.

*Description of Male:* Size medium large, mesonotum with flanks nontuberculate; metanotum and abdominal notites with flanks with few tubercles. Leg spination as follows: forecoxal vertical keel unispinate; forefemora untoothed dorsally and ventrally except for a single long apical spine on the inner inferior lobe. Foretibiae dorsally unspined except for the apical calcars; ventrally with 4 pairs of spurs on the apical half, the outer 4 the largest, plus a larger pair of calcars. Foretarsomeres—3, segments 1 and 2 very short, 3 twice length of 1 and 2; distoventral angles of 1 and 2 lobate, of 3 normal. Middle legs with mesocoxal keel unspined; mesofemora unspined dorsally and ventrally on the keels with each inferior genicular lobe bearing a single spine. Mesotibiae dorsally with 3 pairs aciculate spurs, 1 pair in basal half, 2 pairs in apical half, plus smaller apical calcars; ventrally with 3 external spines and 2 internal spines plus calcars. Mesotarsomeres—4, segment 1 and 4 equal and each twice the length of 2 and 3 combined which are both very short; distoventral angles of 1 and 4 acute, of 2 produced into a large, acute, spindle-shaped process with segment 3 similarly shaped and smaller and interdigitating with it posteriorly. Hind legs typical. Caudal femora with dorsal teeth small and confined to the ridge; external inferior keel with 17-18 strong widely-spaced teeth plus a basal tooth or spine on the inferior genicular lobe; internal inferior keel with 13-15 very widely spaced much smaller teeth plus basal and apical teeth on the internal inferior genicular lobe. Caudal tibiae ventrally unspined except for the preapical spur plus the apical and almost attingent calcars; dorsally with 7 pairs of spurs plus apical calcars arranged in this fashion: first pair small, aciculate, at about the basal third and preceded by 2 outer and 6 internal small teeth; second pair spurs about the apical two-thirds, preceded by 6-7 external and 6-8 internal larger teeth; third pair preceded by 1-2 external and 2 internal teeth; fourth pair preceded by 0-1 and 0-0 internal teeth; the rest of the sand basket entire; the first 3 pairs of spurs smallest and semi-aciculate, the remainder long and narrowly spathulate for digging and forming the sand basket. Caudal tarsomeres 4, first slightly longer than 4 which is twice the combined length of the very short second and third segments; distoventral angle of 1 acute, 2 large and spindle-shaped as typical in the genus, 3 smaller than 2 and interdigitating with it posteriorly and 4 normal.

*Holotype Male:* Kelso Dunes, San Bernardino County, California, elev. 2500 feet, April 30, 1960. Ernest A. Tinkham; on bare hard packed sand ridges one-half mile inland from margin. Calliper measurements: body length 19.0; pronotum 4.8; caudal femora 14.1 x 5.8; caudal tibiae 12.3 mms. Holotype in the Tinkham Eremological Collection.

*Description of Female:* Size medium, slightly smaller than the Holotype, differing from the type in the following features: caudal tibiae straight and variations of spination as follows: forelegs with forefemora similar to Type; foretibiae ventrally with 4 large external and 3 internal smaller spurs plus larger calcars; protarsomere as in Type. Middle legs as in Type. Hind legs: caudal femora much smaller in length and depth with dentition much reduced: dorsal teeth of ridge much reduced in size and numbers and largely confined to a single row on the internal edge; dentition of lower keels greatly reduced, the external inferior keel bearing 11-14 small scattered teeth plus a small basal tooth on the inferior genicular lobe; internal inferior keel with 12-14 minute and widely scattered teeth plus 1-2 small basal and 1 larger apical tooth on the inferior genicular lobes. Caudal tibiae straight, dentition and spuration less than in Holotype and as follows: external dorsals with 5-6 minute teeth preceding the first spur at the basal third, 9-12 larger variable teeth preceding spur 2 at the apical third, 1-2 similar teeth preceding spur 3 and rest of spurs of sand basket entire; internal dorsals with 7-8 small teeth preceding spur 1 at the basal third, 9 variable larger teeth preceding spur 2 at the apical third, 1 tooth preceding spur 3 and rest of sand basket entire. Caudal tarsomeres as in the Holotype.

*Genitalia:* Supraanal plate roundly triangular; subgenital plate semicircular. Ovipositor slightly less than the pronotal length; dorsal valvulae obliquely truncate with its apex armed with an acuminate spine; ventral valvulae with 4 uncinate hooks, the two at the extreme apex much the largest.

*Allotype Female:* Same data as the type. Calliper measurements: body length 15.4; length to apex of ovipositor 17.8; caudal femora 11.2; caudal tibiae 9.8; ovipositor 3.7 mms.

*Paratype Males:* 80, same data as the Holotype but collected on the following nights; 1955: June 18, 2 ♂; 1957: June 14, 1 ♂, June 30, 2 ♂; 1958: April 19, 4 ♂, June 10, 1 ♂, July 1, 2 ♂; 1959: May 9, 25 ♂; May 23, 5 ♂; 1960: April 30, 20 ♂, May 10, 8 ♂; 1961: April 15, 10 ♂. Range in measurements: body length 14.5-18.0; pronotum 4.2-4.8; caudal femora 11.8-16.0, caudal tibiae 9.2-13.0 mms. Paratypes to be distributed to the major orthopterological museums.

*Paratype Females:* 60, same data as the Holotype but collected on the following nights: 1955: June 17, 1 ♀; 1957: June 14, 1 ♀, June 30, 2 ♀; 1958: April 19, 5 ♀, July 1, 1 ♀; 1959: May 9, 2 ♀, May 23, 5 ♀; 1960: April 30, 20 ♀, May 14, 8 ♀; 1961: 15 ♀.

All paratypes similar to their respective Types.

*Historical Ecology:* Although I led a small group of young entomologists to the Kelso Dunes for the first time on June 25-26, 1954, it was not until my second visit on June 17-18, 1955, that the presence of the giant sand-treader became known. The small sand-treader *Ammobaenetes* n. sp., to be shortly described, is usually quite abundant in the soft sand of the marginal areas where Creosote, Sand Paper weed, Galleta Grass (*Hilaria rigida*) are common but the giant sand-treaders dwell on the hard packed sand ridges at least half a mile inland from the dune margins. On my third trip July 12-14, 1956, no *Macrobaenetes* had survived to that late date and only 2 *Ammobaenetes* were found. In the summer of 1957, I commenced my first summer of sand dune research under a three-year grant from the National Science Foundation and my dune research was greatly increased thereby. On June 14-16, I collected 25 "Ammos" and on June 30-July 1 took 2 "Ammos" and 3 *Macrobaenetes*. On the sixth trip, Oct. 25-26, a fine drizzling rain, the only rain in 17 Kelso trips, made a strange night on the dunes. At this time the tiny nymphs of both genera were out and their burrows marked by small sand piles were much in evidence next morning on the sunlit dunes. Despite the winter rains of 1958 that brought a nice array of spring flowers out and made the margins of the Kelso Dunes like drifts of snow from the large white petals of the Dune Primrose, sand-treaders were not abundant, indicating that not winter rains but the late summer and early fall rains regulated the abundance of these creatures. Collections were made on April 19-20, 1958, and later on when the heat of late summer had seared the plant life, I took 7 males and no females and 4 "Ammos" the night of June 10. Still later, after midnight the night of July 1, I found 2 "Macros" and 2 "Ammos." Visits were also made on Sept. 22-23 and Oct. 9-10 of that year. In the spring of 1959 I commenced offering my new course "Nature Study of the Desert" for the Extension Department of San Diego State College and began bringing large classes of teachers and laymen to the Kelso Dunes on an overnight study trip. Such large classes greatly augmented my collecting propensities but naturally destroyed the value of comparative collecting by one person. 1959 trips were made on May 9-10, May 23-24, October 17-18; 1960 trips were on April 30-May 1, May 14-15, Oct. 22-23; 1961 trips on April 15-16.

*Biology:* The ova of *Macrobaenetes kelsoensis* n. sp. is oval elliptical and measures 3.0 x 1.4 mms. in diameter. The exact compliment of ova per female is not known but is in the neighborhood of 50. Where the eggs are laid is not known for certain, but they are probably deposited down in the stygian chambers deep in the damp sand for their chorion walls are thin and subject to desiccation, and the only place providing constant moisture for the ova would be in their chambers. They do not inhabit animal burrows like the much rarer *Ceuthophilus fossor* Hubbell. The advent of the late summer rains in August and September bring out the tiny young and by October these are about the size of a large "match head" although there is naturally some size range. Their presence on the hard-packed sand ridges, half a mile inland from the loose sand and vegetated margins, is conspicuously indicated by the small mounds of sand that in favorable locations resemble the colonies of certain terrestrial bees. With experience one can distinguish between their mounds and those of scorpions, solpugids and spiders. I have taken some of these small young and by placing in small cartons with sand and feeding daily with a little lettuce have brought them through to maturity about the time those on the Kelso Dunes are maturing. These October nymphs are undoubtedly in their second stadia of their lives, there is another molt in January which brings them to almost half-grown size, and perhaps another molt in March before the final molt in April. The young dig their tunnels rather shallowly because the temperatures are cool during the winter months but the tunnels lengthen with the maturity of their occupants. The adults in May and June dig down at about 35-40 degrees of angulation with the surface and continue in a straight line downwards to pierce deeply in the damp sand layer which is usually down 8 or 9 inches. At the end of their tunnel, often two feet or more in length, they excavate a small chamber hardly bigger than themselves and here they rest during the day with their heads always pointing upwards and outwards. How they know, down in that blackness when evening is approaching is perhaps best explainable in the marvelous time mechanism possessed by wild creatures, but as dusk or darkness approaches, the sand-treaders are usually found at the mouths of their burrows waiting for darkness to encompass the dunes so that they can begin their purposeful perigrinations.

At night their wanderings are almost entirely in search for food which seems to be mainly the seeds of the Dune Grass (*Orzyopsis hymenoides*), bits of organic matter such as dried leaves, perhaps nibbles on green dune grass cut down by Kangaroo rats or other dead protein matter such as bits of dead insects or otherwise. No mating observations have ever been witnessed in nine years of study.

The Kelso Dunes are always damp 6-8 inches down, sometimes only 3-4 inches down, even during the driest years. It is believed the Kelso Dunes have their origin in subterranean or subammean springs emanating from the delta region of the Mohave River some miles to the southwest in what is called the "Devil's Playground" for even the highest Kelso Sand Peak of 700 feet elevation and undoubtedly the highest in the United States, is always wet to the top. This fortuitous circumstance is what creates the remarkable and rather indiginous nature of the biotae of the Kelso Dunes.

*Enemies:* The only known enemy is the Sand Dune Scorpion (*Paranurctonus mesaensis* Stahnke). I have found complete and partial remains of these sand treaders in the scorpions' chambers down in the sands. Their enemies have enemies, too, for the American Raven purposely hunts for the sites of the scorpion burrows and exhumes the creatures with their long heavy beaks, whack off their lethal extremities and devour their juicy bodies. Scorpions also kill and eat their own kind, the larger preying on the smaller, so that the effect of scorpions on the sand treader population is negligible. The great factor controlling sand-treaders is heat and the advent of the torrid heat of late May and early June soon decimates the sand-treader population. In general the female sand treaders survive longer than the males because their bodies are packed with developing ova.

This interesting new species of the new genus *Macrobaenetes* which is restricted to aeolian sand dunes of the Colorado Desert and its peripheral area, is named after that magnificent pile of quartz sand, whose high peak of 700 feet is unquestionably the highest in the United States.

*Orthopteran associates:* The Kelso Dune fauna is considerable. Nocturnal associates are the new *Ammobaenetes*, the large camel cricket *Ceuthophilus fossor* Hubbell and a new Jerusalem cricket that may represent a new genus as well as the following Decticids in good years (i.e. considerable winter precipitation), the large grey, black-winged *Capnobotes fulginosis*, the very rare *Anoplodusa arizonensis*, and a new species of *Eremopedes*. Diurnal associates are mostly acridids such as *Coniana snowi* on the sands, *Xeracris minimus* in clumps of *Petalonyx Thurberi*, *Ligurotettix coquilletti* on the stems of Creosote, *Trimerotropis p. pallidipennis* an ubiquitous desert species as well as the mantids *Litaneutria minor* and *Stagmomantis*. Sand roaches of undetermined species are also found on the dunes at night; these are being studied by Drs. Gurney and Friauf.

### **Macrobaenetes valgum** (Strohecker)

Figure 3

*Daihiniodes valgum* Strohecker, 1960: 31-32, fig. 1.

Strohecker's decision to refer the present genus to *Daihiniodes* "largely on the basis of its tarsomeres" and not on the sum total of its characters as should be done for more accurate placement, has resulted in placing this creature in a genus that does not possess a "sand basket." Thus, in choosing a single character, he has not only ignored a character of great taxonomic importance, the "sand basket," but by so doing has ignored zoogeographical concepts as well. In 1936, Hubbell defined the faunistics of his new genus *Daihiniodes* as dwelling "on high plains and eastern foothills of Rocky Mountains in Colorado, to southwestern Texas and Arizona" and I might add, as was also known to Strohecker, as living in the wet, cool, hard gypsum sand substrata of the White Sands. It is hardly conceivable or possible that a creature dwelling in such an environment and at a considerable elevation as defined above, could exist on the torrid sands of the Colorado Desert at elevations little above or even below that of sea level.

*Macrobaenetes valgum* (Strohecker) differs from *kelsoensis* n. sp., *algondonensis*, n. sp. and *sierrapintae* n. sp. by possessing usually 2 or 3 instead of 1 basal tooth on the inferior genicular lobes of the caudal femora. From *kelsoensis* n. sp. it is further separated by its large size and the dentition and spuration of the caudal femora and caudal tibiae; from *algondonensis* n. sp. and *sierrapintea* n. sp. by lacking tuberculation on the flanks of the mesonotum and by the greater number of teeth on the external inferior keel of the caudal femora and by the confinement of the dorsal teeth to the ridge in the caudal femora.

*Description of Male:* Size very large and typical. Mesonotum usually smooth, metanotum and first five abdominal notites weakly tuberculate, the tubercles confined to a sparse row on the flanks just cephalad of the posterior margin. Forelegs with forecoxal vertical keel unispinnate; forefemora dorsally and ventrally unspined except for a slender spine on the internal inferior genicular lobe; foretibiae dorsally unspined except for the calcars, ventrally with 4 pairs of spurs, outer row the largest, on the apical two-thirds, plus a pair of larger calcars. Protarsomeres—3, segments 1 and 2 very short, segment 3 twice combined length of 1 and 2; distoventral angles of 1 and 2 acutely lobate, of 3 acute. Middle legs; mesocoxal ridge unspined; mesofemora dorsally unspined, ventrally with a small spine arising from each of the inferior genicular lobes; mesotibiae with 4, sometimes 3 or 3 and ½, dorsal pairs of spurs plus large calcars, ventrally with 3 external and 2 internal spurs plus larger calcars. Mesotarsomeres—4, segments 1 and 4 equal and each twice the combined length of the very short second and third segments, segment 2 large and acutely spindle-shaped with the smaller segment 3 interdigitating posteriorly with it; distoventral angle of 1 and 4 acute, of 2 and 3 acutely lobate. Hind legs: caudal femora with dorsal teeth confined to ridge; external inferior keel with usually 16-18, sometimes 15-22, large strong, uniform, mostly evenly spaced teeth; internal inferior keel with 12-17 much smaller, much more widely spaced teeth; both lower genicular lobes with 2 or 3 basal teeth or spines. Caudal tibiae typically arched with 7 large or very large pairs of spurs plus an apical pair of very large calcars located as follows: first pair smallest, aciculate, located about the basal third and preceded by 2-7 external and 5-8 internal small teeth; second pair of spurs about the apical two-thirds, slightly larger in size and preceded by 5-6 external and 7-8 internal larger teeth; 3rd pair larger still and preceded by 1-3 external, 1 internal teeth; rest of sand basket entire. Subgenital plate with forcipate arms.

*Males, 100, collected as follows:* 4 miles west of Indio: 1952: 10 ♂, April 26; 1955: 4 ♂, April 10, 5 ♂, April 26, 3 ♂, May 9; 1957: 10 ♂, May 18; 1958: 1 ♂ nymph, Feb. 21, 11 ♂, April 12, 5 ♂, May 3, ♂. 3 miles west of 1000 Palms: 1958: 8 ♂, May 3; 1959: 3 ♂, May 5, 4 ♂, May 16, 2 ♂, May 19, 1 ♂, May 21; 1960: 18 ♂, April. Palm Springs Depot: 1952: 12 ♂, May 1. All collected by E. R. Tinkham.

*Description Female:* Size medium large but smaller than the larger male. Form typical for *Macrobaenetes* females and characterized chiefly by leg spination as follows: Forelegs with vertical procoxal keel unispinate; forefemora unarmed dorsally and ventrally with a spine emanating centrally from the internal inferior genicular lobe; foretibiae dorsally unspined with apical calcars; ventrally with 3 internal, 4 external aciculate spurs in apical half plus pair of larger calcars, the external spurs much the largest and forming the tines of a fossorial basket. Protarsomeres—3, the first two segments very short, segment 3 twice their combined length; distoventral angle of segments 1 and 2 acutely lobate, of 3 normal, the segment bristling with short golden hairs. Middle legs with mesofemora dorsally unarmed and ventrally both keels unarmed but with both lower genicular lobes unispinate with a central tooth. Mesotibiae dorsally with 3 and ½ to 4 pairs of aciculate spurs, 1 and ½ to 2 in basal half, 2 pairs apical half plus terminal calcars; ventrally with 2 pairs spurs at middle and apical third plus terminal calcars. Mesotarsomeres—4, the first and fourth segments equal and each twice combined length of the very short second and third; distoventral angles of 1 acute, of 2 and 3 acutely lobate of which 2 is larger, of 4 almost normal. Hind leg with caudal femora with dorsal teeth of ridge minute and very sparse and chiefly indicated as a row on the inner edge; external inferior keel with 12-14 minute widely scattered teeth with 1-2 variable small to very small basal teeth on the inferior genicular lobe; internal inferior keel with 8-10 similar teeth in basal half and with basal and apical tooth on the inferior genicular lobe. Caudal tibiae with 7 pairs of dorsal spines plus apical calcars, the first two pairs smaller and aciculate, the remainder larger and narrowly spathulate and arranged as follows: first pair at the basal quarter and preceded by 4-5 external and 6 internal minute teeth; 2nd pair just distad of center and preceded by 7-8 external and 4-5 internal larger teeth, 3rd pair about the apical third and preceded by 2 external and 1-2 internal and similar teeth; rest of sand basket entire and closely arranged to form the tines of the sand basket. Metatarsomeres—4, first segment larger than 4th which is twice the combined length of the very short 2 and 3 segments; their distoventral angles as in the mesotarsomeres. Ovipositor shorter than the pronotum, very obliquely truncate with terminal tooth; ventral valvulae with 4 teeth, the 2 apical uncinate, the 2 basal mere serrations.

*Hypoallotype Female:* 3 miles west of 1000 Palms, April 14, 1960, Ernest A. Tinkham; on the wind-swept drift sand in sand dune valley. Measurements: body length 19.8; length to apex of ovipositor 22.8; caudal femur 12.4; caudal tibia 10.0; ovipositor 4.2 mms. Hypoallotype in the Tinkham Collection. A Hypoallotype is one described by a person other than the describer of the species.

*Hypoparatypes:* 149, with following data: 4 miles west of Indio: 1952: 12 ♀ April 26; 1955: 5 ♀ April 10, 3 ♀ April 26, 3 ♀ May 9; 1957: 13 ♀ May 18; 1958: 2 ♀ nymphs Feb. 21, 12 ♀ April 12, 1 ♀ May 3. 3 miles west 1000 Palms: 1958: 10 ♀ May 3; 1959: 6 ♀ May 5, 7 ♀ May 16, 5 ♀ May 19, 5 ♀ May 21; 1960: 20 ♀ April 14. 1 mile N. Palm Desert: 1959; 15 ♀ May 21. Palm Desert Depot: 1952: 10 ♀ May 1. All collected by E. R. Tinkham. 3 miles W. 1000 Palms, 20 ♀ April 14, 1960, Jacques Helfer.

Hypoparatypes similar to the Hypoallotype. Range in measurements: body length 14.3-21.9; pronotum 3.5-5.0; caudal femora 11.0-13.8; caudal tibiae 8.8-10.8; ovipositor 4.4-4.0 mms. Hypoparatypes to be distributed to various museums.

*Distribution: M. valgum* is found from the sand dunes just south of the Palm Springs Depot, 9 miles west of Palm Springs, California, east along the wind swept sand dune ridges to 2 miles west of Indio. The species apparently does not cross south of Highway 111, nor does it extend as far east as where the Dillon Road joins Highway 66.

*Ecology:* This species is largely regulated in its abundance by the winter rains which regulate the spring flowers of Coachella Valley. There are some spots favorable to permanent habitation where springs keep the sands damp, but in very dry years the species disappears over most of the sand areas.

*Biology:* No observations are available for the early stages in the fall. The Feb. 21, 1958, collection record is the earliest and indicates the species is more than half matured at this time. Temperature readings at this time were at 9:25 P.M. with the sand damp from a recent rain as follows: sand surface 57° and air temperature 62° Fahrenheit. On May 3, 1958, at 3 miles west of 1000 Palms many burrows were noted. These went shallowly under the sand surface at about 2 inches depth and parallel to the surface for about one foot then angled downward at about 40° to terminate in the damp sand substratum. Here the female was found resting facing outwards and upwards. On this date many males were found lying dead on the sands, due to lack of food, and although females were fairly common at this date, males were rare. The Sand Dune Scorpion sometimes prey on these sand treaders.

*Orthopteran Associates:* Nocturnal orthopteran associates include the rare camel cricket, *Ceuthophilus fossor*, the much rarer *Stenopelmatus fuscus* found in wet springs around Cathedral City and the common sand roaches which are being studied by Drs. Friauf and Gurney. Diurnal associates include *Coniana snowi* on the plant *Coldenia plicata*, *Xeracris minimus* on *Petalonyx thurberi*, *Ligurotettix coquilletti* on Creosote stems, the common *Trimerotropis p. pallidipennis*, *Cibolacris parviceps aridus* and *Derotmema delicatula*, the latter rare.

## **Macrobaenetes algodonensis** NEW SPECIES

FIGURE 4

*M. algodonensis* n. sp. is differentiated from kelsoensis n. sp. by possessing 5 instead of 3 pairs of dorsal mesotibial spurs, by the extension exterioradly of the dorsal teeth on the ridge of the caudal femora and by fewer teeth, quite widely spaced, on the external inferior keel of the caudal femora; from *valgum* (Strohecker) by possessing 1 instead of 2 or 3 teeth on the basal portions of the lower genicular lobe of the caudal femora, the fewer teeth on the external inferior keel of the caudal femora and by 5 instead of 3 or 4 pairs of dorsal mesotibial spurs; from *sierrapintae* n. sp. by the weaker tuberculation on the flanks of the metanotum and first five abdominal notites and by fewer and more widely spaced teeth on the external inferior keel of the caudal femora.

*Description of Male:* Size medium large, form typical. Flanks of the mesonotum bare, metanotum with less than 10 dentate tubercles, first four abdominal notites with a few tubercles in a single row posteriorly. Leg spination as follows: Forelegs with vertical keel of forecoxae unispinate; forefemora unspined dorsally and ventrally with the inferior genicular lobes each bearing a single spine or tooth, the internal one the larger; foretibiae unspined dorsally plus the apical calcars, ventrally with 3 pairs of spurs in the apical half plus the calcars. Protarsomeres—3, first 2 segments very short, third about 2 and ½ times 1 and 2; distoventral angles of 1 and 2 lobate, of 3 normal. Middle legs; mesocoxae unspined; mesofemora unspined dorsally, ventrally as in the profemora with an additional small tooth on the apical external keel; mesotibiae dorsally with 5 pairs of long aciculate spurs plus similar calcars, ventrally 2 pairs of spurs, one median, one apical plus apical calcars. Mesotarsomeres—4, first slightly longer than the fourth, the fourth about twice the combined length of the very short 2 and 3 segments; distoventral angles somewhat acute in 1 and 4, greatly produced in 2 and smaller in 3 which interdigitates posteriorly with it. Hind legs typical; caudal femora with dorsal teeth mostly confined to the dorsal ridge, some extending exterioradly in oblique rows onto the upper edge of the outer pagina; external inferior keel with 9-10 mostly large, widely spaced teeth plus a large tooth on the basal portion of the lower genicular lobe; internal inferior keel with 6-11 very widely spaced, minute teeth plus a basal tooth on the inferior genicular lobe. Caudal tibiae with 8 pairs of spurs including the calcars of which the five apical pair plus the calcars are very long and narrowly spathulate to form the sand basket, the remaining three pairs aciculate and arranged in this fashion: first pair small at the basal third preceded by 7 small teeth on each keel, 2nd pair at the apical two-thirds and preceded by 12-13 external and 8-10 internal similar teeth, third pair and first pair of the "sand basket" preceded by 1-2 external and 2-3 internal teeth, fourth pair preceded by 1 external and 1 internal tooth, rest of the sand basket without teeth between them.

*Holotype Male:* Algodones Dunes, 15 miles NW of Yuma in California and ¼ mi. E bridge on All American Canal, Apr. 25, 1958. Ernest R. Tinkham. Calliper Measurements: body length 11.8; pronotum 3.9; caudal femora 14.9; caudal tibiae 12.2 mms. for dried alcoholic material. Type in the Tinkham Eremological Collection.

*Description of Female:* Size similar to Holotype from which it differs chiefly in spination of legs and genitalia. Forelegs with forefemora unspined dorsally and ventrally with the internal inferior genicular bearing an apical spine, remainder as in Holotype. Middle legs as in Holotype. Hind legs with caudal femora shorter and less deep than in Holotype, the dentition much reduced and as follows: dorsal teeth on ridge of caudal femora minute and largely confined to a row on the internal edge; external inferior keel with 4 medium-sized teeth widely separated on the middle portions of the keel plus a basal tooth on the lower genicular lobe; internal inferior keel unarmed with basal and apical small teeth on the lower genicular lobe. Caudal tibiae dorsally with 8 pairs of spurs characterized as follows: externally first spur at basal quarter preceded by 6 small teeth, second spur just distad of center and preceded by 10-11 larger teeth; third spur just distad of the apical third and preceded by 1-2 similar teeth; rest of spurs entire and forming the outer tines of the sand basket; internal dorsal keel with first spur at basal quarter preceded by 9-10 small teeth, second spur situated in the middle and preceded by 6-7 larger teeth, spur three at about apical third and preceded by 4 similar teeth and rest of sand basket entire. Caudal tarsomeres as in Holotype. Ovipositor typical of the genus, shorter than the pronotum; the dorsal valvulae obliquely truncate and terminating in a spine; ventral valvulae with 4 apical uncinate hooks, the two at extreme tip conspicuous, the two basal minute.

*Allotype Female:* Same data as the Holotype. Calliper measurements: body length 14.3; pronotum 3.9; caudal femora 11.0; caudal tibiae 9.8; ovipositor 2.7. Allotype in the Tinkham Collection.

*Paratype Males:* 115 with data as follows: 19, April 28, 1952, same location as Holotype; 13, April 25, 1958, same location as Holotype; 62, April 29, 1961, 2 miles west of Glamis, Calif.; 10, May 13, 1961, same location; 8, 4 miles west Glamis, April 29, 1961; 3, June 5, 1960, 4 mis. W. Ogilby, Calif., Roth and Irwin. Range in measurement as follows for series: 1952 series, body length 11.2-15.9; pronotum 3.0-4.2; caudal femora 10.7-15.0; caudal tibiae 8.8-13.5 mms. 2 miles W. Glamis series: body length 10.0-15.3; pronotum 3.0-3.9; caudal femora 10.6-13.2; caudal tibiae 8.9-11.2 mms. 4 mis. W. Glamis series: body length 16.5-19.2; pronotum 4.2-4.6; caudal femora 14.6-17.0; caudal tibiae 12.5-14.5 mms. Ogilby series: body length 10.5-13.4; pronotum 2.7-3.0; caudal femora 11.0-10.9; caudal tibiae 9.1-9.2 mms.

Paratypes closely similar to the Holotype with slight variation in the dentition of the caudal tibiae but within the species range.

*Paratype Females:* 140 with data as follows: 9, April 28, 1952, same data as Allotype; 10, April 25, 1958, same location as Allotype; 54, April 29, 1961, 2 mis. W. Glamis; 41, May 13, 1961, 2 mis. W. Glamis; 26, 4 mis. W. Ogilby, June 5, 1960, Roth and Irwin. Range in measurements for series as follows: 1952 series: body length, 13.2-22.8; pronotum 3.2-4.2; caudal femora 9.2-13.0; caudal tibiae 7.8-10.0; ovipositor 2.4-4.1 mms. 2 mis. W. Glamis series: body length 11.0-15.0; pronotum 3.4-3.5; caudal femora 10.7-11.2; caudal tibiae 8.8-9.0; ovipositor 2.8-2.6 mms. Ogilby series: body length 12.8-17.0; pronotum 3.1-3.8; caudal femora 9.7-11.2; caudal tibiae 7.4-9.3; ovipositor 2.2-3.8 mms.

Female Paratypes, closely similar to the Allotype but with considerable size variation depending upon the aridity of the season.

Male and Female Paratypes to be deposited in the major museums and the Tinkham Collection.

*Ecology:* The dune fauna in recent years with little precipitation is much less than in such springs as 1953, when on the night of April 28, the cold dunes, wet with a late evening cold rain, were covered with dune creatures such as sand treaders, scorpions, solpugids, tenebrionid beetles of several genera and species as well as geckos, all in considerable profusion and immobile on the cold sands. Never before or since have I witnessed such an array of life.

The 1958 and 1960, and 1961 series of sand-treaders average much smaller than the 1953 series. It was interesting in 1961 to find sand-treaders at 4 miles west of Glamis (on the west edge of the dunes) to be much larger than those 2 miles west of Glamis along the main ridge of the Algodones.

*Biology:* Very little is known specifically about the life history of this new species but generally its life history is similar to that of *M. kelsoensis* n. sp. and the other species. Some adults persist through until mid-June, rarely to late June.

*Orthopteran Associates:* Nocturnal associates include sand roaches, being studied and the large camel cricket *Ceuthophilus fossor;* diurnal orthopteran associates include such acridids as *Xeracris minimus, Coniana snowi* and the everpresent *Trimerotropis p. pallidipennis.*

### **Macrobaenetes sierrapintae** NEW SPECIES

FIGURE 2

Differs from *kelsoensis* n. sp .and *valgum* (Strohecker) by the heavy tuberculation on the sides of the meso-, metanotum and first five ab-

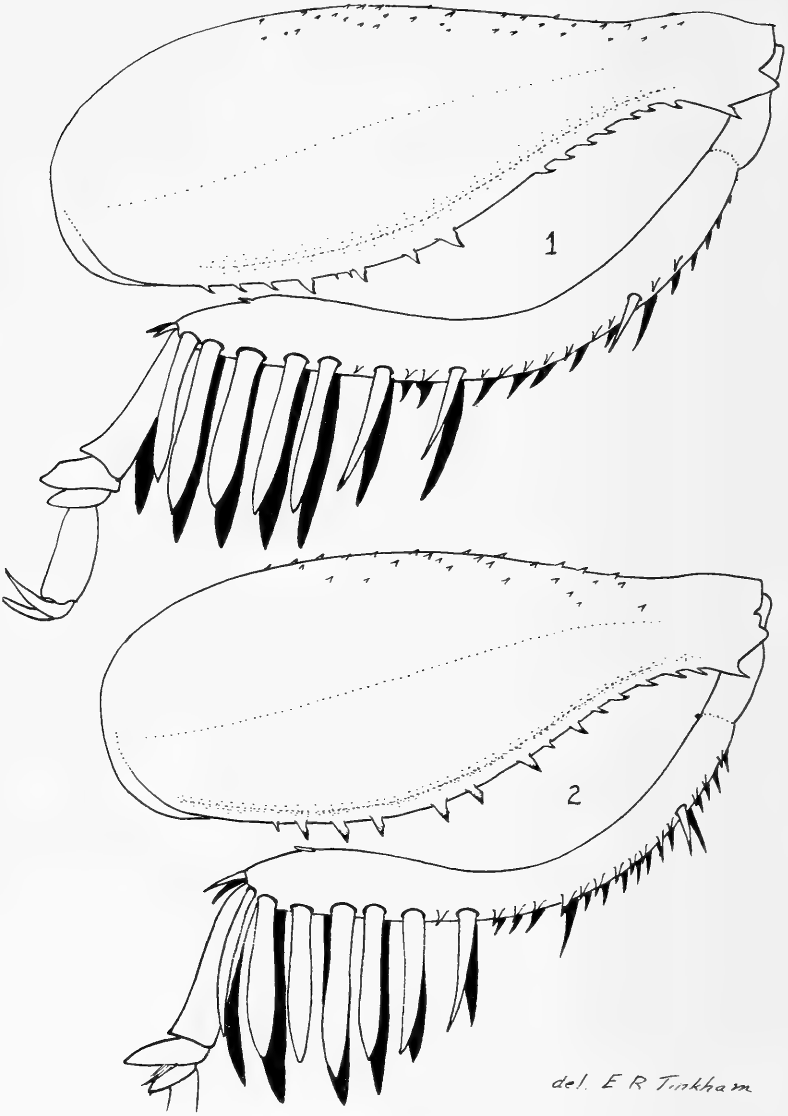

*Figure 1. Macrobaenetes kelsoensis* n. g. et n. sp. Left hind leg of Holotype. Kelso Dunes, San Bernardino County, California.

*Figure 2. Macrobaenetes sierrapintae* n. sp. Left hind leg of Holotype. Sierra Pinta Dunes, 65 miles south of Mexicali, Baja California, Mexico.

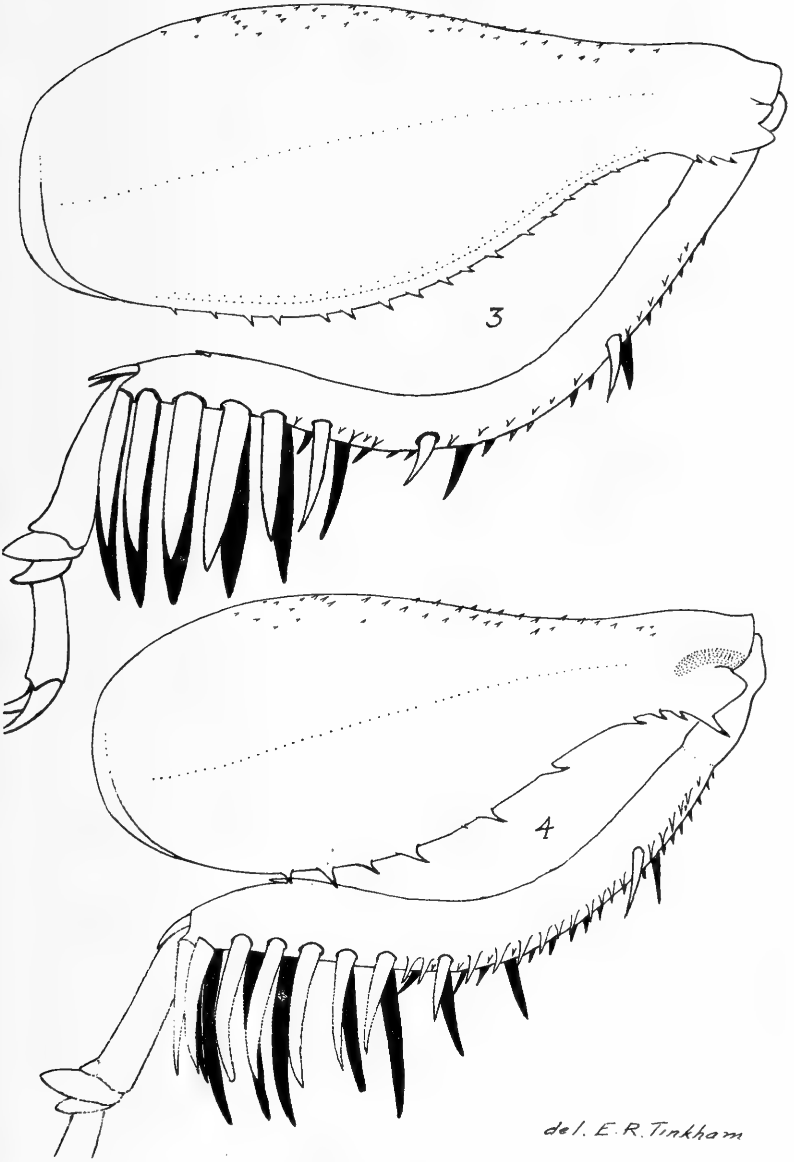

*Figure 3. Macrobaenetes valgum* (Strohecker). Left hind leg of male from dunes 3 miles west of 1000 Palms, Coachella Valley, Riverside County, California.

*Figure 4. Macrobaenetes algodonensis* n. sp. Left hind leg of Holotype Male. Algodones Dunes, 15 miles NW of Yuma, Imperial County, California.

dominal notites; by the larger dorsal teeth of the caudal femora extending obliquely in rows onto the upper portions of the outer pagina; by the dentition on the external inferior keel of the caudal femora and the spination and dentition on the caudal tibiae. From *kelsoensis* it is further distinguished by possessing 4 or more pairs, instead of three, dorsal mesotibial spurs and from *valgus* by having only one instead of two or three teeth on the basal portions of both external and internal lower genicular lobes of the caudal femora. From *algodonensis* n. sp. it is separated by the greater dentition on the external inferior keel of the caudal femora; the dentition and spuration of the caudal tibiae as well as by the heavy tuberculation on the flanks of the metanotum and first five abdominal notites which in *algodonensis* is sparse.

*Description of Male:* Size large, flanks of pronotum bare, mesonotum posteriorly with few scattered tubercles; metanotum and first five abdominal notites heavily dentate tuberculate. Leg spination as follows: Forelegs with vertical procoxal ridge unispinate; profemora unspined dorsally and ventrally with both lower genicular lobes unispinate, the internal one larger. Protibiae dorsally with 2 internal, 1 external spur basally plus apical calcars; ventrally with 3 pairs of aciculate spurs in apical half plus a pair of larger similar calcars. Protarsomeres—3, first 2 segments very short, the third twice the combined length of 1 and 2; distoventral angles of 1 and 2 lobate, of three normal. Middle legs with mesocoxal ridge unspined; mesofemora as in the profemora. Mesotibiae dorsally with 4 and ½ pairs of aciculate spurs, 2 pair basal half, 2 pair apical half and one intermediate spur on the external keel; ventrally as in the protibiae. Mesotarsomeres—4, first and 4th segments about equal and each twice the combined length of the very short second and third segments; distoventral angle of 1 lobate, of 2 produced into a long acute spindle-shaped process with segment 3 similar but smaller and interdigitating with it posteriorly, and segment 4 normal. Hind legs with caudal femora very deep, the external inferior keel gently arcuate; dorsal ridge bearing obliquely running rows of short semi-appressed teeth extending exterioradly onto the upper portions of the face of the outer pagina especially in the apical third; inferior genicular lobes each with a basal tooth, the inner lobe also with an apical tooth; external inferior keels with 13 to 14 mostly large, strong, well spaced teeth; internal inferior keel with 12-13 much scattered and much reduced teeth. Caudal tibiae strongly arched with 8 external and 8 internal dorsal spurs of which 6 pairs in the apical region are long, narrowly spathulate spurs and form the sand basket, the rest are smaller and more aciculate, the basal 2 pairs located as follows: first pair about the basal third and preceded by 4-5 external and 4-7 internal small teeth; second pair about the ⅔rds position and preceded by 7-9 external and 5-7 internal larger teeth; the third pair of spurs preceded by 3 external and 2-3 internal similar teeth; pair 4 by 0-1 external and 1-0 internal teeth, the remainder of the sand basket entire. Caudotarsomeres—4, segment 1 longest and longer than the first mesotarsomere, segments 2 and 3 very short, segment 4 about twice the combined length of 2 and 3; lobation of the distoventral angle as described in the mesotarsomeres.

*Holotype Male:* Sierra Pinta Dunes, 65 miles south of Mexicali on Highway No. 5, Baja California, Mexico, April 3, 1958, Ernest R. Tinkham. Calliper measurements: body length 14.8; pronotum 4.4; caudal femur 15.0 x 5.8; caudal tibiae 12.1 mms. Holotype in the Tinkham Eremological Collection.

*Description of Female:* Closely similar in size to Holotype but differing chiefly in dentition of hind legs and genitalia. Leg spination as follows: Fore and middle legs as in Holotype. Hind legs with caudal femora less massive and caudal tibiae straight. Caudal femora with minute dorsal teeth and largely confined to a row on the internal keel; external keel with 14-15 minute teeth plus a larger basal tooth on the inferior genicular lobe; internal inferior keel unarmed, the lower genicular lobe with 1-2 basal and 1 apical larger teeth. Caudal tibiae with only 7 well-arranged pairs of spurs plus apical calcars, the external dorsal keel with the basal pair situated at the basal quarter and preceded by 5-6 small teeth, spur 2 just basad of the apical third and preceded by 10-11 larger teeth, spur 3 at the apical quarter and preceded by 1 tooth, the rest of the sand basket spurs entire or lacking teeth between them; internal dorsal keel with all spurs opposite and matching those on the external keel, spur 1 preceded by 6 small teeth, spur 2 preceded by 10-12 larger teeth, spur 3 preceded by 1 similar tooth and rest of sand basket entire. Caudal tarsomeres as in Holotype. Ovipositor shorter than the pronotum, the dorsal valvulae squarely and obliquely truncate with terminal spine; ventral valvulae with 5 teeth of which the 2 apical are uncinate, the median small and the two basal mere serrations.

*Allotype Female:* Same data as the Holotype. Measurements as follows: body length 13.8; length to tip ovipositor 16.8; pronotum 4.7; caudal femur 13.3 x 4.5; caudal tibia 11.6; ovipositor 4.0 mms. Allotype in the Tinkham Collection.

*Paratype Males:* 82, same location as Holotype but collected as follows: 10 ♂, April 11, 1953; 29 ♂, April 3, 1958; 18 ♂, May 13, 1961, all E. R. Tinkham. 25 ♂, April 15, 1960, Pearson, San Diego State College. Paratypes closely similar to the Holotype with slight deviation in dentition of caudal tibia falling within the species range.

*Paratype Females:* 104; same locality as Holotype but collected as follows: 31 ♀, April 11, 1953; 26 ♀, April 3, 1958; 22 ♀, May 13, 1961, all E. R. Tinkham. 25 ♀, April 15, 1960 (Pearson; Michigan Cln).

Paratypes closely similar to Allotype.

Paratypes to be deposited in the major Museums and Tinkham Cln.

*Ecology:* With no meteorological stations or records available from northeastern Baja California, it is difficult to determine good or bad years as far as precipitation is concerned, but usually the west coastal plain of the Gulf of California is exceedingly dry and drier than even the Californian portion of the Colorado Desert. In 1953, the species was fairly common in the swales lying between the bare sand ridges, these swales being flat bottomed and containing semistabilized hummocks of *Atriplex polycarpa* and Creosote (*Larrea divaricata*). On April 3, 1958, in the same swale I counted 25 specimens around one large hummock of approximately 10 x 15 feet dimensions. In 1961, the sand ridges bordering this swale had grown considerably in height but the swale bottom was unchanged. Despite a winter with practically no precipitation in the northern Californian portion of the Colorado Desert, *Macrobaenetes sierrapintae* was not rare, although there were rumors of a fall storm in 1960 crossing the area but not verified.

*Biology:* Nothing in particular is known about the more intimate life history of this species. The sands are much drier than the Algodones or Kelso Dunes and yet this distinct and attractive species survives under much more xeric conditions.

*Orthopteran Associates:* These are very few. The only other nocturnal orthopteran is a large species of *Ceuthophilus* of the *fossor* group and sand roaches which are being studies by Dr. Gurney and Dr. Friauf. The only diurnal orthopteran is the acridid *Anconia integra* which feeds on *Atriplex*.

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# A NEW *MEGAHIPPUS* FROM THE BARSTOW FORMATION SAN BERNARDINO COUNTY, CALIFORNIA

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## Introduction

The fossil beds of the Barstow syncline have been worked by amateur and professional paleontologists since 1911. It was the good fortune of the Peccary Society of the Webb School of California in 1955 to find an upper molar of an anchitherine horse and later in 1957 to find a palate of the same type of animal.

These discoveries represent the first record of the genus *Megahippus* from the Pacific coast and the first reported from deposits of Barstovian age.

We would like to thank Dr. M. C. McKenna of the American Museum of Natural History, and Dr. T. Downs of the Los Angeles County Museum for critically reviewing the manuscript. The holotype was carefully prepared by Mr. Sanford Gifford of Claremont, and the line-drawing restoration painstakingly rendered by Mr. Robert Fakundiny of Riverside.

The abbrevation UCMP refers to material in the University of California, Museum of Paleontology collections; UCR to collections at the University of California, Riverside; and RAM to material in the Raymond Alf Museum, Webb School of California, Claremont.

All measurements are in millimeters.

## Systematic Descriptions

Class Mammalia
Order Perissodactyla
Family Equidae Gray, 1821
Subfamily Anchitheriinae Osborn, 1910
Genus *Megahippus* McGrew, 1938
(Genotype: *Hypohippus matthewi* Barbour, 1914)

### **Megahippus mckennai** new species

Figures 1 and 2

*Etymology:* Named in honor of Dr. Malcolm C. McKenna of the American Museum, who has been a constant inspiration in encouraging our paleontological work.

*Holotype:* Palate with shattered, but complete, well worn cheek tooth dentition, left I1/, right I2/, and both canines, RAM 6500.

*Type locality:* Barstow syncline, UCR locality 3695, western side of "Fuller's Earth Canyon" just north of major north bend approximately in southwest corner of N.W. ¼, sec. 14, T. 11 N., R. 2 W., Opal Mountain Quadrangle, 1:62,500, U.S.G.S. Edition 1955; 10,900 ft. N. 24° W. of road intersection 2825: Brown sandstones overlying grey siltstones. *Megahippus* palate from the base of the sandstones. Stratigraphic position near the base of the upper member of Barstow formation (Lewis, 1960).

*Referred specimens:* Well worn left M1/ or M2/, UCR 3696-1, lacking both the labial and lingual borders, UCR locality 3696, outcrops on south side of badland amphitheatre north of Fossil Canyon, approximately in center of N.W. ¼, sec. 15, T. 11 N., R. 2 W., Opal Mountain Quadrangle, 1:62,500 U.S.G.S. Edition 1955, 15,300 ft. N. 35° W. of road intersection 2825: Greenish and tan siltstones and sandstones near top of the upper member of the Barstow formation (Lewis, 1960).

Left lower jaw fragment with M/1 and M/2, UCMP 21215, figured by Merriam (1919, fig. 28) from UCMP locality 2060 northwestern exposures of the Barstow formation in the north limb of the Barstow syncline at a stratigraphic position roughly equivalent to the holotype of *M. mckennai.*

Merriam (1919:473) also mentions a fragmentary upper molar, UCMP 21214 of "a large species of *Hypohippus*" from the Barstow syncline, UCMP locality 2056, Barstow formation stratigraphically slightly below the occurrence of the holotype of *M. mckennai.* This specimen was not figured or further described and it is only provisionally referred here.

Fragmentary limb bones of a large anchitherine are known from several horizons in the upper part of the Barstow formation of the Barstow syncline. Some of these are described by Merriam (1910). They compare closely in size and general morphology with the sample of *Hypohippus* nr. *affinis* described by Henshaw from Tonopah, Nevada (Henshaw, 1942).

*Age:* late Barstovian.

*Diagnosis:* Approximately 25 percent smaller than *M. matthewi;* lingual cingula on premolars not as well developed as in *M. matthewi*; mesostyles with sharper crests than in *M. matthewi.*

## DESCRIPTION AND COMPARISONS

*Palate:* Only the sides of the skull anterior to the orbits and the ventral rim of the right orbit are present in the holotype. The Barstow species was compared with figures of *Hypohippus osborni* (*in* Osborn, 1918) and *H. affinis* (*in* McGrew, 1938) and directly with specimens of the Tonopah *H.* nr. *affinis.*

The premaxilla is short and narrow with a pronounced constriction in front of the P1/ alveolus. The I3/-C diastema is shorter than in *H. affinis* and *H.* nr. *affinis* and about the length in *H. osborni*. The C-P1/ diastema is similar in length to that in *H.* nr. *affinis*, but much shorter than in *H. affinis* or *H. osborni.*

The infraorbital foramen lies in the ventral margin of the facial fossa above the parastyle of P4/. Part of the deep facial fossa is visible on the right side. It extends posteriorly from a point just above and behind the infra-orbital foramen as a deep pocket into the anterior end of the jugal and adjacent maxillary bones. The portion of the facial fossa visible is more like that in *Archaeohippus* (both *A. ultimus* and a specimen referred to *A. mourningi* from the Punchbowl formation, Cajon Pass, California) than described in *H. affinis* and *H. osborni. Hypohippus* nr. *affinis*, however, shows a deep malar pocket as in *Megahippus mckennai.*

Crushing and distortion of the palate makes it difficult to discern the true posterior border of the palatal portion of the palatine bone. It seems to lie opposite the hypocone of M1/. Likewise, the exact position of the posterior palatine foramen is in some doubt although the groove which extends from this foramen anteriorly along the palatal surface can be clearly seen opposite M1/ on the right side of the holotype.

*Dentition: Incisors.* The I1/ is the largest incisor with a massive, high crown and prominent lingual cingulum. A deep median pit is present on the occlusal surface which apparently opened laterally in early wear. The I2/ is decidedly smaller than I1/, but like the latter it has a massive high crown and large labially opening median pit on the occlusal surface. This tooth lacks a lingual cingulum at the stage of wear of the holotype. The I3/ is unknown, but its alveolus indicates that it was smaller than I2/.

The large and high crowned incisors are unlike those of any species of *Hypohippus*. They agree with the large and procumbent lower incisors held diagnostic of *Megahippus* and thus constitute one of the principal reasons for assignment of the Barstow form to that genus.

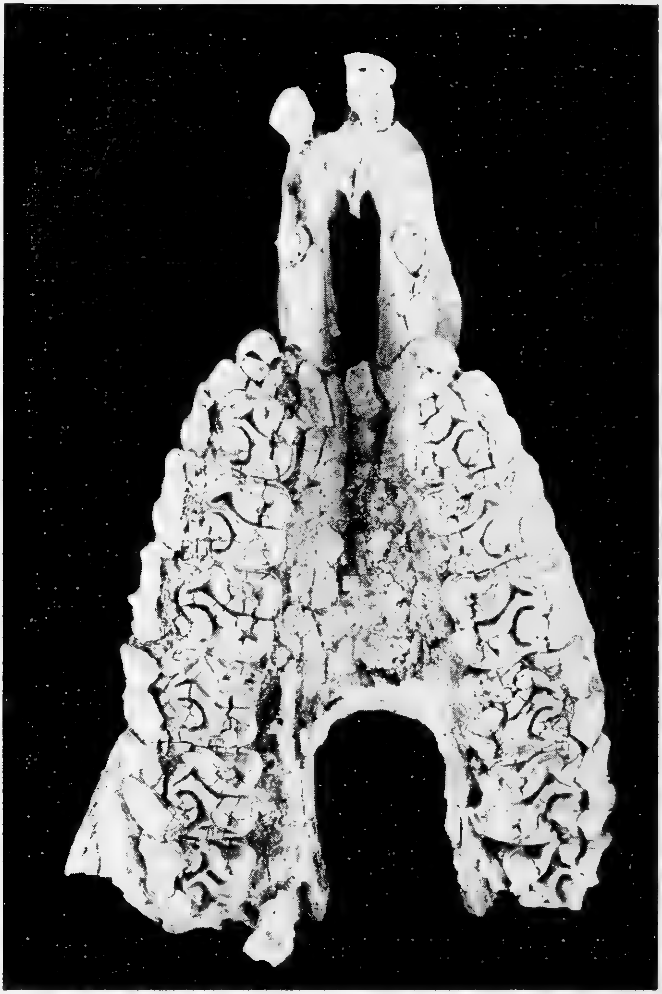

*Figure 1. Megahippus mckennai*, new species, palatal view of holotype, RAM 6500, approximately X0.5. Specimen whitened with ammonium chloride before photographing.

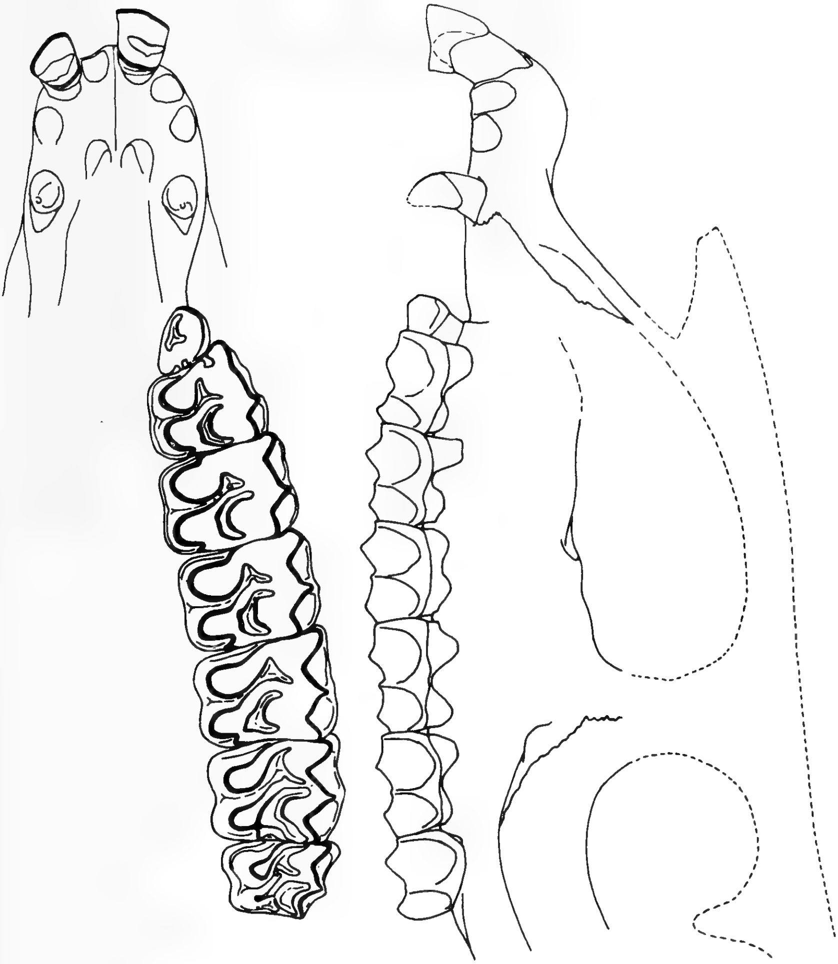

*Figure 2. Megahippus mckennai*, new species, incisors and left cheek tooth series in occlusal and lateral view, holotype, RAM 6500, X0.5. Teeth restored.

*Canines.* Large teeth with recurved compressed conical crowns bearing lingual cingula.

*Premolars.* P1/ is a birooted or fused birooted tooth. The roots appear relatively larger than in *M. matthewi* indicating that this tooth may not have been as reduced as in the latter species. The P1/ is ovoid in occlusal outline, flattened lingually, and bears low anterolabial and well developed lingual cingula. The longitudinal valley branches posteriorly at this state of wear. There is a low anterolabial cinglum on the P1/.

The premolars increase in size posteriorly with P4/ being the largest molariform tooth. As in *M. matthewi* P2/ and P3/ have continuous lingual cingula, somewhat better developed on P2/ than on P3/. P4/ lacks a cingulum on the lingual faces of the protocone and hypocone. There is a cingulum on the anterior face of the protocone in all the premolars. An homologous cingulum is conspicuously better developed on the molars. This cingulum is as well developed on the molars as on the premolars in *Hypohippus.* The protocone P2/ is nearly circular in occlusal outline at the stage of wear of the holotype; it has a flattened anterior wall in P3/ and P4/. The protoconule is poorly differentiated. The hypocone is smaller than the protocone except in P2/ and its posterior wall is flattened. A crochet is present on the right and left P3/ and left P4/. There is a trace of this fold (angulation of the metaloph border at the proper position) on P2/ and the right P4/. This is probably a very variable feature, but its frequency in the holotype suggests that the presence of the crochet on some of the teeth may be a constant feature. This fold is far more variable in *Hypohippus* and usually present only as a spur of enamel, not a dentine filled fold as in *Megahippus mckennai.* The premolar mesostyles are sharper crests than in *M. matthewi,* more as in *H.* nr. *affinis* from Tonopah.

*Molars.* The M1/ is the largest molar, the molars gradually decrease in size posteriorly. The M1/ and M2/ are rectangular in occlusal outline; the M3/ is wider anteriorly than posteriorly. In morphology the molars are much like the premolars. They differ in having weaker parastyles, stronger cingula anterior to the protocones, and in lacking continuous lingual cingula (continuous across the protocone but not the hypocone in M3/). The crochet is strong on M3/. In that tooth it blocks the floor of the protoconal valley. A crochet is present on M2/ of the holotype and represented on the M1/ by a thickening of the enamel (left M1/) or angulation of the metaloph border (right M1/). The referred M1/ or M2/, UCR 3693-1, bears a well developed crochet. Enough of the base of the hypostyle remains on M2/ to indicate that it was a crescent-shaped cusp connected by a ridge to the hypocone. The ends of the crescentic hypostyle join the posterior cingulum enclosing an enamel-lined pit which is still visible at this stage of wear. The hypocone and hypostyle on M3/ are reduced over the condition in the anterior molars. The hypostyle is represented by a ridge which connects the hypocone with the posterior cingulum.

*Discussion:* The new species is clearly a member of the genus *Megahippus* as defined by McGrew (1938: 315). It differs from the Clarendonian *M. matthewi* principally in being smaller sized. The lesser development of internal cingula on the premolars and sharper mesostyles in the Barstovian form may or may not serve as valid differences when both species are better known. The P1/ may be slightly better developed in the Barstow species. It seems clear from the close relationships of these animals that they very likely represent two members of a single phyletic line. If true, the dominant morphological trend in that phylum was simple size increase from the Barstovian to Clarendonian.

The discovery of the Barstow species carries this lineage back into the later Barstovian, but does not appreciably clarify the exact ancestry of the genus. There are many resemblances in dentition between *Megahippus* and its contemporary *Hypohippus*. These resemblances can be interpreted as implying either the derivation of the larger, specialized *Megahippus* directly from species that would be recognized as belonging to the genus *Hypohippus* or the derivation of both genera from a common anchitherine ancestor in the earlier Miocene. The genus *Anchitherium*, long regarded as ancestral to *Hypohippus*, may also have yielded *Megahippus* as an independent derivative.

Roughly contemporaneous with *Megahippus mckennai* is the well known *Hypohippus osborni* from Pawnee Creek (probably the Kennesaw fauna), Colorado, and *H.* nr. *affinis* from Tonopah, Nevada. The oldest well known species of *Hypohippus* is *H. equinus* from the Barstovo-Hemingfordian Deep River fauna, Montana. Of about the same age as the latter are specimens referred to *H. osborni* from various Great Basin localities. Matthew (1924: 72) mentions isolated teeth from the Hemingfordian Sheep Creek fauna which agree with the Snake Creek *H. pertinax*. These undescribed specimens are probably some of the earliest known representatives of the genus. It seems clear that in the early Hemingfordian or late Arikareean *Hypohippus* merges with *Anchitherium*, yet thus far this critical stage in the evolution of *Hypohippus* lacks documentation.

*Hypohippus equinus* is generalized enough in structure to serve as a common ancestor for both the later *Hypohippus* species and *Megahippus.* It occurs too late in time to be directly ancestral to *Megahippus* unless one entertains the possibility of rapid hypertrophy of the dentition in the course of evolution of this group in Barstovian time.

Isolated teeth and jaw fragments referred to *H. osborni* from the Virgin Valley, Sucker Creek, Skull Springs, Beatty Buttes and Mascall faunas are approximately contemporaneous with *H. equinus.* Most of these teeth are slightly larger than those of the holotype of *H. equinus,* and somewhat smaller than *H. osborni.* They show a reduced P/1 as in *H. pertinax* and *H. osborni,* and in addition show a tendency to develop a lingual cingulum on the protocone of the upper cheek teeth. A distinct crochet appears on some of the upper cheek teeth from Virgin Valley. Unfortunately no specimens showing the upper or lower incisors are known from these Barstovo-Hemingfordian sites. When Hemingfordian *Hypohippus* species become better known we may find suitable ancestral types for the Barstovian *Megahippus.*

When we consider the hypothesis that *Megahippus* has an independent origin in *Anchitherium* we find that the North American Arikareean species of *Anchitherium* show no special affinity with *Megahippus.* None of the new or Old World species of *Anchitherium* whose skulls are known show the deeply pocketed facial fossae typical of *Megahippus.* However, if we examine the Old World species we do find forms whose dental features approach *Megahippus.* This is particularly true of the Asiatic species *Anchitherium gobiense* Colbert, 1939, which differs from the European *A. aurelianense* and approaches *Megahippus* in such features as increased size, enlargement of I/1-2 and reduction of I/3, reduction of P/1, and lack of ribs on the labial surface of the ectoloph between the styles. Unfortunately the two occurrences of *A. gobiense,* the Chokrak formation of the northern Caucasus (Tortonian, Borissiak, 1945) and the Tung Gur formation of Mongolia (Sarmatian), are too late in time to represent animals conceivably ancestral to *Megahippus. Anchitherium gobiense* probably represents an Asiatic line of *Anchitherium* showing dental trends parallel to that of *Megahippus* just as its contemporary *Paranchitherium karpinskii* Borissak, 1937, parallels *Parahippus.* Nevertheless it is worthy of note that the closest approach to the dental peculiarities of *Megahippus* lie in the Asiatic anchitherines.

TABLE 1

Measurements of the Palate and Dentition of *Megahippus mckennai:* The lengths of the upper molariform teeth were measured across the occlusal surface from the protoconule to the hypostyle. Their widths were measured at the base of the crown from the paracone to the protocone. The lengths and widths of the incisors, canine and P1/ are maximum diameters.

| | | |
|---|---|---|
| Approximate length of palate from posterior palatine border to tip of premaxillary | | 165 |
| I3/-C | diastema | 10.2 |
| C-P1/ | diastema | ca 25 |
| Width across premaxillary outside I3/ | | 44.1 |
| Left I1/ | Length | 17.1 |
| | Width | ca 17 |
| Right I2/ | Length | 12.6 |
| | Width | ca 13.5 |
| Left Canine | Length | ca 9 |
| | Width | 7.8 |
| Left P1/ | Length | 17.8 |
| | Width | 12.1 |
| Left P2/ | Length | 23.1 |
| | Width | 29.7 |
| Left P3/ | Length | 26.4 |
| | Width | 35.3 |
| Left P4/ | Length | 27.4 |
| | Width | 38.2 |
| Left M1/ | Length | 27.2 |
| | Width | 39.7 |
| Left M2/ | Length | 25.3 |
| | Width | ca 39 |
| Right M3/ | Length | 21.3 |
| | Width, paracone to protocone | 31.7 |
| | Width, metacone to hypocone | 27.3 |
| Left P2/-P4/ | Length | 81.5 |
| Left M1/-M3/ | Length | ca 77 |

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REPORT OF AN ECHIUROID WORM *HAMINGIA ARCTICA* DANIELSSEN AND KOREN FROM THE BEAUFORT SEA. While the icebreaker USS Burton Island was enroute to establish a research station on floe ice in the Beaufort Sea, five bottom samples were taken. A complete echiuroid worm of the species *Hamingia arctica* Danielssen and Koren was brought up in an orange peel bucket by John Tibbs on September 6, 1960. This represents the first report of this species in normal substrate in the Beaufort Sea, although the find was not unexpected. MacGinitie (1955) reports that *H. arctica* was washed onto the shore at Point Barrow, Alaska after a storm. There are other reports of this species from arctic and antarctic seas.

*Hamingia arctica* has been found from a depth of 20 to 440 meters and a related species, *Hamingia sibogae* has been reported by Sluiter (1902) from 4391 meters in the Banda Sea. These specimens have been found in clay or mud. The specimen found by Tibbs was recovered from 110 meters in clayey silt.

This specimen agrees with the description of Wesenberg-Lund (1934) in both internal and external characteristics including the observation that in her material, the papillae described by Danielssen and Koren (1881) were lacking. The only exception to her account is that the proboscis was somewhat shorter in relation to the rest of the body. This difference is considered to be not significant.

The specimen was fixed in 7% formalin sea water buffered with hexamethylenamine and preserved in 70% ethanol. Measurements of this preserved specimen are:

| | |
|---|---|
| Length of trunk | 35mm. |
| Widest diameter of trunk | 18mm. |
| Length of proboscis | 22mm. |
| Length of bifurcated part of proboscis | 22mm. |

These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Southern California, NR 107-567. We also gratefully acknowledge the use of the laboratory facilities of the Allan Hancock Foundation.—**Carolyn Brahm** and **John L. Mohr,** Biology Department, University of Southern California, Los Angeles 7.

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# BULLETIN OF THE Southern California Academy of Sciences

LOS ANGELES, CALIFORNIA

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BULLETIN OF THE SOUTHERN CALIFORNIA
ACADEMY OF SCIENCES

VOL. 61 JULY-SEPTEMBER, 1962 PART 3

# SUSPECTED MELANOPHORE MOVEMENT IN FISHES BEYOND THE LARVAL STAGE[1]

MELBA C. CALDWELL[2] AND DAVID K. CALDWELL[3]
Los Angeles County Museum

In his summary of the migration of melanophores, Parker (1948:256) stated that melanophore movement "is limited in amount and restricted to the very early stages in the life of these cells" and that "locomotor activity . . . is apparently characteristic of chromatophores only in their very early stages of growth." Parker (*loc. cit.*) summarized the conclusions of Franz (1935) by stating that "after they [chromatophores] have become members of a general pattern, even in larval individuals, they retain their places in that pattern and their original locomotor powers seem to subside almost completely." However, it has recently been strongly indicated (Caldwell, M. C., *in press*; Caldwell, D. K., *in press*) that melanophores continue to move well beyond the larval stage in some marine fishes that undergo metamorphosis with an environmental change. This migration was shown for melanophores in the second dorsal fin of an Atlantic goatfish, *Mullus auratus* Jordan and Gilbert, up to a standard length of 47 mm., and for the soft dorsal, soft anal, and caudal fins of the Atlantic short bigeye, *Pseudopriacanthus altus* (Gill), to a length of 73 mm. In view of these findings the generally accepted assumptions concerning melanophores in fishes must be restricted to observed species.

In the development of the color patterns of certain marine fishes (*e.g.*, *M. auratus*, *P. altus*, *Chaetodon striatus* Linnaeus) the fins are particularly susceptible to drastic color pattern changes at the time of change of habitat. The change of pattern, however, is not restricted to the fins. A change in body color pattern, as well as that of the verti-

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[1] Portions of this study were aided by a grant to the senior author from The Society of the Sigma Xi RESA Research Fund.

[2] Also, Department of Zoology, University of California, Los Angeles.

[3] Also, Research Associate, Florida State Museum and Collaborator in Ichthyology, Institute of Jamaica.

cal fins, was noted by Gosline and Brock (1960:200, 201, Fig. 217 h & i) for the Pacific butterfly fish *Chaetodon lunula* (Lacépède). The changes are probably as much the rule as the exception among tropical shallow-water marine fishes with a pelagic early stage. These changes in color pattern should not be confused with that so frequently seen in fishes responding to shifting changes in their environment, in which the distribution of the pigment within the melanophores changes, often very rapidly (Odiorne, 1957).

The first question raised in regard to a change in color pattern is whether the melanophores arise *in situ* at the time of change of pattern. Although only preserved fish were examined, the definite impression gained in our observations is that the melanophores move and that there is not a successive generation of melanin aggregates (Fox, 1957; Blackburn, 1950: 155) and degeneration of melanophores (Odiorne, 1936: 28). Examinations of series of metamorphosing *M. auratus* and *P. altus* clearly indicate progressive migration of melanophores from the base of the fins to a geneticaally fixed area on the fin. The path of melanophore migration is out along the fin rays, although some melanophores cross the interray membrane of the fin before coming to rest (Caldwell, M. C., *in press*; Caldwell, D. K., *in press*). Enough of these in proper location form the adult color patterns of the fins typical of the species.

Aggregations of melanin-containing cells in regions of encysted unidentified skin parasites (Fig. 1) in large preserved specimens of *Mulloidichthys xanthogrammus* (Gilbert), one of the Pacific goatfishes, raises the possibility of the melanophores' ability to migrate even when the fish has become adult. The tissue surrounding parasitized areas shows what appears to be a streaming of elongated melanin-containing cells either into or away from the site of the cyst. Direct observation of the parasitized areas should be made *in vivo* during the formation of the aggregations to determine the direction of the flow. If the cells arise in the infected area, and stream outward, they are probably atypical cells caused by the parasite or melanin-containing macrophages. If they migrate into the area, the melanophores could possess a defense role similar to that of the leucocytes which they so closely resemble histologically. This would necessitate a review of the origin and role of the macromelanophores found in melanotic tissue (Gordon, 1957) as it should be established that they are not initially present as defense mechanisms.

A parasitized area on the lower jaw in a region in which melanophores normally do not exist contained no melanin-containing cells at the site of infection. If melanophores arise *in situ*, they should be expected here as well as in other infected parts of the body. With one exception, in all areas of *M. xanthogrammus* where there exists a generalized spotting of melanophores and there was a parasite, there was an accompanying aggregation of melanin-containing cells at the site. The exception was an embedded parasite, smaller than the others, that may well have been of too recent implantation to have stimulated a reaction.

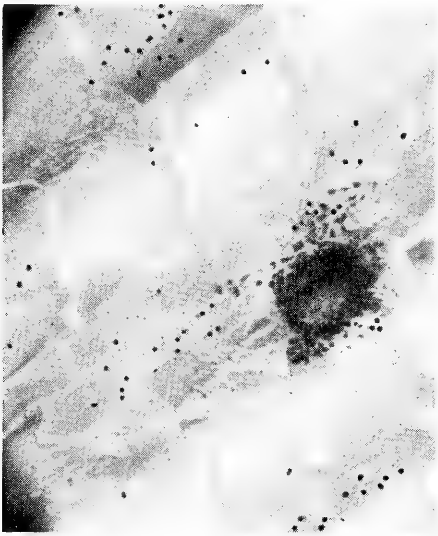

*Figure 1.* Encysted unidentified parasite in the caudal fin interray membrane of a Pacific goatfish, *Mulloidichthys xanthogrammus*, showing associated heavy aggregation of melanin-containing cells. Normal scattering of melanophores (retouched in the photograph) can be seen at the extreme top, left and bottom of the photograph. (About X 10.)

The reaction of these cells is probably due to a chemical rather than to a physical stimulus. One of the parasitized goatfish was found to have two embedded and overgrown sand grains within the skin, neither of which showed an aggregation of these cells, although they were in an area normally having scattered melanophores.

The site of implantation of one of the parasites was dissected and pigmentation was found to extend into the muscle tissue surrounding the parasite.

This aggregation of melanin-containing cells around encysted parasites is probably not unusual. Hoffman (1960:439) refers to the cysts as being "pigmented (usually with melanin, black . . .," but he makes no mention of the term *melanophores* or of movement of pigment into the infected area.

## ACKNOWLEDGMENTS

We wish to thank the following for commenting on earlier versions of the manuscript: Dr. Joseph M. Odiorne of the New York University School of Medicine, Dr. Denis L. Fox of Scripps Institution of Oceanography, and Dr. Otto H. Scherbaum of the Department of Zoology of the University of California, Los Angeles.

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# TAXONOMIC CHANGES AND DESCRIPTIONS OF NEW TINGIDAE (HEMIPTERA)

Carl J. Drake and Florence A. Ruhoff
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This paper describes a new genus and three new species of Tingidae. The taxonomic changes include the suppression of several trivial names of species as synonyms and the creation of either new names or resurrection of available names for homonyms that have been theretofore overlooked. The location of the holotype is recorded beneath the descriptions of each new species. We are indebted to Elinor Stromberg and Lisa Biganzoli, both of Washington, D. C., for the fine illustrations. This study was supported in part by National Science Foundation Grant 18721.

## New Synonyms

*Diplocysta nubila* Drake is suppressed as a synonym of *Penottus monticollis* (Walker); *Stephanitis oschanini* Vasilev as synonym of *S. pyri* (Fabricius): *Teleonemia lanceolata* (Walker) as synonym of *T. tricolor* (Mayr); *Tingis bengalana* Drake as synonym of *Dasytingis rudis* Drake and Poor; *Tingis himalayae* Drake as synonym of *T. buddleiae* Drake; *Urentius abutilinus* Priesner and Alfieri as synonym of *U. eunonymus* Distant; and *U. sentis* Distant as synonym *U. hystricellus* (Richter).

## **Naitingis,** NEW GENUS

Obovate or oblong, dorsal and ventral surfaces moderately clothed with very short golden pubescence. Head very short, armed with the usual dorsal spines; bucculae wide, areolate, closed in front; eyes moderately large; antenniferous tubercles short, thick, bluntly rounded in front, concave within. Antennae long, slender, segment I and II short, III very long, and IV moderately long, only slightly swollen. Rostrum long, reaching to end of sulcus; sternal laminae of rostral sulcus low, areolate, widely separated from each other, open at base. Ostiolar sulcus of metathoracic scent glands present on each metapleuron.

Pronotum moderately convex, punctate, tricarinate; collar distinct, areolate, truncate in front, without hood; paranota narrow, erect, composed of one row of small cells; outer margins of paranota and elytra without hairs or bristles. Elytra slightly wider and longer than abdomen, divided into the usual division; costal area narrow, composed of

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[1] United States National Museum (USNM).

one row of areolae, sometimes biseriate in hollow of costal area; discoidal area extending beyond middle of elytron, on same level as the sutural area; sutural areas overlapping each other so that their apices lie jointly rounded in resting position. Metathoracic wings longer than abdomen. Legs moderately long, femora slightly swollen.

TYPE SPECIES, *Tropidocheila maynei*
Schouteden, Africa

This new genus is founded for the reception of *Tropidocheila maynei* and var. *biseriata* Schouteden, *T. nyanzae* Schouteden and *Tingis blukwana* Drake. *Biseriata* represents a variety with a partial second row of areolae in hollow of costal area.

*Naitingis*, n. gen., may be separated from *Tingis* and its subgenera by the lack of pronotal hood, very narrow paranota, and dorsal clothing of very short golden hairs. The exterior margins of the paranota and elytra are without hairs or bristles.

### **Engynoma isolata**, NEW NAME

*Tingis insularis* Hacker 1929, Mem. Queensland Mus., vol. 9, p. 330, pl. 34, fig. 10.

*Engynoma insularis:* Drake 1942, Jour. Washington Acad. Sci., vol. 32, p. 362.

Since the trivial names of *Tingis insularis* (Horváth) (1902) and *Tingis insularis* Hacker (1929) are homonyms, we are here proposing the specific name of *isolata* for the species described by Hacker.

### *Tingis strictula* (Puton)

*Monanthia platychila strictula* Puton 1878, Ann. Soc. Ent. France, ser. 5, vol. 8, p. lxvi.

*Tingis strictula:* Horváth 1906, Ann. Mus. Nat. Hungarici, vol. 4, p. 77.

*Tingis montana* Lindberg 1932, Soc. Sci. Fennica Comm. Biol., vol. 3, p. 42. (New Synonymy)

A comparison of a paratype of *T. montana* Lindberg from Spain with a specimen of *T. strictula* (Puton) (det. Puton) from Oran, Algeria, shows that these two trivial names were given to the same species, the latter having priority by many years. The illustration by Lindberg (*loc. cit.* p. 42, pl. 2, fig. 5) is *Tingis cardui* (Linnaeus) and not *T. montana* as labeled.

### *Tingis stachydis* (Fieber)

*Monanthia maculata* Herrich-Schaeffer 1838, Wanzen. Insekt., vol. 4, pp. 51, 56, pl. 123, fig. 389, a-c.

*Monanthia stachydis* Fieber 1844, Ent. Mon., p. 73, pl. 6, figs. 13-15.

*Tingis maculata:* Horváth 1906, Ann. Mus. Nat. Hungarici, vol. 4, pp. 69, 84.

The transference of *Monanthia maculata* Herrich-Schaeffer to the genus *Tingis* by Horváth (1906) made the specific names of this species and that of *Tingis maculata* Herrich-Schaeffer homonyms. As the first revisors, we are here resurrecting *Monanthia stachydis* Fieber as the available trivial name for the former species, and are citing the references needed to verify the homonym and validity of *stachydis* as the valid trivial name.

### *Galeatus maculatus* (Herrich-Schaeffer)

*Tingis maculata* Herrich-Schaeffer 1838, Wanzen. Insekt., vol. 4, p. 68, pl. 126, fig. 393.

*Tingis subglobosa* Herrich-Schaeffer 1838, Wanzen. Insekt., vol. 4, p. 68.—Fieber 1844, Ent. Mon., p. 106, pl. 9, figs. 17-20.

*Galeatus maculatus:* Stål 1874, Ofv. Vet. Förh., p. 48.

As explained beneath the above caption, *Tingis maculata* Herrich-Schaeffer and *Monanthia maculata* Herrich-Schaeffer (now in *Tingis*) are homonyms. Stål (1874) correctly transferred *T. maculata* to the genus *Galeatus*.

### *Galeatus spinifrons* (Fallén)

*Tingis spinifrons* Fallén 1807, Monographia cimicum Sveciae, p. 38.

*Galeatus spinifrons:* Horváth 1906, Ann. Mus. Nat. Hungarici, vol. 4, p. 53.

*Copium artemisifolium* Shinji 1938, Zool. Mag. Japan, vol. 50, p. 316. —Takeya 1951, Kurume Univ. Jour. (Nat. Sci.), vol. 4, p. 19. (New Synonymy)

The type of *C. artemisifolium* Shinji from Honshû Island (Morioka Island, Prov. Rikuchu), Japan, is apparently lost. Since the original description of *artemisifolium* fits that of *Galeatus spinifrons* and since it breeds on the leaves of *Artemisia vulgaris*, we are here treating the two trivial names as synonyms, *spinifrons* having the priority by many years. In a paper in press elsewhere, the authors have placed other species in synonymy with *spinifrons*.

## **Leptodictya elitha,** NEW SPECIES

Large, very broad. Head blackish fuscous with dorsal spines testaceous; bucculae dark fuscous. Pronotum blackish fuscous with hood, collar, paranota, carinae, and apex of hind projection testaceous. Elytra pale testaceous with exterior veins, six obliquely transverse bands (each band consists of one depressed vein and adjoining rows of cells) in costal area blackish fuscous; subcostal area with veinlets brown; discoidal area with boundary veins and two adventitious veins brown to fuscous; sutural area with veinlets blackish fuscous. Antenna fuscous-brown with first two segments blackish. Legs light brown with tarsi blackish. Body beneath black, with entire abdomen or only genital segments reddish brown. Length 4.70 mm., width (elytra) 2.70 mm.

Head very short, armed with five, very long, sharp spines; eyes moderately large, dark fuscous; bucculae long, wide, five areolae deep in widest part, closed in front. Antennae long, slender, clothed with whitish pubescense, measurements: segment I, 0.25 mm.; II, 0.12 mm.; III, 3.50 mm.; IV, 0.75 mm. Labium testaceous, extending to base of sulcus; laminae of sulcus very wide, mostly biseriate, with large V-shaped opening at base, without laminae on prosternum.

Pronotum moderately convex, coarsely punctate, tricarinate; median carina composed of one complete row of moderately large areolae, plus two extra cells just behind the hood; lateral carinae less raised than median carina, uniseriate, slightly constricted behind middle of pronotal disc; hood moderately large, strongly compressed laterally. about twice as long as high, feebly produced in front, extending backwards between calli on fore part of pronotal disc; paranotum fairly wide, outer part reflexed so as to leave two rows of areolae on underside and then between two and three rows on upper side, only the outer row of latter resting on the dorsal surface of pronotum; posterior process triangular, areolate. Ostiole and ostiolar canal prominent on each metapleuron, the side of the channel raised, vertical and slightly tilted posteriorly.

Elytra sharply widened at base, much wider and longer than abdomen, sutural areas only partly overlapping so that their apices, in resting position, are separated from each other; costal area very wide with areolae irregular in size, arrangement, and not in regular rows, ten to eleven cells deep in widest part; subcostal area very narrow. vertical, composed of two rows of small areolae, discoidal area extending beyond middle of elytron, acutely angulate at base and apex, seven areolae deep in middle; sutural area large. with areolae as variable in size and as confused in arrangement as in costal area. Hind pair of wings slightly longer than abdomen.

*Holotype* (male) and *allotype* (female), macropterous, Queros, Rio Cosñipata, Department Cuszo, Peru, l.iv. 1952, F. Woytkowski, in Drake Coll. (USNM).

The markings of the elytra are prominent and very similar in appearance to those in *L. approximata.* It differs from the latter species by its larger size, slightly more elevated pronotal carinae, longer cephalic spines, and especially by the longer and distinctly laterally compressed hood. These two species have the sternal laminae of the rostral sulcus biseriate.

### **Amblystira angella,** NEW SPECIES

FIGURE 1

Small, oblong, deep black, shiny, with hollow part of costal area brownish testaceous; eyes moderately large, black; body beneath black, shiny, sparsely clothed with pale pubescence; laminae of rostral sulcus black, dull. Labium brownish with apex black. Antenna pale brown with fourth segment black and shiny, the pubescent hairs sparse on third segment, much more numerous and longer on fourth segment. Legs pale brown with tarsi black, pubescence sparse and pale. Length 2.60 mm., width (elytra) 1.07 mm.

Head very short, with an irregular, median, longitudinal furrow on vertex, armed with three, short, blunt anterior tubercles and two longer, closely appressed, ridgelike occipital spines; buccal laminae wide, areolate, black, closed in front. Labium extending to middle of mesosternum; laminae of sulcus low, widely separated from each other, composed of one row of tiny cells, present on all three sternal divisions, closed at base. Antenniferous tubercles very short, thick, blunt, concave within. Antenna moderately long, slender, measurements: segment I, 0.10 mm.; II, 0.09 mm.; III, 0.70 mm.; IV, 0.38 mm.

Pronotum moderately convex, coarsely punctate, tricarinate, each carina composed of a single row of very small areolae, lateral carinae less raised than median and slightly divergent anteriorly; collar raised, composed of three transverse rows of tiny punctures; calli small, impressed, impunctate; paranotum narrow, slightly reflexed, slightly wider at humeral angle, with two to three rows of tiny punctures, distinctly obtusely angulate opposite humeral angle. Metathoracic

*Figure 1. Amblystira angella*, n. sp.

scent glands with a prominent, nearly vertical sulcus on each metapleuron.

Elytra with outer margins (also those of paranota) minutely serrate, longer than abdomen; costal area narrow, composed of one row of small rounded cells on basal half, thence posteriorly in hollowed part wider with large areolae and bi- to triseriate; subcostal area wide, five areolae deep in widest part (six opposite apex of discoidal area);

discoidal area reaching to middle of elytron, widened posteriorly, obliquely truncate at apex, there six areolae deep, acutely angulate at base; sutural areas overlapping each other at rest. Hind pair of wings nearly as long as elytra, pale fuscous.

*Holotype*, macropterous female, (fig. 1), Monson Valley, Tingo Maria, Peru, 29.II.1954, E. I. Schlinger and E. S. Ross, in Calif. Acad. Sciences, San Francisco.

This shiny black species can be separated at once from all other members of the genus by having the paranota distinctly angulate opposite the humeral angles. As in other members of the genus, the clavus is narrow and concealed beneath the backward projection of the pronotum when elytra are in resting position.

### **Haedus oios,** NEW SPECIES

FIGURE 2

Small, oblong, widest across apices of elytra, tapering anteriorly with a large hollowed sinus behind the middle of outer margin of each elytron; testaceous with head, pronotal disc and the discoidal, subcostal, and sutural areas of elytra brownish, also with a wide transverse band across apices of elytra dark fuscous; body beneath pale brown, shiny. Antenna pale testaceous with fourth segment slightly brownish. Legs pale testaceous with tip of tarsi blackish. Rostrum testaceous with tip blackish. Buccal and sternal laminae of rostral sulcus testaceous. Antenniferous tubercles and cephalic spines pale testaceous. Length 2.65 mm., width (across middle and apices of elytra) 0.82 mm., and 0.95 mm., respectively.

Head short, armed with five very long, subporrect spines; bucculae wide, mostly four areolae deep, closed in front. Labium extending to middle of mesosternum; sternal laminae of sulcus uniseriate, composed of one row of areolae, channel narrow and open at base. Antenna very slender, sparsely clothed with short setal hairs, with longer hairs on fourth segment; measurements: segment I, 0.10 mm.; II, 0.08 mm.; III, 1.20 mm.; IV, 0.32 mm. Antenniferous tubercles very long, transversely compressed, feebly curved inwardly, extending slightly beyond apices of second sternal segments. Orifice and ostiolar channel not visible on metapleuron.

Pronotum with sides narrowed anteriorly, moderately convex, reticuately punctate, tricarinate; median carina much higher than lateral pair, raised anteriorly, biseriate behind hood, uniseriate with larger rectangular areolae behind middle of pronotal disc, there with areolae

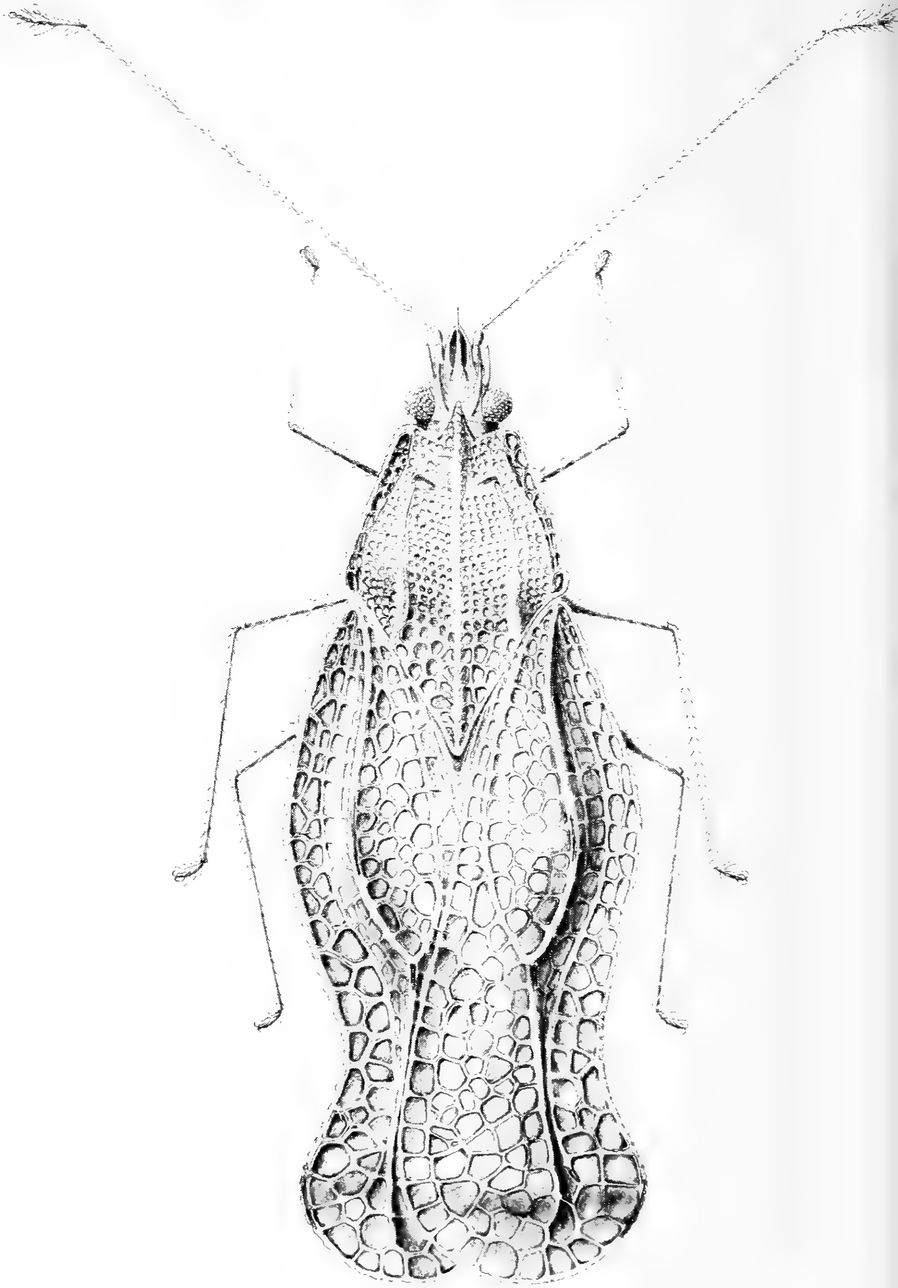

*Figure 2. Haedus oios*, n. sp.

shorter than high; lateral carinae low, indistinctly areolate, nearly parallel; hood small, tectiform, angulately produced in front; paranotum narrow, long, slightly reflexed, mostly uniseriate, wider and biseriate opposite calli and collar. Legs very slender, indistinctly pubescent.

Elytra with outer marginal veins (also that of paranota) minutely serrate, apices partly overlapping in resting position; costal area fairly wide, mostly biseriate; discoidal area mostly biseriate, nearly vertical, extending a little beyond middle of elytron, widest behind middle, there four areolae deep, with boundary vein separating it from subcostal area obtusely angulately raised, highest behind middle, there and at apex with black spots; sutural area with areolae subequal in size to those in discoidal area; hypocostal laminae uniseriate, the areolae small and rounded. Abdomen, as seen from beneath, rather densely clothed with short, pale hairs along the upper margins of each side. Male parameres strongly curved inwardly.

*Holotype*, macropterous male, Salisbury, Southern Rhodesia, collected by C. M. Smithers, in Drake Collection (USNM).

This species can be separated from other members of the genus by the strongly constricted elytron behind the middle and the form of body and color markings as shown in the illustration of the type.

### *Dictyonota maroccana* Ribaut

*Dictyonota maroccana* Ribaut 1939, Bull. Soc. Sci. Nat. Maroc, vol. 19, p. 186.

An examination of the type (lectotype) of *D. maroccana* Ribaut, brachypterous female, Djebel M'Goun Canyon Tessaut, Morocco, 1.IX.1915, shows that it belongs to the subgenus *Alcletha* Kirkaldy, and that it is a synonym of *aridula* Jakovlev. *Maroccana* differs from the latter in having the first antennal segment slightly longer and the antenniferous tubercle more narrowed anteriorly and pointed at the apex. The other structural characters are similar to each other.

### *Dictyonota tricornis* (Schrank)

*Acanthia tricornis* Schrank 1801, Fauna Boica, p. 67.

*Dictyonota dictyesthes* Garbiglietti 1869, Bull. Soc. Entom. Italiana, vol. 1, p. 274. —Drake and Ruhoff 1960, Proc. U.S. Natl. Mus., vol. 112, p. 7. (New Synonymy)

*Dictyonota tricornis:* Horváth 1906, Ann. Mus. Nat. Hungarici, vol. 4, p. 41.

*Dictyonota ifranensis* Vidal 1951, Bull. Soc. Sci. Nat. Maroc, vol. 31, p. 63. (New Synonymy)

*Dictyonota tricornis americana* Parshley 1916, Psyche, vol. 23, p. 164. (New Synonymy)

An examination of the holotype of *Dictyonota ifranensis* Vidal, macropterous female, Ifrane, Morocco, VII.1938, J. P. Vidal, shows that it is inseparable from and a synonym of *D. tricornis* (Schrank) (*det.* Horváth). An examination of many specimens of *tricornis* from Europe shows that it is very variable in size and in the areolation of the paranota and elytra, especially costal area. *D. tricornis americana* Parshley is also suppressed here as a synonym of *tricornis*, as well as *dictyesthes* Garbiglietti.

# FOSSIL ARTHROPODS OF CALIFORNIA. 24. SOME UNUSUAL FOSSIL ARTHROPODS FROM THE CALICO MOUNTAINS NODULES.

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and
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The unusual silicified arthropods recovered from Miocene petroliferous nodules, described in this article, were collected by Gibron at U. S. Geological Survey Site #19057, the original discovery site of Dr. Allen M. Bassett, reported on by Dr. Allison R. Palmer (1957). This site is located in S.W. ¼ Section 24, R.1.E., T.10.N., Calico Mountains, San Bernardino County, California, at 2420 feet altitude. We believe that this is the oldest fossil site yet reported on in this mountain range.

The specimens were all extracted from the nodules by use of hydrochloric acid by Gibron and Mrs. Gibron (Julia). Critical study has been made by Pierce, who also prepared the figures.

### Class ARACHNIDA
### Order ARANEI
### Family Dictynidae
### Genus *Argenna* Thorell

### **Argenna fossilis** PETRUNKEVITCH 1957

FIGURES 1A AND 1B

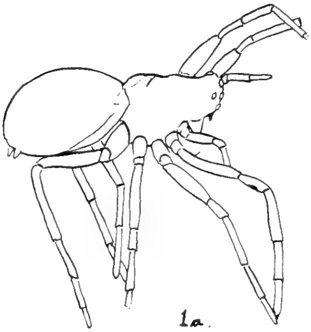
A beautiful, crystalline spider, specimen 5275, (Gibron #H) was obtained from the type site of the Petrunkevitch species, and although larger than the type probably represents an older instar. It is mounted in balsam.

Total length 2.16 mm., cephalothorax 0.96 mm., abdomen 1.20 mm. The leg pattern (Table I) shows minor differences from those given in the original description. (See Palmer, 1957:246-248.)

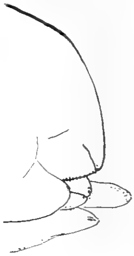
TABLE I

Leg dimensions in millimeters of specimen No. 5275

| Leg | Femur | Patella and Tibia | Metatarsus | Tarsus | Total |
|---|---|---|---|---|---|
| I | 0.68 | 0.68 | 0.40 | 0.36 | 2.12 |
| II | 0.60 | 0.64 | 0.40 | 0.32 | 1.96 |
| III | 0.60 | 0.64 | 0.48 | 0.36 | 2.08 |
| IV | 0.68 | 0.76 | 0.40 | 0.28 | 2.12 |



1a.



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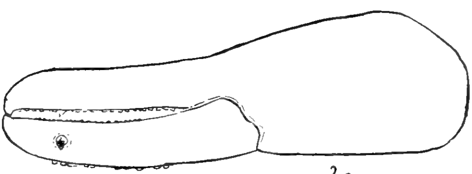
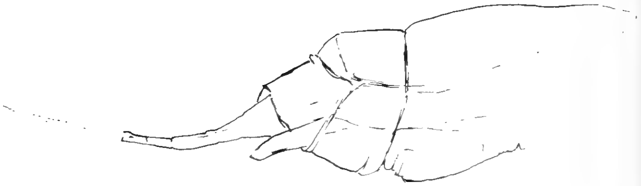


2a.

2b.

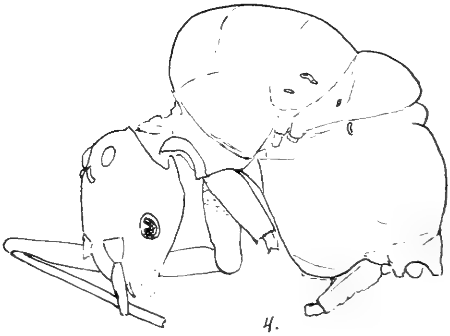
2c.



3.

5a.

5b.



4.

The specimen is crystal clear except as mentioned below.

The nervous system is pigmented with black masses almost filling the center of the cephalothorax, from which radiate nerves reaching the whole length of the appendages, and a large mass in the abdomen.

The cribellum is transverse, and the four spinnerets seem to be in a row, the outer ones larger with anal lobe below (Fig. 1b).

### Order CHELONETHIDA Thorell
### Suborder HETEROSPHYRONIDA J. C. Chamberlin 1929
### Family Chthoniidae Hansen 1894

A silicified pseudoscorpion cheliceral claw was extracted from a nodule from the same site (19057) noted above.

In view of the absence of any indication of poison apparatus in either finger, and because the chela has no pedicel, but rather a socket for attachment, it is assigned as follows:

### Subfamily Chthoniinae Daday 1887
### Tribe Lechytini J. C. Chamberlin 1929
### Genus *Lechytia* Balzan 1891

### FIGURES 2A AND 2B

Chamberlin (1929), in his monograph of this suborder, figured the right chela of *Lechytia pacifica* (Banks) *(Roncus)*, which most closely resembles this specimen in proportions and general shape, although differing in minor details. Banks (1893) very briefly described the hand of his species from Washington state, and Chamberlin records it also from California.

Length of chela 2.32 mm.; width 0.72 mm.; movable finger length 1.20 mm.; width 0.24 mm.

No setae are visible. The inner margin of each finger is armed with small quadrate teeth, and similar teeth occur on the outer margin of the movable finger, in the position often occupied by spinnarets.

A peculiar organ (Fig. 2c), looking like a tree growing out of a

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*Facing page:*

*Figure 1a.* Side view of *Argenna fossilis;* size 2.16 mm. *Figure 1b.* Enlarged side view of end of abdomen of *A. fossilis*, showing spinnerets. *Figure 2a.* Cheliceral claw of pseudoscorpion, outer side; length 2.32 mm. *Figure 2b.* Inner side of base of cheliceral claw of pseudoscorpion, showing articulation. *Figure 2c.* Enlargement of unusual organ on finger of claw of pseudoscorpion. *Figure 3.* Posterior portion of an *Entomobrya*; length of specimen 1.6 mm. *Figure 4. Palaeosminthurus juliae*, new species of symphypleonid; length 2.4 mm. *Figure 5a.* Dorsal view of anterior portion of Trogiid corrodentian; length of specimen 1.6 mm. *Figure 5b.* Face and leg fragments of Trogiid corrodentian.

circular depression, occurs near the distal fourth of the movable finger.

The attachment of the chela is in a socket on the upper inner side, a little beyond the base. This claw differs from *L. pacifica*, in which the attachment is basal.

This seems to be the first fossil evidence of the pseudoscorpions in America, although there are European records.

### Class INSECTA

### Order COLLEMBOLA Lubbock 1873

### Suborder ARTHROPLEONA Börner 1901

### Family Entomobryidae (Tömösvary 1883) Gisin 1944

### Genus *Entomobrya* Rondani 1861

Pierce (1960) described a fossil Collembolan, *Entomobrya (Entomobrya) kirkbyae* from the other side of the Calico Mountains in N.W. ¼ Section 19, R.2.E., T.10.N., a little over one mile away but in a much later geological horizon of the Miocene. It measured only 1.50 mm., for complete insect with extended springer.

A second record (Fig. 3) is now added, of a posterior portion of an *Entomobrya* without the complete springer. The preserved portion measures 1.6 mm., and therefore the entire insect would be considerably larger than *E. kirkbyae*, but still could be a later instar of that species.

### Suborder SYMPHYPLEONA Börner 1901

The unusual specimen now to be described is in some respects intermediate between the two suborders, and in absence of a collophore would seem to stand by itself. The condensed form of the body otherwise places it in this suborder but a number of characters require separation to form a new family.

### Family Palaeosminthuridae, New Family

Head with pigmented eyes beyond middle and lateral to insertion of antennae, and with four clear lensed ocelli on vertex. Prothorax reduced, but bearing the only functional legs. Mesothorax greatly enlarged; metathorax dorsally distinct. Middle and hind legs greatly reduced. First abdominal indicated but without collophore. Anal papilla and furcula distinct.

### Genus Palaeosminthurus, New Genus

Fore legs elongate; middle and hind legs rudimentary; collophore lacking; small oval spiracles on mesothorax; metathorax and first abdominal.

## **Palaeosminthurus juliae,** NEW SPECIES

FIGURE 4

Named in honor of Julia, Mrs. John Gibron, Sr., in recognition of her constant collaboration with her husband in the work of collection and separation of the fossils.

Although this interesting insect is crystallized and semi-transparent, the white surface pigmentation remains.

Length, 2.4 mm.; height, 2 mm.

Head on flexible neck, directed downward, hypognathous. Antennae located in front of the middle. Only two joints of one antenna remain. Pigmented eyes outlined by a clear oval line occur lateral to the bases of the antennae. On the vertex are two large oval, and two smaller crescent shaped ocelli with clear convex lenses. These are placed in the area where the so-called eye patches of separate ocelli occur in other Collembola. An ensiform mandible is indistinctly visible, slender, acute. Other mouth parts are indistinct in a foamy mass of crystal.

The prothorax is membranous, small, with a curved cervical plate from base of head to anterior corner of coxae. The front legs are long (one is complete except for claws), with coxa, trochanter, femur and tibiotarsus in the proportions 30:20:50:60.

Mesothorax massive, humped high above prothorax, strongly convex, definitely defined by deep suture behind, but ventrally meets the prothorax and abdomen in a point. Faintly the prescutum, scutum and scutellum are defined, and on scutellum at the side is an elongate oval opening which seems to be a spiracle, and on one side there is a sinuous scar above this. The rudimentary second legs are indicated by two segments, upon the side of the body below the first spiracle.

Metathorax dorsally consists of scutellum, but laterally this is preceded by a narrow scutum, which bears a transverse opening or spiracle, and below this are the rudiments of the third leg.

First segment of abdomen is dorsally distinctly outlined, bears an opening or spiracle opposite that of metathorax, and the lateral boundary is faintly outlined. There is no trace of a collophore, nor is there any space for such an organ, as the mesothorax, metathorax, and first abdominal come to a single ventral point adjoining the prothorax.

The second, third and fourth abdominal segments are one large undifferentiated mass, except that from the venter of the fourth springs the manubrium of the springer.

This organ is soft, two-segmented, and lacks the dens and mucro in the present specimen.

The anal papilla, or fifth and sixth segments from side view, has a dorsal and ventral process, with a central lobe (sixth).

The presence of eyes and ocelli, absence of collophore, reduction of middle and hind legs, and great development of meso- and metathorax, set this insect off as very distinct from any insect described in either suborder of springtails.

### Superorder CORRODENTIA Burmeister 1839
### Order COPEOGNATHA Enderlein 1903
### Suborder TROGIOMORPHA
### Family Trogiidae

FIGURES 5A AND 5B

A fragment of a crystallized procid is represented by Specimen 5282, collected and extracted by Gibron.

This is the second record for this order, from the Miocene of the Calico Mountains (for the first, see Pierce, 1960:45-46.).

Length of specimen 1.6 mm.; width of head 0.72 mm.

The head is turned down beneath the thorax, but the broad face is complete with bulging eyes, broad clypeus and labrium. The thorax is definitely three segmented, mesothorax largest. An oval disc on metathorax may be a wing pad.

### Order EPHEMERIDA Leach 1817
### Family Baetidae Ulmer 1920

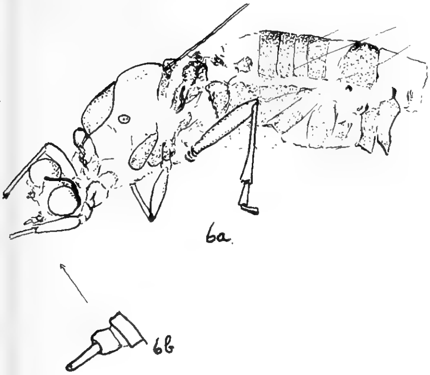
FIGURES 6, 7, AND 8

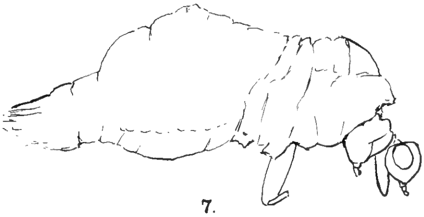
In article No. 23 of the Series W.D.P. recorded a fossil mayfly and her egg mass found in Section 19, R.2.E., T.10.N., Calico Mountains.

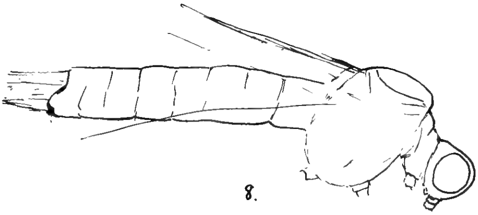
We are now able to report on three crystallized mayfly adults, Specimens 5096, 5286, 5307; all found by Gibron at U.S.G.S. site No. 19057, noted above.

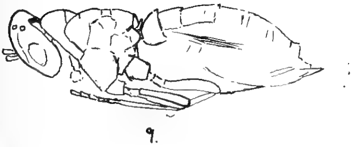
Fossil mayflies date back to the Permian Period, but the record is based almost entirely on winged adults crushed and lying in shales. In these new specimens we have two crystallized adults, and one subimago, with only fragments of the wings, and it is hardly yet advisable to name them. The small size seems to limit them to the family Baetidae. Only the genera *Caenis*, *Baetis*, *Pseudocloeon* and *Cloeon* are recorded as holding species with adult size under 3 mm.

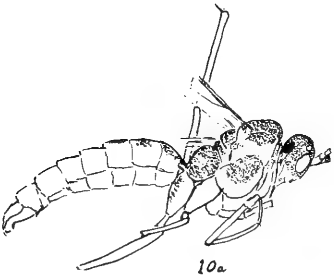
Organisms of decay are in all three specimens, indicating death before preservation. This is natural as the usual life of a mayfly is but a day.

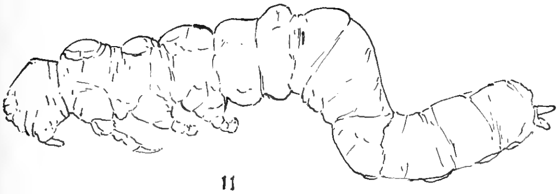












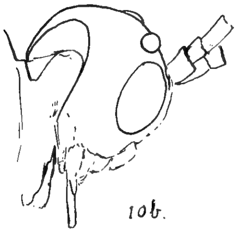


*Figure 6*. Adult mayfly, No. 5286; length 1.96 mm. *Figure 7*. Subimago mayfly, No. 5096; length 1.92 mm. *Figure 8*. Adult mayfly, No. 5307; length 3.04 mm. *Figure 9*. Adult chalcid wasp; length 1.88 mm. *Figure 10a*. Adult ichneumonid wasp; length 6.0 mm. *Figure 10b*. Side view of head of ichneumonid wasp. *Figure 11*. Lepidopterous larva; length 1.03 mm.

Specimen 5096 (Fig. 7) is a subimago, measuring 1.92 mm. Crystallization is not clear cut. There are round bodies in the intestinal tract.

Specimen 5286 (Fig. 6a and 6b), is a mature insect, measuring 1.96 mm. in length without its cauda; with three legs and antenna visible. There is considerable brown pigmentation of the thoracic and abdominal sclerites. Viewed from an unnatural angle, the posterior margin of the head appears to be arched posteriorly, neither straight nor emarginate, and this would seem to remove it from any of the genera mentioned above. The antennae (Fig. 6b), have a short, transverse first joint, a longer but transverse second joint, and an elongate third joint. The legs are short.

Specimen 5307 (Fig. 8) is a larger insect, measuring 3.04 mm., with only the bases of the caudal filaments present; and only the coxal bases of the legs. In side view it has a typical mayfly appearance with large meso-metathorax; small prothorax. Crystallization is not clear cut due to decay materials which obscure many outlines.

## Order HYMENOPTERA

### Superfamily Chalcidoidea Ashmead

#### FIGURE 9

A minute crystallized Chalcid adult, Specimen 5289 (Gibron H35) was recovered by Gibron, from a nodule from Site 19057, U.S.G.S.

Length 1.88 mm., specimen pigmented dorsally. Fragments of wings, mouth parts, and legs are undecipherable.

### Superfamily Ichneumonoidea

#### FIGURES 10A AND 10B

An excellent specimen of ichneumonid wasp, Specimen 5087 was recovered from a nodule found at Site 19057, U.S.G.S.

Length 6.0 mm. Crystallized, but with reddish brown pigmentation on head, thorax and three abdominal segments. The head (Fig. 10b) has three round ocelli, but mouth parts are not distinct, and only the bases of antennae are present. The legs are long and slender.

## Order LEPIDOPTERA

#### FIGURE 11

A crystallized first instar larva, Specimen 5079 (Gibron #6) is an interesting addition to the series collected at Site 19057, U.S.G.S.

Size 1.03 mm. This larva has three pairs of legs, and also evidences of four pairs of prolegs, and two caudal cerci. It is presented to represent the order until certain moths found by Mrs. Kirkby can be studied.

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# ON THE RECOGNITION OF A SECOND SPECIES OF THE GENUS *PELAGOPHYCUS*[1]

E. Yale Dawson

University of Southern California, Los Angeles[2]

The Elk Kelp or Bull Kelp, *Pelagophycus*, is one of the best known seaweeds of southern California and northwestern Baja California where it grows abundantly in depths of 40-100 feet along the seaward margins of the *Macrocystis* beds. The very long stipe with its massive terminal pneumatocyst and antlers is a common sight on the beaches. It has been known and described in the scientific literature since 1822, and Setchell (1896, 1908, 1912) has given the extensive historical and descriptive accounts of it that have established the currently accepted name *Pelagophycus porra* (Leman) Setchell.

In May, 1961, Dr. Wheeler J. North, diving at the north tip of Catalina Island for a cruise of the Scripps Institution of Oceanography, noticed and photographed specimens of a peculiar "dwarf" *Pelagophycus* in which the stipes, of what appeared to be fully adult plants, were only about 1 meter long, and the 5-7 meter-long blades lay along the bottom in the manner of *Laminaria farlowii*. Inasmuch as neither he nor other experienced divers had ever seen such *Pelagophycus* plants elsewhere among the Channel Islands or along the mainland, he called my attention to them and proposed to make special collections for study. His observation brought to mind a group of juvenile, short-stiped *Pelagophycus* specimens that I had dredged at depths of 48-90 feet at Whites Cove, Catalina Island in 1948-49.

Dr. North subsequently searched on five dives along the west side of Catalina Island from Catalina Harbor to Eagle Rock without finding specimens of the *Pelagophycus* again, but upon my suggestion of White's Point on the east side, he succeeded in locating a colony near Emerald Cove from which in July, 1961, he obtained a complete series of specimens from juveniles to the largest adults present. These were growing on a bottom of sand grading into silt at depths of 50-100+ feet. The greatest concentration was at about 90 feet. Although adult

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[1] This study was conducted incidentally to other researches on Pacific marine algae under support of contract Nonr-3096(00) Amend. 2 between the Office of Naval Research and the Beaudette Foundation. Reproduction in whole or in part is permitted for any purposes of the United States government.

[2] Allan Hancock Foundation.

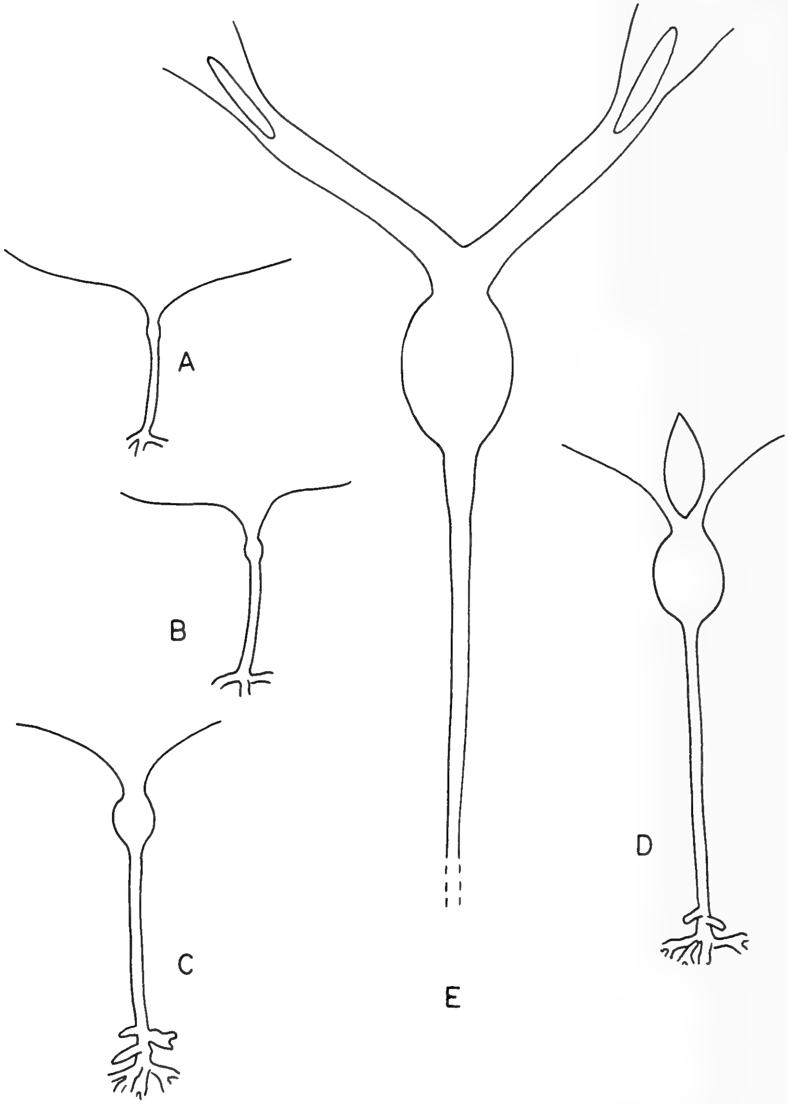

*Figure 1. Pelagophycus giganteus.* Juvenile plants collected at Catalina Island by W. North, 7/25/61 at a depth of 90 ft., showing progressive development of stipe and pneumatocyst, and division of blade. E represents a plant with 22 cm. stipe. Note early development of haptera from lower part of stipe. These plants are essentially equivalent in development to their counterparts in Fig. 2. All × 0.47.

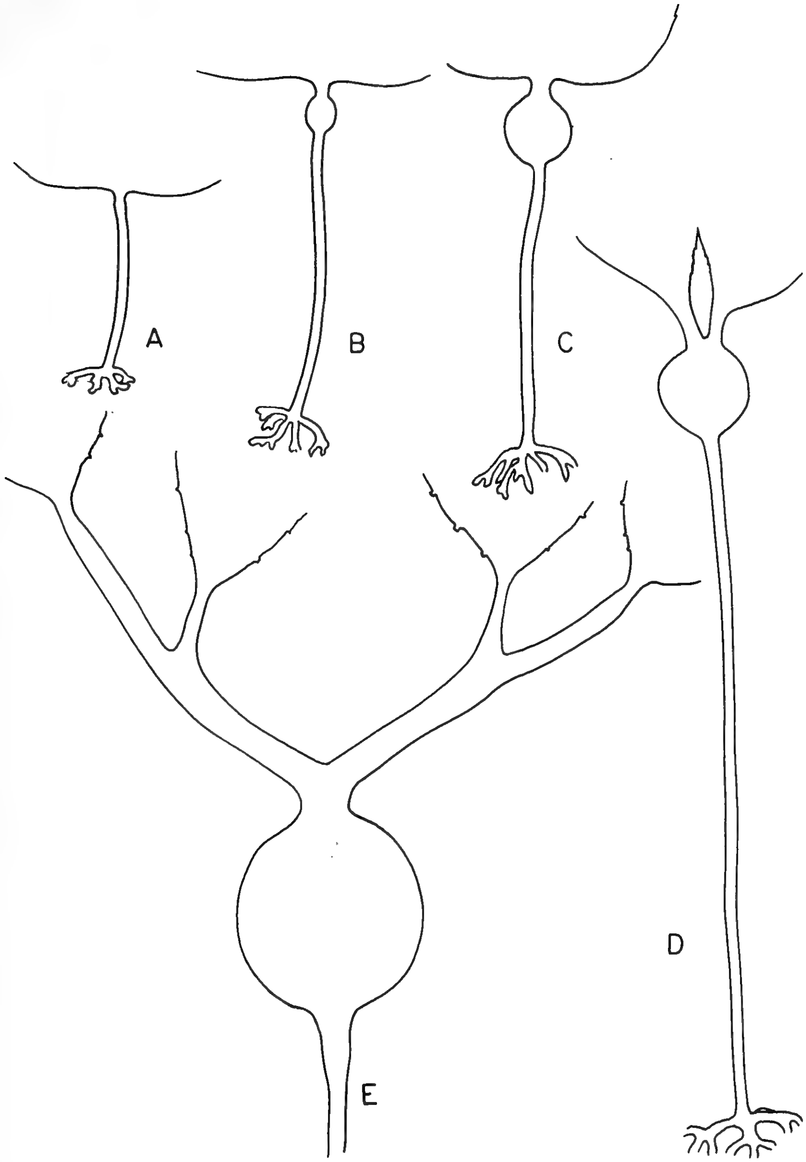

*Figure 2. Pelagophycus porra.* Juvenile plants collected at La Jolla by B. Best, 7/29/61 at a depth of 90 ft., showing progressive development of stipe and pneumatocyst, and division of blade. E represents a plant with *77* cm. stipe. These plants are essentially equivalent in development with their counterparts in Fig. 1. All × 0.47.

plants there were not so short-stiped as those observed and photographed on the west side of the island in April (10 ft. vs. 3 ft.), they nevertheless showed distinct differences from the characteristic mainland plants of *Pelagophycus porra*, and a comparison of the two forms has led to a curious discovery.

A review of the *Pelagophycus* literature revealed that the Swedish botanist Areschoug's (1876) fragmentary type specimens of *Nereocystis gigantea*, a collection by Gustav Eisen from Santa Catalina Island, is, indeed, this dwarfish plant that shows such different characters from the mainland *Pelagophycus porra*. The original description clearly shows that Areschoug had a plant with long-elliptical vesicle (5-6 cm. long, 3.5 cm. wide) and a doubly furcate "petiole" above the vesicle. The type has been reexamined for me by Dr. Sten Ahlner, curator of the Naturhistorska Riksmuseet, Stockholm. It agrees in all essential details with some of the Catalina Island topotypes recently collected by North. Five years later, in 1881, Areschoug set up the new genus *Pelagophycus* to receive Eisen's plant, but in distinguishing it from *Nereocystis* he did not recognize, working in his laboratory in Sweden, the differences between his type specimen from Catalina Island and the large plants with spherical vesicles that were known on the southern California mainland. Neither did Setchell, many years later at the University of California, recognize these differences, for his experiences were only with mainland plants at San Pedro (Fig. 3), and Areschoug's imperfect type was in Sweden. Instead, Setchell's discovery of a much earlier description by Leman (1822) of the California Elk Kelp led him to assume the Areschoug plant, the Leman plant and his own to be a single species which he called *Pelagophycus porra* according to Areschoug's genus but Leman's earlier specific epithet. It is now clear, however, that Areschoug's type actually represents a different species from the common coastal *Pelagophycus porra* and is a plant of apparently restricted insular distribution. This species, which must be known as *Pelagophycus giganteus* (Areschoug) Areschoug, is distinguished from *P. porra* according to the following comparison:

| | *P. giganteus* | *P. porra* |
|---|---|---|
| HOLDFAST | haptera developing from progressively higher levels on base of stipe, becoming extensive, to 60 cm. broad or more, spreading into sand and shell. | haptera confined to a short length of lowermost stipe, not extensive, 10-15 (20) cm. broad, usually attached to a rock. |

| | *P. giganteus* | *P. porra* |
|---|---|---|
| STIPE | short, 10-35 cm. long in young plants, reaching a maximum of about 2.5-3 meters. | long, 1-3 meters in young specimens, to 20-27 meters long in adults. |
| VESICLE | elliptical, to 12 cm. long, 9 cm. wide. | essentially spherical, 12-20 cm. in diameter. |
| ANTLERS | flattened. | essentially cylindrical. |
| BLADES | 4 only in number, comparatively large in young plants, much longer than the stipe, lying undulately along the bottom. | usually 8, but sometimes 12-20, not especially large in young plants, usually shorter than the stipe. |

Except for specimens from the vicinity of San Pedro and La Jolla, California, actual herbarium records of *Pelagophycus* are few. This is largely due to the excessive size of the plant which makes preparation

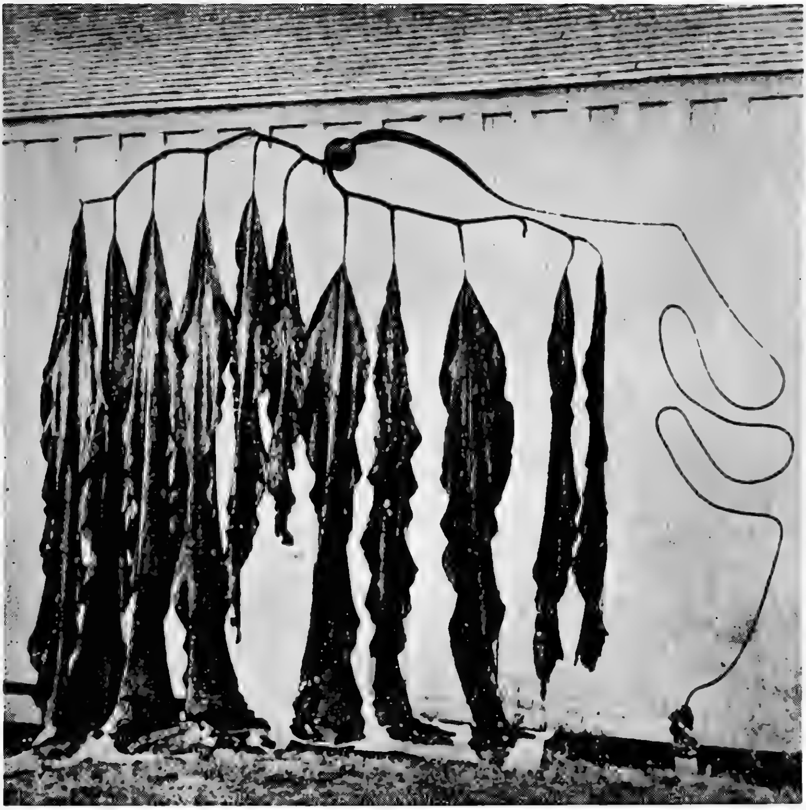

*Figure 3. Pelagophycus porra.* A complete plant of medium size collected and photographed by W. A. Setchell at San Pedro, Calif., in 1895. Note the numerous blades, small holdfast and spherical vesicle giving rise to cylindrical "antlers."

difficult. Accordingly, our knowledge of the range is based mainly on observations.

From north to south the distribution of *Pelagophycus porra* is represented as follows:

Entrance to Tomales Bay, Central California. Drifted specimen only.

Santa Cruz Island, at 15-16 fms., between Smugglers Cove and Yellow Banks anchorage. This C. L. Hubbs field note is verified by personal communication with Dr. Thomas Sharp and Robert Fritzen who report individuals 30-40 ft. long, almost certainly of *P. porra*. These men and Dr. North searched Anacapa Island but found no *Pelagophycus*.

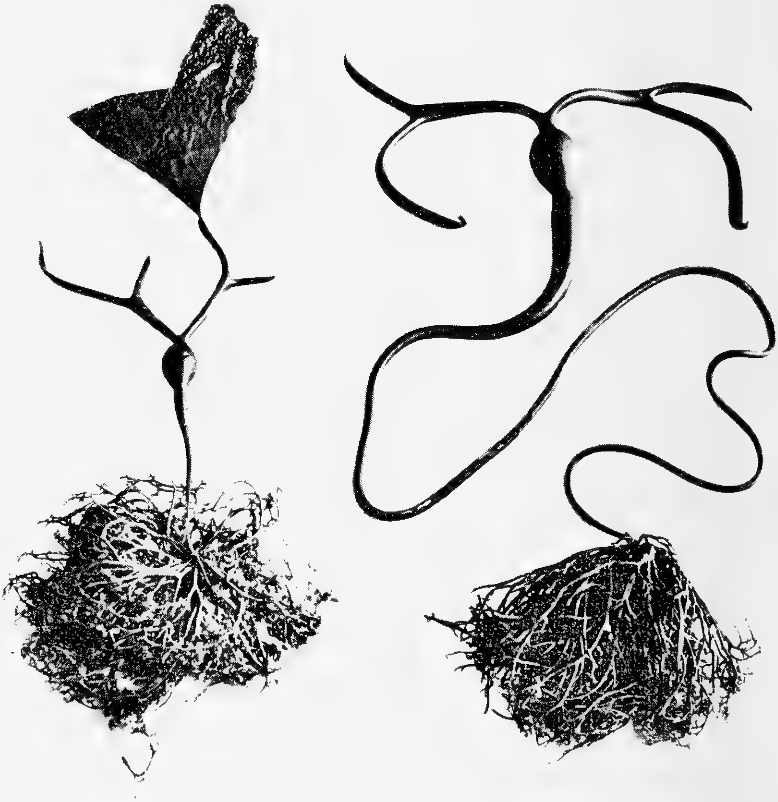

*Figure 4. Pelagophycus giganteus.* A medium size plant (left) and an adult plant (right) collected at Catalina Island by W. North. Note the large spreading holdfasts, the relatively short stipes and the elliptical vesicles giving rise to flattened, twice-furcate "antlers."

San Pedro, California. Setchell 1146, Dec. 1895, 12 fms. (Herb. U.C.)

La Jolla, California. Several herbarium specimens in Herb. Hancock and Herb. U.C. Many observations by W. J. North from La Jolla to Point Loma at depths of 40-100 ft.

San Diego, California. Several specimens from San Diego Bay and Coronado Island in Herb. U.C. An extensive bed at Point Loma examined by Dr. North.

Off Tijuana Slough, Baja California, at depth of 120 ft. midway between Point Loma and Islas Coronados. Observed by J. R. Stewart, early 1957.

Islas Coronados, Baja California. Abundant at about 70 ft. on a bank about 6 miles southeast of Isla Coronado del Sur. Observed by J. R. Stewart and considered to be the largest colony known in Baja California.

Bahia de Todos Santos, Baja California. Specimen in Herb. Farlow.

Punta San Jose, Baja California. Observations by Dr. Michael Neushul, Nov. 18, 1957: "many plants up to 15 m. long at a depth of 18 m. About half of them had a peculiar bend in the stipe [at about the point of transition from solid stipe to hollow vesicle]."

Punta San Jose to Isla San Martin. Observed on several occasions from shipboard by Charles Martin. Some plants assuredly attached.

Islas San Benitos. Drifted specimens observed by the writer.

Apparently absent at Bahia Tortuga where North searched extensively between depths of 25 and 80 ft.

*Pelagophycus giganteus* is known positively only from Santa Catalina Island: the Gustav Eisen type; Dawson 5609, 5599, 8055, Silva 4229, all from 8-15 fms. at White Cove; Silva 4261, cast ashore White Cove; Dawson 4794, floating near Avalon; North 7/25/61, Emerald Cove, 50-100 ft. (Fig. 1, 4); North, May 1961 (color photograph only) north tip, west side, while setting anchor.

Young *Pelagophycus* plants now thought by North possibly to be *P. giganteus* were observed at the outer edge of the *Macrocystis* bed at the northeast end of San Clemente Island, Jan. 28, 1957. "The *Pelagophycus* was noted at the bottom of a cliff estimated at 20 ft. high; the divers remained at the top of the cliff which was at a depth of about 100 ft." Neushul reports similar observations of *Pelagophycus* at San Clemente Island on the same date: "Northwest Harbor at 50 ft.; west side of island at 78 ft." A fragmentary specimen, probably of this species but lacking stipe and pneumatocyst, from Wilson Cove, San

Clemente Island is in Herb. U.C.: Silva 4715, Feb. 22, 1949, pulled up on anchor from 12 m.

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# BLOOD PARASITES OF MAMMALS OF THE CALIFORNIAN SIERRA NEVADA FOOTHILLS, WITH SPECIAL REFERENCE TO *TRYPANOSOMA CRUZI* CHAGAS AND *HEPATOZOON LEPTOSOMA* SP. N.

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## Introduction

Blood films were made from 509 native mammals during the summers of 1950, 1951, and 1952 at the San Joaquin Experimental Range, O'Neals, Madera Co., California, while the writer engaged in the study of the ecology of parasitic diseases, especially *Trypanosoma cruzi* Chagas. Four more samples were received in 1953, bringing the total to 513. This sampling program was greatly facilitated by concurrent studies of other investigators on the mammals and reptiles in areas where permanent drift traps were maintained. The prime purpose of this paper is to identify and enumerate the blood protozoa.

The writer is indebted to the Pacific Southwest Forest and Range Experiment Station, Berkeley, for use of facilities at the San Joaquin Experimental Range, O'Neals, California; to Dr. E. L. Biberstein, University of California, Davis, for identification of the spirochetes; to Dr. F. D. Wood for suggestions in preparation of the figures; and to Dr. G. H. Ball, University of California, Los Angeles, for supervision of and helpful suggestions in preparation of the manuscript.

Previous publications on trypanosomes in conenose bugs (Wood, 1950), contaminative effect of conenose bugs (Wood, 1951a), trypanosome development in bat bedbugs (Wood, 1951b), annoyance by house invading conenose bugs (Wood, 1951c), occurrence of blood parasites in 215 range mammals (Wood, 1952a), bug and mammal transport (Wood and Wood, 1952), natural occurrence of *Trypanosoma cruzi* (Wood, 1952b), and prevalence of ectoparasites (Augustson and Wood, 1953) have dealt with related studies in this area. Additional details of the general environment, wildlife habitat and related investigations can be found in Hutchison and Kotok (1942) and Reppert and Green (1958).

## Materials and Methods

Most live animals were transported in small wire cages or live traps to the headquarters laboratory building where a fresh blood sample and one blood smear were taken from each animal. The fresh blood was examined immediately and if spirochetes, trypanosomes, or *Plasmodium* microgametes were seen, additional smears were made.

All terrestrial mammals were marked by a standard toe clipping system of the station and released in the original area of capture. No marked land animals were recaptured. Bats were marked with aluminum numbered bands from the U. S. Fish and Wildlife Service and some individuals were recaptured at irregular intervals, usually in new roosts.

Rodents were run into wire cylinders from transport cages or live traps and blood taken from the clipped tail or ears before marking. *Microtus* and *Peromyscus* were sampled from ear veins. Dead animals were sampled from the heart in addition to tissue touch preparations from internal organs. Some samples were taken at the field plots where ecological studies were under way. Since this is a dry dusty area for most of the year, the smears show the usual contaminants of field prepared slides.

Slides were stained with Jenner-Giemsa, labelled and stored for future study. The 1950 slides were mounted in Piccolyte and all others in Grubler's Euparal Green.

Rapid examination of the summer 1950 slides revealed 30 infections. The recognition of pathological blood patterns and abnormal cells led the writer to use differential blood counts in searching for parasites in all other slides. A minimum of 200 leukocytes was counted on all slides reported here. This technique resulted in detection of many more parasites as noted below although some increase is attributable to seasonal sampling.

The per cent of host cells infected and the number of parasites for each 100 leukocytes were recorded for each differential count. Since age of infection was unknown, great variation in numbers of leukocytes was expected. Differentiation of neutrophils is the same as previously used for *Peromyscus californicus* (Wood, 1937).

## OBSERVATIONS

One hundred twenty-five bacterial, protozoal, and helminthological blood infections were found in 513 mammals representing 19 genera and 22 species, a general infection rate of 24.3%. Thirty infections, or 13.9%, were recognized in 1950 from 215 mammals. Seventy-seven infections, or 34.1%, were detected in 225 in 1951 and 19, or 26%, were found in 73 examined in 1952 (69) and 1953 (4).

Table 1 lists the number of uninfected and infected hosts. Chroma-

### TABLE 1

Blood parasites of mammals from the San Joaquin Experimental Range, O'Neals, California

| HOSTS | Totals | Negative | Bacteria | | Protozoa | | | | | | | Worms |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Trypanosoma* | | | | | | | |
| | | | *Haemobartonella* | *Borrelia* | *cruzi* | *microti* | *neotomae* | *peromysci* | *vespertilionis* | *Plasmodium* | *Hepatozoon* | *Microfilaria* |
| | | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ | ♂ ♀ |
| *Antrozous pallidus pacificus* | 142 | 58, 49 | | 1 | | | | | 12, 3 | 10, 9 | | |
| **Eptesicus fuscus bernardinus* | 11 | 2, 7 | | | | | | | 1 | | | 1 |
| *Microtus californicus mariposae* | 76 | 26, 16 | 1 | | | 11, 6 | | | | | 11, 10 | 1 |
| *Neotoma fuscipes streatori* | 13 | 4, 7 | | | | | 2 | | | | | |
| *Perognathus californicus ochrus* | 7 | 2 | 1, 4 | | | | | | | | | |
| *Perognathus inornatus inornatus* | 14 | 9, 4 | 1 | | | | | | | | | |
| *Peromyscus boylii boylii* | 48 | 20, 20 | 1 | 1 | | | | 1, 4 | | | 1, 1 | |
| *Peromyscus maniculatus gambelii* | 86 | 43, 35 | | | | | | | | | 4, 3 | 1 |
| *Peromyscus truei gilberti* | 52 | 15, 19 | 2, 1 | 4, 1 | | | | 3, 2 | | | 3, 3 | |
| *Reithrodontomys megalotis longicaudus* | 2 | 1 | 1 | | 2, 1 | | | | | | | |
| | | TOTALS: | 12 | 7 | 3 | 17 | 2 | 10 | 16 | 19 | 36 | 3 |

*Collected at North Fork, California

### TABLE 2

Seasonal blood parasite infection summary for *Peromyscus and Microtus*

| Rodent Host | Spring | | | Summer | | | Winter | | |
|---|---|---|---|---|---|---|---|---|---|
| | Neg. | Pos. | % | Neg. | Pos. | % | Neg. | Pos. | % |
| *Microtus californicus mariposae* | 28 | 11 | 28.2 | 46 | 20 | 30.3 | | 2 | 100 |
| *Peromyscus boylii boylii* | 6 | | | 23 | | | 19 | 8 | 29.6 |
| *Peromyscus maniculatus gambelii* | 18 | 4 | 18.1 | 47 | | | 21 | 4 | 16 |
| *Peromyscus truei gilberti* | 9 | 6 | 40 | 33 | 10 | 23.2 | 10 | 1 | 9 |

tin remnants representing nuclear fragments of *Hepatozoon* or *Trypanosoma* were found in the monocytes on smears from 4 ♂ and 4 ♀ *Microtus californicus mariposae* R. Kellogg, 4 ♂ and 1 ♀ *Peromyscus boylii boylii* (Baird) and 3 ♂ *Peromyscus truei gilberti* (J. A. Allen). This means these rodents were infected at the time sampled although no intact parasites or trypanosome "shadows" could be found. The nuclear-like structure of these larger granular masses of irregular size but generally spherical shape is distinct from the occasional small azurophil granules seen in normal monocytes.

Double infections with *Hepatozoon citellicola* and *Trypanosoma microti* were found in 3 ♂ and 3 ♀ *Microtus californicus. Trypanosoma microti* and microfilariae were found in 1 ♀ *Microtus. Hepatozoon muris* with *Trypanosoma cruzi* was found in 1 ♂ *Peromyscus truei. Hepatozoon muris* and *Trypanosoma peromysci* were found in 1 ♂ and 1 ♀ *Peromyscus truei. Borrelia* and *Haemobartonella* were found in 1 ♀ and *Haemobartonella* with *Hepatozoon muris* in another ♂ *Peromyscus truei.*

Special effort was made to trap *Peromyscus* since this rodent was found previously to be susceptible to infection with *Trypanosoma cruzi* from California sources (F. D. Wood, 1934, S. F. Wood, 1937). General results for these rodents are summarized in Table 2 and indicate an infection rate of 20.4%.

Figures 1 and 2 of Plate I are the first illustrations of *Trypanosoma cruzi* from a naturally infected native host in California. The typical regressive C form blood trypanosome (Pl. I, Fig. 1) was found in a 375 sq. mm. smear from 1 ♂ *Peromyscus truei gilberti* trapped 8-IV-52 from the garage shed near the horse barn in the headquarters area. The trypanosome shows a deep basophilia characteristic of active forms resident in the blood for some time.

Slides from a previously reported *Peromyscus truei gilberti* revealed five typical blood forms in one thick drop and the one intact parasite of Pl. I, Fig. 2 (Wood, 1952b). This transitional regressive parasite shows increasing vacuolization and volutinization associated with the assumption of a rounded body form between figs. 2 and 3 of Pl. I of Wood (1953). The lighter, more dispersed basophilia is a reflection of the increased volume of the parasite preparatory to fission. The flagellum and undulating membrane begin resorption as the kinetoplast complex becomes more rounded and the parasite folds upon itself assuming the rounded leishmaniform shape. These parasites probably drift into capillary networks where, if host resistance is overcome, they complete regression to the leishmaniform stage and by cell division

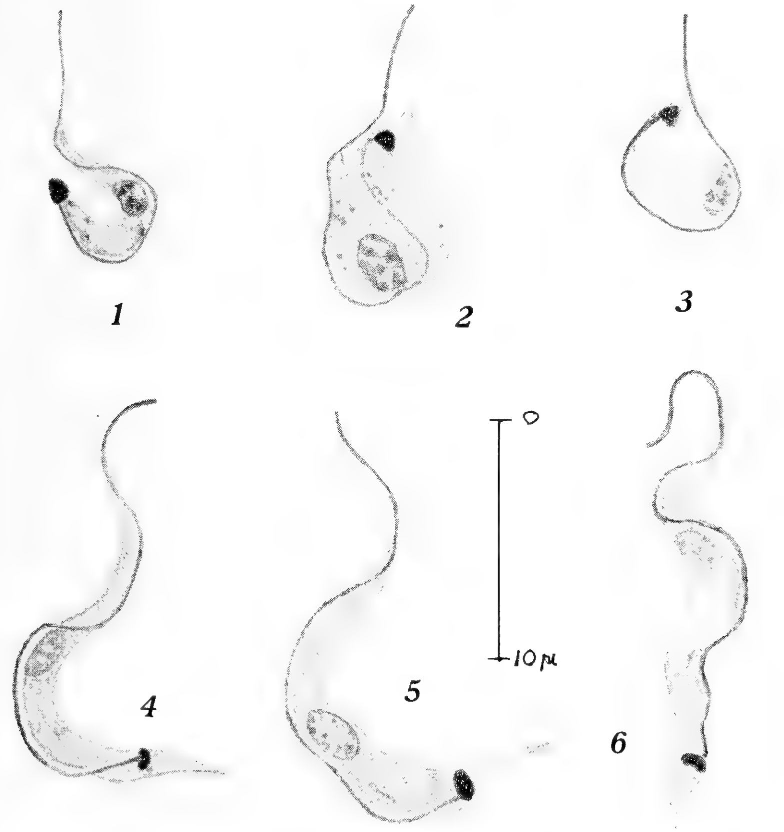


*Plate I.* All figures were drawn with the aid of a camera lucida. *Fig. 1.* Typical regressive C form *Trypanosoma cruzi* from ♂ *Peromyscus truei gilberti*, 8-IV-52. *Fig. 2.* Circulating regressive *Trypanosoma cruzi* from ♀ *Peromyscus truei gilberti*, 6-VII-50. *Fig. 3.* C form *Trypanosoma vespertilionis* from tissue contact lung preparation of ♂ *Antrozous pallidus pacificus*, 22-VIII-50. *Fig. 4. Trypanosoma peromysci* from ♀ *Peromyscus b. boylii*, 30-XII-51. *Fig. 5. Trypanosoma microti* from ♂ *Microtus californicus mariposae*, 26-VI-51. *Fig. 6. Trypanosoma neotomae* from ♂ *Neotoma fuscipes streatori*, 8-IV-52.

give rise to more progressively differentiating parasites which repopulate the blood stream as does *Trypanosoma zapi* (Davis, 1952). Recent studies by Rêgo (1956) report developmental forms of *Trypanosoma cruzi* in the circulating blood of white mice. This is probably the way long standing light blood parasitemias are maintained although limited foci of reticulotropic or myotropic forms are also present.

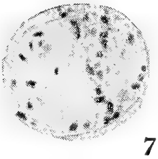
*Microtus* neutrophils averaged 2.7 (6.6%) segemented forms (0.5 to 7), 27.6 (68.5%) type (a) cells (8 to 53.5), 8.8 (21.7%) type (b) cells (0.5 to 23), and 1.3 (3.2%) unsegmented forms (0 to 4.5) for each 100 leukocytes from 23 infected voles. Six *Microtus californicus* revealing infections with *Hepatozoon citellicola* (Pl. II, Figs. 9 and 10) during the differential counts showed 7.1% (3.2 to 15.5) infection of monocytes. Three of these voles also revealed 81.1% (66.6 to 100) infection of unsegmented neutrophils or 14.2% (1.8 to 37.7) of all classes of neutrophils. Trypanosome and hepatozoan infections stimulate a shift to the younger type (b) and unsegmented neutrophils. In six double infections with *Trypanosoma microti* (Pl. I, Fig. 5) and *Hepatozoon*, trypanosomes averaged 111.6 (0.5 to 328.5), hepatozoans (2 infections) 0.5, one parasite in a monocyte (5.8%) and one in an unsegmented neutrophil (100%). For seven voles with *T. microti* only, trypanosomes averaged 38.7 (1 to 111.5).

Monocytes averaged 23.7% (10 to 35) for 14 infected *Peromyscus*. Neutrophils for these same mice averaged 0.6 (2.2%) segmented forms (0 to 3), 15.9 (59.3%) type (a) cells (4.5 to 43), 7.1 (26.4%) type (b) cells (1 to 21), and 3.2 (11.9%) unsegmented forms (0 to 11) for each 100 leukocytes. In one *Peromyscus boylii* with *Hepatozoon muris* (Pl. II, Fig. 11) three parasites were found in monocytes (9.6%). In four mice with *Trypanosoma peromysci* (Pl. I, Fig. 4), trypanosomes averaged 280.7 (32 to 805).

In three *Peromyscus maniculatus gambelii* (Baird), *Hepatozoon leptosoma* (Pl. II, Figs. 13 and 14) averaged 3.6 (0.5 to 8) with 6.5% (2.3 to 10) in monocytes and 45.8% in unsegmented neutrophils (two mice).

In *Peromyscus truei*, one mouse with *Hepatozoon muris* (Pl. II, Fig. 12) and *Trypanosoma cruzi* (Pl. I, Fig. 1) revealed 1.5 hepatozoans in monocytes (7.8%) and two mice with *H. muris* and *T. peromysci* revealed 0.5 hepatozoans, 0 and 1, in monocytes (6.2%) and 8.7 trypanosomes, 0 and 17.5. Two mice with *T. peromysci* only averaged 24.2 trypanosomes (0 and 48.5) for each 100 leukocytes.

The following mammals were negative for blood parasites: 2 ♂, 1 ♀ *Spermophilus beecheyi fisheri*, 14 *Dipodomys heermanni tularensis*, 1 ♂ *Eutamias m. merriami*, 1 ♂, 1 ♀ *Lepus c. californicus*, 1 ♂ *Lynx rufus californicus*, 2 ♂, 4 ♀ *Myotis yumanensis sociabilis*, 1 ♀ *Pipistrellus hesperus merriami*, 1 ♂, 2 ♀ *Procyon lotor psora*, 1 ♀ *Scapanus l. latimanus*, 1 ♂, 7 ♀ *Sylvilagus audubonii vallicola*, 2 ♂ *Tadarida brasiliensis mexicana*, and 13 ♂, 7 ♀ *Thomomys bottae mewa*.



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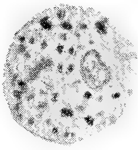

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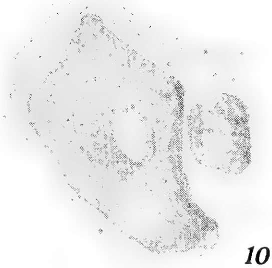

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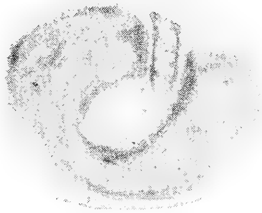

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*Plate II. Fig. 7.* Microgametocyte of *Plasmodium* sp. from ♂ *Antrozous pallidus pacificus*, 9-VII-51. *Fig. 8.* Macrogametocyte of *Plasmodium* sp. from ♂ *Antrozous pallidus pacificus*, 9-VII-51. *Fig. 9. Hepatozoon citellicola* in monocyte from ♂ *Microtus californicus mariposae*, 19-IV-51. *Fig. 10. Hepatozoon citellicola* in unsegmented neutrophil from ♂ *Microtus californicus mariposae*, 19-IV-51. *Fig. 11. Hepatozoon muris* in a monocyte from ♂ *Peromyscus b. boylii*, 30-XII-51. *Fig. 12. Hepatozoon muris* from a monocyte from ♂ *Peromyscus truei gilberti*, 8-IV-52. *Fig. 13. Hepatozoon leptosoma* sp. n., freed by rupture from a monocyte from ♀ *Peromyscus maniculatus gambelii*, 8-IV-52. *Fig. 14. Hepatozoon leptosoma* sp. n., in a monocyte from ♀ *Peromyscus maniculatus gambelii*, 8-IV-52.

*Hepatozoon citellicola* (Wellman and Wherry, 1910)

Gametocytes (Pl. II, Figs. 9 and 10) on one stained slide from a California vole, *Microtus californicus*, averaged 9.3 $\mu$ long (8.1 to 10.3) by 3.9 $\mu$ wide (3.3 to 4.5) for 25 specimens chosen at random. The gametocyte nuclei of these parasites averaged 4.2 $\mu$ long (3.9 to 5.1) by 3.3 $\mu$ wide (3 to 3.9).

This sausage-shaped parasite exhibits a distinct limiting plasma membrane which pulls away from the host cell cytoplasm in some cells. The lightly basophilic cytoplasm appears irregularly vacuolated towards each end of the cytosome. The average number of metachromatic granules was 9.8 (6 to 14) for the 25 parasites. These are similar to volutin granules of trypanosomes and occur in the nuclear area or scattered through the cytoplasm. Most parasites lie parallel to the main axis of orientation of the monocyte nucleus but occasionally the organism lies within the crescentic cavity of the horseshoe shaped structure.

The parasite nucleus is irregularly oval or rounded in shape tending to be slightly elongate. The peripheral chromatin (basichromatin) appears in irregular clumps or bands separated by compact or broad irregular parachromatin (oxychromatin) spaces and surrounding a less dense central core of nucleoplasm.

*Hepatozoon citellicolla* is parasitic in the monocytes and unsegmented neutrophils of the blood of *Microtus californicus mariposae*, San Joaquin Experimental Range, O'Neals, California. There is no way at present of distinguishing this parasite from that described by Wellman and Wherry (1910) from the California ground squirrel, *Spermophilus beecheyi*. Since the same species of ground squirrel is commonly associated with the foothill mammals studied here, their name is used in preference to *Hepatozoon microti* (Coles, 1914) until more data is available on the life cycle.

The host cells of the blood of the vole are the unsegmented neutrophils and monocytes. The cytoplasm of the unsegmented neutrophil is moderately basophilic, lightly vacuolated, and with none or a few distinct neutrophilic granules.

The ring shaped neutrophil nucleus shows a compact chromatin structure similar to the smaller monocytes and larger lymphocytes. Where the central aperture has enlarged and the circular, band-form nucleus has become more labile, the parasite may extend into the immature neutrophils have not yet developed their distinctive granulation. Older cells with more irregular banded nuclei show the diagnostic granules clearly. One segmented type (a) neutrophil showed *Hepatozoon* remnants in the densely granulated cytoplasm similar to those seen in monocytes.

The moderately basophilic monocyte cytoplasm has a lightly vacuolated and granular appearance. Granules are fine or coarse. The finely granular appearance is due to the presence of normal azurophil spherules similar to that found in the blood of other rodents. The coarse granules, numbering 22 to 27 in the cells counted, are breakdown products of the nuclei of hepatozoans or trypanosomes as shown by the similar structure and staining in the nuclei of these parasites. The general absence of a perinuclear halo, variable shaped nuclear structure, and extensive less basophilic cytoplasm distinguish this cell from the lymphocyte. There are medium sized lymphocytes in *Microtus* blood with looser chromatin organization suggesting a transition form to the monocyte.

The monocyte nucleus has broad or narrow dense chromatin masses with narrow or broad irregular parachromatin spaces. In younger cells it is rounded or slightly crescentic. Older parasitized cells show an elongate C shaped structure in which occasionally the lobes are folded back over each other. The labile nucleus in one instance was folded S like along one side of the cytosome.

Specimens are deposited at the Department of Zoology, University of California, Los Angeles.

### *Hepatozoon muris* (Balfour, 1905)

Gametocytes (Pl. II, Figs. 11 and 12) on one slide from Boyle's white-footed mouse, *Peromyscus boylii*, averaged 8.2 $\mu$ long (7.8 to 9.3) by 3.5 $\mu$ wide (3 to 4.2) for 15 specimens chosen at random. The gametocyte nuclei of these parasites averaged 3.5 $\mu$ long (2.7 to 4.2) by 2.8 $\mu$ wide (2.1 to 3.3). Measurement of seven parasites from four slides of the Gilbert white-footed mouse, *Peromyscus truei*, averaged 8 $\mu$ long by 3.4 $\mu$ wide for the cytosome and 4 $\mu$ by 3.1 $\mu$ for the nuclei.

Terminal cytoplasmic caps within the parasites' plasma membrane of a substance staining similarly to the protoplasmic metachromatic granules or nuclear chromatin distinguished this parasite from all others studied here. The slightly shorter and broader cytosome occasionally reveals from two to six free metachromatic granules. The similarity in staining reaction of the substance of the cytoplasmic caps to that of the metachromatic granules and nuclear chromatin suggests origin from these cytosomal components. In some parasites, the caps form a distinct broad band, 1 to 2 u thick at the center, and tapering away to the plasma membrane halfway from the end of the cytosome to the edge of the central nucleus. Parasites freed by rupture of the host cell and those extending into the host cell protoplasm without overlying the nucleus show this structure most clearly. Although appearing homogeneous in side view in some cells, it is more granular appearing in others. This narrower parasite appears more often in varying positions in the host cell. It was found along the convex surface of the host nucleus, within the elongate U shaped lobes, or extending across the cytosome at an angle to the nucleus.

The parasite nucleus is oval or rectangular with rounded corners. The chromatin is peripherally concentrated in broad bands with irregularly shaped less extensive parachromatin spaces. Some nuclei appear nearly solid from one surface.

*Hepatozoon muris* is parasitic in the monocytes of the blood of *Peromyscus boylii boylii* and *P. truei gilberti* from the San Joaquin Experimental Range, O'Neals, California. This parasite is probably the same as the parasite described by Balfour (1905) from mononuclear leukocytes of *Mus decumanus* and whose life history was reported by Miller (1908). Although the cytoplasmic caps were indicated by Balfour (1905), Porter (1908) and Mackerras (1959), they were not mentioned by Miller (1908). Hoogstraal (1957) noted these "caps" in *Hepatozoon balfouri.*

The monocyte cytosome exhibits a lightly basophilic reticulated cytoplasm often suggesting an alveolar pattern. There is sometimes a perinuclear halo.

The monocyte nucleus shows broad homogenous, dense basichromatin masses separated with a few irregular, parachromatin spaces detracting little from the general homogeneity of the structure. The oval or slightly indented nucleus of normal cells becomes U shaped in response to parasitism.

Specimens are deposited at the Department of Zoology, University of California, Los Angeles.

## Diagnosis

### **Hepatozoon leptosoma,** NEW SPECIES

Gametocytes (Pl. II, Figs. 13 and 14) on one slide from a Gambel white-footed mouse, *Peromyscus maniculatus*, averaged 10.5 $\mu$ long (9.6 to 11.5) by 2.1 $\mu$ wide (1.8 to 2.7) for 15 specimens chosen at random. The gametocyte nuclei of these parasites averaged 4.6 $\mu$ long (2.4 to 6) by 1.7 $\mu$ wide (1.5 to 2.4).

The elongated, crescent shaped parasite often occupies a position within the concavity of the horseshoe-shaped nucleus of the monocyte (Pl. II, Fig. 14). It is sharply delimited by a distinctly stiff plasma membrane. It is narrowly elongate and crescentic with slightly basophilic, more homogeneous cytoplasm containing from five to twelve metachromatic granules in some specimens. Although the commonest orientation of the parasites is enclosed in the arms of the U shaped nucleus of monocytes, some parasites lie under the plasma membrane of the unsegmented neutrophils on the concave or convex side of the host cell nucleus. In one instance, a parasite extended through the opening of the neutrophil nucleus. In some parasites with terminally displaced nuclei, a clearer large vacuolated area occupied the opposite end of the cytosome.

In surface view, the oblong parasite nucleus consists of broad chromatin bands with narrow irregular parachromatin spaces (Pl. II, Fig. 13). In some nuclei the bulk of the chromatin was distributed peripherally presenting a tube effect with a central nucleoplasmic core. In other parasites, the nuclear chromatin appeared barrel shaped with parachromatin scattered through the nucleoplasmic core. In one instance, the chromatin and parachromatin mass appeared cup-shaped.

*Hepatozoon leptosoma* is parasitic in the monocytes and unsegmented neutrophils of the blood of *Peromyscus maniculatus gambelii* at the San Joaquin Experimental Range, O'Neals, California.

The host monocyte is similar to those described for *Peromyscus californicus insignis* (Wood, 1937). Most nuclei of monocytes have an elongate C shape enclosing the parasite. There are also numbers of unsegmented neutrophils with heavy ring shaped nuclei of broad basichromatin bands and narrow oxychromatin spaces crowding the parasite to the edge of the cytosome.

*Hepatozoon leptosoma* may be distinguished from other California rodent hepatozoans by size, narrow elongate form and preferred host.

Type specimens are deposited in the Department of Zoology, University of California, Los Angeles.

## XENODIAGNOSIS

Xenodiagnosis was carried out for 186 mammals in 1950, 99 in 1951 and 71 in 1952 and 1953. The 356 mammals included 253 rodents, 91 bats, 8 rabbits, 2 raccoons and 2 domestic cats. This involved the feeding of 1,275 conenose bugs, mostly laboratory raised, including

896 *Triatoma p. protracta* (Uhler), 321 *T. rubida uhleri* (Neiva), 49 *Paratriatoma hirsuta* Barber, and 9 *Triatoma recurva (longipes)* Stål. Most of these bugs were 1st and 2nd instar nymphs at time of initial blood meal.

The 12 infections in *Triatoma p. protracta* were from three Gilbert white-footed mice, *Peromyscus truei gilberti*, from the range headquarters area. Six 1st instar nymphs fed on 1 ♀ trapped 6-VII-50 in an old wood pile, three of four 1st fed on 1 ♂ trapped 13-VII-50 near buildings, and three 2nd fed on 1 ♂ trapped 8-IV-52 from the open garage shed near the horse barn showed metacyclic *Trypanosoma cruzi* in voluntary fecal droplets released from the 94th to 104th days after the original infective meal.

## Discussion

Miller (1908) used the term mononuclear for lymphocytes of the rat but listed the infected cells as large lymphocytes. Harris (1960) points out that only monocytes and neutrophils are phagocytic. Miller (1908) states that *Hepatozoon* is engulfed by the host cell with no effect on it but Balfour (1905), Porter (1908) and Laird (1959) infer active penetration of the host cell or nucleus by the parasite. If *Hepatozoon* actively penetrates the host cell, it could be found in any adaptable blood cell. If we follow Harris (1960) and Miller (1908) as to engulfment, then the host cells are neutrophils or monocytes. *Hepatozoon canis* is reported from neutrophils (Laird, 1959). If the *Hepatozoon* gametocyte is mature when released by the internal tissue cells, engulfment would seem logical. In some species the red blood corpuscles are invaded and "young" gametocytes are found so this would indicate active penetration (Hoogstraal, 1957, Wellman and Wherry, 1910). In heavy *Hepatozoon citellicola* infections of *Microtus*, both monocytes and neutrophils contain parasites but not the lymphocytes. Coles (1914) reported karyolytic action on the monocyte nucleus in *Hepatozoon microti* which was not noted here. The above observations suggest engulfment of *Hepatozoon citellicola* by the host cells in view of known function (Harris, 1960). Research on the cellular reactions to *Hepatozoon* might add new insight to the functions of leukocytes.

Analysis of the data as to season reflects the relationship of environmental temperature to intensity of blood parasitemias. This is a definite clue to use for retrieving material for additional study with the exception of those mammals restricted to warmer activity periods as bats. Summer samples numbered 378, spring 76, and winter 59 with 74, 23, and 20 infections, respectively, for rates of 19.5, 31.2 and 33.8

per cent. If we deduct the bats from the summer total, the infection rate drops to 17.1%.

Of the 162 bats examined, 37 or 22.8% were infected. These mammals offer a special study of the relationship of *Trypanosoma cruzi* and *T. vespertilionis* which are closely allied species as shown in Pl. I, Figs. 1 and 3. The life cycle of the *Plasmodium* (Pl. II, Figs. 7 and 8) from *Antrozous* deserves intensive study since this bat can be maintained in captivity.

The use of the differential leukocyte count is well known as a diagnostic aid in clinical hematology. It was used here as an aid in enumerating and finding blood parasites, and to standardize coverage of the smear. The same problem exists here for differentiation of lymphocytes and monocytes as occurs in human blood (Fey, 1958, Harris, 1960). Until detailed studies of normal blood of native rodents are made, it is not possible to relate accurately changes in the blood picture to infection. Therefore, the writer has used normal figures for *Peromyscus californicus* and *Mus musculus* for the comparisons indicated below.

The structure of the rodent monocyte host cell is similar to that of human blood in size of the cytosome, extent and staining of the cytoplasm and the usual absence of a perinuclear halo. The dense banded and blotched pattern of basichromatin with little oxychromatin is more distinctive of lymphocyte nuclei than monocytes where the amount of basichromatin and oxychromatin is more equal. The extensive cytoplasm of these leukocytes of *Peromyscus* and *Microtus* and the variable nuclear shape in an irregular S, C or U form agrees with the differentiation for white mice (Fey, 1958). There is also considerable numerical variability in normal white mice (Snell, 1941). Detailed study of monocytes and lymphocytes led to the recognition of the parasite remnants from normal cytoplasmic granulation. Both hepatozoans and trypanosomes contribute to these remnants. Similar chromatin remnants have been reported in polymorphonuclear neutrophils for *Hepatozoon canis* (Laird, 1959).

Differential leukocyte counts on 12 normal *Peromyscus californicus* revealed 27% neutrophils, 7% eosinophils, 3% basophils, 9% monocytes, and 54% lymphocytes since rodent lymphoid cells with wide zones of cytoplasm are now considered monocytes (Fey, 1958, Harris, 1960, Wood, 1937). Normal differential counts for white mice of various strains averaged 18% neutrophils, 2% eosinophils, 11% monocytes, and 69% lymphocytes (Snell, 1941). Niño (1929) studying the blood picture of white mice infected with virulent *Trypanosoma cruzi* found an initial lymphocytosis followed by a neutrophil leukocytosis 25 to 35 days after infection. The high neutrophil count then persisted in numerical balance with the lymphocyte count until death. Since Niño did not separate monocytes and the age of the wild infections here is unknown, it is not possible to compare the two sets of data.

Tabulated differential leukocyte counts here revealed a monocytosis with marked reduction of neutrophils for three *Peromyscus boylii* with *Trypanosoma peromysci* and four *P. truei*, one with *T. cruzi*, two with *T. peromysci*, and one with *T. peryomysci* and *Hepatozoon muris*. A monocytosis only was found in one *P. boylii* with *Hepatozoon muris* and one *P. truei* with *T. cruzi*. A neutrophil leukocytosis was found in one *P. maniculatus* with *Hepatozoon leptosoma* and two *P. truei*, one with *T. cruzi* and one with *T. peromysci* but both also harboring *Hepatozoon muris*.

Differential counts for the California vole, *Microtus*, revealed a lymphocytosis with reduced neutrophils in one animal with *Trypanosoma microti*. A monocytosis only occurred in three voles with *T. microti* and one with *Hepatozoon citellicola*. A monocytosis with reduced neutrophils was found in one vole with *T. microti* and two with *T. microti* and *H. citellicola*. A neutrophil leukocytosis was found in two voles with *T. microti*, seven with *H. citellicola* and two with both infections.

Galliard *et al.* (1959) demonstrated persistent low grade parasitemias in white mice with chronic infections of *Trypanosoma cruzi* long after experimental infection of the same mice with *Borrelia duttoni* and *B. crociduri*. Therefore, the presence of spirochetes in the blood of *Peromyscus truei* is probably an important factor in maintenance of *T. cruzi* infections in native rodents of California.

## Summary

Blood infections of mammals with *Haemobartonella* (12), *Borrelia* (7), *Trypanosoma cruzi* (3), *T. microti* (17), *T. neotomae* (2), *T. peromysci* (10), *T. vespertilionis* (16), *Plasmodium* (19), *Hepatozoon* (36) and microfilaria (3) are recorded from central California. *Hepatozoon citellicola* is reported from *Microtus californicus muriposae* and *Hepatozoon muris* from *Peromyscus boylii boylii* and *Peromyscus truei gilberti*. *Hepatozoon leptosoma* sp. n. is described from *Peromyscus maniculatus gambelii*.

Differential leukocyte counts used in finding parasites revealed a neutrophil leukocytosis, lymphocytosis and monocytosis in infections with trypanosomes and hepatozoans.

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# A NEW SPECIES OF CHIGGER, GENUS *EUSCHOENGASTIA* (ACARINA, TROMBICULIDAE), WITH NOTES ON OTHER SPECIES OF CHIGGERS FROM THE SANTA ANA MOUNTAINS, CALIFORNIA

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Examination of available specimens of several species of mammals, from the Santa Ana Mountains and adjacent areas in Orange and Riverside counties, California, has revealed larvae of eleven species of chiggers. One species in the Genus *Euschoengastia* is described as new, and range extensions of more than 200 miles to the southeast from previous records are reported for five species. New host records are listed, along with notes on the attachment sites and their seasonal occurrence. Only the characteristics which are at variance with other published information are described. Selected scutal measurements are included for each species.

The Santa Ana Mountains are located in both Orange and Riverside counties with the county line nearly bisecting the range. The mountains are ten miles east of Santa Ana and some twenty miles from the Pacific Ocean. The range covers nearly 400 square miles and has an elevation of 5600 feet at its highest point.

The climate is affected by the position of the mountains, with southwesterly winds driving the rain-bearing clouds at a right angle to the length of the mountains. The wet season begins in December and ends sometime in April. Over 90 per cent of the rainfall occurs during these months. The rest of the year is considered the dry season. For additional information, especially on the biota, the reader should refer to Pequegnat (1951).

## Accounts of the Species

The terminology used throughout this paper is that of Wharton, *et al.* (1951), with few modifications. All of the measurements are in microns. All of the larvae were studied by means of a phase contrast microscope, with specimens mounted on slides in polyvinyl alcohol L-P medium. Readers are referred to Brennan and Jones (1959) and

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Vercammen-Grandjean (1960) for certain taxonomic changes and for keys including the species listed below.

### *Odontacarus linsdalei* (Brennan and Jones)

*Specimens examined.* Total, 17 larvae, as follows:

RIVERSIDE CO., 2½ mi. SW Lake Mathews, *Dipodomys agilis*, 16 April 1957.

*Remarks.* The above locality represents a range extension of 285 airline miles to the southeast from the type locality in Monterey County, California. Some variation was noted in the dorsal body setal formula, 8-8-8-10-12-10-6-2-2 in above, as compared to the holotype with 10-10-8-10-10-8-6-2-2. Averages of scutal measurements of 4 specimens are as follows: AW-55, PW-75, SB-25, ASB-26, PSB-18, AP-17, AM-35, AL-37, PL-39, S-72.

### *Neotrombicula californica* (Ewing)

*Specimens examined.* Total, 59 larvae, as follows:

ORANGE CO., Modjeska Canyon, *Neotoma fuscipes*, 19 Jan. 1957 (19), *Peromyscus californicus*, 19 Jan. 1957 (2), 12 March 1957 (3). RIVERSIDE CO., 2¾ mi. S, 4 mi. W Corona, Tin Mine Canyon, *Neotoma fuscipes*, 17 March 1956 (26); 3 mi. SW Lake Mathews, *Neotoma lepida*, 23 Feb. 1957 (7).

*Remarks.* Larvae were found attached to the external auditory canal and the proximal areas of the pinna. Averages of scutal measurements of 4 specimens from Orange Co. are as follows: AW-66, PW-80, SB-25, ASB-34, PSB-25, AP-28, AM-38, AL-43, PL-43, S-83.

### *Neotrombicula dinehartae* (Brennan and Wharton)

*Specimens examined.* Total, 18 larvae, as follows:

ORANGE CO., 1 mi. E O'Neill Park, Trabuco Canyon, *Peromyscus californicus*, 18 Nov. 1956.

*Remarks.* This locality represents a range extension of 285 airline miles to the southeast from the type locality in Monterey County. Chiggers were found attached to the external auditory canal with a few scattered on the ear pinna. Averages of scutal measurements of 4 specimens are as follows: AW-65, PW-89, SB-23, ASB-36, PSB-23, AP-32, AM-39, AL-55, PL-62, S-78.

## *Miyatrombicula scottae* (Brennan)

*Specimens examined.* Total, 8 larvae, as follows:

ORANGE CO., 1 mi. E O'Neill Park, Trabuco Canyon, *Peromyscus californicus*, 18 Nov. 1956.

*Remarks.* This record represents a range extension of 285 airline miles to the southeast from Monterey County. Averages of scutal measurements of 4 specimens are as follows: AW-39, PW-44, SB-12, ASB-20, PSB-26, AP-22, AM-24, AL-21, PL-31, S-32. Most of these measurements are slightly smaller than those given for the holotype.

## *Euschoengastia frondifera* Gould

(Figures D and E)

*Euschoengastia frondifera* Gould, 1956: 53.

*Specimens examined.* Total, 34 larvae, as follows:

RIVERSIDE CO., 8 mi. SSE Lake Mathews, *Neotoma lepida*, 22 Dec. 1956 (12); 3 mi. SW Lake Mathews, *Neotoma lepida*, 23 Feb. 1957 (21). ORANGE CO., Modjeska Canyon, *Peromyscus californicus*, 14 May 1957 (1).

*Remarks.* See remarks under *E. otophila* for comparison of the two species. Averages of scutal measurements from 7 types (Los Angeles Co.) and from 4 specimens from Riverside Co., in that order, are as follows: AW-62, 64, PW-80, 79, SB-30, 31, ASB-22, 18, PSB-16, 12, AP-14, 13, AM-26, 22, AL-27, 30, PL-44, 43, S-31, 34. Larvae were found attached to the external auditory canal.

## **Euschoengastia otophila,** NEW SPECIES

(Figures A-C, F and G)

*Type data.* Holotype and 30 paratypes from 1 mile east of O'Neill Park, Trabuco Canyon, Orange County, California, host *Peromyscus californicus*, field number RL561118-1, collected 18 November 1956, by R. B. Loomis. Additional paratypes from the same locality are listed below. The holotype and two paratypes will be deposited in the Rocky Mountain Laboratory, Hamilton, Montana. Paratypes, now in the collection of R. B. Loomis, will be distributed to the United States National Museum, the University of Kansas and to other appropriate institutions and individuals.

*Diagnosis.* Resembling *Euschoengastia micheneri* Gould, *E. lanceo-*

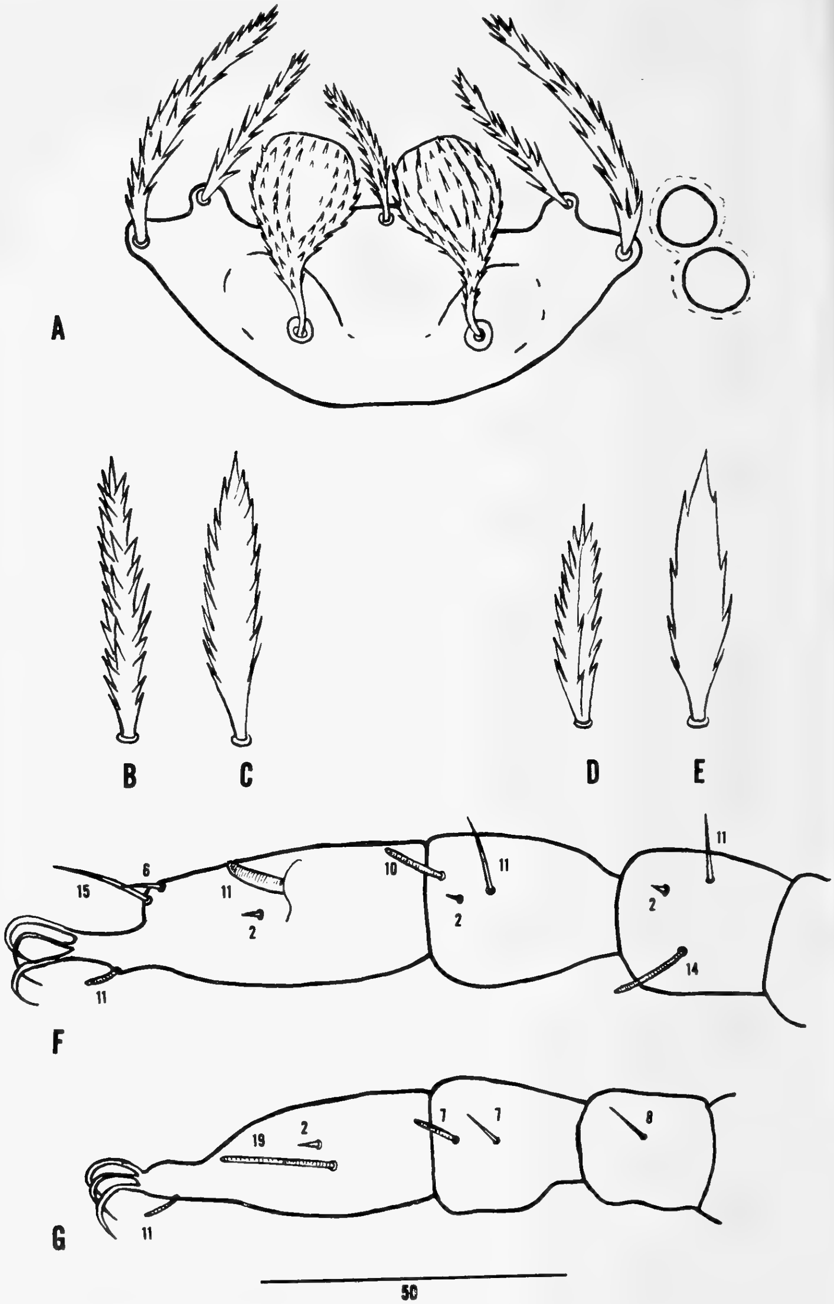

PLATE I. Numbers adjacent to the nude setae represent measurements in microns. *Euschoengastia otophila* new species. *Figure A*. Scutum and eyes. *Figure B*. Dorsal seta of the first posthumeral row. *Figure C*. Posterior dorsal seta. *Figure F*. Leg I, showing nude setae. *Figure G*. Leg II, showing nude setae. *Euschoengastia frondifera* Gould. *Figure D*. Dorsal seta of the first posthumeral row. *Figure E*. Posterior dorsal seta.

*lata* Brennan and Beck, *E. frondifera* Gould, *E. nihi* Brennan and Jones, and *E. romola* Brennan and Jones in having broadly expanded dorsal setae, trifurcate palpal claw and lacking tibiala III. Differs from *E. micheneri* and *E. romola* in having subterminala I; from *E. lanceolata* and *E. micheneri* by nude or forked lateral setae on palpal tibia; from *E. nihi* by presence of genuala III; and from *E. frondifera* by difference in shape of dorsal setae, dorsal setal formula 2-10-10-; and longer humeral setae (40$\mu$).

*Description of holotype.* (With differences noted in paratypes in parentheses.)

Body: Small, nearly round. Color white in life. Two pairs of eyes widely separated and ocular plate lacking. (Body length and width varies from 246/265 to 379/333, average 260/270, in 10 specimens.)

Gnathosoma: Cheliceral base with few scattered puncta posteriorly. Blade slender, typical, with tricuspid cap. Palpal femoral and genual setae with numerous branches, dorsal and ventral palpal tibial seta nude or forked. Palpal tibial claw trifurcate. Tarsus with 7 branched setae and moderate tarsala (8$\mu$). Galeal seta with 4 to 5 branches.

Scutum: More than twice as wide as long with scattered puncta medially. Anterior and posterior margins of scutum sinuous; lateral margins concave, diverging posteriorly. Sensillae clavate, short stemmed and bases slightly posterior to bases of PL's. AL's subequal and much shorter than PL's. AM slightly shorter than AL's. Measurements of holotype as follows: AW-59, PW-76, SB-26, ASB-24, PSB-11, AP-12, AM-23, AL-28, PL-41, S-31. Measurements of 4 types, averages and extremes, are as follows: AW-57 (55-59), PW-75 (74-77), SB-26 (23-29), ASB-21 (18-24), PSB-11 (11-12), AP-13 (12-14), AM-21 (20-23), AL-27 (26-28), PL-41 (39-43), S-30 (30-31).

Body setae: (see Figs. B and C) Approximately 50 broad dorsal setae with numerous heavy setules. Dorsal setae of first row measuring 44 becoming progressively shorter (36$\mu$) and thicker posteriorly. One pair of broad humeral setae (40$\mu$). Dorsal setal formula of holotype 2-10-10-10-8-6-4 (dorsal formula varying from 2-10-10-10-8-6-4 to 2-11-10-8-6-4-2). Ventral setae numbering from 34 to 40; small (23u) and not broadly expanded. Last two posterior rows resemble dorsal setae. Sternal setae (2-2) measuring 38$\mu$ and 29$\mu$ respectively.

Legs: Coxae lightly punctate. Tarsala II longer than tarsala I, ratio 1.4 to 1.7. Tibialae I and II bluntly tipped. Arrangement of branched setae similar to *E. frondifera* Gould, 1956. (See Figs. F and G). Nude sensory setae (and measurements) as follows: Leg I, with 2 genualae (11-13$\mu$), microgenuala; 2 tibialae (11-13$\mu$), microtibiala; middorsal tarsala ($11$-$12\mu$), microtarsala, subterminala, parasubterminala and pretarsala. Leg II, with genuala ($6$-$7\mu$), 2 tibialae ($6$-$8\mu$), long mid-dorsal tarsala ($17$-$19\mu$), proximal anterior microtarsala, and pretarsala. Leg III, with genuala ($7$-$8\mu$) (tibiala absent).

*Specimens examined.* Total, 62 larvae, as follows: Holotype and 61 paratypes, all from ORANGE CO., 1 mi. E O'Neill Park, Trabuco Canyon, *Peromyscus californicus*, 18 Nov. 1956 (30); Modjeska Canyon, *Peromyscus californicus*, 19 Jan. 1957 (18); 12 March 1957 (6); and 14 May 1957 (8).

*Remarks.* This species closely resembles *E. frondifera* but is separated by the following characters. The dorsal setae are not flattened dorsoventrally but are broad with numerous thickened setules. The dorsal formula is variable in both species but *E. otophila* maintains a 2-10-10- as compared to *E. frondifera* with a 2-14-14. Humeral setae are much longer, $40\mu$ as to $31\mu$ in *E. frondifera*. The lateral palpal tibial seta is usually forked and occasionally nude whereas in *E. frondifera* it is usually nude and occasionally forked. One specimen of *E. frondifera* was found with a series of *E. otophila* from Modjeska Canyon.

*Peromyscus californicus* had heavy infestations of these larvae on the pinnae. Two mice had more than 100 chiggers on each of their ears.

### *Euschoengastia terrestris* Gould

*Specimen examined.* Total, 1 larva, from RIVERSIDE CO., 2½ mi. SW Lake Mathews, *Dipodomys agilis*, 16 April 1957.

*Remarks.* This locality represents a range extension of 225 airline miles to the southeast of the localities in Fresno, Monterey, San Mateo, and Napa counties as reported by Gould (1956:56). Scutal measurements of the single specimen are: AW-54, PW-66, SB-20, ASB-21, PSB-21, AP-23, AM-25, AL-24, PL-36, S- lacking. The larva was removed from the external auditory canal.

### *Euschoengastia californica* (Ewing)

*Specimens examined.* Total, 150 larvae, as follows: ORANGE CO., 1 mi. E O'Neill Park, Trabuco Canyon, *Peromyscus californicus*, 18 Nov. 1956 (23); Modjeska Canyon, *Neotoma fuscipes* (11), *Peromyscus californicus* (22), 19 Jan. 1957; *Peromyscus californicus*, 12 March 1957 (39); and 4 May 1957 (8). RIVERSIDE CO., 2¾ mi. S, 4 mi. W Corona, *Neotoma fuscipes*, 17 March 1956 (5); 8 mi.

SSE Lake Mathews, *Neotoma lepida*, 22 Dec. 1956 (19); *Neotoma lepida* (21) and *Peromyscus maniculatus* (23), 23 Feb. 1957.

*Remarks*. Averages of scutal measurements of 4 specimens from Orange Co. are as follows: AW-43, PW-55, SB-18, ASB-26, PSB-13, AP-13, AM-32, AL-50, PL-47, S-31. The hosts were found with heavy infestations in the external auditory canals and the chiggers were grouped in clusters on the inner part of the ear pinna.

### *Euschoengastia radfordi* Brennan and Jones

*Specimens examined*. Total, 6 larvae, as follows:

ORANGE CO., Modjeska Canyon, *Neotoma fuscipes*, 19 Jan. 1957 (5). RIVERSIDE CO., 3 mi. SW Lake Mathews, *Neotoma lepida*, 23 Feb. 1957 (1).

*Remarks*. Averages of scutal measurements of 4 specimens are as follows: AW-52, PW-75, SB-25, ASB-25, PSB-11, AP-20, AM-28, AL-47, PL-36, S-29.

### *Euschoengastia criceticola* Brennan

*Specimens examined*. Total, 23 larvae, as follows:

ORANGE CO., 1 mi. E O'Neill Park, Trabuco Canyon, *Peromyscus californicus*, 18 Nov. 1956 (9); Modjeska Canyon, *Peromyscus californicus*, 19 Jan. 1957 (2); *Peromyscus californicus*, 12 March 1957 (1). RIVERSIDE CO., 2¾ mi. W Corona, Tin Mine Canyon, *Neotoma fuscipes*, 17 March 1956 (8). 8 mi. SSE Lake Mathews, *Neotoma lepida*, 22 Dec. 1956 (3).

*Remarks*. This species is widespread throughout western United States, from California eastward to Kansas. Averages of scutal measurements of 4 specimens from Orange Co. are as follows: AW-50, PW-61, SB-21, ASB-23, PSB-7, AP-11, AM-26, AL-30, PL-42, S-32. The larvae were attached to the external auditory canal and the adjacent area of the ear pinna.

### *Pseudoschoengastia occidentalis* Brennan

*Specimen examined*. Total, 1 larva, as follows:

RIVERSIDE CO., 3 mi. SW Lake Mathews, *Peromyscus maniculatus*, 23 Feb. 1957.

*Remarks*. The specimen from Riverside County represents a range extension of 285 airline miles from previous localities in Plumas and Monterey counties, California (Gould, 1956). Scutal measurements of the single specimen are: AW-37, PW-57, SB-13, ASB-18, PSB-16, AP-27, AM-19, AL-15, PL-26, S- lacking.

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# A NEW *AMBRYSUS* FROM SOUTH AMERICA (HEMIPTERA, NAUCORIDAE)

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The distinctive genus *Ambrysus*, occurring from north-central United States south to central Argentina, contains approximately 75 species of aquatic, vegetation-crawling bugs. The following new species adds another entity from the largely untapped South American reservoir of these distinctive insects. It may be known as:

### **Ambrysus stali,** NEW SPECIES

*General appearance:* size medium for the genus, rather narrow, 9.0-9.25 mm. long, 5.0 mm. wide. Dorsum more-or-less unicolorous dark brown, often blackish on head, pronotum and scutellum.

*Head:* Very deeply set into pronotum in center, its postero-centrum squarely-set into pronotum. Shiny. Eyes completely flush with head surface, convergent anteriorly, black, distinctly darker than head. Head ratios are: (1) Total length to width (including eyes), 50::67 (75%); (2) Anterior distance between eyes to posterior distance, 28::43 (65%); (3) Anterior distance between eyes to inner eye length, 28::30 (93%); (4) Posterior distance between eyes to greatest length of head posterior to this line, 43::15 (35%).

*Pronotum:* Ratios are: (1) Width between anterior angles to width between posterior angles, 55::102 (54%); (2) Median length to greatest width, 36::100 (36%); (3) Distance between anterior and posterior angles on the same side to perpendicular distance between anterior angle and baseline of pronotum, 55::52 (95%).

*Scutellum:* Unicolorous, blackish; ratio of three sides, anterior and two laterals, 90::70::70.

*Hemelytra:* Lighter in color than remainder of dorsum, reddish-brown to blackish. Embolia long, narrow (length to width 80::20= 25%), narrow anteriorly, widest at posterior end. Hemelytra narrowly exposing lateral connexiva and covering abdominal tip. Fully winged, capable of flight, wing with one "costal" cell.

*Venter:* Blackish anteriorly, whitish posteriorly due to heavy pelt of hydrofuge pile. Propleura fused medially, and free from posterior slope of prosternum. Connexival segments smooth-edged, I-II non-spinose, III-IV moderately spined at latero-posterior angles. Male genital process prominent, medium-sized, very broadly capitate with club much swollen. Female subgenital plate-tip of tripartite shape, the broad central swelling flanked by two sharp tips at the postero-lateral region (see illustrations).

*Legs:* PROLEGS: Femur incrassate; ratio of length to greatest ventral width, 72::45 (62%); Tibia and single tarsus fused into the usual slender, moderately curved structure. MESOLEGS: Femur 2.5 mm. long, ratio of length to median ventral width 70::10 (14%); Tibia 2 mm. long, ratio of length to median ventral width 60::7 (12%), two transverse rows of spines across distal tip, second row from tip incomplete. METALEGS: Femur 2.75 mm. long, ratio of length to greatest median ventral width 80::10 (12%); Tibia 3 mm. long, ratio of length to width 100::4 (4%), three transverse rows of spines across distal end, the two non-terminal rows incomplete.

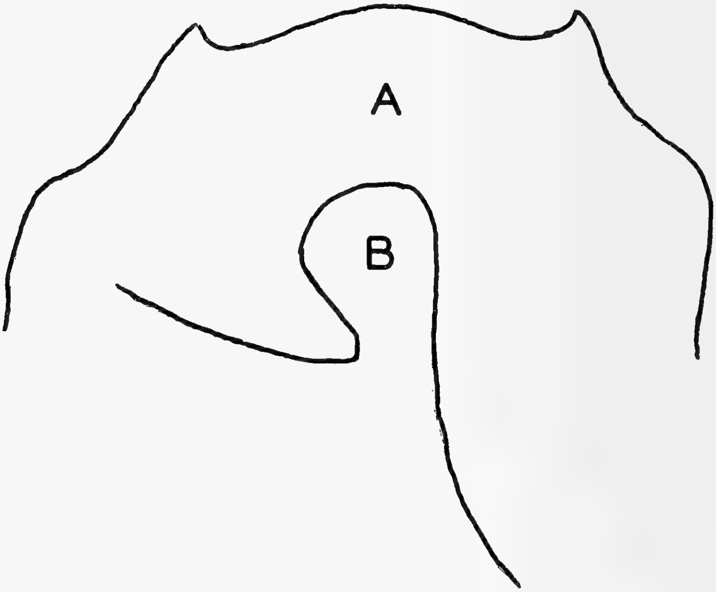

*Figure 1. Ambrysus stali:* (A) Terminal outline of female subgenital plate, holotype. (B) Male genital process, allotype.

*Type and locality data:* Holotype female, allotype male and several paratypes from FRENCH GUIANA—St. Laurent, October 1937, H. E. Hinton. Paratypes from: DUTCH GUIANA—14 November 1942, 16-19 September 1943, D. C. Geiskos; TRINIDAD, British West Indies, 27-29 October 1938, C. J. Drake; BRAZIL—*Belem*, 21 September 1937, H. E. Hinton—*Manaos*, September 1937, H. E. Hinton—*Rio Candeia*, 30 November 1937, H. E. Hinton.

*Location of types:* Robert L. Usinger collection (Berkeley, California)—holotype, allotype and paratypes from the type locality as well as from Dutch Guiana and *Belem* and *Manaos*, Brazil. Carl J. Drake collection (Ames, Iowa)—one paratype from Trinidad, B.W.I. La Rivers collection (Reno, Nevada)—paratypes from French and Dutch Guiana; from Trinidad, B.W.I.; from *Manaos* and *Rio Candeia*, Brazil. Snow Museum collection, University of Kansas at Lawrence—two paratypes from French Guiana. U.S. National Museum collection—one paratype from French Guiana. British Museum (Natural History)—one paratype from French Guiana.

*Comparisons:* the new species is closely related to *Ambrysus oblongulus* Montandon 1897. The differences between the two species can be summarized as:

| OBLONGULUS | STALI |
|---|---|
| Male genital process parallel-sided, non-capitate. Female subgenital plate tip quadrisinuate in outline. Known only from Central America. | Male genital process strongly capitate. Female subgenital plate tip trisinuate in outline. Known from the Guianas, Trinidad and neighboring Brazil. |

## LITERATURE CITED

MONTANDON, A. L.

1897. Hemiptera cryptocerata. Fam. Naucoridae.—Sous-fam. Cryptocricinae. Verhandlungen zoölogische-botanische Gesellschaft Wein, 47:6-23.

# PROCEEDINGS OF THE ACADEMY

The Southern California Academy of Sciences met nine times during the fiscal year 1961-1962. Seven of these meetings were held in the Jean Delacour Auditorium at the Los Angeles County Museum, the Botany Section was held at the Los Angeles State and County Arboretum and the Annual Meeting was at Cerritos College, Norwalk. The section on Earth Sciences held regular meetings at various schools and institutions in the area.

The following talks were presented at the monthly meetings. The Section on Invertebrate Zoology met September 15, 1961, and Dr. John Belkin of U.C.L.A. presented a talk entitled "Entomological Work in the Society Islands." The Section on Experimental Biology (including Medical Sciences) heard the talk "Biological Clocks" by Dr. Karl Hamner of U.C.L.A. on October 20. On November 17, Dr. Egon T. Degens of California Institute of Technology presented the talk "Project New Valley—Geochemical Water Studies in the Sahara Desert" for the Section on Physical Sciences. Dr. M. Dale Arvey of Long Beach State College discussed "Birds of Colombia" for the Section on Vertebrate Zoology on December 8. The Section on Anthropology met on January 19, 1962, and heard "Climatic Changes as it affected early human populations in the Great Basin" by Dr. Homer Aschman of the University of California, Riverside. On February 16, the Section on Earth Sciences presented Dr. Richard H. Tedford of the University of California, Riverside, who reported on "Cenozoic Mammals from Australia." The Section on Botany met at the Arboretum and heard the talk "Plants and People of South Africa" by Dr. William Stewart, the director of the Arboretum, on March 16. The Section of the Junior Academy met April 13 and two papers were presented by junior members.

The newly elected Board of Directors and Advisory Board met on May 4, 1962, to hear reports and elect officers for 1962-1963.

The Second Annual Meeting was held at Cerritos College, Norwalk on Saturday, May 12, 1962. More than 100 persons registered for the Scientific Sessions, which consisted of 34 papers presented in the six sections. Papers presented were:

A species problem in the genus *Branchiostoma*. Alfred Egge, Long Beach State College.

Factors in the ability of the eastern Pacific Green turtle, *Chelonia mydas agassizi*, to orient toward the sea from the land. Melba C. Caldwell and David K. Caldwell, Los Angeles County Museum. (Presented by D. K. Caldwell)

Carotenoid metabolism in a marine fish under heterosmotic conditions. Arthur S. Lockley, Long Beach State College.

Intranasal chiggers (Acarina: Trombiculidae) in rodents from California and northwestern Mexico. Richard B. Loomis, Long Beach State College.

Variations in the benthic fauna of Alamitos Bay marina, California. Donald J. Reish, Long Beach State College.

On some effects of salinity variation in the ontogenetic development of selected marine invertebrate animals. DeBoyd L. Smith, Cerritos College.

A correlation of the internal anatomy of the sand dune weevils with the geological history of the Pacific coast. W. Dwight Pierce, Los Angeles County Museum.

A new cotylosaurian reptile from the Permian of southeastern Utah, and its bearing on the origin of the reptiles. Peter P. Vaughn, University of California, Los Angeles.

Pachyostosis in desmostylid bones. Edward D. Mitchell, Jr., Los Angeles County Museum.

An approach to the study of molars in hypsodont cricetines. John A. White and Theodore Downs. (Presented by White)

An analysis of heart sounds in the sidewinder. *Crotalus cerastes.* Robert K. Mullen, San Fernando Valley State College.

Induction of melanin pigment formation in *Drosophila melanogaster*. A. D. Keith and R. A. Kroman, Long Beach State College. (Presented by Keith)

Effect of age and stress on lipemia clearance in dogs. Harry Sobel, Veterans Administration Hospital, Sepulveda, and Heriberto V. Thomas, St. Thomas Hospital, Burbank. (Presented by Sobel)

Body form and swimming performance in the scombrid fishes. Vladimir Walters, University of California, Los Angeles.

Call order and social behavior in the foam-building frog, *Engystomops pustulosus*. Bayard H. Brattstrom, Orange County State College.

A population study of the Sideblotched lizard, *Uta stansburiana*, in southern California. Robert C. Stephens, El Camino College.

The avifauna of a Joshua Tree woodland community. Dennis G. Rainey and S. G. Van Hoose, Jr., Long Beach State College. (Presented by Rainey)

Metabolism of *Chlamydomonas* in sewage lagoons. Richard W. Eppley, Northrop Corporation.

A systematic study of the *Capsicum baccatum* L. complex. William A. Emboden, Jr., University of California, Los Angeles.

A study of photoperiodic inhibition of floral induction in a single leaf system. Michael Stanford and Richard G. Lincoln, Long Beach State College. (Presented by Stanford)

Pollen of the Sarcolaenaceae, Madagascar. Sherwin Carlquist, Rancho Santa Ana Botanic Garden.

Aquatic adaptations of marine and salt lake fungi. C. J. Anastasion, Rancho Santa Ana Botanic Garden.

The origin of sea lions. Edward D. Mitchell, Jr., Los Angeles County Museum.

Paleontology and stratigraphy of Miocene marine deposits on San Clemente Island, California. Jere H. Lipps, University of California, Los Angeles, and Edward D. Mitchell, Jr., Los Angeles County Museum. (Presented by Lipps)

Oligo-Miocene marine-nonmarine relationships in southern California. Richard H. Tedford, University of California, Riverside.

On some behavioral responses of intertidal mollusks in the presence of starfishes. DeBoyd L. Smith, Cerritos College.

The origin and distribution of the snout beetles of the Joshua Tree National Monument and the adjacent region. Elbert L. Sleeper, Long Beach State College.

Observations of problem-solving behavior and associated sound production by the Pacific bottlenose dolphin, *Tursiops gilli.* William E. Evans, Lockheed Corporation.

The young Pacific Grey whales in Scammon Lagoon, Mexico. Robert L. Eberhart, Lockheed Corporation, and Kenneth S. Norris, University of California, Los Angeles. (Presented by Eberhart)

The ecology of the late prehistoric population of the San Diego coast. Claude N. Warren, Venice, California.

Colossal ground figures of the California deserts. Emma Lou Davis, Los Angeles, California.

Radiocarbon dates from La Jolla laboratory. Carl L. Hubbs, Scripps Institute of Oceanography.

Documentary research into polynesian ethnohistory. Richard P. Gilson, Los Angeles State College.

The influence of agriculture on the aboriginal social organization of the lower Colorado river tribes. Frederick Hicks, University of California, Los Angeles.

Over one hundred members and guests attended the annual dinner meeting which featured an outstanding lecture by Dr. Laurence M. Klauber on "Rattlesnakes and People."

The success of the meeting was due largely to the enthusiastic cooperation and help of the local committee, especially Dr. Henry Childs and Mr. DeBoyd Smith, the co-chairmen. We appreciate the support of Dr. Ralph F. Burnight, President of Cerritos College, who presented the address of welcome.

Fellows elected to the Academy were announced at the Annual Dinner. They are: Dr. M. Dale Arvey, Long Beach State College; Dr. Loye Holmes Miller, U.C.L.A. emeritus; Dr. I. M. Newell, University of California, Riverside, and Miss Gretchen Sibley, Los Angeles County Museum.

The 1963 Annual Meeting will be held Saturday, May 18, at the University of Southern California. Dr. Jay M. Savage will serve as the local chairman.

Dr. Peter P. Vaughn, as chairman of the Earth Sciences Section, reports there were three technical meetings of the Section held during 1961-62 academic year: In November, at the University of California, Los Angeles, Mr. James W. Warren spoke on "Skeletal growth zones in living and fossil tetrapods." In December, at the Southwest Museum, Dr. N. Gary Lane discussed "Faunal succession in the lower Bird Spring formation, Clark County, Nevada." In March, at Orange County State College, Dr. Bayard H. Brattstrom outlined various approaches in "Progress towards a paleoecology of reptiles." Members of the Earth Sciences Section presented eight technical papers at the May Annual Meeting of the Academy at Cerritos College.

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## PUBLICATIONS OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

*The Academy has published to date the following:*

PROCEEDINGS, 1896 to 1899. Six numbers—Vol. 1, Nos. 1 to 6.

MISCELLANEOUS BULLETINS issued under the imprint of the Agricultural Experiment Station, 1897 to 1907. *Ten numbers.*

All issues of the above are now out of print.

## BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

Began issue with Vol. 1, No. 1, January, 1902. Issued ten numbers in 1902; nine numbers in 1903, 1904, 1905; three numbers in 1906. Issued two numbers annually from 1907 to 1919, both inclusive (except 1908—one issue only). Issued four numbers (January, May, July and October) in 1920.

The 1921 issues are: Vol. XX, No. 1, April; Vol. XX, No. 2, August; Vol. XX, No. 3, December.

The 1922 issues are: Vol. XXI, No. 1, March; Vol. XXI, No. 2, September.

The 1923 issues are: Vol. XXII, No. 1, March; No. 2, July.

The 1924 issues are: Vol. XXIII, No. 1, January-February; No. 2, March-April; No. 3, May-June; No. 4, July-August; No. 5, September-October; No. 6, November-December.

From 1925 to 1961, including volumes XXIV to 60, three numbers were published each year. Beginning with volume 61, four numbers will be published each year.

## MEMOIRS

Vol. 1, 1938. Vol. 2, Part 1, 1939. Vol. 2, Part 2, 1944. Vol. 3, Part. 1, 1947.

Vol. 3, Part 2, 1949. Vol. 3, Part 3, 1956.

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**MANUSCRIPT FORM**—(1) The 1960 AIBS Style Manual for Biological Journals is highly recommended as a guide. (2) Typewrite material, using double spacing throughout and leaving ample margins, on only one side of 8½ x 11 inch standard weight paper. (3) Submit the original and one carbon copy. The author should also keep a copy. (4) Place tables on separate pages. (5) Footnotes should be avoided if possible. (6) Legends for figures and unavoidable footnotes should be typed on separate sheets. Several of one kind may be placed on a sheet. (7) Method of literature citation *must* conform to BULLETIN style—see Vol. 61 and later issues. Spell out in full the titles of non-English serials and places of publication. (8) A factual summary is recommended for longer papers.

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# BULLETIN OF THE
# Southern California Academy of Sciences

LOS ANGELES, CALIFORNIA

Nostra tuebimur ipsi.

Vol. 61 October-December, 1962 Part 4

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BULLETIN OF THE SOUTHERN CALIFORNIA
ACADEMY OF SCIENCES

VOL. 61 OCTOBER-DECEMBER, 1962 PART 4

# NOTES ON SOME REPTILES AND AMPHIBIANS FROM WESTERN MEXICO

HOWARD W. CAMPBELL
University of California[1]
Los Angeles
and
ROBERT S. SIMMONS
Baltimore, Maryland[2]

In the course of recent field work in western Mexico a number of specimens were obtained that furnish additional information on the distribution and variation of several species of reptiles and amphibians. Singly these do not represent sufficient data to justify publication, however, it was felt that the information is of sufficient interest to justify a combined report. No effort has been made to list all of the specimens collected, only those which present new information on the distribution, variation, or taxonomic relationships of the species will be considered.

We would like to express our appreciation to Mr. James K. Anderson of Berkeley, California, and Helen Ann Campbell for their valuable assistance and companionship in the field, and to Mr. Sam R. Telford for many valuable criticisms and assistance in identifying several of the specimens. Dr. Robert Stebbins of the Museum of Vertebrate Zoology in Berkeley, and Dr. Doris Cochran of the U. S. National Museum kindly allowed us to use specimens in their care for comparative purposes. Dr. Kenneth S. Norris of the University of California, Los Angeles, has reviewed the manuscript and made many suggestions.

The following abbreviations have been used: MVZ, Museum of Vertebrate Zoology, Berkeley; UCLA, Department of Zoology, University of California, Los Angeles.

[1] Department of Zoology.

[2] 1305 Light Street.

## ANNOTATED LIST OF SPECIES

### *Syrrhophis interorbitalis* Langbartel and Shannon

One specimen, UCLA 14,599, was collected approximately 65 miles N. Mazatlán, Sinaloa, on July 16, 1961. This specimen is a male, taken while calling at 10:30 p.m. It was found in a crack in a granite boulder on a densely vegetated rocky road-shoulder.

Apparently no additional specimens of this species have been reported since the type description in 1955. The call of this specimen was a long, drawn-out whistle, quite human in quality. Calls similar to this were heard from a point well north of Culiacán, Sinaloa, to 10 miles south of Mazatlán, lending support to Duellman's (1958) suggestion that this species may range along the Pacific lowlands of Sinaloa.

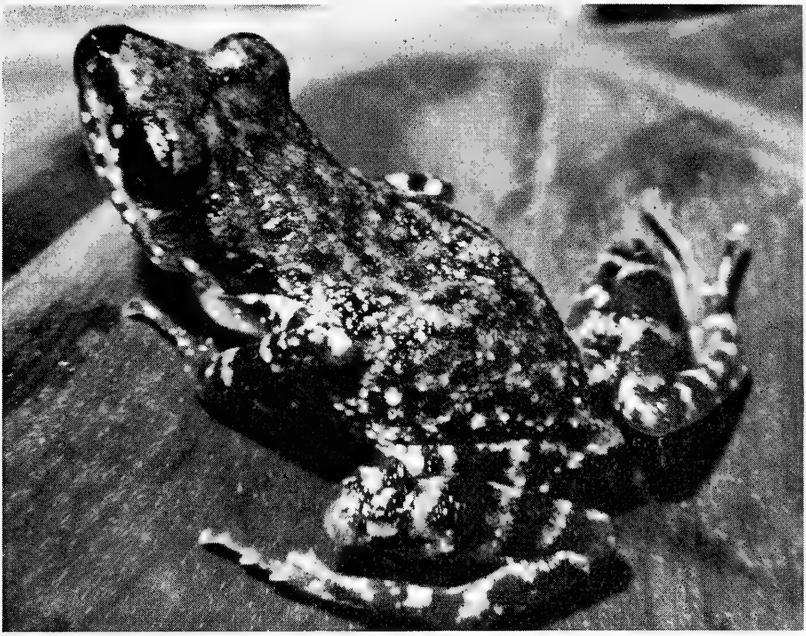
This specimen agrees with the type description in all essential details except the interorbital light band, which is barely discernable and interrupted (see Fig. 1). It is well defined and continuous in the type specimen.

### *Syrrhophis modestus pallidus* Duellman

Four speciments of this species were collected (UCLA 14,600-3), all on the night of July 19, 1961. Two were collected on the side of a steep roadcut, 2.8 miles N. Tepic, Nayarít, and two in a similar situation 3.9 miles N. Tepic. The species was in full chorus following a mild shower.

Two distinct pattern types are represented by these four frogs. Two are very light dorsally with little dark pigmentation. In one of these the dark pre-ocular stripe continues posteriorly through the axilla to the groin as a series of spots. The other two are heavily mottled dorsally with dark reticulations on a light background. No structural differences could be discerned between these two pattern types, and the calls are apparently identical.

The call of this species is a short "chirp," and was heard from the northern outskirts of Tepic, Nayarít, into southern Sinaloa, a linear distance of 110 miles. Along Mexico Hwy. 15 from Tepic to southern Sinaloa these frogs are usually found calling on the steep sides of roadcuts. Calling individuals are usually 6″-10″ above the ground in the vegetation, or sometimes perched on boulders. West of Mexico Hwy. 15 on Nayarít 54, the road to San Blas, the frogs are usually found calling from low areas along the road shoulder, and seem to prefer calling sta-



Photograph by Robert S. Simmons

*Figure 1. Syrrhophis interorbitalis* from Sinaloa, Mexico, x3

tions on the ground. Too few specimens were taken to show whether or not these apparent ecological differences might be correlated with taxonomically distinct forms.

### *Enulius unicolor* (Fischer)

A specimen of this snake, UCLA 14,604, was collected 9.6 miles S. Santiago, Colima, on August 10, 1960. It represents the first record of this species from the state and extends the range north westward from Coalcoman, Michoacán, a linear distance of 65 miles.

It is a female, 349 mm. total length, with a small portion of the tail missing. Scale counts are, ventrals: 185, subcaudals: 57, and anal divided. This subcaudal count is considerably less than any previously reported for the species, the lowest being 85 reported by Boulenger (1896) for a female from Lake Nicaragua, Nicaragua. As only a small portion of the tail is missing from this specimen it is doubtful if more than 10 subcaudals are lacking. This would still give a count much lower than the previous minimum.

The head scales are normal for the species. Dorsal scale rows are

17-17-17, and each has a single apical pit. The dorsal color is light brown and each scale is outlined with a slightly darker brown. Ventrals and first scale rows are pearly white. There is no evidence of the light neck collar characteristic of *E. flavitotorques.*

### *Gyalopion quadrangularis* (Günter)

Numerous specimens of this snake were collected in 1960 and 1961. They were found rather abundantly from Navojoa, Sonora, to 40 miles south of Mazatlán, Sinaloa. Specimens from 47.5 and 55.2 miles south of Culiacán, Sinaloa, show characters intermediate between the two subspecies, *G. q. quadrangularis* and *G. q. desertorum,* thus confirming Dixon and Fugler's (1959) decision to consider them as races of the same species. Several specimens have been deposited in the University of Florida collections and in the junior author's personal collection.

Specimens from the southernmost localities, 20-40 miles south of Mazatlán, Sinaloa, show an extreme reduction of the dorsal bands, these becoming small spots posteriorly and occasionally absent on the tail. One specimen from 40 miles south of Mazatlán, which was unfortunately not preserved, had no indication of the dorsal bands except the nuchal band and two small spots posterior to it.

### *Lampropeltis getulus nigritus* Zweifel and Norris

Two specimens were collected, both on the night of July 22, 1961. The first, UCLA 14,645, an adult male, measured 1053 mm. total length, of which the tail was 157 mm. It was collected 5.6 miles south of the Sonora-Sinaloa State line on Mexico Hwy. 15 in the state of Sinaloa. The second, a juvenile male measuring 419 mm. total length with a 71 mm. tail, was taken 38.9 miles south Navojoa, Sonora. Both were taken on the road around midnight after a slight shower. The surrounding countryside was semidesert with palo verdes *(Cercidium)*, mesquite trees *(Prosopis)*, and vegetated roadside ponds. The type and paratype of this subspecies were collected under similar circumstances (Zweifel and Norris, 1955).

These two specimens agree in high dorsal scale count, black coloration, and other essentials with the type description of the subspecies (Zweifel & Norris, supra. cit.). They are the fifth and sixth specimens of this race to be reported and extend the range of the race, as well as the species, southward, approximately 140 miles, into Sinaloa.

### *Pseudoficimia frontalis hiltoni* Bogert and Oliver, new comb.

One specimen of this uncommon snake was collected 11.5 miles N.

Espinal, Sinaloa, on July 22, 1961. Our reasons for the use of the trinominal will be covered in the following discussion.

Our specimen, UCLA 14,644, is a male, 393 mm. total length, tail 80 mm., 20.3% of the total length. There are 34 dark blotches on the body and 16 on the tail. There are 155 ventrals, 49 subcaudals. The dorsal scales are smooth and in 17 rows. Supralabials are 7—7, infralabials 8—7, the anal is divided.

*Pseudoficimia hiltoni* was named in 1945 by Bogert and Oliver on the basis of one specimen from Guirocoba, Sonora, Mexico. It was diagnosed as being closely related to *P. pulcherrima* but with a proportionally longer tail, wider light interspaces between the dark body blotches, eight instead of seven infralabials, more subcaudals, and a double instead of a single dark line across the frontal region of the head.

From the data they supplied their specimen could be distinguished easily from *pulcherrima*, but falls within the range of *P. frontalis* in many characters. The tail of the type of *P. hiltoni*, with a small portion missing, comprises 18.8% of the total length; Taylor and Smith (1942) state the range for male *frontalis* to be 16.2-19.1%. The tail of the present specimen is 20.3% of the total length.

The light interspaces between the dorsal blotches in the present specimen vary from one to three scales in width, intermediate between *hiltoni* with three or more and *frontalis* with one.

*Pseudoficimia frontalis* and *pulcherrima* both possess seven infralabials on both sides, *hiltoni* is stated to have eight. Our specimen has eight on the left and seven on the right. The double band across the frontal region found in *hiltoni* is indicated in our specimen, but the posterior band is incomplete. Only the anterior band is present in *frontalis*.

Our specimen has 49 subcaudal scales, closer to *hiltoni* with 50+ than to *pulcherrima* with a maximum of 43, but only one more than the maximum of 48 reported for *frontalis* (Taylor and Smith, 1942).

Due to the intermediate nature of our specimen, and the slight differences between the two forms, we feel that *Pseudoficimia hiltoni* should be considered a northern subspecies of *Pseudoficimia frontalis*, ranging from northern Sinaloa into southern, and possibly central, Sonora.

### *Tropidodipsas occidentalis* Oliver

Four specimens of this snake were collected in July, 1961. Two, UCLA 14,640-1, were collected 1:05 A.M. July 20, 1.2 miles south of Acaponeta, Nayarít. They were found D.O.R. within 25 feet of each other between a pasture and a rocky hillside. UCLA 14,642 was taken 13.7 miles north of Mazatlán, Sinaloa at 12:00 midnight on July 20. It was crossing the road between two rocky hillsides. UCLA 14,643 was collected D.O.R., 16.2 miles north of Espinal, Sinaloa at 2:45 A.M. July 22.

Four species of *Tropidodipsas* belonging to the group characterized by having 15 scale rows are currently recognized from the west coast of Mexico. One of these, *Tropidodipsas philippi*, is recognized on the basis of pattern. It has previously been considered a "spottted" snake (Boulenger, 1896 and Shannon and Humphrey, 1959). However, a reconsideration of Boulenger's description in the light of Smith's description of a specimen from "Colima" (1943) indicates that it differs from the others only in the possession of a light-colored venter. Other specimens of *Tropidodipsas* from localities near Mazatlán, the type locality of *T. philippi*, show a tendency for the light body annuli to become connected ventrally by a light stripe (Shannon and Humphrey, 1959). Should this tendency be fully developed it could produce the light-colored venter of *philippi*. The remaining dark areas between the annuli could then be considered large rectangular "spots." Indeed, this is how Boulenger (supra cit.) describes them. Additional specimens from the west coast of Mexico may show that this condition is a geographic variation within a wide-ranging species.

The other three species are black with white or yellow dorsal annuli which frequently cross the venter. They are distinguished by details of pattern and scutellation.

*Tropidodipsas occidentalis*, described from a Colima specimen by Oliver (1937), was previously known only from the type and one other specimen from Michoacán (Peters, 1954). In addition to our four specimens there is a specimen collected near the type locality in Colima by T. Papenfuss in the collection of the Museum of Vertebrate Zoology in Berkeley (MVZ 71367). Its characteristics are included in this discussion.

The other two species, *T. malacodryas* and *T. freiae*, were named by Shannon and Humphrey (loc. cit.) from single specimens from San Blas, Nayarít, and central Sinaloa, respectively. No additional specimens of these species have been reported since the type descriptions.

Of the five unreported specimens at our disposal, one, MVZ 71367, is clearly referable to *Tropidodipsas occidentalis*. The other four specimens show a varied combination of characters.

*Tripidodipsas freiae*, from central Sinaloa, is more similar to *T. occi-*

*dentalis* from Colima and southward, than it is to *T. malacodryas* or any of our specimens (one of which is from within ten miles of the type locality of *T. freiae*). A higher ventral count and more body annuli distinguish *T. freiae* from *T. occidentalis* (*freiae:* 200 ventrals, 18 annuli; *occidentalis:* 175-86 ventrals, 10-13 annuli). Several of the other characters by which *freiae* was originally distinguished are variable in the specimens we have examined. *T. freiae* is stated to have a nuchal band only one scale row long. This varies from one to three and one-half scale rows in specimens of *occidentalis*. The body annuli are one scale row long in *freiae*, they vary from one to four in the others. *T. freiae* is also stated to have three preoculars in the type description, as opposed to two in *occidentalis*, however, the illustration of the type specimen shows only two preoculars and a loreal, which is stated to be absent in the type description. The three-preocular condition has also been reported for one side of the head in a specimen from Michoacán (Peters, 1954). Therefore, it seems that the length of the nuchal and body annuli and number of preoculars are of little value in distinguishing *T. freiae* from *T. occidentalis*.

*Tropidodipsas malacodryas* is distinguished from *T. freiae* and *T. occidentalis* by its lower ventral count (143) and the absence of preoculars. Our four specimens agree most closely with these characters than with those of *occidentalis* or *freiae*. The ventral counts range from 143-154, the preoculars are absent in two, and one small preocular is present on both sides in the other two. Our specimens do not agree with *malacodryas* in subcaudal count; the type of *malacodryas* has 96 subcaudals while our specimens have 40, 41, 43 and 44. Our specimens also have fewer body and tail annuli than previously reported for any of the other species.

The presence or absence of keels on the dorsal scales has previously been considered of taxonomic value in defining species in this genus. Our specimens are highly variable in extent of keeling. The type specimen of *T. occidentalis* is the only known specimen which completely lacks keels on the scales. MVZ 71367 from Colima possesses weak keels in the anal region. In the other specimens the keels are present but vary from being weakly developed in the region of the vent to clearly indicated over the posterior half, or more, of the body. No correlation of degree of keeling with any other character could be discerned.

In general there appear to be two trends within these snakes from the west coast of Mexico. From Nayarít north to central Sinaloa there is a general tendency for reduction in number of body and tail annuli, preoculars, ventrals, and subcaudals (the type of *T. malacodryas* is exceptional in this last character). The type of *T. freiae* from central Sinaloa is exceptional in all these characters, being more similar to specimens of *T. occidentalis* from Colima. On the basis of the specimens we have examined we are unwilling to make any decisions on the exact relationships of these snakes. Our decision to assign our specimens to *Tropidodipsas occidentalis* is only tentative in the absence of any comprehensive treatment of the forms. There may be one wide-ranging highly variable species with recognizable geographic races, or two, or even three, distinct species which are sympatric over part of their ranges (Fig. 2).

Some comments on the status of the genus *Exelencophis* seem appropriate here. This genus was described by Slevin (1926) as *Tantilla nelsoni* on the basis of a specimen from the Tres Marías Islands off the coast of Nayarít. In 1942 Smith distinguished it from *Tantilla* and erected the genus *Exelencophis* for the unique specimen. Since that time the specimen has been lost and no others have been taken in collections from these islands.

The herpetological fauna of these islands is little different from that of the adjacent mainland. Most of the islands' species may be assigned to the same subspecies as the mainland populations (Zweifel, 1960). The presence of this one endemic genus in the island group has caused some comment by zoologists, and Zweifel compared the known characteristics of this form with the mainland genera to which it might be related. In his discussion of the relationship of *Exelencophis* to *Tropidodipsas* Zweifel cited the considerable difference in ventral and subcaudal counts of the two forms (130, 39, respectively, for *Exelencophis*). The specimens of *Tropidodipsas* now available from adjacent mainland areas have reduced the distinctiveness of these characters. One hundred and forty-three ventrals have been recorded twice for *Tropidodipsas* (type of *T. malacodryas* and UCLA 14,641), and two of our specimens have subcaudal counts of 40 and 41, thus approaching the condition in *Exelencophis*.

Examination of the type description of *Exelencophis* reveals two additional characters which serve to distinguish it from *Tropidodipsas;* the nasal is entire, and the first infralabials do not meet behind the mental scale. This combination of characters is not found in other forms of *Tropidodipsas* except in the type specimen of *T. annulifera*. Variations in the latter character are known to occur frequently in insular populations of *Tantilla* in Florida (Telford, in MS), and we feel that additional collecting on the Tres Marías Islands and adjacent mainland may justify placing *Exelencophis nelsoni* in the genus *Tropidodipsas.*

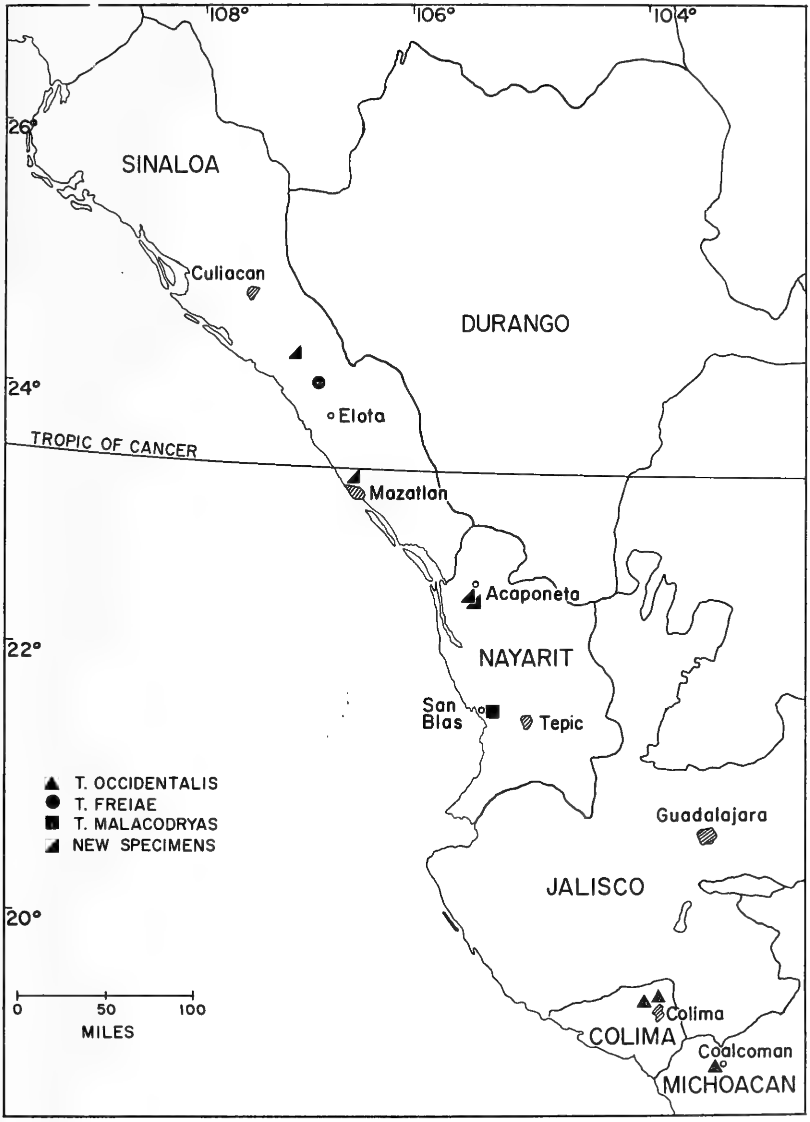


*Figure 2.* Localities for *Tropidodipsas* from the west coast of Mexico.

### *Typhlops braminus* (Daudin)

A specimen of this snake was collected under a rock at the Mazatlán, Sinaloa, airport on December 28, 1961, by F. Howard and George Sphon. The specimen, of undetermined sex, measures 69 mm. in total length. It has been deposited in the collections of the University of California at Los Angeles (UCLA 14,693).

This specimen represents the first record of this species from the state of Sinaloa and is the most northernly record for the species in Mexico. Its occurrence here is not surprising in view of the species' world-wide dispersal through the agency of man's activities.

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# SHOULDER AND UPPER ARM MUSCLES OF SALAMANDERS

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This is the fourth of a series of papers recently published on the muscles of salamanders as a group. Previous to this, a series was completed on the skeleton consisting of twenty or more separate articles with a smaller number on other features of the group.

Certain areas or regions have been discussed separately as a matter of convenience, but at the end of the morphological publications it is planned to bring all together for a general summary as well as an application to other topics in connection with the world group.

*M. Cucullaris*, Edgeworth '20, Rylkoff '24, Francis '34; Onomastoideus, Funk 1827, Meckel 1828; Levator scapulae (in part), Carus 1828; Spini-sus-scapulare, Dugès 1834; Protractor scapulae (part), Owen 1866; Curcularis et Sterno-cleido-mastoideus, Rüdinger 1868; Trapezius, Mivard 1869, Drüner 1901, Osawa 1902; Capiti-dorso-scapularis S. Cucularis, Fürbinger 1873, Hoffman 1878; Petroso-dorso-scapularis, Perrin 1899.

This sheet of muscle arises from cephalic-dorsal fascia and from the posterior dorsal surface of the skull. It is inserted on the pro-coracoid and scapula.

It is supplied by a branch of the 10th cranial nerve and a part of the 2d spinal.

It turns or depresses the head. When the head is firmly held it protracts the shoulder girdle.

*M. Opercularis* Gaup '98, Kingsbury and Reed 1909; Levator anguli scapulae, Funk 1827, Rüdinger 1868, Mivart 1869; Levator scapulae, Carus 1828, Humphrey 1871, Osawa 1902, Rylkoff 1924; Sous-occipito-adscapulaire, Dugès 1834; Protractor scapulae (part), Owen 1866; Basi-scapularis, Fürbringer 1873, Hoffman 1878; Protractor du scapulum, Perrin 1899; Levator scapuli, Drüner 1901.

This takes origin from the operculum of the ear capsule and is inserted on the anterior border of the supra-scapula.

It is supplied by fibers from the first spinal nerve. It acts in relation to audition.

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*M. Dorsalis scapulae*, Humphrey 1872, Fürbinger 1873, Hoffman 1875, Osawa 1902, Francis '34; Sur-épineux et Sous-épineux conjoints, Cuvier 1800; Scapularis, Funk 1827; —Shulterblattmuskel, Meckel 1828; (Subscapularis), Carus 1828; Adscapulo-huméral, sous-épineux, Dugès 1834; Suprascapularis, Stannius 1854, Ryhikoff 1924; Subscapularis, Schmidt, Goddard, van d. Hoeven 1864; Supra- and infra-spinosus, Owen 1866; Deltoid, Mivart 1869; Elevateur scapulaire du bras, Perrin 1899.

This arises from the dorso-lateral surface of the suprascapularis and is inserted on the side of the humerus.

It is supplied by a branch of the 3d spinal nerve.

It elevates the arm.

*M. Dorso-humeralis*, Francis 1934; Grand dorsal, Cuvier 1828; Latissimus dorsi, Funk 1827, Carus 1828, Stannius 1854-6, Schmidt, Goddard and van de Hoven 1864, Owen 1866, Rüdinger 1868, Mivart 1869, Humphrey 1872, Osawa 1902, Rylkoff 1924; Vertébrato-costo-huméral, grand dorsal, Dugés 1834; Dorso-humeralis, Fürbinger 1873, Hoffman 1873-8; Élevator dorsal du bras, Perrin 1899.

This muscle behind the shoulder arises from fascia, it is inserted into the edge of the shoulder joint with another insertion into the anterio-lateral border of the humerus.

It is supplied by the dorso-humeral nerve which comes from an anastomosis of the 3d and 4th spinal nerves.

It retracts the humerus.

M. *Thoraci-scapularis* or *Serratus magnus*, Fürbinger 1873, Hoffman 1873; Francis 1934; Depressor anguli scapulae inferioris, Funk 1827; Serratus anticus magnus, Carus 1828; Grosser Rückwärtszieher der Schulter, Meckel 1828; Costo-sous-scapulaire, ou grand dentelé, Dugès 1834; Levator scapulaore, ou grand dentelé, Dugès 1834; Levator scapulae et serratus anticus major, Owen 1866; Serratus anticus magnus, Rüdinger 1868; Serratus magnus, Mivart 1869, Humphrey 1872; Retractor et suspenseur du scapulum, Perrin 1899; Thoraci-superiores-serrati, Rylkoff 1924.

This is a series of slips from the first ribs, inserted on the medial or mesal surface of the scapula.

It is supplied by branches from the 2d, 3d and 4th spinal nerves.

It retracts the scapula.

## MUSCLES ESPECIALLY RELATED TO THE UPPER ARM

*M. Pectoralis*, Schmidt, Goddard, van d. Hoven 1864; Owen 1866, Mivart 1869, Humphrey 1872, Fürbinger 1873, Hoffman 1873-8, Rykoff 1924, Francis 1934; Grand pectoral, Cuvier 1800; P. inf. pectoralis major, Funk 1827. Grosser Buustmuskel, Meckel 1828; Abdomino-corico-humeral, portion du grand pectoral, Dugès 1834; Pectoralis major, Stannius 1854-6, Rüdinger 1868; Pectoralis sternalis with p. abdominalis, Eisler 1895; Tête sternale; Fléchisseur du bras, Perrin 1899; Pectoralis magnus with pars anterior, Carus 1828.

This is a large fan-shaped flat muscle over the chest region. The fibers converge to a tendon inserted on the back side of the humerus.

It is supplied by the pectoral nerve from the 4th and 5th spinal nerves.

It draws the arm inwards toward the body.

*M. Supracoracoideus*, Osawa 1902, Rylkoff 1924, Francis 1934; Portio media m. pectoralis major, Funk 1827; Portion of the big breast muscle, Meckel 1828; Clavi-huméral part of the great pectoral, Dugès 1834; Pectoralis secundus, Stannius 1854-6; Pectoralis minor, Schmidt, Goddard and van d. Hoeven 1864; Part of pectoralis, Owen 1866; Corico-branchialis proprius, Rüdinger 1868; First part of the coraco-brachialis, Mivart 1869; Epicoraco-humeral, Humphry 1872.

This arises from the cartilagenous portion of the coracoid. Its fibers in a flat plate are inserted by a tendon on the posterior surface of the humerus. Its more caudal portion is covered by fibers of the pectoralis. It is served by the second and third spinal nerves.

It draws the arm towards the body.

*M. Procoraco-humeralis*, Fürbinger 1873, Hoffman 1875-8, Osawa 1902, Rylkoff 1924; Portio superior m. pectoralis majoris, Funk 1827; Vorwärtszieher oder Heber des Oberarms Muskel, Meckel 1828; Acromio-huméral, Deltoide, Dugès 1834; Deltoides, Stannius 1854-6, Rüdinger 1868; Subclavious, Mivart 1869; precoraco-brachíal, Humphrey 1872; Adductor inférior du bras, Perrin 1859.

This muscle arises from the pro-coracoid and is inserted near or on the head of the humerus. It is supplied by the N. dorsalis scapulae on the lateral border and by the N. supracoracoideus on the middle border.

When the foot is on the ground it assists in forcing the body forward. When the foot is free from support is tends to draw the foot forward.

*M. Coraco-radialis*, Stannius 1854-6, Francis 1934; Biceps brachii, Rüdinger 1868; part of biceps, Mivart 1869; Coraco-radialis or biceps, Humphrey 1872; Long fléchisseur de l'avant-bras, Perrin 1899; Coraco radialis, Osawa 1902.

This muscle arises from the ventral side of the coracoid and is not very distinct from the last muscle. One end is inserted near the head of the humerus, the other is on the middle mesial side, near the proximal end of the radius.

It is supplied by the Supracoracoideus nerve which comes from the second and third spinal trunks.

It draws the arm towards the body.

*M. Procoraco-humeralis*, Fürbinger 1873, Hoffman 1873-8, Osawa 1902, Rylkoff 1924, Francis 1934; Portio superior m. pectoralis majoris, Funk 1827; Vorvartszierher oder Heber des Oberarms, dreieckiger Muskel, Meckel 1828; Acromino-huméral, deltoide, Dugès 1834; Deltoides, Stannius 1854-6, Rüdinger 1868; Subclavious, Mivart 1869; Precoraco-brachial, Humphrey 1872; Adductor inférior du bras, Perrin 1899.

It arises from the procoracid portion of the pectoral arch and is inserted on the head of the humerus.

Its lateral portion is supplied by a branch of the dorsal scapular nerve, its middle part is supplied by the supracoracoid nerve.

If the arm is raised from the ground the contraction of this muscle draws the arm forward with something of a twist of the humerus.

*MM. Coraco-brachialis longus et brevis*, Humphrey 1872, Fürbinger 1873, Hoffman 1873-8, Osawa 1902, Rylkoff 1924, Francis 1934; Hakenarmmuskeln, Meckel 1828; Costo-huméral, Dugès 1834; Coraco-brachialis, Stannius 1854-6, Rüdinger 1868, Schmidt, Goddard and van d. Hoeven 1864; Second part of the coraco-brachialis, Mivart 1869; Coraco-brachialis longus, superficialis, and brevis, Eisler 1895; Tête coracoidienne; flechisseur du bras, Perrin 1899; Deductor du bras, Perrin 1899.

The long head arises from the postero-lateral border of the coracoid a little towards its dorsal side. There is a fleshy insertion along the distal half of the humerus on the posterior side.

The short head arises from the proximal half of the humerus on the posterior side.

The muscle is supplied by the coraco-branchial nerves from the ramus superficialis of the N. Branchialis.

Both parts of the muscle draw the arm cadually; if the foot rests on the ground the body is propelled forward.

*M. Subscapularis*, Funk 1827, Stannius 1854-6, Rüdinger 1868, Mivart 1869, Osawa 1902, Francis 1934; Sous-scapulaire, Dugès 1834; Coraco-brachialis or Subscapularis, Humphrey 1872; Subcoracoscapularis, Fürbinger 1873, Hoffman 1873-8, Rylkoff 1924; Subscapularis (dorsal portion) Subcoaracoscapularis, Eisler, 1895; Adductor supérieur du bras, Perrin 1899.

This arises from the dorsal surface of the pro-coracoid and is inserted on the dorsal surface of the humerus.

It is supplied by the subscapular nerve from the 3d spinal.

It draws the arm backwards. If the hand(foot) is resting on the ground it helps advance the body.

*M. Anconaeus*, Fürbinger 1873, Hoffman 1873-8, Rylkoff 1924, Osawa 1902, Francis 1934; Anaconaeus internus et externus, Funk 1827; Triceps brachii extensor, Carus 1828; Strecker des Vorderarms, Meckel 1828; Scapulo-humero-olecranien, or triceps, Dugès 1834; Streckmuskelmasse, Stannius 1854-6; Triceps brachii S. anconaeus, Rüdinger 1868, Mivart 1869; Triceps and coraco-olecranalis, Humphrey 1872; Extenseur de l'avant-bras, Perrin 1899.

This arises from the shoulder girdle and humerous by four heads which unite to be inserted on the olecranon process of the ulna.

It is supplied by the extensor nerves.

Its function is to extend the forearm.

Head A, arises from the scapula near the posterior margin of the gelenoid fossa. This part was called M.a.s. medialis, by Fürbinger 1873; Hoffman 1873-8, Rylkoff 1924, Francis 1934; Anconaeus longus, Eisler 1895; Tête antérior, Perrin 1899; Anconaeus caput scapulare, Osawa 1902.

Head B, arises by a long tendon from the inner, bony part of the coracoid. It is rather small and joins the last division at about the middle of the humerus. It has been called, M.a. coracoideus, by Fürbinger 1873, Hoffman 1873-8, Eisler 1895, Rykoff 1924, Francis 1934; Coraco-olecranonalis, Humphry, Tête postérieur, Humphrey 1872; Anconaeus caput coracoideum, Osawa 1922.

Head C, arises from the anterio-lateral surface of the humerus, to later join the other parts of the muscle mass. It has been called, M. anconseus humeralis lateralis, by Fürbringer 1873, Hoffman 1873-8, Rylkoff 1924; Anconaeus caput humerale mediale, Osawa 1902; With head D=Tête profunde, Perin 1899. It arises from the lateral surface of the humerus.

Head D, arises from the surface of the humerus. It has been called, M. Anconaeus humeralis medialis by Fürbringer 1873, Hoffman 1873-8, Rylkoff 1924, Francis 1934; Aconteus caput humerale laterale, Osawa 1902; With head C, Tête profunde, Perrin 1899.

It arises from the surface of the humerus.

*M. Humero-antibrachialis*, Rylkoff 1924, Francis 1934; Brachialis medius, Funk 1827; Flexor brachii, Carus 1828; Oberer Beuger des Vorderarms, Meckel 1828; Humeroradial s. biceps, Dugès 1834; Humero-radialis, Stannius 1854-6; Osawa 1902; Biceps, Schmidt, Goddard, and van d. Hoeven 1864; Biceps and brachialis internus, Owen 1866; Brachialis internus, Rüdinger 1868; Part of the biceps, Mivart 1869; Brachialis anticus, Humphrey 1872, Eisler 1895: Humero-antibrachialis inferior, or brachialis inferior, Fürbringer 1873, Hoffman 1873-8; Court fléchisseur de l'avant bras, Perrin 1899.

This muscle arises from the flexor side of the humerus. It is inserted on the proximal end of the radius.

It is supplied by one or more branches from the superficial division of the brachialis nerve.

It bends the elbow.

## COMPARISONS

The preceeding general account follows Francis 1934, and is largely based upon the muscles of Salamandra as a standard for comparison. In the various groups there are variations in position and in size—especially with certain muscles. In general the pectoralis is constant in form and appearance and the dorso-humeralis is about the same in all groups. The dorsales scapulae varies in size, but the central part of the shoulder muscles is convenient to start from in determing the others. The procoracohumeralis and the supracoracoideus are seldom distinctive.

The greatest differences are found in the cucullaris and the so-called opercularis or levator scapulae. As Dunn '41 pointed out, that called the opercularis has really two different elements. When in Salamandridae, Hynobiidae and Amblsttomidae it is all or part of the levater scapulae; while in Plethodontidae it is part of the cuccularis.

### PROTEIDAE

In *Proteus*, the procoraco-humeralis is especially long and slender. At first sight it seems continuous with the abdomino-hyoideus, being separated from it by a very slight line of connective tissue. The cucullaris is a long and slender filament and there is a very delicate levator scapulae and also there are more posterior fibers which connect the scapula with the body wall. A very delicate omo-arcualis (discussed in another paper) is present.

*Necturus* is similar to Proteus but the procoraco-humeralis is not so long in proportion to other parts, the omo-arcualis is more evident and like Proteus the levator scapulae is incompletely differentiated from the dorsal trunk muscles. The cucularis is more evident and of two divisions.

### SIRENIDAE

In *Siren* the levator scapulae is quite unusual. A single slip extends from the pharynx to be inserted on the cartilagenous suprascapula. I was not able to determine whether this was the case in *Pseudobranchus* in the material at hand.

Siren has a well developed omo-arcualis as does Pseudobranchus as well. The cucullaris has two divisions in Siren, but this and other muscles of the region are not well developed.

### AMPHIUMIDAE

The muscles of the shoulder girdle are greatly reduced. There is no levator scapulae, the cucullaris is a single rather slender band. Including the pectoralis there are two muscles of the region ventrally and three dorsally. In a larva of 50 mm, the pectoralis is evident with slight signs of two or three other muscles in the region.

### CRYPTOBRANCHIDAE

The levator scapulae is incompletely separated from the trunk muscles. Dorsally the scapula is connected to the wall by muscle fibers. The cucullaris, a single band arises from the skull and dorsalfascia.

### HYNOBIIDAE

In *Salamandrella*, the levator scapulae muscle is single and forms the opercular muscle. The cucularis is of two slips, the upper is the larger. They arise from the skull and dorsal fascia.

The general position of the muscles in this form differs from many other salamanders. A part of the suprascapularis muscle may be seen from the outer surface.

### AMBYSTOMIDAE

The levator scapuli which forms the opercularis muscle differs in size in different species. It is frequently attached to a great part of the cephalic border of the scapula, then narrows down to a small insertion on the opercular plate. In some cases fibers are attached to skull parts near. In larval-like forms such as Siredon it is not clearly separate from the lateral muscles of the body. Some forms also have this condition, partly due to the fact that transformation is quite recent. In one specimen of *Rhyocotriton* which looked like an adult externally, this muscle of two different parts ran to the neighborhood of the ear plate, but all its fibers were attached to nearby bone and none to the plate itself, which later however, was more like a columella than an operculum.

In this family the cucullaris was usually of two parts, sometimes three.

In *Ambystoma maculatum* larva of 45 mm length there were distinct opercular muscles, one seemed to be the cucullaris, but the levator scapulae muscles were not distinct, a more or less characteristic larval condition.

## SALAMADRIDAE

The levator scapulae has two slimps in some forms, one only in others. In *Diemyctylus viridescens*, I found two slips for this, in *Taricha* examined there was one broad one, in Pleurodellides two, in Tylops two and in a specimen of Triturus cristatus, one.

The cucullaris attached to the skull and fascia in the head region frequently had two slips.

## PLETHODONTIDAE

The levator scapulae arises from the base of the skull and is inserted on the forward edge of the scapula. It is frequently, or is near the portion of the cucullaris muscle which is attached to the operculum. In most cases it is single, but it may have other fibers. The cucullaris is usually of three parts. One of the deeper or lower portions forms the opercularis muscle. Often parts of this slip or portions near are attached to the skull. In all the genera examined the conditions were much like those described. In *Hydromantes*, a powerful superficial branch of the cucullaris runs in the same direction as the deeper opercular muscle, but is very much longer and takes origin from the skull just back of the orbit. *Typhlomolge* differs from most in having the larval condition of the operculum muscle and a poorly developed levator scapulae which last consists of a few weak strands well separated.

In the larval condition, the so-called operculis muscle does not end on the free plate of bone in the ear and the levator scapulae muscle is not well differentiated from lateral body muscles—a condition like that of Necturus.

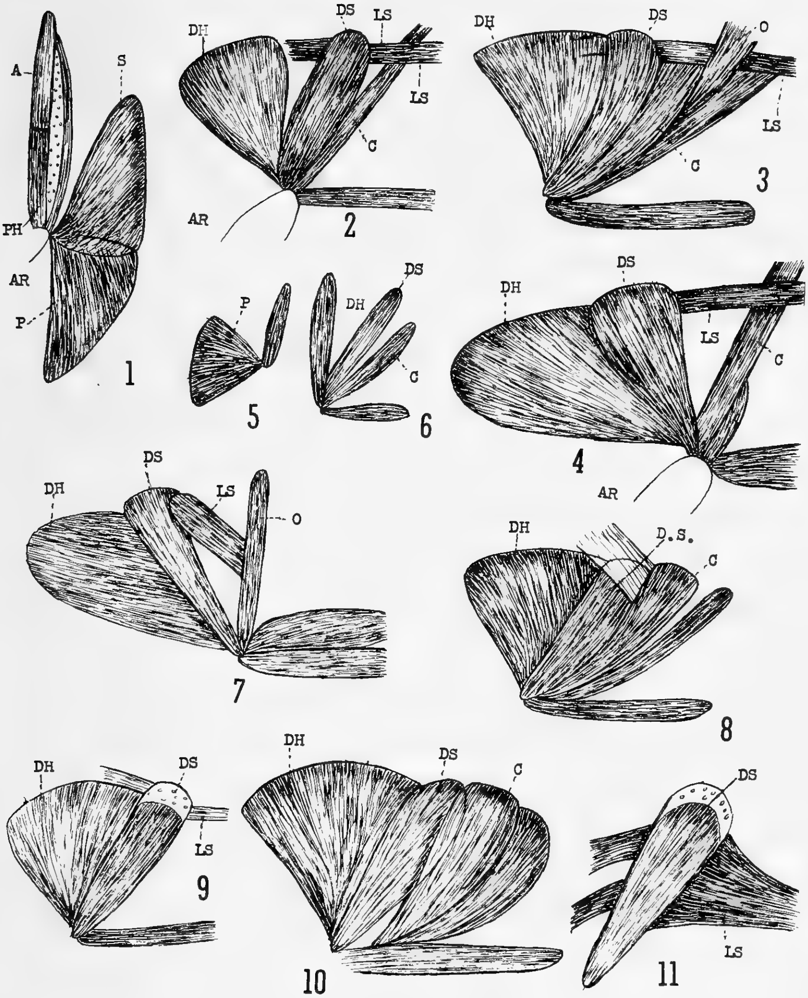

*Plate I:* 1. Proteus shoulder girdle from the front. 2. Same from the side, cephalic end at the right, dorsal side above. 3. Necturus, side view of shoulder muscles. 4. Crytobranchus, same from the side. 5. Amphiuma, breast muscles from the front, right side. 6. Amphiuma, lateral shoulder muscles, left side. 7. Siren, side shoulder muscles. 8. Salamandrella, side view of shoulder muscles. 9. Same as the last with cucullaris removed. 10. Ambystoma maculatum adult, side shoulder muscles. 11. The last with superficial muscles removed.

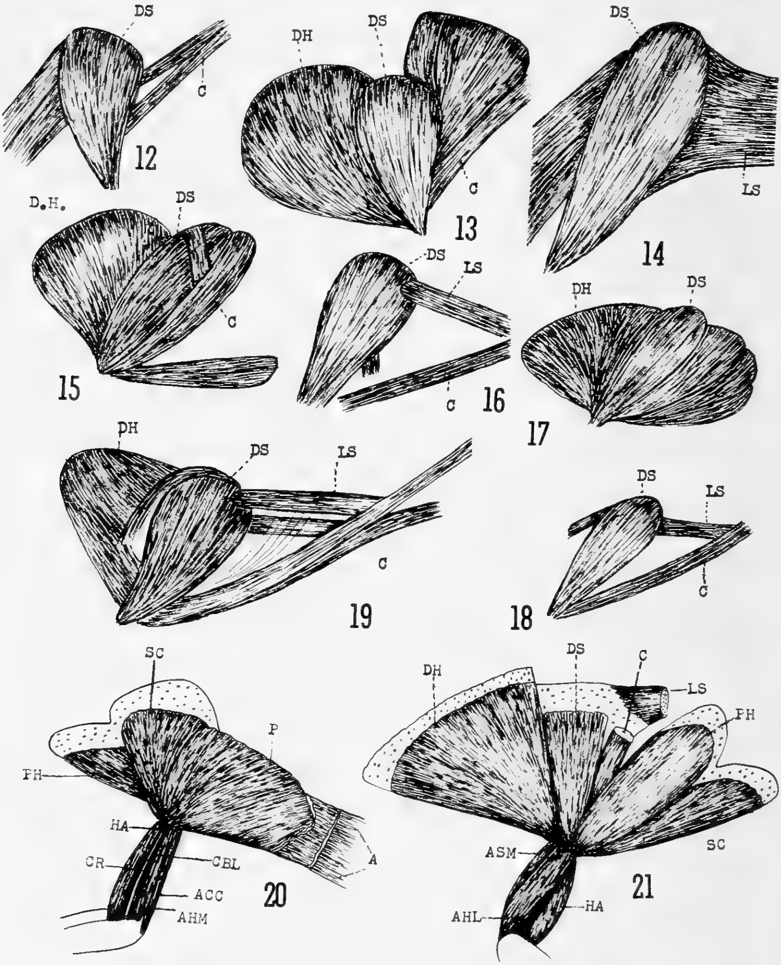

*Plate II:* 12. Side shoulder muscles of Diamectylus viridescens, with the superficial muscles removed. 13. D. viridescens, shoulder muscles in place. 14. Taricha torosus, lateral shoulder muscles with the superficial ones removed. 15. Lateral shoulder muscles of Desmognathus fuscus. 16. The same with superficial muscles removed. 17. Lateral shoulder muscles of Psepdotriton. 18. Deeper muscles of the last 19. Lateral shoulder muscles of Hydromantes platycephalus. 20. Outer view of the muscles of breast and leg of Salamandra, after Francis. 21. Inner view of shoulder, breast and upper leg muscles of Salamandra, after Francis.

## INDEX TO ILLUSTRATIONS

A., Abdominal muscles; ACC Anconaeus coracoideus cucullaris; AHL, Anconaeus humeralis; AHM, Anconaeus humeralis medialis; C, Cucullaris; CBL, Coraco-brachialis longus; CR, Coraco-radialis; DH, Dorso-humeralis; DS, Dorsalis scapuli; HA, Humero-antibrachialis; LS, Levator scapuli (operculus); O, Omo-arcualis; P, Pectoralis; PH, Procoraco-humeralis; S, Supra-coracoideus.

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# OBSERVATIONS ON SCOUTING BEHAVIOR AND ASSOCIATED SOUND PRODUCTION BY THE PACIFIC BOTTLENOSED PORPOISE

## (*Tursiops gilli* Dall)[1]

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## Introduction

The sounds produced by cetacea and the possibility of their use for communication has long been of interest to scientists. As early as 1935, the sound production of cetacea in the Black Sea was observed and the hypothesis offered that these sounds could be communicative in nature (Tomilin, 1955). Since this time the literature pertaining to this hypothesis has become voluminous (see, for example, Tomilin, 1955; Frazer, 1947; McBride and Hebb, 1948; Wood, 1953; Lilly, 1961; Norris and Prescott, 1961; and Dreher, 1961). Although some of these contributions on the subject of cetacean sound production and communication have been based on observations of wild populations, the majority of the more recent work has been based on captive animals.

The study of the communicative behavior of captive animal populations, especially cetacea, has many advantages over field observations. In working with cetacea, which are normally quite mobile, the restricted environment affords better control of observational conditions as well as the possibility of long-term constant monitoring of sound production and concurrent behavior. On the other hand, one is limited to working with those species which readily adapt to captivity, and most certainly all behavior of the animals under study is modified by the restriction. An ideal solution to this quandry would be the capability to make observations of sound production and concurrent behavior on the same genus and/or species of cetacea both in captivity and in its natural habitat. The difficulties of this approach are obvious.

With the cooperation of Marineland of the Pacific oceanarium in the use of its facilities and animals, and the availability of a 50-foot oceanographic vessel specially adapted for sound recording at sea, it

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[1] These studies were aided by Contract Nonr (N.R. 301-604) between the Office of Naval Research, Department of the Navy, and the Lockheed Aircraft Corporation, California Division.

has been possible to start compiling sound data on some genera of Delphinidae under both captive and natural conditions. At present, data have been collected on *Tursiops truncatus* (Montagu), *Tursiops gilli* (Dall), *Lagenorhynchus obliquidens* (Gill), *Delphinus bairdi* (Dall), and *Globicephala scammoni* (Cope).

The purpose of this paper is to discuss observations of the sound production of the Pacific bottlenose porpoise (*Tursiops gilli*) and some concurrent behavior made during a cruise to Scammon's Lagoon (28° N, 114° W), Baja California del Sur, Mexico. In addition, some comparison will be made between these data and data collected from *T. truncatus* in captivity.

The primary purpose of the biological cruise to Scammon's Lagoon from 22 January to 8 February, 1962, was to study in general the behavior of the California gray whale, *Eschrichtius glaucus* (Cope) and specifically to make observations of sound production. However, the common occurrence of *T. gilli* in the lagoon afforded excellent opportunity for frequent observation of the behavior of these animals also.

## Facilities and Instrumentation

The Lockheed California Company oceanographic research vessel *Sea Quest* is a 50-foot, diesel-powered, converted salmon trawler which has been especially fitted for accomplishing a wide range of oceanographic missions. From the standpoint of underwater sound recording one of the more important modifications has been the installation of a battery-powered generator which can silently provide adequate stable 115 volts, 60 cycle, power for periods up to 4 hours of continuous "silent ship operation."

The recording system used consisted of an AN/PQM-A1 Noise Measuring Set and an Ampex 351, 2 channel, Tape Recorder. Channel 1 was used as the data channel and channel 2 as the voice channel in both systems. The hydrophones for the system were mounted in botom-tripods. The hydrophone positioned alongside the ship was designated as Hyd. #1 and the distant (200′) hydrophone as Hyd. #2. (Fig. 1).

The frequency response of the Ampex 351 at 7½ inch/sec is flat from approximately 30 cps to 16,000 cps and at 15 inch/sec flat (±2 db) from 20 cps to 20,000 cps and down 11 db at 29,000 cps. The AN/PQM-A1 is flat from approximately 40 cps to 40,000 cps. Due to the limitation on the lower end of the hydrophone system (40 cps), and on the upper end of the tape recorder, 16 kcps-20 kcps depending

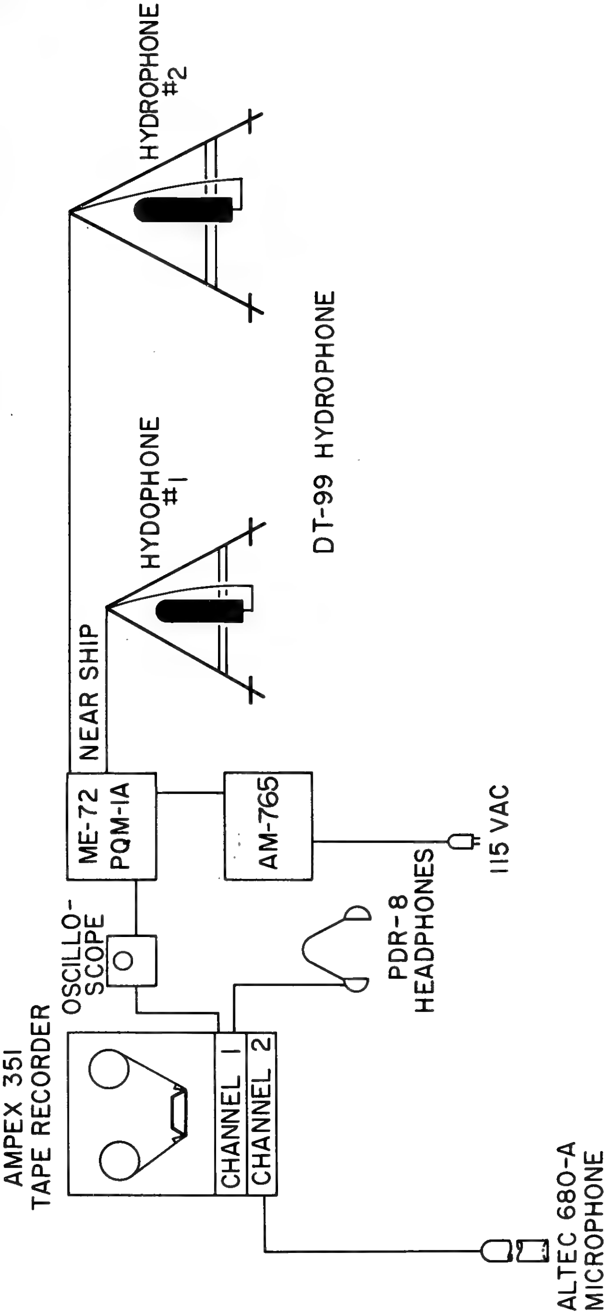

*Figure 1.* Diagram of recording system used in tests described herein.

on speed, the flat response of the complete system, ±2 db can be assumed to be 40-20,000 cps.

## PROCEDURE

In attempting to obtain sound production in reference to some known condition, a portable floating barrier was constructed which hopefully would divert the animals' direction of movement and provide a good "sonar" target if the animals under study were using some form of echolocation. The barrier selected consisted of 15 air-filled aluminum tubes, 2 inches in diameter and 15 feet long. Each tube (spar buoy) was weighted with chain, and when placed in the water 12 feet were below the surface. During the particular phase of the cruise under discussion in this paper, the individual units of the barrier were placed at 50-foot intervals, with one end anchored and the other end moored to the ship. When placing the barrier an attempt was always made to cross a channel which was, or had been observed to be, in use by the animals. The hydrophones were put in place as close to the barrier as was possible with available cable.

## *Tursiops gilli* VOCALIZATIONS

During the period of observation in the lagoon, *T. gilli* were sighted and listened to several times. The animals occurred in groups of 2 to 5 and approached up to 100-200 feet from the ship. During the majority of contacts, the only sounds heard were echolocation pulses at various repetition rates. These signals were very similar, if not identical, to those produced by *T. truncatus* in captivity. Maximum range of sound contact was approximately 500 yards from the ship.

On February 1, 1962, at 1600 hrs, the ship was located in Piedra Channel, at 27°41′8″ N, 114°8′ W. Hydrophone #1 was in position, and the barrier was streamed between the ship and a shoal, a distance of approximately 250 yds. Hydrophone #1 was at a depth of 24 feet. At approximately 1650 hours, Wendell Tripp, the assistant master of the ship, sighted five *Tursiops gilli* moving slowly up the channel from the east toward the barrier at a range of about 500 yards. The sound gear was switched on to monitor. Very slow echolocation clicks were heard. At a distance of approximately 400 yards, the group, still echolocating, moved over to shoal water (4-9 feet deep) and schooled into a tight group. After about five minutes of very sparse sound activity, a single animal left the group and headed toward the barrier. This animal made a "sonar" run along the barrier, turned, and headed back

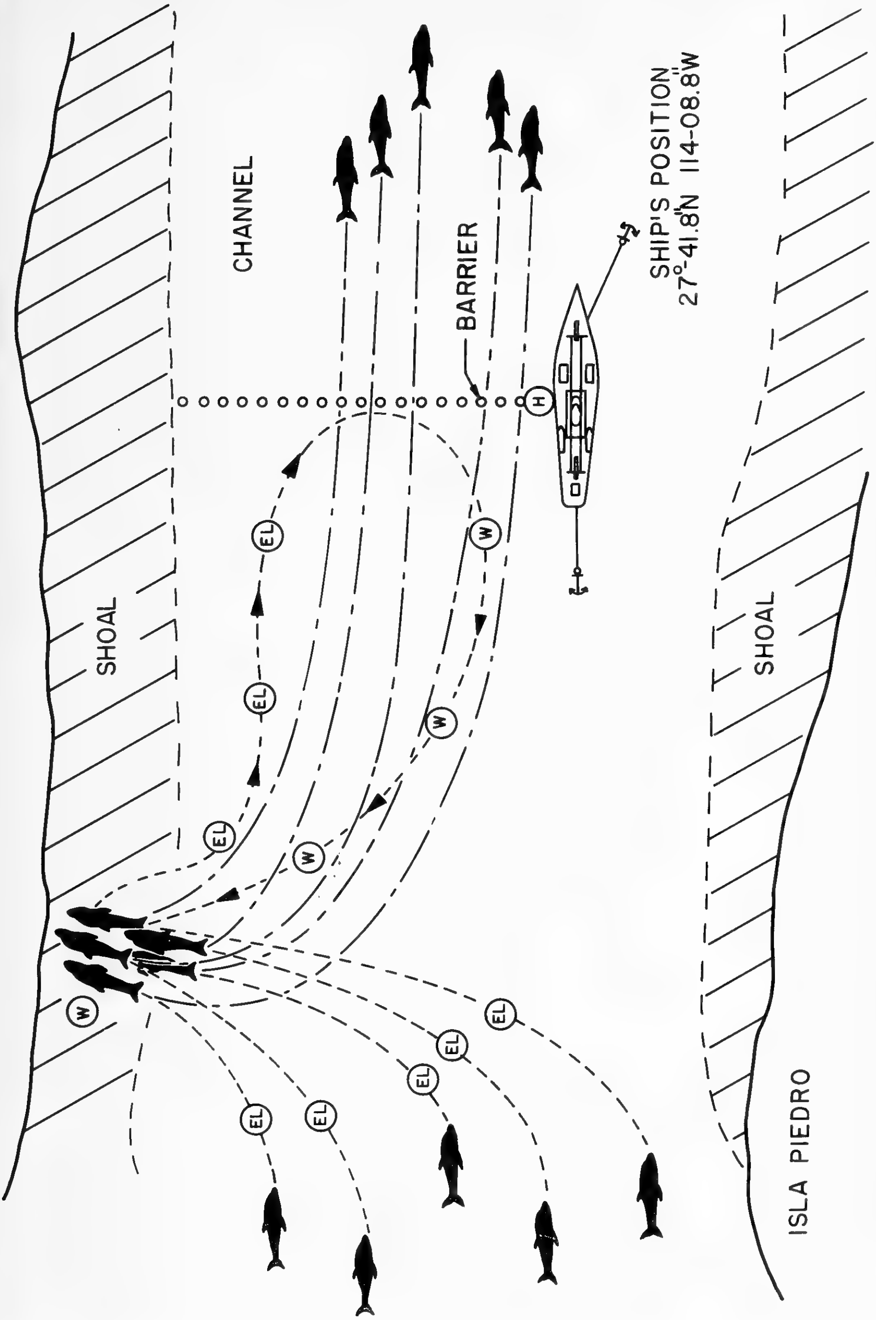

*Figure 2.* Schematic diagram of the location of research vessel, barriers and animals during vocalization incident discussed in text.

to the group. At this time, whistle activity started. This represented the first time on the cruise that prolonged whistling activity was observed. The single animal runs on the net, followed by whistling, were repeated 2 to 3 times then the group left the shoal and proceeded cautiously up the channel. After passing the barrier, sound activity ceased and the animals went west and through the barrier, whereupon visual contact with the animals was lost. A schematic diagram of the location of ship, barrier and animals during this incident is presented in Figure 2.

It is interesting to note that on the several other occasions of *Tursiops* sighting, only intermittent echolocation signals were recorded. However, the placement of a sound reflecting barrier across a normally non-restricted channel did elicit some form of cautious behavior accompanied by what appeared to be scouting. Also of interest is the sequence of echolocation scanning behavior-whistling-scanning behavior, in this order. Although it is possible that similar events occur in captivity with *T. truncatus*, the small confines of the usual holding facility make specific comments on groupings and orientation of animals difficult if not impossible.

## *T. gilli-T. truncatus:* Tone Contour Comparison

Having obtained a relatively good sample of *T. gilli* whistles, a comparison was made between these signals and similar vocalizations produced by *T. truncatus* in captivity. To aid in this comparison, a simple notation system was developed to symbolize the various whistle contours (Fig. 3). In each of these symbols the abscissa represents time and the ordinate represents frequency or pitch. The contours used in the following comparison, it should be pointed out, were transcribed by ear from sound tapes slowed down four times. This is a relatively easy and accurate process after several preliminary auditions of the tape. While linguistics recognizes some eight different forms of tone-modulated language (Pike 1948), involving pitch change, register change, durations, relative beginning and end registers, and various combinations, these analyses were assumed to follow the pattern of a Class I language wherein lexical significance is denoted by changes in pitch shift only. This does not preclude sandhi (linking) accommodation, or semantic contour profiles, but does relegate them to second or higher order determinants.

Earlier analyses of porpoise whistles (Dreher, 1961) dealt with

*Figure 3.* Typical example of the notation system used in this study to symbolize cetacean whistle contours.

some statistical aspects of *Tursiops truncatus* signals as produced in a relatively restricted tank with nine interacting animals over several situations of feeding, play, and rest. The question naturally arises: Do other species (or genera) use the same whistle contours, and if not, what differences are noted? A partial answer is possibly present in analyses of the vocalization of *T. gilli* in the process of responding to the sound-reflecting barrier. The previously described caution and approach behavior serves as a context for the observed whistles. In all, from the first detection of the barrier to the successful passing, some 66 whistles were noted. These comprised 16 different contours, 8 of which were similar to those used by the captive *T. truncatus* in the 12 most frequent calls.

One salient difference between *T. truncatus* whistles and *T. gilli* whistles appears. The wild *T. gilli* whistles, while sometimes similar in contour, were usually longer in duration than those produced by captive animals. This is an acoustically predictable happening, based on the sound production behavior of other animals, notably man. That is, as the reverberation of the environments is decreased and anechoicity is approached, any given utterance becomes longer in time. This is equivalent to saying that humans in a small room with sound reflecting walls will produce words shorter in duration than if they are some

TABLE I

OCCURRENCE OF WHISTLE CONTOURS FOR
TURSIOPS TRUNCATUS AND TURSIOPS GILLI

| | | ANIMAL | | |
|---|---|---|---|---|
| CONTOUR | T. TRUNCATUS | RANK | T. GILLI | RANK |
|  | USED | 1 | USED | 13.5 |
|  | USED | 2 | —— | —— |
|  | USED | 3 | USED | 1.0 |
|  | USED | 4 | USED | 4.5 |
|  | USED | 5 | USED | 13.5 |
|  | USED | 6 | USED | 4.5 |
|  | USED | 7 | USED | 13.5 |
|  | USED | 8 | USED | 2.5 |
|  | USED | 9 | —— | —— |
|  | USED | 10 | —— | —— |
|  | USED | 11 | USED | 13.5 |
|  | USED | 12 | USED | 13.5 |
|  | USED | 13 | —— | —— |
|  | USED | 14 | —— | —— |
|  | USED | 15 | —— | —— |
|  | —— | — | USED | 13.5 |
|  | —— | — | USED | 9.0 |
|  | —— | — | USED | 6.5 |
|  | —— | — | USED | 9.0 |
|  | —— | — | USED | 9.0 |
|  | —— | — | USED | 6.5 |
|  | —— | — | USED | 2.5 |

distance apart in an open field. Table 1 summarizes the whistle contours noted in interchange between captive *T. truncatus* and those observed in *T. gilli* during the barrier problem, with due allowance for the lengthening phenomena.

It will be noted that several identical rank occurrences have been entered for *T. gilli*, a reflection of the small sample observed. The rankings tell only how often a signal was produced, not when. Several of the contours were produced in isolation, with several short sequences also occurring. It is not known at this juncture just what constraints exist in their syntax, although the increasingly greater library of their sounds will eventually make such a determination possible.

## Discussion

Direct conclusions as to the communicative value of whistles produced by either species of *Tursiops* considered are of course not possible from the aforementioned observations. However, these observations do add some interesting support to the porpoise whistle communication hypothesis. The occurrence of whistling in a precise relationship to specific behavior, *i.e.* response to a new situation, does indicate the possibility of purposeful sound production. Of further interest is the use of some identical or near identical contours by different species. In fact, it would seem almost mandatory for mutually understandable calls to exist in light of observation of cooperative behavior as pointed out by Brown and Norris (1956) and Norris and Prescott (1961). Enough importance has been placed on the significance of the interspecific whistle similarities observed by authors in this present study that further analyses into possible intergeneric similarities are in progress.

## Acknowledgments

We wish to thank Dr. K. S. Norris of the Department of Zoology of the University of California, Los Angeles, and R. L. Eberhardt of the Lockheed-California Company, Burbank, for their assistance in field observations. Also we wish to thank Miss Ruth M. Haugen, of Lockheed and Dr. David K. Caldwell, Los Angeles County Museum for their constructive comments on the manuscript. In addition we appreciate the cooperation of Messers. D. H. Brown and J. H. Prescott of the Marineland of the Pacific Oceanarium in the collecting of data on *T. truncatus*.

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# CONTRIBUTIONS FROM THE LOS ANGELES MUSEUM —CHANNEL ISLANDS BIOLOGICAL SURVEY

## 34. A FOSSIL BIRD, CARACARA, FROM SANTA ROSA ISLAND

Hildegarde Howard
Los Angeles County Museum

The Los Angeles Museum Channel Islands Biological Survey was curtailed precipitately in December, 1941, with the bombing of Pearl Harbor. Expedition No. 13 was at that time on Santa Rosa Island. Comstock (1946: 105-107) gave a brief report of this last expedition. Regarding the paleontological work, there is the notation that King A. Richey, John C. Stock and Harry Fletcher prospected in the Tecolote Canyon area, November 11-14, 1941, and "reported a number of exposures suitable for working." Two of the paleontologists returned to the mainland on November 15, presumably with the intent of reporting their investigations to the late Chester Stock, then Senior Curator of Earth Sciences at the Los Angeles Museum, and also of the geological faculty of the California Institute of Technology. The Institute, under Dr. Stock, had some years before conducted paleontological work in Santa Rosa Island. All plans for continuing excavations by either institution were, of course, set aside with the advent of the war. The few Dwarf Elephant fossils collected on the prospecting trip of 1941 (in field bags labelled "S.R.I.-1" to "S.R.I.-4") were stored for future study. No one noted that the three fragments in the bag marked "S.R.I.-2" were avian.

As part of a project concerning fossil birds of the southwest (supported by a John Simon Guggenheim Foundation Fellowship) I was assisted in the summer of 1962, by Wm. D. Arvey, Long Beach State College. A search was made through the entire vertebrate fossil collection of the Los Angeles County Museum for unrecorded avian material. In this manner we came upon the fragments from Santa Rosa Island.

In addition to the "S.R.I.—2" notation on the field bag, the inscription with the bird bones reads, "Santa Rosa Island, near mouth of Corral Canyon in sea cliff. Richey, 11.12.41." Phil C. Orr, who in recent years has led the Santa Barbara Museum of Natural History's paleontological investigations on the Channel Islands, describes in detail the wavecut platforms of Santa Rosa Island and the deposits that cover them (Orr, 1960) and refers the upper, or Tecolote member of the Santa Rosa Island Formation to Wisconsin age, based on radiocarbon datings of from 10,400 to beyond 30,000 years B.P. In correspondence he states that the deposits in Corral (better known as Arlington) Canyon are all of the Tecolote member.

The specimens collected by Richey consist of a proximal and distal end of tarsometatarsus and a distal end of tibiotarsus, probably all of a single individual. The bird represented was a caracara, which I assign to the species *Caracara prelutosus* (Howard) described from the Pleistocene of Rancho La Brea. The tibiotarsus shows no diagnostic characters, but both fragments of tarsometatarsus agree with this element of *C. prelutosus* (Howard, 1938; 235-236) as follows: distalmost foramen on posterior side very slightly above intertrochlear space and 3.5 mm. below upper foramen; near proximal end, internal side of shaft with deep central depression, and greatest depth of internal face of shaft at approximately 7 mm. below distal extremity of calcaneum. Other measurements are as follows: tarsometatarsus, breadth of proximal end 13.6 mm., breadth distal end 14.5 mm., breadth middle trochlea 5.0 mm.; tibiotarsus, breadth distal end 13.4 mm.

Other recorded species of birds from Santa Rosa Island (Howard, 1944) were collected by the California Institute of Technology in the late 1920's and early 1930's, and were referred to recent species of goose and ducks (*Branta canadensis*, *Anas carolinensis*, and *Anas*, sp.). The Santa Barbara Museum of Natural History's expeditions to Santa Rosa Island during the last fifteen years, have yielded a few more avian fossils. A report on this material will be forthcoming.

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# A NEW GULF OF CALIFORNIA *PERIPLOMA*

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Loma Linda, California

## INTRODUCTION

Among the many interesting and unusual mollusks taken by the "Ariel" Expedition, August 28 through September 2, 1960, was a new member of the genus *Periploma*. This new species is of especial interest as it represents the second member of the subgenus *Halistrepta*, Dall 1904, and the first of that taxon to be recorded from the Gulf of California. It may be known as:

### **Periploma (Halistrepta) myrae,** NEW SPECIES

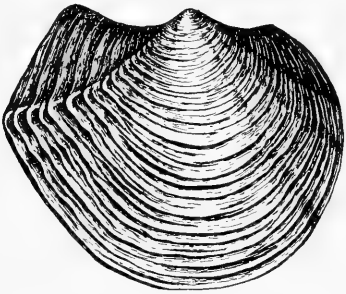

*Figure 1. Periploma (Halistrepeta) myrae,* new species. Exterior view of right valve of holotype, x2.

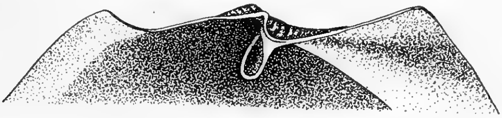

*Figure 2. Periploma (Halistrepta) myrae* new species. Hinge area of right valve of holotype, x3.

*Description:* Shell rotund, with a concave dorsal margin both anterior and posterior to the beaks, so thin as to be fragile, white, the left valve flatter than the right. The right valve is ornamented by somewhat discontinuous undulant sculpture. Left valve less coarsely sculptured, the undulations seemingly more continuous, though discontinuity does exist. Surface of shell smooth. Under high magnification the texture of the shell appears granular. The anterior and ventral margins are broadly rounded; three minute lines extend anteriorly from the beaks but are visible only with difficulty (slightly overemphasized in Fig. 1). These lines are apparently very shallow furrows, and are shown as such in Figure 1, but this could not be determined with certainty. Posterior margin abruptly truncated, producing a broad, short rostrum. This rostrum is set off by a low rib, which extends diagonally from the beak, formed by the folding of the concentric undulations. This rib forms the boundary between the posterior and ventral margins. The rostrum is ornamented by faint continuations of the concentric undulations and by fine growth lines. Interior subnacreous. Posterior muscle-scar quite large, wedge-shaped, very faint. Anterior muscle-scar and pallial line obscure. The pallial sinus broadly wedge-shaped, with the anterior end rounded. Resilifer small, narrowly spoon-shaped, nearly vertical. A dull area bordered by a more polished narrow margin indicates the resilium attachment. A short, narrow clavicular prop supports the resilifers. The props extend diagonally and posteriorly, fading out along the anterior-dorsal edge of the posterior muscle-scar. It is possible that this prop serves more as a muscle attachment than as a support for the resilifer.

*Holotype:* To be deposited in the Stanford Univ. Paleo. Type Coll., number 9499. Length, 20.2 mm., altitude 16.4 mm. The holotype was broken subsequent to collecting and is represented by the repaired right valve and fragments of the left valve.

*Type locality:* Trawled in 15-25 fms., just off Loreto, in the channel between Loreto and Carmen Id., Baja California, Mexico. 29 August 1960. "Ariel" Expedition.

*Commentary:* In 1904 Dall described the very rare *Periploma sulcata*, from San Pedro, California, and established the sectional name *Halistrepta* for it. In both 1908 and 1915 he used *Halistrepta* in a subgeneric sense, which rank it is accorded here.

The discontinuous, undulant sculpture and prominent rostrum place *Periploma myrae* in this subgenus. It is very unfortunate that the lithodesma was not present for comparison.

While *Periploma myrae* is related to *P. sulcata* it may be distinguished at a glance by the truncated posterior end, by the doubly concave dorsal margin, prominent rostrum, and three faint furrows rather than a single furrow extending toward the anterior end. The clavicular prop is also less heavily developed and the resilifer is vertical rather than extending forward.

*Periploma myrae* resembles *P. discus* Stearns, 1890 in general shape, but that form lacks the undulant sculpture in the adult form. The prominently truncated posterior and rostrum are also not present on *P. discus*. Young specimens of *P. discus* occasionally have undulant interior sculpture (as shown by a specimen in the Burch coll. from off Redondo Beach, California) which disappears as the shell grows older.

This beautiful new form is dedicated to Dr. A. Myra Keen of Stanford University in grateful appreciation of her many contributions to malacology and paleontology.

## ACKNOWLEDGEMENTS

I wish to express my thanks for much assistance to Mr. and Mrs. E. P. Chase of the San Diego Museum of Natural History, to Dr. A. Myra Keen, to Mr. and Mrs. J. Q. Burch and to Dr. S. Stillman Berry for his help and guidance.

The excellent hand drawings are by Dr. Bruce Campbell.

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# THE OCCURRENCE OF *SONORASPIS CALIFORNICA* FROM EAST-CENTRAL NEVADA

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and
William W. Lumsden
Long Beach State College

In several publications the genus *Sonoraspis* Stoyanow (1952:50-53) was either regarded as a paleontological puzzle (Lochman, 1952:137) or overlooked in its stratigraphic significance (Palmer, 1954:67), or even misrepresented (Moore, *et al.*, 1959:0224), but invariably confused with *Glossopleura* Poulsen (1927:268), from which it sharply differs in its paleontological and easily observable nature, its stratigraphic position, and its paleogeographical distribution. This genus possesses clearly outlined characteristics: a thorax always with eight segments, and certain mixed features of *Anoria* Walcott (1924:54) and *Glossopleura* but never all of them. This provides a basis for specific separation and an easy identification. It should be stated that thus far *Sonoraspis* has never been located in the same strata with *Glossopleura.* The purpose of this article is to present additional data acquired in the recent research of the writers. This paper is the first in a series of proposed reports dealing with the distribution of *Sonoraspis* and its relation to *Glossopleura.*

A significant clue as to the presence of an eight-segmented form in southern California was briefly mentioned by Clark (1921:6) while discussing *Bathyuriscus howelli* var. *lodensis.* Based on Clark's discussion, Stoyanow and Susuki (1955:467-470, pl. 1, figs. 1, 2) conducted an extensive research in the Marble Mountains, San Bernardino County, California (Bristol Mountains of Clark), and located there specimens of *Sonoraspis* about fifty feet below the base of the Bonanza King formation (Hazzard and Mason, 1936:234-238). This find by Stoyanow and Susuki revealed that a seaway containing *Sonoraspis* fauna existed between the Sonora Basin, Mexico and southern California. Before *Sonoraspis* was discovered in southern California, McKee (1947:288) postulated an early Middle Cambrian seaway continuous from western Sonora north through Arizona and into the Grand Canyon area. McKee (1947:288) based this seaway on the presence of *Glossopleura* in the Harquahala Mountains to the south of the Grand

Canyon. Stoyanow (1948:323-324) was not in agreement with McKee's interpretation, pointing out the lithological similarity between the Cambrian of Harquahala Mountains and the Grand Canyon, and that it seemed more probable that the Harquahala trilobites belonged in the Cambrian basin of the Grand Canyon, inasmuch as southwestern Arizona was occupied by a pre-Cambrian Massive of Mazatzal Land (Stoyanow, 1942:1264; 1936:462). A westward Paleozoic portal in the Sonora Basin was first suggested by Schuchert (1910: pl. 52) and Schuchert's idea was corroborated by Stoyanow (1942:1263-1264).

The presence of *Sonoraspis* thirty feet below the stratum containing *Albertella* was established in the Inyo Mountains, California (Stoyanow, 1958:347), thus extending northwestward the geographic distribution of *Sonoraspis*. The occurrence of *Sonoraspis* in the Inyo Mountains may well suggest a connection with the Sonora Basin through the Marble Mountains during early Middle Cambrian time. This discovery is not only significant paleogeographically, but extremely important stratigraphically in that from this relationship, the stratigraphic position of *Sonoraspis* was determined. It should be noted that in the Canadian Rockies (Rasetti, 1951:109), *Glossopleura* zone is well above the *Albertella* zone and a similar stratigraphic relation exists in the Grand Canyon section (McKee, 1945:30, 33). Although *Sonoraspis* and *Albertella* had been found in the Sonora section, their stratigraphic interrelation there was not clearly understood, since Lochman (1952:180) did not recognize *Sonoraspis* as a valid genus but equated it both paleontologically and stratigraphically with *Glossopleura*. In discussing Glossopleura species, Lochman (1952:137) was unable to explain why *Glossopleura mckee* Resser from the Bright Angel shale of the Grand Canyon section showed consistently seven segments in the thorax, yet all the species from Sonora, even though the cephalon and pygidium appeared identical to *G. mckee*, showed eight thoracic segments.

The find of *Sonoraspis* by the present writers in Currant Creek Gap section, east-central Nevada (Fig. 1) indicates the first recorded extent of the *Sonoraspis* fauna considerably northeastward within the main Cordilleran trough.

This specimen from Nevada is closer to *S. californica* Stoyanow and Susuki (Holotype, UCLA Invert. Paleo. Cat. no. 23460) than to *S. gomezi* Stoyanow (1952:54-55) by tuberculation on all thoracic segments which increase in size (from circular to elongated) toward

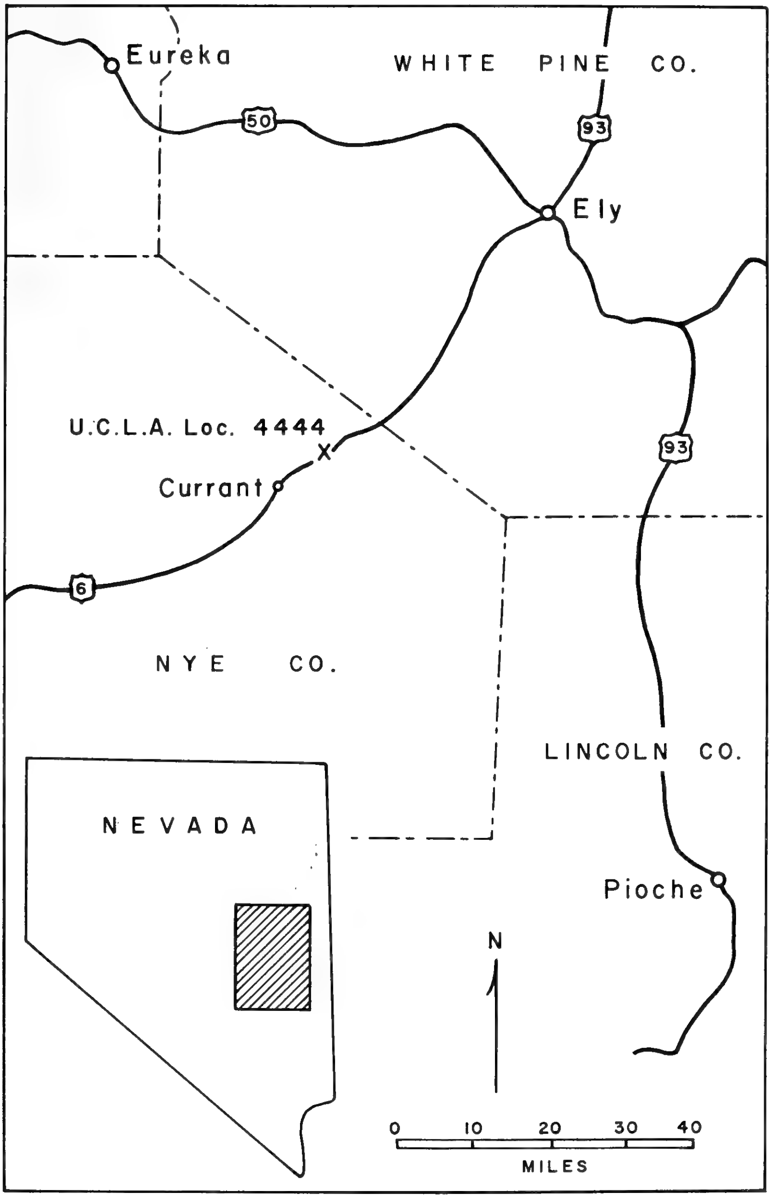

*Figure 1.* Map showing east-central Nevada where *Sonoraspis californica* was found.

the segmented pygidium, whereas *S. gomezi* has only six posterior thoracic segments bearing tubercles and an unsegmented pygidium.

*Type: Hypotype,* UCLA Invert. Paleo. Cat. no. 34974, Figure 2.

*Locality:* UCLA Invert. Paleo. Loc. no. 4444.

*Occurrence:* The described type has been collected at a roadcut on

*Figure 2. Sonoraspis californica* Stoyanow and Susuki, Hypotype, UCLA Invert. Paleo. Cat. no. 34974, specimen enlarged x2 to show posteriorward development from circular to elongated tubercles on the thoracic segments.

the northside of U.S. Highway 6, in thin-bedded, platy, gray limestone, 300 feet north and 400 feet west of the southeast corner of Sec. 24, T. 11 N., R. 58 E., Currant Mountain quadrangle (U.S.G.S., 1957 ed.), Currant Creek, Nye County, Nevada (Figs. 3 and 4).

*Figure 3.* Currant Creek Gap, Nevada. Westward view. Lighter colored exposure at the base, on the right side of photograph is where *Sonorapsis californica* was found.

*Figure 4.* Close-up of the limestone outcrop.

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# NOTES ON THE OCCURRENCE, OBSERVATIONS AND PUBLIC HEALTH SIGNIFICANCE OF THE PAJAROELLO TICK – *ORNITHODOROS CORIACEUS* KOCH, IN LOS ANGELES COUNTY

William G. Waldron[1]
Los Angeles County Health Department

Recently, several reports in non-scientific publications have disclosed that little is known locally about the Pajaroello tick—*Ornithodoros coriaceus* Koch. Because of these reports, studies were conducted by the author in the Los Angeles National Forest, the suggested habitat of this tick, to gather data on the prevalence of *O. coriaceus* and information on the severity and virulence of its bite.

Nutall (1908) first described the Pajaroello in Mexico around the Gulf of Tehuantepec. He also found this tick in 1908 in Santa Barbara County. Hermes (1960) and Kohls (1944) have collected numerous specimens in the Mount Hamilton area where it "flourishes in the deer beds among the low scrub oaks," *Quercus dumosa*. Hermes likewise acknowledges that this species occurs commonly in the more mountainous coastal counties in California. Hoffman, quoted in Cooley & Kohls (1944), states "*O. coriaceus* is a native of the hot and temperate regions along the Pacific extending all the way from California to Chiapas (Mexico)."

The first step on this Pajaroello study involved checking records of collections made locally. Surprisingly few were available. A total of only 4 collections were located which had been made in the San Gabriel and Santa Monica Mountains.

*O. coriaceus* collections:

A. UCLA, Dr. J. N. Belkin
  1. Los Angeles County, Pasadena, ex: soil, IV-7-53
     22 nymphs, coll. student (UCLA)
B. Los Angeles County Museum, Dr. Fred Truxal
  1. Los Angeles County, Township T2N-R11W, Sec. 29
     SW¼ ex: dirt, 5800′, 6/49, coll.
     Dr. R. O. Gilbert, 1 nymph, 1 ad.
  2. Los Angeles County, Devil's Punch Bowl, Ex: man,
     8/21/52, 1 nymph, 1 larvae

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[1] Entomologist.

C. Long Beach State College, Dr. Elbert Sleeper
  1. Los Angeles County, San Dimas Exp. Forest.,
    VII-II-59, #2, 1 ad. Coll. M. Knox and E. Sleeper.

Forest rangers, patrolmen and fire guards of the U.S. Forest Service were quite familiar with the Pajaroello. Many advised the author that they first became acquainted with the tick and its bite while assigned to the Los Padres National Forest in the Santa Barbara area.

A great deal of interesting and pertinent information was gathered from these men, who not only were aware of the Pajaroello, but were

*Figure 1.* Ventral (upper) and dorsal (lower) view of *Ornithodoros coriaceus* Koch. Photos courtesy of Dr. Fred Truxal, Los Angeles County Museum.

likewise highly trained and capable observers. In practically every instance the bites, which allegedly implicated the Pajaroello, occurred while the Forest Service personnel were working on a forest fire. This, of course, implies that the men were away from their stations and offices and were living in a more or less primitive fashion for the period of the fire. Also, the men were working in the brush where they had ample opportunity for exposure to arthropod bites.

According to Merrell (1948), the U.S. Forest Service in the Angeles National Forest reported in 1940 that several members of a CCC maintenance crew allegedly were bitten by arthropods thought to be Pajaroello ticks. This is the first recorded reference to *O. coriaceus* in Los Angeles County.

According to Herms (1950) the main host of *O. coriaceus* is the mule deer, *Odocoileus* species. It is therefore reasonable to assume that ectoparasites may be spread into new areas as the deer herds migrate from one section to the other due to the pressures of food, fire, water and hunters. The first collections above 6,000 ft. known to the author were made at Table Mountain in the Big Pines area which is about 7200 ft. altitude. The other 5 collections made by the author were primarily between 4500 and 7000 ft. It was observed that the highest density of Pajaroellos should occur in the spring of the year.

*O. coriaceus* specimens in the author's collection:

1. Los Angeles County, Camp 37, Calif. State Highway Camp,
   Angeles Forest Highway, Ang. Forest, 6000′, 9/58,
   coll. W. G. Waldron, 3 ad., ex: brush.
2. Los Angeles County, 300′ S of Table Mt. Reservoir,
   So. Slope, 7200 ft., Big Pines, Ang. Forest,
   4/2/59, 1 ad., coll. W. G. Waldron, Ex: brush, 162-59.
3. Los Angeles County, Table Mt. Campgrounds at West Bend,
   Big Pines, Ang. Forest, coll: W. G. Waldron, 1 ad,
   1 nymph, ex: brush, 7500 ft.
4. Los Angeles County, Swartout, Big Pines,
   Ang. Forest, 6/30/58,
   1 ad., 2 nymphs, coll. W. G. Waldron, ex: man, 6800 ft.
5. Los Angeles County, Jackson Lake, Big Pines, Ang. Forest,
   4/1/59, coll. E. S. Cross (USFS), 2 ad, 5 nymphs,
   ex: brush, 6500 ft.

Although most Forest Service personnel are not trained entomologists and do not usually have equipment necessary for identification of the arthropods, they accurately described and even furnished the proper tick upon request (collection #5 above). Apparently other *Ornithodoros* species such as *O. hermsi*, *O. turicata* and *O. parkeri* which could be mistaken for *O. coriaceus* are not readily found where the Pajaroellos have been collected.

Nutall (1908) graphically described the effect of the bite and feeding habits of *O. coriaceus*. Hermes (1950) also describes an account of two bites which a former student suffered some years ago. The descriptions by Nutall and Hermes are very similar. Hesper N. MacMillen and E. C. Loomis, in personal communications to the author, likewise give the same general description of the Pajaroello tick bite from their own personal experiences.

The author has gathered a great deal of data on the Pajaroello bite, particularly from Forest Service personnel, and they all follow more or less the same pattern and in most instances no pain is felt at the time the tick attaches its mouth parts to the skin of the human host. This is the converse of descriptions cited above from Nutall and others. Possibly, most of the tick bites investigated by the author were inflicted while the person was at rest and therefore no noticeable pain was evidenced. It is also possible that the tick actually causes pain as a result of feverishly attaching its mouth parts to the host while the body of the host is in motion, the tick thus protecting itself from being dislodged from the point of attachment. This is an assumption upon the part of the author and does not reflect any valid data. The author also has noted that the reaction to the bite appears to be a direct allergic response of the host to the saliva of the tick.

Despite comments to the contrary, the Pajaroello is not as dangerous as a rattlesnake. The tick injects no toxin *per se,* and very few bite patients have been hospitalized. Actually only two cases of this severity have been recorded locally. The bite may be more painful and annoying to those people who react strongly to the material in the saliva. Likewise, as MacMillen and Loomis graphically indicated to me, a person may become increasingly sensitized to the bite to the point where additional exposures could cause acute discomfort to the human host.

Records are available where the "incise and suck" treatment has been employed for Pajaroello as well as for rattlesnake bites. The method suggested by the Health Officer of the Los Angeles County Health Department and the local office of the American Red Cross suggests suction might be of aid if applied soon enough after the bite, but neither recommend the need for incision. One of the most important steps is the application of a good salve, preferably with an analgesic, and *extreme* care against secondary infection. No records are available which in any way implicate the Pajaroello as being a vector of disease. This is not to say that this Argasid is not a potential, but rather that it has never been implicated, circumstantially or otherwise, as a transmitter of disease to men or animals.

## SUMMARY

It appears that the Pajaroello, contrary to some reports, is not as dangerous as a rattlesnake although its bite can be painful and uncomfortable. Also, *O. coriaceus* is not new in California, although there is a definite dearth of collecting information for the area between Santa Barbara and the Mexican border. The Pajaroello is part of the fauna in the Angeles Forest and care should be taken to prevent unnecessary exposure to its bite; however, it does not appear to be a "menace" to public health at this time.

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## ERRATA

The following errors regrettably appeared in the article "Blood parasites of mammals of the Californian Sierra Nevada foothills, with special reference to *Trypanosoma cruzi* Chagas and *Hepatozoon leptosoma* Sp. N." by Sherwin F. Wood which appeared in volume 61, part 3, of the *Bulletin:*

1. In Table 1, page 163, the numbers "2,1" in the *T. cruzi* column should appear opposite *Peromyscus truei gilberti*, and not opposite *Reithrodontomys megalotis longicaudus*.

2. The last two full sentences on page 168 should read: "Where the central aperture has enlarged and the circular, band-form nucleus has become more labile, the parasite may extend into the aperture pushing a band of nuclear material before it. Most of these immature neutrophils have not yet developed their distinctive granulation."

3. On page 170, line 2, the correct statement should be "2 $\mu$ thick" and not "2 u thick."

# A NEW SPECIES OF COLUMBELLID GASTROPOD FROM EASTER ISLAND

Leo George Hertlein
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San Francisco

Two lots of shells from Easter Island were presented to the California Academy of Sciences, one by Ray Summers and the other by Mrs. Paul Steele. These specimens were collected by Frey Sebastian Englert.

Among these shells is an interesting little columbellid which appears to be quite distinct from any described species. Accordingly, it is here described as new.

The writer here expresses his gratitude to several persons who compared specimens of this species with specimens in the collections in their respective institutions as follows: Dr. A. Myra Keen, Stanford University; Dr. Alison Kay, University of Hawaii and Bernice P. Bishop Museum; Dr. Harald A. Rehder, United States National Museum.

The photographs, retouched by Mrs. Margaret Hanna, were prepared by Maurice Giles. Measurements were made by Dr. G Dallas Hanna.

The new species may be known as:

### **Zafra pascua** Hertlein, NEW SPECIES

*Figures 1-3. Zafra pascua* Hertlein, new species. Fig. 1. Holotype. Height, 6.15 mm., maximum diameter, 2.83 mm. Fig. 2. Paratype. Height, 5.91 mm., maximum diameter, 2.80 mm. Fig. 3. Paratype. Height, 6.05 mm., maximum diameter, 3.06 mm. (Photographs by Maurice Giles, retouched by Margaret Hanna).

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[1] Department of Geology.

Shell small, elongately ovate, fairly thick; 4½ whorls, the sutures impressed; protoconch dome-shaped, smooth; whorls sloping with a slight concavity on the posterior third; axial sculpture consists of rounded, axial ribs, about 15 on the penultimate whorl, extending from suture to suture but fading out on the anterior half of the body whorl; interspaces narrower than the ribs and crossed by very fine incised spiral striae; canal short, sculptured with 5 or 6 fine, well-defined, obliquely sloping spiral grooves which above and below give way to finer striae; aperture rather narrow, columella slightly curved, interior of inner and outer lips smooth; shell white except for a narrow black band beginning near the middle of the edge of the columellar lip and extending obliquely downward around the base of the canal, visible through the inside of the shell. Length, 6.15 mm.; maximum diameter, 2.83 mm.

*Holotype*: no. 12408 and paratypes, nos. 12409, 12410 (California Academy of Sciences Department of Geology Type Collection), from Loc. 34203 (CAS), Easter Island; Frey Sebastian Englert, collector.

On some specimens of the paratypes of this species the axial ribs are nearly obsolete on the body whorl. The fine lines of growth are crossed by concentric striae lending a decussate appearance under magnification.

The general shape and sculpture of the present species bear a general resemblance to that of *Anachis*. However, the narrow aperture and smooth inner and outer lips are quite different from members of that group. The characters of the aperture suggest the reason for placing it in the genus *Zafra* A. Adams. Dr. Rehder agreed in this general placement of this species (written communication May 18, 1962) in or near the *Zafra* group and it is here provisionally so placed.

The general shape and external sculpture of *Zafra pascua*, new species, resemble that of the species described as *Columbella pumila* Dunker[2] from Japan which later was placed in the genus *Zafra* by Taki and Oyama[3]. The shell of the new species differs from that of Dunker's species in the smooth interior of the outer lip and in the dark band of color around the canal, whereas the corresponding lip of *Z. pumila* was described as plicated or subdenticulated and the color of the exterior uniformly fuscous.

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[2] *Columbella pumila* Dunker, Malakozool. Blätter, Bd. 6, p. 224, January, 1860. Japan.—Dunker, Moll. Jap. Descript. et Tab. Trib. Icon., p. 6, pl. 1, fig. 4, 1861.

[3] *Zafra pumila* (Dunker), Taki and Oyama, Palaeo. Soc. Japan, Special Paper No. 2, pl. 43, fig. 10, 1954.

# A NEW SPECIES OF SAND-BURROWING MARINE AMPHIPODA FROM CALIFORNIA

J. Laurens Barnard
Beaudette Foundation[1]

Another species of the magnificent crustacean genus *Eohaustorius* J. L. Barnard (1957) is described. These small but complexly ornamented animals apparently represent adaptations in the Amphipoda that are known for various sand-crabs in the Decapoda, namely greatly expanded, processiferous appendages for digging in sands and strongly setose antennae for filtering particles. The weakly armored mandibles apparently are related to the particulate kind of food obtained by many haustoriids.

## Family Haustoriidae

### Genus *Eohaustorius* J. L. Barnard

*Eohaustorius* J. L. Barnard 1957: 81; Gurjanova 1962: 400.

### Key to Eohaustorius

1\. Peraeopod 5 with erect cusp on dorsal posterior edge of article 2 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *washingtonianus*
1\. Peraeopod 5 lacking cusp on article 2 of peraeopod 5 . . . . . . . . 2
2\. Article 7 of gnathopod 1 as long as article 4 . . . . . *sencillus*, n.sp.
2\. Article 7 of gnathopod 1 half as long as article 4 . . . . . . . . . . . . . 3
3\. Hind lobe of article 5 on peraeopod 2 large and long, reaching down to end of article 6, article 6 rectangular . . . . . . . . *cheliferus*
3\. Hind lobe of article 5 on peraeopod 2 smaller, not reaching to end of article 6, article 6 bulbous . . . . . . . . . . . . . . . . . . . . . . . . *eous*

### **Eohaustorius sencillus,** new species

Figures 1 and 2

*Diagnosis*: Article 6 of gnathopod 1 long, bulbous, bearing a short apical spine; peraeopod 5 lacking a cusp on dorsal posterior edge of article 2; hind lobe of article 5 on peraeopod 2 small, not reaching downward strongly (see figure).

*Holotype*: Allan Hancock Foundation (AHF) No. 5736, female, 4.5 mm.

[1] Santa Ynez, California.

*Figure 1. Eohaustorius sencillus*, n.sp. Female, 4.5 mm, station 4812. Lateral view of animal.

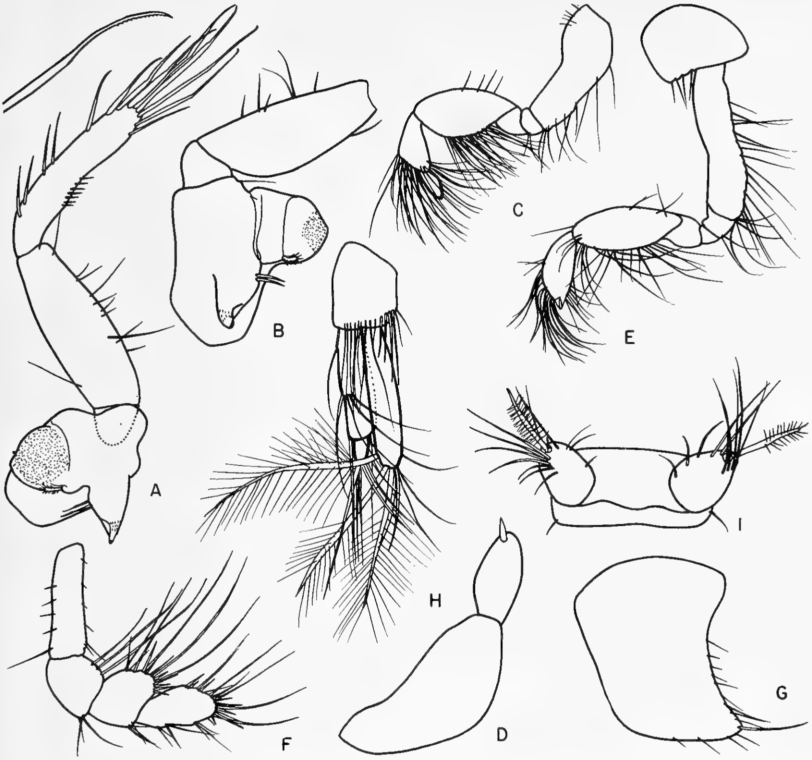

*Figure 2. Eohaustorius sencillus,* n.sp. Female, 4.5 mm, station 4812. A, B, mandibles; C, D, gnathopod 1; E, gnathopod 2; F, peraeopod 2; G, coxa 3; H, uropod 3; I, telson.

*Type locality*: Station 4812, near Pt. Conception, California, 34°34′05″ N, 120°39′05″ W, in 14 meters depth, January 16, 1957, collected by R. V. *Velero IV* of University of Southern California.

*Material*: 42 specimens from 3 stations.

*Relationship*: Unlike other species of the genus, this bears a large, inflated sixth article of gnathopod 1, armed with a small spine. In other species this sixth article is short and bears a spine either as long as the article or as much as twice as long. In southern California, the species is quickly distinguished from *E. washingtonianus* (Thorsteinson) (see J. L. Barnard 1957) by the lack of cusp on article 2 of peraeopod 5.

*Ecology*: In southern California this species has been found in only two samples at Pt. Conception in depths less than 10 fms and thus, scarcely penetrates into the southern area and its frequency in southern California is negligible. The species is better represented in Monterey Bay (station 6444, 18 specimens).

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# SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

## VOLUME 61, 1962

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# BULLETIN OF THE
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Nostra tuebimur ipsi.

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BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

VOL. 62 JANUARY-MARCH, 1963 PART 1

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# *ORCHESTOIDEA GRACILIS*, A NEW BEACH HOPPER (AMPHIPODA: TALITRIDAE) FROM LOWER CALIFORNIA, MEXICO, WITH REMARKS ON ITS LUMINESCENCE

E. L. BOUSFIELD
National Museum of Canada[1]
and
W. L. KLAWE
Inter-American Tropical Tuna Commission[2]

During a recent research cruise "La Blota" of the Inter-American Tropical Tuna Commission in Mexican coastal waters, Mr. James Joseph, Mr. Enrique Díaz, and the junior author made a small night collection of beach hoppers on a sandy beach at Cabo San Lucas, Baja California (22° 53′ N, 109° 53′ W). The animals were easily located through their luminescence as they hopped about on the wet sand near the water's edge. They were collected individually with the aid of a flashlight. Upon close examination the amphipods were found to be distinct from any of the eight species of beach hoppers previously known from the Pacific coast of North and Central America (Bousfield 1957, 1960) and from other species of the genus *Orchestoidea* and are herewith described as *Orchestoidea gracilis* n. sp.

The present species is closely related to *Orchestoidea meridionalis* Schuster from El Salvador and *O. biolleyi* Stebbing from the Pacific coast of Costa Rica. The three species may constitute a natural subgroup within the genus *Orchestoidea* as presently defined. This tropical and warm-temperate subgroup differs from the cool-temperate typical forms (e.g. *O. tuberculata*, *O. pugettensis*, *O. californiana*) in having relatively long and slender body and limbs, shallow head, pronounced inferior antennal sinus, large maxilliped palp, complex and specialized peraeopod dactyls (especially in peraeopod 3), elon-

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[1] Ottawa, Canada.

[2] La Jolla, California.

gate peraeopod 5. slender pleopods. non-telescoping urosome, well-developed prepeduncle in uropod 1. elongate uropod 3, and spade-shaped bilobed telson. Moreover. the group exhibits unusual features of sexual dimorphism. not only in the expected differences between antennae 2. gnathopods. and peraeopods. but also in the differential development of the rami of uropods 2 and 3. Most of these features are shared also by "*Talorchestia*" *brito* Stebbing from western Europe and by *Orchestoidea brasiliensis* Dana from the Atlantic coast of South America. a fact indicating that presently accepted generic criteria have outlived their usefulness. However, formal recognition of these relationships must await a revision of the entire beach-hopper complex within the terrestrial amphipod family Talitridae.

## Key to Tropical American-Pacific Species of *Orchestoidea*

1. Dactyl of peraeopods 4 and 5 with 4-5 stiff bristles along inner margin; pleopods very weak, rami with only 3-5 plumose segments; uropod 3 of mature male longer than uropod 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Orchestoidea meridionalis* Schuster

   Dactyl of peraeopods 4 and 5 with single marginal bristle; pleopod rami with 7-14 plumose segments; uropod 3 of male short . . . . 2

2. Outer ramus of uropod 1 smooth, inner ramus with terminal spine about half its length; pleopod rami with 7-8 plumose segments; uropod 2 of mature male, inner ramus much longer than outer . . . . . . . . . . . . . . . . . . . . . . . . . . . *Orchestoidea biolleyi* Stebbing

   Outer ramus of uropod 1 armed with small outer marginal spines. inner ramus with terminal spine about one-quarter its length; pleopod rami with 11-15 plumose segments; uropod 2 of mature male, rami subequal . . . . . . . . . . . . *Orchestoidea gracilis* n. sp.

### Abbreviations for Figs.

| | | | |
|---|---|---|---|
| A1 | Antenna 1 | Mxpd | Maxilliped |
| A2 | Antenna 2 | Gn1 | Gnathopod 1 |
| Hd | Head | Gn2 | Gnathopod 2 |
| UL | Upper lip | P1-5 | Peraeopods 1-5 |
| LL | Lower lip | Ep1-3 | Abdominal side plates 1-3 |
| Rt. Md. | Right Mandible | Pl1-3 | Pleopods 1-3 |
| Lft. Md. | Left Mandible | U1-3 | Uropods 1-3 |
| Mx1 | Maxilla 1 | T | Telson |
| Mx2 | Maxilla 2 | | |

Family TALITRIDAE Bulycheva 1957
Genus *Orchestoidea* Nicolet 1849
**Orchestoidea gracilis,** new species

*Description:* Male (17.5 mm.). Head about as deep as long, convex above; inferior antennal sinus well incised. Eye very large, black, sub-trapezoidal, more than half length of head. Antenna 1 short, peduncular segments subequal, flagellum of 6-7 short segments. Antenna 2 very long, about equal to body length; flagellum much longer

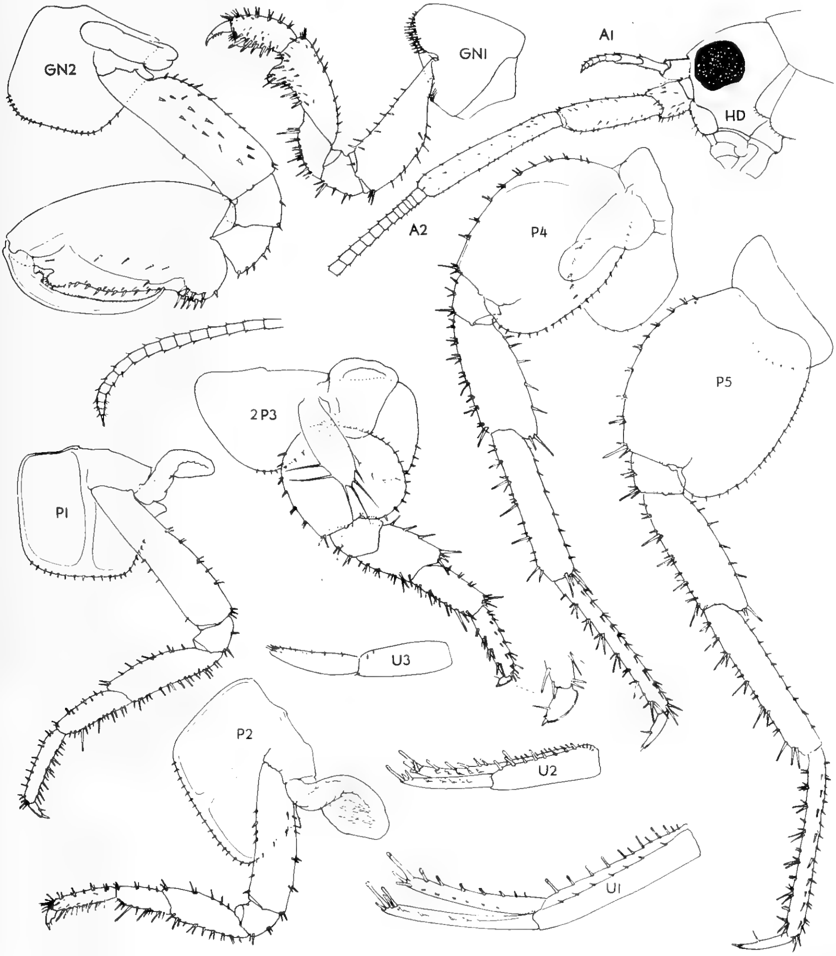

*Figure 1. Orchestoidea gracilis* new species from Cabo San Lucas, Baja California, Mexico. 1. Male, 17.5 mm. 2. Female, 14.5 mm.

than peduncle, of about 45 short untoothed segments, peduncular segments strong but not powerfully expanded, surfaces spinulose.

Upper lip slightly wider than deep, apically pilose. Lower lip with prominent lateral lobes, densely pilose along inner margin. Mandible, cutting edge with 4-6 teeth; left lacinia is 4-cuspate, right lacinia is bifid; molar process finely striate (about 30 striations). Maxilla 1, apical spine-teeth of outer lobe relatively long and slender, all pectinate, a row of fine bristles at base of inner spine teeth; palp minute, appearing

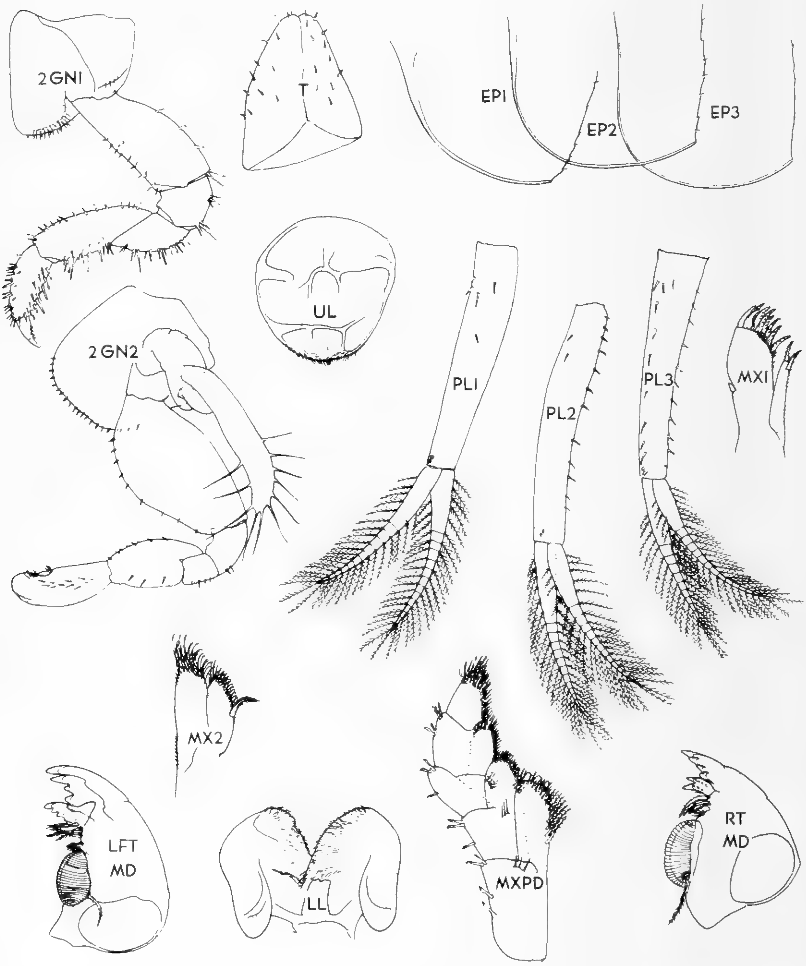

*Figure 2. Orchestoidea gracilis* new species from Cabo San Lucas, Baja California, Mexico. 1. Male, 17.5 mm. 2. Female, 14.5 mm.

one-segmented; inner plate with rather short plumose apical setae. Maxilla 2, inner lobe with strong proximal plumose seta; outer lobe larger, apically rounded. Maxilliped, inner lobe apically sub-truncate, with 3 subequal conical spine-teeth and about 8 marginal plumose setae; outer lobe apically rounded, extending well beyond inner lobe, outer apical setae are plumose, inner setae are minutely pectinate; palp very large, 3-segmented, outer marginal spines with compound tips.

Coxal plates 2-4 successively broader, each with distinct posterior lobe or knob. Coxa 5 much longer than deep, anterior lobe a little larger than posterior lobe. Gnathopod 1, coxal shelf prominent, forming a complete inner lower margin armed with long stiff spines; segment 5 with large and prominent pellucid process below; segment 6 rather broad, lower margin distally tumid and armed with heavy compound spines; dactyl strong, inner margin pectinate. Gnathopod 2 very large and robust; propod (segment 6) sub-ovate, spinose palm very oblique, slightly convex, with spinulose knob near base of dactyl, posterior angle defined by twin prominences each armed with 4-5 stout spines; dactyl strong, inner margin lined with minute spinules and a spinulose knob near hinge.

Peraeopods generally slender, anterior and posterior margins well armed with compound spines. Dactyls are relatively short, nails very small, outer margin convex, well chitinized, and minutely pilose distally, inner margin with single stiff bristle. Dactyl of peraeopod 2 with prominent spur on inner margin. Dactyl of peraeopod 3 very short, inflated and strongly convex behind, nail vestigial. Anterior marginal spines of segment 5 of peraeopod 3 not exceptionally long and strong. Peraeopod 5 distinctly longer than peraeopod 4, especially in segment 6. Coxal gills small, sac-like, somewhat elongate on peraeopod 4 and gnathopod 2.

Pleosome side plates 1-3 smoothly rounded below, posterior margins lined with 4-6 minute spinules. Pleopods 1 and 3 subequal, 2 largest; peduncles slender throughout, not laterally expanded, outer margin of 2 and both margins of 3 sparsely spinose; two small coupling spines; rami subequal, shorter than peduncles, each with 11-15 plumose segments.

Urosome segment 2 distinct, not telescoping dorsally with segment 1. Uropod 1 with strong prepeduncle; rami slender, subequal, nearly equal to peduncle, outer ramus with outer marginal spines only, terminal spines not spade-tipped nor exceptionally long. Uropod 2, rami and peduncle subequal, inner ramus with both margins spinose, outer ramus with inner margin bare. Uropod 3 somewhat elongate, ramus slightly longer than peduncle. not laterally compressed, posterior margin minutely spinose. apex with tuft of short slender spines. Telson spade-shaped. longer than wide. dorsally and apically spinose, consisting of two medially fused lobes.

Female (14.5 mm.). Generally smaller and more compact than male. Antenna 1 much shorter. flagellum of 29-30 segments, slightly longer than peduncle.

Gnathopod 1 strong. blister lacking on lower margin of segments 5 and 6. Gnathopod 2. segment 2 moderately expanded in front, anterior margin sparingly spinose, distally sinuous or indented; segment 4 with short posterior lobe; segment 5 rounded beneath, upper margin minutely spinose; segment 6. "mitten" lobe extending well beyond dactyl. minute lateral spines rather sparse. Brood plates on segments 2-4 rather slender throughout. somewhat linear, with about 12 simple marginal setae; that of segment 5 shorter but broader. with fewer apical setae.

Uropod 2. rami subequal. Uropod 3. ramus and peduncle subequal. Telson short, slightly longer than wide.

*Material Examined:* Cabo San Lucas. Territorio Sur de Baja California. Mexico. on wet sand at water's edge. LW level. May 31, 1962. W. L. Klawe, J. Joseph, and E. Díaz coll.

Male (HOLOTYPE). Female (ALLOTYPE). NMC No. 6634; 7 female. 1 imm. male PARATYPES. NMC No. 6635.

## HABITAT

The beach hoppers were collected on the Cabo San Lucas beach between one-half and one mile east of the Cabo San Lucas Pier. The animals were hopping on the wet. medium-to-coarse, arkosic sand.

## LUMINESCENCE

Some individuals of *Orchestoidea gracilis* were luminescent. which aided in their location and capture. The entire body of the animals appeared to emit light.

There are several reports on luminous gammarids (*sensu lato*). According to Harvey (1952) the oldest is perhaps that by Thulis and Bernard. published in 1786. of a fresh water species from southern France. The earliest report on luminous marine gammarids is most likely that of Viviani (1805). Tilesius (1819) presents a figure of a luminous marine amphipod and Van Vollenhoven (1860) reports on luminous *Orchestia littorea.*

Giard (1889, 1890) and Giard and Billet (1889) are to be credited with demonstrating the bacterial origin of luminescence in beach fleas. They inoculated non-luminous individuals of *Talitrus*, *Orchestia littorea*, *Hyale nilssoni*, and even some other crustacea, with light-producing bacteria from *Talitrus*. According to the above authors, the infection leads ultimately to death.

In 1927 Inman reported the bacteria-induced luminescence of *Talorchestia longicornis* and *Orchestia platensis*. He examined about 20,000 individuals, mostly of *T. longicornis*. The contents of the digestive tracts of some of the non-luminous individuals revealed the presence of a bacterium, causing the luminescence, which he referred to as *Bacterium giardi*. Although present in small numbers, it was an ubiquitous component of the intestinal flora of the animals he investigated. He postulated that under certain conditions these bacteria invade the muscles of the animal and increase in number so rapidly that the animal becomes luminous and finally dies. He pointed out the possibility that the bacteria may sometimes cause the death of a beach hopper without its becoming luminous.

Similarly, in the case of *Orchestoidea gracilis* collected in the area of Cabo San Lucas, we are dealing not with a self-induced luminescence but with one caused by luminous bacteria. Three facts lead to this conclusion: (1) The origin of light was not restricted to any particular part of the body, but the entire animal was glowing, (2) there is no morphological evidence that the animal possesses special light-producing organs, and (3) not all of the hoppers observed and collected were luminous.

Of pertinent interest is our observation that, at the water's edge where *O. gracilis* was collected, wave-cast fish bones emitted a faint glow. As beach hoppers in general are scavengers, the animals possibly become infected through ingestion of foodstuff on which the luminous bacteria are growing.

For a more detailed discussion, and also for a summary of reports and investigations on luminescence of amphipods caused by bacteria, we refer the reader to the classical treatise on bioluminescence by Harvey (1952).

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# THE LATE PLEISTOCENE 150 FOOT FRESH WATER BEACH LINE OF THE SALTON SEA AREA

Robert G. Thomas[1]
Los Angeles, California

## Introduction

The physical situation in the Salton Sea region in recent years will be briefly discussed in order to provide some ideas which are important in the interpretation of a 150 foot fresh water beach line which is reported here for the first time. Earlier lake levels will then be discussed, followed by a brief description of sea level changes, and finally by a tentative outline of Pleistocene events.

Through the early years of recorded history of this region, what is now called the Salton Sea was a dry lake bed. In 1905, however, the Colorado River inundated the area, and the sea which it formed remains today, even though the major river flow was turned back toward the Gulf of California in 1907.

Since the forming of the Salton Sea, it has not been connected with the Gulf of California, even though the historic high water level in 1907 was still far below sea level and the waters of the sea have presently the approximate composition of sea water. It is separated from the Gulf of California by the southwestward trending ridge of the Colorado River Delta (Fig. 1.). The lowest natural elevation on the delta is about 30 feet and is reported to be located at Volcano Lake southeasterly of Mexicali near the north end of the Rio Hardy shown on Figure 1. The Colorado River in pre-historic times has flowed south to the Gulf and at times to the north. It is likely that it has flowed in both directions at the same time, breaking into two or more rivers. The depositional processes have built a delta with the north slope considerably steeper than the south slope although the difference is apparent only on a profile with greatly exaggerated scale.

The prominent shoreline of an ancient lake at about 40 feet above sea level in the Salton Sea area has been discussed by many authors. This lake, variously called Lake Coahuila, Lake Cahuilla, Lake Le Conte and Blakes Sea, extended from the vicinity of Volcano Lake some 105 miles north to the vicinity of Indio, and was 35 miles wide and about 300 feet deep. The shoreline features are well preserved and

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215 W. 7th Street, Los Angeles 14.

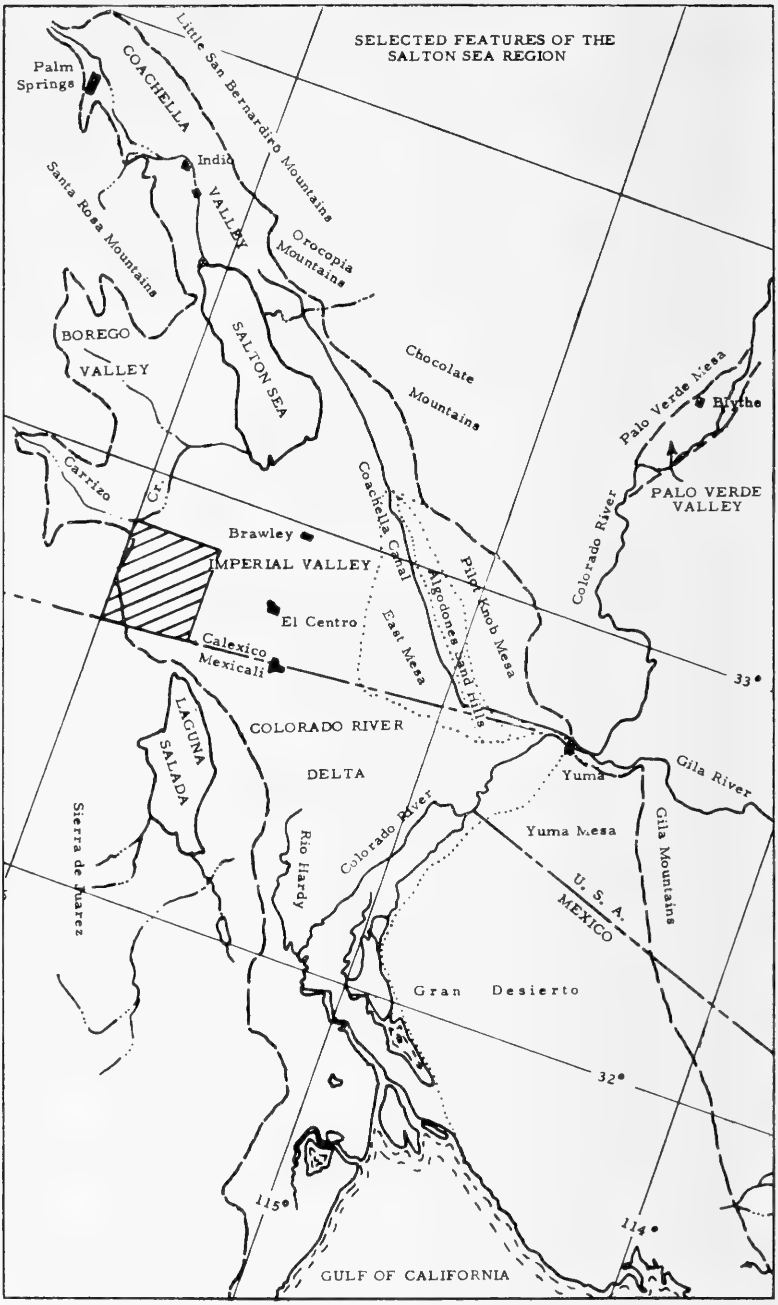

*Figure 1.* Selected features of the Salton Sea region.

little weathered. Fresh water fossil molluscs are abundant around its higher shorelines. Radiocarbon dating indicates that the forty foot beach line was last occupied only about 300 years ago, but that it existed at least 1600 years ago (Hubbs *et al.*, 1960). Hubbs and Miller (1948) discuss many of the problems concerning this ancient, though relatively recent, lake.

Much work remains to be done on this phase of the geologic history of the region, but the purpose of this note is to discuss the significance of even higher shorelines near the present Salton Sea.

Figure 1 shows many of the geographic and physiographic features in the region of the Colorado River Delta. Figure 2 is a more detailed sketch of the location of the preserved 40, 100 and 150 foot beach lines.

## 150 and 100 Foot Shorelines

Brown (1923) suggested that there are higher shorelines than the obvious and extensive 40[2] foot shoreline around the Salton Sea. Since the author had never observed any obvious higher shorelines in the region, a search was started for them on new U.S. Geological Survey 1/24,000 scale topographic maps. Features resembling beach bars were noted on the maps at an elevation of about 150 feet above sea level. They are located west of El Centro and extend about 15 miles from the Mexican border to north of Highway 80. These were found to be fresh water beach bars.

Figure 3 shows the gravel pits which contain fresh water fossils at the 150 foot beach line west of El Centro near Highway 80. These fossils, identified by the author, are the same kind as found near the 40 foot shoreline, but here they are pitted and poorly preserved. Subsurface caliche deposits shown on Figure 4 are very well developed, but no surface tufas or lime deposits were noted at those areas visited. The surface soil is weathered to a reddish color and the pebbles above and below the beach line are thickly coated with desert varnish. Most of the beach bars are discontinuous and have been partly dissected by stream erosion. These conditions suggest considerably greater age than the well-preserved 40 foot beach line. A poorly preserved remnant of a beach bar was also noted at about 100 feet above sea level. Except for the presence of fresh water fossils, these older beach bars closely resemble older bars found in closed desert basins in the Great Basin region.

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[2] 40, 100 and 150 hereafter refer to approximate elevations above sea level

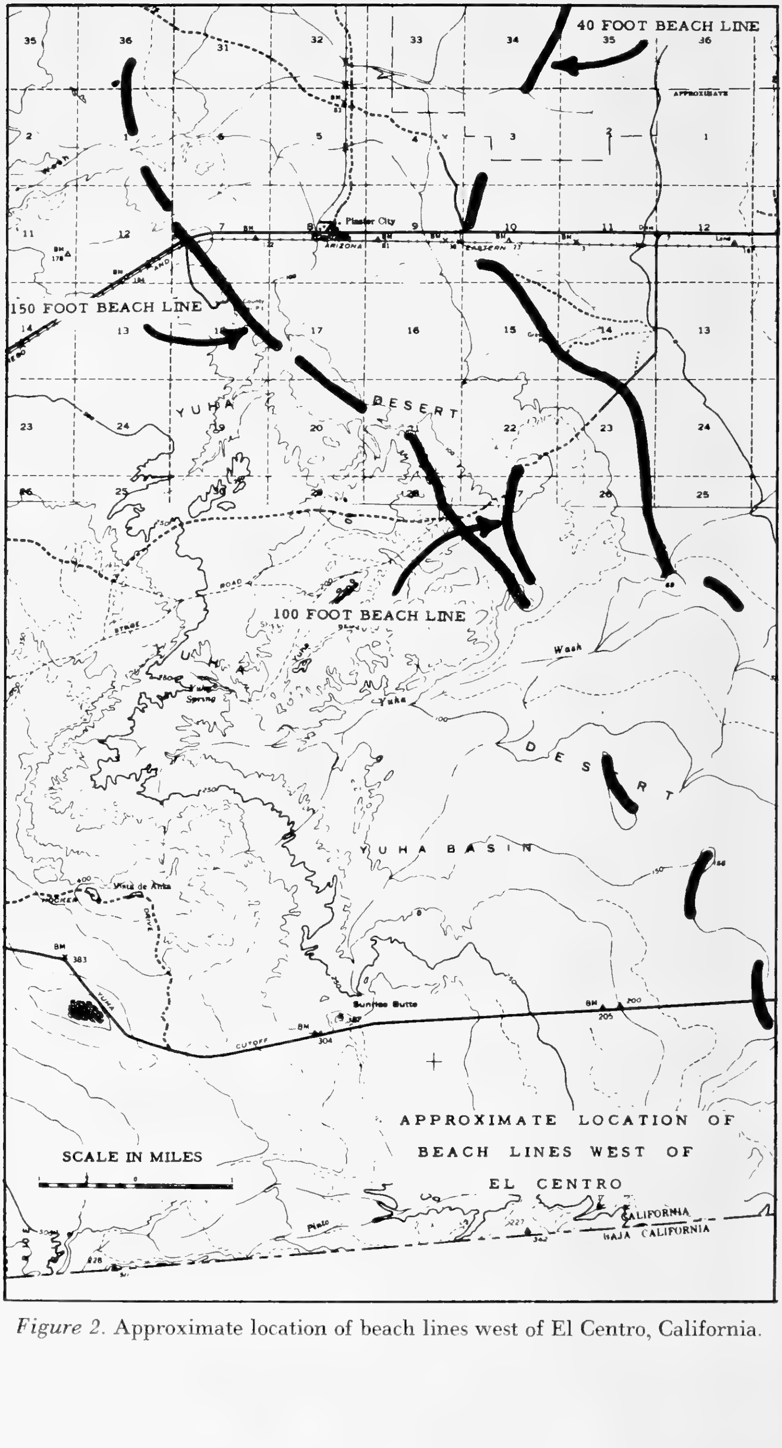

*Figure 2.* Approximate location of beach lines west of El Centro, California.

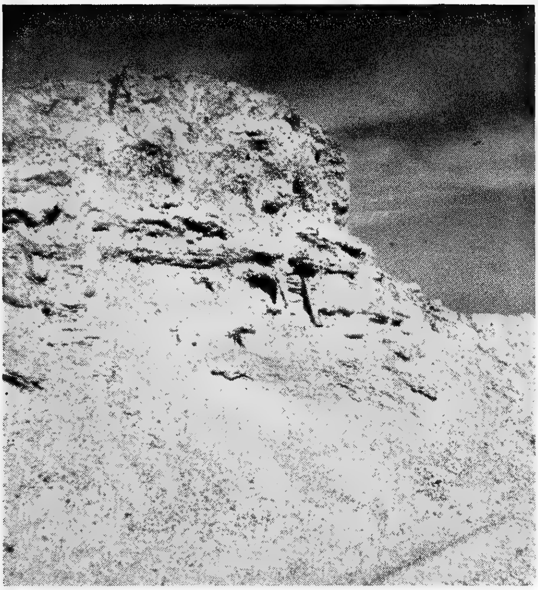

*Figure 3.* Gravel pit north of Highway 80 about 1.4 miles west of Plaster City. Hammer leans against gravel containing pitted and poorly preserved fresh water molluscs.

## SEA LEVEL CHANGES

Studies in coastal southern California (Thomas, 1961) and in other parts of the world (Russel, 1957), indicate that effects of world-wide changes of sea level on stream systems has been considerable. Erosion of considerable lengths of alluvial filled valleys near the coast occurred during the period of Wisconsin low sea level. These eroded valleys have refilled as the post-Wisconsin sea level rise occurred (Shepard and Suess, 1956). The sea level changes must have also affected the Colorado River.

## TENTATIVE OUTLINE OF QUATERNARY GEOLOGIC HISTORY

The Pliocene and possibly Miocene marine Imperial formation was deposited from the Gulf of California to the north of the present Salton Sea while alluvial fans were being deposited from the nearby mountains. These mountains were probably considerably lower than they are today. Formations deposited in late Pliocene and in early and middle Pleistocene times include parts of the Canebrake conglomerate.

*Figure 4.* Gravel pit south of Highway 80 (in distance) about 1.4 miles west of Plaster City. Clay and silt layers are shown near the bottom of the cut. The upper portion of the cut is gravel with thin horizontal caliche layers and thick vertical caliche columns.

the Palm Spring, Brawley and Borego formations and possibly part of the sediments mapped as the Ocotillo conglomerate (Dibblee, 1954).

In the Vallecitos Creek area south of Borego Valley, Downs (personal communication) and Downs and Woodward (1961) have reported a vertebrate fauna of Irvingtonian age (early Pleistocene of most California geologists at the time of this writing, but middle Pleistocene of vertebrate paleontologists) throughout the upper 2500 feet thickness of the Palm Spring formation. The vertebrate fauna indicates that the area was a prairie grassland with wooded areas near stream margins (White and Downs, 1961: 32). These conditions suggest that more rain fell than at present in that now desert area. A simple explanation would be that the Peninsular ranges were lower, allowing a greater moisture flow over them, as has been suggested for the Sierra Nevada (Axelrod, 1958; Putnam, 1960). Downs and Woodard (1961) also report at least one thin marine shell layer in these sediments which suggests a lagunal embayment. This is confirmed by Arnal (1961) from microfossils in the Borego formation. The possibility that these marine organisms may have lived in ancient, closed saline lakes, as some species do now in the Salton Sea, has not been adequately explored.

The available data, then, suggest that the Salton Sea area was, from time to time, inundated in limited areas by the Gulf, and that at other times a fresh water lake or lakes existed, bordered by extensive alluvial fans. The considerable thickness of these early and middle Pleistocene sediments exposed around and buried beneath the Imperial and Coachella Valleys and the presence of the many large fault systems, including the San Andreas, suggest that tectonic activity was continually in progress during deposition.

As a result of erosion due to uplift, large pediments or eroded surfaces with little or no alluvial cover were formed on the earlier Pleistocene folded sediments by late Pleistocene time. Some large alluvial fans related to pediment forming were deposited near the mountains. Remnants of both pediments and fans are still abundant along the western mountains from the Salton Sea to the Mexican border and along the eastern mountains in the vicinity of the Salton Sea.

The Colorado River had no doubt entered the scene prior to this period of folding and erosion. The first clear evidence of its appearance is recorded by the 130 foot terrace on Palo Verde Mesa near Blythe, a part of the East Mesa near Yuma, and part of the Gran Desierto. These are probably remnants of a more widespread alluvial deposit which extended unbroken to the Gulf of California. The deposit probably formed a delta some 100 feet higher than the present delta surface. The reason for the higher surface may well have been the higher eustatic sea level during Sangamon interglacial time. The Colorado River must have flowed both directly to the Gulf and to the Salton Sea region forming a southwesterly trending nose or ridge.

When the ancient delta had built up to about 150 feet above present sea level, one of many fresh water lakes was formed. Remnants of the eastern shore line may be buried under the Algodones sand hills east of El Centro, but the features west of El Centro described above are still preserved.

With the onset of Wisconsin glaciation, the Colorado River probably had greater runoff than at present. World-wide sea level fell, causing erosion of the ancient delta. Much of the material of the Algodones sand dunes may have originated as the lake level fell and exposed the beaches. The 75-foot terraces at both Palo Verde Mesa and Yuma Mesa may be erosion features formed during a relatively stable period. It is possible that the very poorly preserved 100 foot beach line (Figure 2) may represent a lake level corresponding to this stable period.

Sea level eventually fell to about 300 or 400 feet below present sea level during the Wisconsin Glacial period and the Colorado River eroded great quantities of the old delta away as it adjusted to the lower sea level. It is possible that the delta was completely removed in the present Imperial Valley, allowing the Whitewater River to flow to the Gulf. Such a condition may help explain the lack of recent sediments on both the east and west sides of the Salton Sea, where the folded and eroded Borego and Brawley formations are exposed or covered by only a few feet of younger material over wide areas. During this period of downcutting, most of the alluvial fans previously deposited and sediments previously formed were deeply eroded and partly removed. Remnants of alluvial fans of similar age to that on which the 150 foot beach is found may be seen along the mountains on both sides of the Salton Sea, but only at considerably higher elevations. Some preliminary work with air photos and in the field clearly shows that the fans are of various ages. The various aged fans can be recognized and reasonably correlated over much of the region by their colors in photos and by geomorphic relationships.

As the Wisconsin glacial period ended, sea level once again rose. The Colorado River, adjusting to this rise, deposited materials once again. Basal gravels were deposited in Palo Verde Valley and in Yuma Valley and then finer materials covered them, finally forming the present delta surface.

Ancient lakes probably existed from time to time throughout the various Pleistocene phases described above, their salinity varying with rate of inflow (depending upon the vagaries of the Colorado River), outflow and evaporation. The most recent pre-historic lake, with the 40 foot shoreline, was probably formed as the delta accumulated during post-Wisconsin sea level rise. It existed up to the 40 foot beach line only a few hundred years ago and dried up when the Colorado River flowed directly south to the Gulf of California.

The 150 foot shoreline is essentially at the same elevation in the few miles of its known exposure. It appears that tectonic activity since its formation has been relatively small compared with that which resulted in the major middle or late middle Pleistocene unconformity. The meager regional physiographic evidence available does not suggest large regional upwarping of the 150 foot shoreline, although it remains a distinct possibility.

It is hoped that this brief note will stimulate interest in the Pleistocene problems of the region and encourage the collecting of evidence, not only in the Salton Sea region, but also in the Colorado River drainage further upstream, and in the northern part of the Gulf of California. The events described here should have left much evidence in these other areas.

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## ERRATUM

The following correction should be made in the title of the article by Hildegarde Howard, "A fossil bird, Caracara, from Santa Rosa Island," which appeared in volume 61, part 4, of the *Bulletin*:

The paper is number 36 in the "Contributions from the Los Angeles Museum Channel Islands Biological Survey," not number 34.

# NOTES ON THE LARVA AND PUPA OF *EUPHYDRYAS EURYTION* (LEPIDOPTERA, NYMPHALIDAE)

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The checkerspot butterfly *Euphydryas eurytion* Mead and its forms range through the mountains and foothills of northern New Mexico to southern Wyoming. Although *E. eurytion* and its presumed parent species *anicia* are very widespread and fairly abundant in favored localities of the West, Dr. J. A. Comstock (personal communication) states that nothing is known of the early stages of *eurytion*, and that the only information on record for the metamorphosis of *anicia* is an early paper on the larval habits (no description and no illustration) by W. H. Edwards (1892). The following notes describe the present author's observations on the last instar larva and pupa of *E. eurytion*.

In Colorado, this member of the *anicia* complex is found from the southwestern mountains to the higher areas east of the Continental Divide (Brown, Eff, & Rotger, 1957). The *E. eurytion* larva to be described was collected in a dry meadow habitat (elevation 8,700 feet above sea level) about one mile southeast of the ranch house at Big Spring Ranch, Florissant (Teller County), Colorado, on July 9, 1962. When found, it was not on a plant but was crawling along the ground. Food-plant genera reported for closely-related *Euphydryas* species were in the larva's immediate vicinity, but a search of these plants (*Penstemon* and *Castilleja*) did not produce more larvae.

*Description of Mature Larva.* Length, 26 mm. Ground color, ivory white, mottled irregularly with black.

Black branching spines are present in the usual dorso-lateral rows. Unfortunately, more precise notes were not taken before the larva pupated on July 15. Before pupation, the larva shrunk to a length of about 17 mm. The imago emerged August 2, 1962.

*Description of Pupa.* Length, 16 mm. Maximum width, 7.4 mm. Ground color, lustrous silvery-white, marked with black blotches and striations as shown in the illustration, Figure 1.

Wing cases, silvery-white divided obliquely by a prominent broad band of black. Slightly tinged with orange-brown along the shoulders, around the black blotches, and along the wing tips.

Antennal sheaths, heavily checked with black squares which are separated by very narrow white segmental lines.

*Figure 1.* Lateral view of the pupa of *Euphydryas eurytion*, showing the distinctive wing case markings.

*Figure 2.* Dorsal view of the pupa of *Euphydryas eurytion*.

Dorso-lateral nodules (representing vestiges of the larval spines) are orange with black blotches surrounding the nodules on all but the posterior aspects.

Cremaster, dark brown at the end.

From comparison with published figures of pupae of other *Euphydryas* species, it appears that the wing-case markings on this *E. eurytion* pupa are the most distinguishing features, particularly with regard to the broad, continuous, obliquely-crossing band of black.

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# IN MEMORIAM
# BESS REED PEACOCK
## 1887-1962

Bess Reed Peacock, a member of the Southern California Academy of Sciences since 1951, passed away on November 24, 1962, at her family home in Los Angeles.

Miss Peacock was born in Independence, Missouri, on March 2, 1887, the only child of Judge J. Mack and Bettie Reed Peacock. Shortly thereafter, the family moved to Roswell, New Mexico, where her father served as Circuit Judge for many years.

Miss Peacock received her elementary and secondary education in Roswell, and there demonstrated her aptitude for instruction by teaching classes before she had finished high school. She attended the University of Missouri in 1906, and later went to the University of Chicago where she received her AB degree in education in 1912, with Phi Beta Kappa honors.

In connection with her studies at the University of Chicago, she did welfare work in the settlement houses in Chicago. This led to her doing physiotherapy work in army hospitals during World War I.

She attended San Diego Teachers College in 1921, but returned to the University of Chicago to complete her MA degree in botany in 1923.

When her father retired from his judgeship in 1920, the family moved to Los Angeles. In 1923, after receiving her graduate degree, she taught for a short time in Orange County before entering the Los Angeles City school system. In 1924, she taught at Roosevelt High School, and then at Mt. Vernon Junior High School in 1926, where she taught science in the eighth and ninth grades until she retired in 1952.

Bess Peacock had a lively interest in all things in science. This kept her constantly in the pursuit of knowledge which she passed on to her many students during the approximately 35 years she served as a teacher. She earned her teaching credential in science at the University of Southern California in 1930, and became a member of Delta Kappa Gamma. She felt her greatest ability was in teaching boys and often preferred the supervision of "boys home room."

She was active in the Southern California Academy of Sciences, the Southern California Botanical Society, the Nature Conservancy and nature study groups. Her other activities included Women's University Club and the Los Angeles County Museum Association.

Her chief interests were in nature everywhere and the cultural welfare of all her students. Her many financial gifts, most of them anonymous, went toward conservation of nature, gave culturally deprived youngsters camping experiences, and promoted the advanced education of a number of worthy students. Each student that she sponsored and guided to higher education became her adopted "niece" or "nephew" during the period she assumed the obligation of his education.

Her close friends and teaching colleagues cherish her for her dedication to learning, integrity, and devotion to the truth as she saw it.

Bonnie C. Templeton

# FURTHER STUDIES ON THE BENTHIC FAUNA IN A RECENTLY CONSTRUCTED BOAT HARBOR IN SOUTHERN CALIFORNIA[1]

DONALD J. REISH
Long Beach State College[2]

## INTRODUCTION

In a previous study of a newly constructed harbor the author (Reish, 1961) found no evidence that succession occurred in the subtidal benthic environment. The principal species were dominant during the entire 2.5 years of study. However, a decrease in the number of species and specimens occurred about 1.5 years after the study was initiated which was believed to be related to the effects of limited water circulation in Basin 1 (Fig. 1). A drop in the dissolved oxygen content of the water and subsequent appearance of sulfide odors to the sediments was cited as supporting evidence. In the course of dredging Basins 2, 3, and 4 (Fig. 1), a channel was formed connecting one part of the bay (Fig. 1, Station I) with the Marine Stadium (compare Fig. 1, Reish, 1961 with Fig. 1, herein). This provided an opportunity not only to verify whether or not benthic succession occurs, but also to determine whether or not a similar reduction occurred in an area with unimpaired water movements. The purpose of this paper therefore is to describe the benthic fauna in a newly established marine area possessing adequate water circulation.

The subject of colonization of animals in the subtidal benthos has been reviewed by the author in the previous study (1961); included were the papers by Brandt (1897), Shelford, *et al* (1935), and the author (1956, 1957).

The author wishes to thank Miss Emile Bender, Mrs. Bettye Byrne, Miss Ruth Zakem, Mr. Harold Pope, and Mr. Alfred Stone for their assistance in the collecting and sorting of the material.

## DESCRIPTION OF ALAMITOS BAY MARINA

Alamitos Bay (Fig. 1) is a small body of water used primarily for recreational purposes, which is located within the City of Long Beach.

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[1] This study was supported by research grant NSFG-8914 from the National Science Foundation.

[2] Department of Biological Sciences.

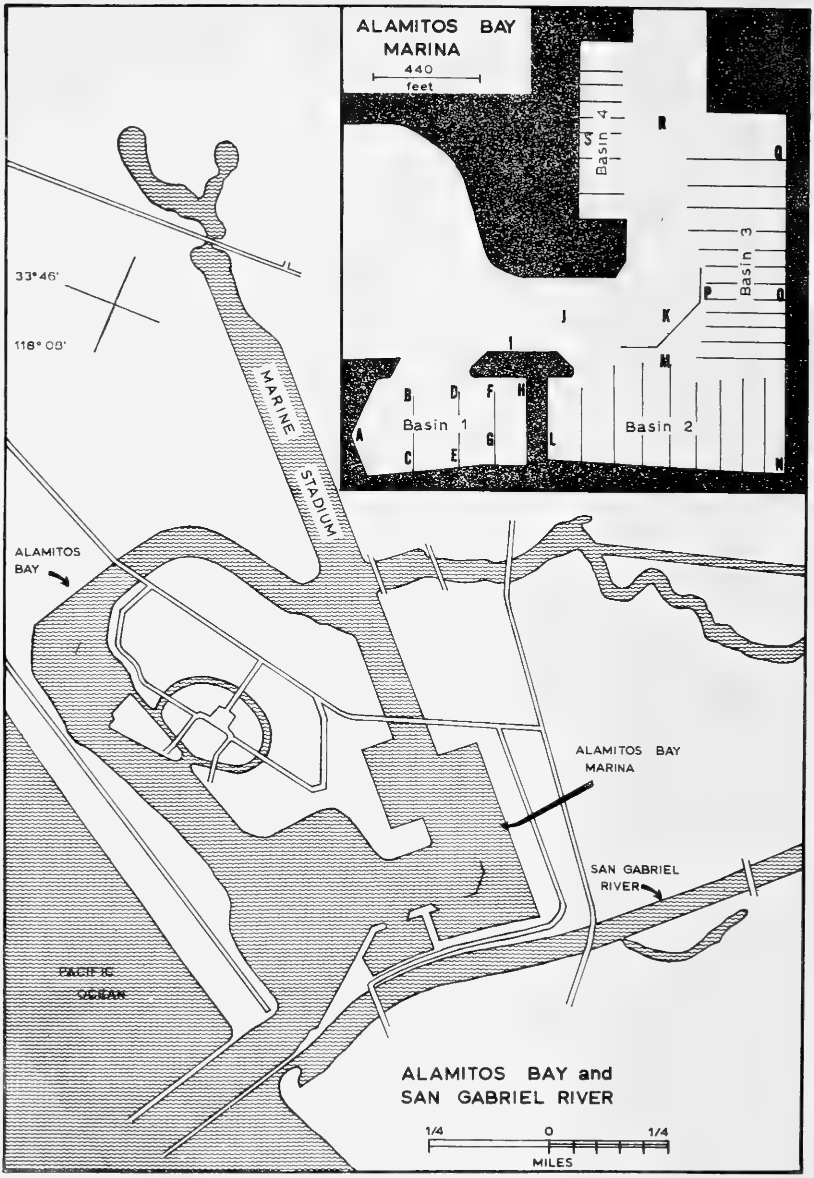


*Figure 1.* Map of Alamitos Bay, California. The boat basins and station locations are shown in the inset.

Basin 1 was dredged in 1955, while the dredging of Basins 2, 3, 4, and the connection to Marine Stadium commenced August 1959. The marina was dredged to a depth of —12 feet and the main channel (Fig. 1, Stations J, K, and R) to a depth of —15 feet. The sides of the marina consist of cement bulkheads and rock rick-rack. See Reish and Winter (1954) for the early history and development of the other parts of Alamitos Bay.

## Materials and Methods

Quantitative samples were taken with a size one Hayward orange peel bucket (Reish, 1959b). The samples were preserved in formalin, then washed later through a screen having 20 openings to the inch (0.85 mm.). The animals were separated and weighed. The data given in Figure 2 are wet weights and include structures formed by the animal such as shells of molluscans and tubes of polychaetes. Collections were made August 19, September 30, and November 17, 1959, January 17, May 10 and August 31, 1960, January 6, and June 29, 1961, and April 16, 1962. Currents were measured during July and August 1962, with a pygmy current meter (G. M. Manufacturing Co., New York).

## Results

The data have been summarized in Table 1, and Figures 2 and 3. Table 1 shows the principal species and the number of specimens taken each sampling period; the species of lesser incidence are given below. Figure 2 summarizes the occurrence and abundance of the principal bottom-dwelling species. Figure 3 represents graphically the number of species and specimens and the biomass for each survey.

The first animals were not encountered until September 30, 1959, seven weeks after dredging began (Table 1, Fig. 2). No animals were collected during an earlier sampling period in August 19, 1959. Additional species appeared rapidly with a peak being reached about 10 months later (Fig. 2). Fluctuations, possibly seasonal, were noted in the total number of species present following the initial rise. Additional species not listed in Table 1 include the polychaetes: unidentified polynoids (5 specimens), *Eumida sanguinea* (Oersted) (3), unidentified phyllodocids (9), *Exogone* sp. (1), *Platynereis bicanaliculata* (Baird) (3), *Boccardia uncata* Berkeley (1), *Polydora paucibranchiata* Okuda (2), unidentified spionids (10), *Spiochaetopterus* sp. (3), *Polyophthalmus pictus* (Dujardin) (1), *Capitella capitata*

TABLE I

List of Principal Species and Number of Specimens Collected from the Bottom of the Channel of Alamitos Bay Marina
August 1959 through April 1962

| List of Species | 9-59 | 11-59 | 1-60 | 5-60 | 8-60 | 1-61 | 6-61 | 4-62 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Phylum Platyhelminthes, unidentified | | | | | 3 | 4 | | | 7 |
| Phylum Nemertea, unidentified | | | 6 | 19 | 18 | 26 | 34 | 18 | 121 |
| Phylum Annelida, Class Polychaeta | | | | | | | | | |
| *Halosydna johnsoni* (Darboux) | | | | 1 | 2 | | 1 | | 4 |
| *Eteone dilatae* Hartman | | 2 | 2 | 3 | 13 | 5 | 2 | 2 | 32 |
| *Hypoeulalia bilineata* (Johnson) | | 1 | 1 | | | 6 | | | 8 |
| *Ophiodromus pugettensis* (Johnson) | | | | | 6 | | 2 | | 8 |
| *Nereis procera* Ehlers | | | | | 2 | 7 | | 1 | 10 |
| *Nephtys caecoides* Hartman | | | 3 | 8 | 3 | 5 | 2 | 21 | 42 |
| *Glycera americana* Leidy | | | | 1 | 5 | 4 | 3 | 1 | 14 |
| *Goniada littorea* Hartman | | | | 1 | 2 | 21 | 7 | 43 | 74 |
| *Diopatra splendidissima* Kinberg | | | | 1 | 2 | | 1 | | 4 |
| *Lumbrineris erecta* (Moore) | | 1 | 1 | 3 | 6 | 5 | 2 | 2 | 20 |
| *L. minima* Hartman | | | 3 | 14 | 13 | 17 | 41 | 24 | 112 |
| *Dorvillea articulata* (Hartman) | | | 1 | 12 | 48 | 2 | 71 | 6 | 140 |
| *Haploscoloplos elongatus* (Johnson) | | | 3 | 28 | 37 | 8 | 44 | 23 | 143 |
| *Nerinides pigmentata* (Reish) | | 1 | 1 | 1 | 9 | 6 | | | 18 |
| *Polydora ligni* Webster | 1 | | 3 | 6 | | | | | 10 |
| *Prionospio cirrifera* Wirén | | 1 | | 4 | 46 | 51 | 14 | 50 | 166 |
| *P. heterobranchia newportensis* Reish | | | 4 | 2 | 3 | 5 | | | 14 |
| *P. pinnata* Ehlers | | | 3 | | 2 | | 1 | | 6 |
| *Spiophanes missionensis* Hartman | | 1 | 1 | 8 | 2 | 1 | | 1 | 14 |
| *Chaetozone corona* Berkeley and Berkeley | | | 1 | 11 | 3 | 9 | 7 | 2 | 33 |
| *Cossura candida* Hartman | | | | | 6 | 6 | 19 | 8 | 39 |
| *Tharyx parvus* Berkeley | | 1 | | 1 | 7 | 18 | 42 | 7 | 76 |

TABLE I (Continued)

| List of Species | 9-59 | 11-59 | 1-60 | 5-60 | 8-60 | 1-61 | 6-61 | 4-62 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| *Pherusa capulata* (Moore) | | | 2 | 2 | 4 | 6 | 4 | | 18 |
| *Armandia bioculata* Hartman | | | | 2 | 6 | 2 | 14 | 8 | 32 |
| *Capitita ambiseta* Hartman | 3 | 69 | 20 | 240 | 123 | 96 | 471 | 624 | 1646 |
| *Pectinaria californiensis* Hartman | | | | | 3 | 2 | 7 | 1 | 13 |
| *Amaeana occidentalis* (Hartman) | 1 | | 7 | 6 | 14 | 8 | 3 | 4 | 43 |
| *Amphicteis scaphobranchiata* Moore | | | | | 34 | | | 1 | 35 |
| *Pista alata* Moore | | | | 8 | | | 1 | 1 | 10 |
| *Euchone limnicola* Reish | 10 | 12 | 231 | 605 | 1309 | 1 | 23 | 36 | 2227 |
| *Megalomma* sp. | | | | | 15 | 1 | | | 16 |
| Phylum Arthropoda, Class Crustacea | | | | | | | | | |
| *Callianassa californiensis* Dana | | 1 | | | 3 | 12 | 1 | 9 | 26 |
| *Pinnixa franciscana* Rathbun | | | | | | | 2 | 2 | 4 |
| Phylum Mollusca, Class Pelecypoda | | | | | | | | | |
| *Chione californiensis* Broderip | | | | | 1 | | 2 | 1 | 4 |
| *Macoma nasuta* (Conrad) | | | | 3 | 6 | 7 | 19 | 2 | 37 |
| *Tagelus californica* Conrad | | 1 | | 7 | 6 | 6 | 21 | 1 | 42 |
| *Tellina buttoni* Dall | | | | 1 | | | 3 | 1 | 5 |
| Class Gastropoda | | | | | | | | | |
| *Olivella biplicata* Sowerby | | | | | | | 3 | 1 | 4 |
| *Acteon punctocoelata* Carpenter | | | | | 6 | 2 | | | 8 |
| *Tephtys* sp. | | | | | 2 | 4 | 5 | 2 | 13 |
| Phylum Phoronidea, unidentified | | | | 7 | 4 | | 1 | | 12 |
| Additional Species | 3 | 2 | 7 | 12 | 9 | 7 | 12 | 5 | 34 |
| Additional Specimens | 3 | 3 | 16 | 22 | 17 | 11 | 21 | 7 | 100 |
| Total Number of Species | 7 | 13 | 25 | 41 | 45 | 38 | 46 | 35 | 78 |
| Total Number of Specimens | 18 | 94 | 309 | 1038 | 1791 | 364 | 895 | 910 | 5419 |

(Fabricius) (3), *Asychis disparidentata* (Moore) (2), *Axiothella rubrocincta* (Johnson) (2), *Owenia fusiformis collaris* Hartman (1), unidentified ampharetids (3), unidentified terebellids (3), and *Fabricia limnicola* Hartman (1); crustaceans: *Corophium acherusicum* Costa (2), *Caprella equilibra* Say (1), unidentified amphipods (12), unidentified isopod (1), cumacean (1), shrimp (1), and crab (1); molluscans: *Chione undatellum* (Sowerby) (1), *Lysonia californica* Conrad (1), *Protothaca staminea* Conrad (2), *Tellina carpenteri* Dall (1), unidentified juvenile clams (19), *Bullaria gouldiana* (Pilsbry) (3); the holothurian *Leptosynpta albicans* (Selenka) (3), un-

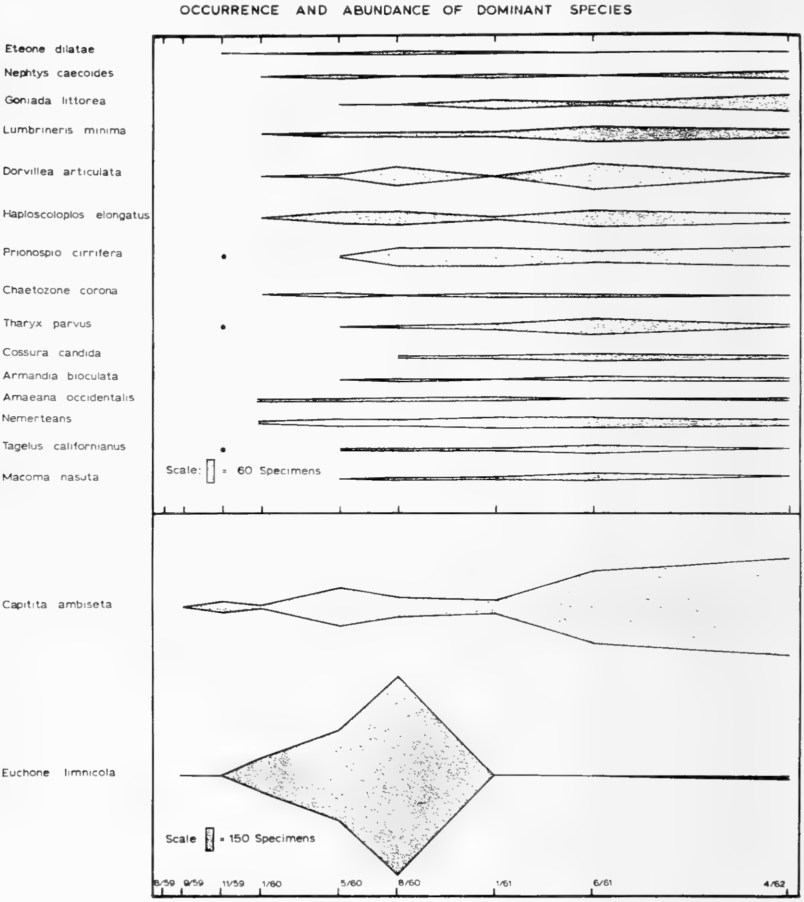
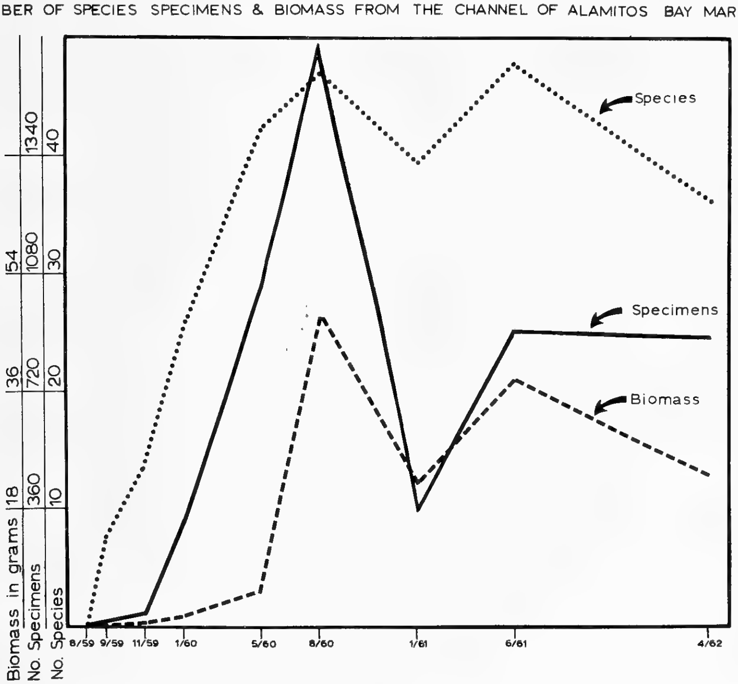


*Figure 2.* Diagramatic representation of the occurrence and abundance of the dominant benthic species collected from the marina channel stations J, K, and R.

identified sea anemone (1), sipunculid (1), phoronids (11), and an ophiuroid (1). A total of 78 species were collected during 2.7 years of study of which 49 (63%) were polychaetes, 13 (17%) were molluscans, 9 (12%) were crustaceans, and the remaining 7 (8%) were sea anemones, turbellarians, nemerteans, sipunculids, phoronids, and echinoderms.

The curve for the number of specimens collected each sampling period lagged the species curve during the first year (Fig. 2). A sharp decrease occurred between August 1960, and January 1961. This decrease was primarily the result of near disappearance of the polychaete *Euchone limnicola* Reish. The number of specimens taken the last two sampling periods were nearly identical.

The growth of the animals proceeded slowly as indicated by the curve for biomass (Fig. 2). The drop in biomass following the peak in August 1960, is again the result of the decrease of *Euchone limnicola.*



NUMBER OF SPECIES SPECIMENS & BIOMASS FROM THE CHANNEL OF ALAMITOS BAY MARINA

*Figure 3.* Graphic representation of the number of species, the number of specimens, and the biomass in grams collected each survey from the marina channel stations J, K, and R.

## Discussion

As previously found in Basin 1 of Alamitos Bay Marina, there was no indication of a succession of animal populations in the subtidal benthic bay environment. Since the collections that were made shortly after dredging was completed contained no animals, it is reasonable to assume that the animals taken in September 1959, were the first inhabitants of the area. One of these, *Capitita ambiseta* Hartman, continued to be one of the principal species throughout the 2.7 years of study (Table 1, Fig. 3).

All but two of the 44 more frequently occuring animals, *Pinnixa franciscana* Rathbun and *Olivella biplicata* Sowerby, were collected by August 1960. (Table 1). Since *P. franciscana* is a commensal crab that lives in the burrow of the ghost shrimp *Callianassa californiensis* Dana, it is evident that the appearance of *P. franciscana* must await the development and growth of a population of *C. californiensis*. It is possible that *O. biplicata* may be only an occasional inhabitant since it has not been reported in the previous studies of Alamitos Bay (Reish and Winter, 1954; Reish, 1959a, 1961).

Several early inhabitants appeared, then later dropped out. These were the spionid polychaetes *Polydora ligni* Webster, *Prionispio heterobranchia newportensis* Reish, *P. pinnata Ehlers*, and *Nerinides pigmentata*, (Reish). None of these species was a dominant member at any time. The two former species are abundant in other parts of Alamitos Bay and the two latter are present offshore.

The occurrence and abundance of the principal species have been summarized in Figure 3. These species may be grouped according to the characteristic feature of their curve, namely, species which reached a peak then decreased, species which show fluctuations (possibly seasonal), species which reached a plateau, and species which are apparently still increasing in numbers.

*Euchone limnicola*, known only from Alamitos Bay, demonstrates markedly a build up in the population followed by sharp decrease in numbers. The number of individuals (1309) taken during August 1960, strongly influenced the values for the number of specimens and the weight of biomass summarized in Figure 2, as discussed above. Four additional species may be included here, *Eteone dilatae* Hartman, *Chaetozone corona* Berkeley, *Tharyx parvus* Berkeley, and *Macoma nasuta* (Conrad). While not as many specimens of these species were collected in comparison to *E. limnicola*, the results are nearly identical to what was found previously in Basin 1. Perhaps these species can not successfully compete with the other species or are unable to repopulate themselves in an established population. Many specimens of *E. liminicola* were observed with eggs in their coelom, but it is not known whether or not spawning, fertilization, and development occurs in the marina.

The polychaetes *Nephtys caecoides* Hartman, *Dorvillea articulata* (Hartman), and *Haploscoloplos elongatus* (Johnson) show at least two population peaks followed by a drop in the number of specimens. With the latter two species the peaks apparently are seasonal with the highs occurring during the warmer months of the year. No seasonal conclusions can be made with respect to *N. caecoides*.

The population of possibly two species, *Goniada littorea* Hartman and *Capitita ambiseta*, is still increasing. The greatest number of specimens for each species were collected at the time of the last sampling. Definite conclusions regarding these species must await further samples.

Following the initial rise, a more or less stable population has been reached by *Lumbrineris minima* Hartman, *Prionospio cirrifera* Wiren, *Cossura candida* Hartman, and the unidentified nemerteans. While fluctuations in numbers occurred with these species, it may be the result of either patchiness in distribution or collecting techniques. The conclusions regarding the unidentified nemeteans may not be valid since it is possible that more than one species is involved.

*Tagelus californica* Conrad did not fit into any of the above four categories because one-half of the total number of specimens was collected during one sampling period.

The findings reported herein differ from the previous study in that no marked drop off in the animal population was observed in the channel as was the case in Basin 1 and more recently (Reish 1962) in the innermost stations of Basins 2, 3, and 4 (Fig. 1, L, N, O, Q, S). This supports the earlier view that the decrease in the population is the result of limited water circulation. The dissolved oxygen content of the water drops and the substrate, which originally was gray in color and odorless, became black and possessed a strong sulfide odor. Apparently it takes about one year for the effect of limited water movement to alter the benthic environment of a newly established marine area. In the channel where the water movement is unobstructed, there is no marked change in the animal population. The decrease in the number of specimens between August 1960 and January 1961 was largely the result of the near extinction of one dominant species rather than the decrease of specimens in all species of the population

(Fig. 2 and 3). Currents have been determined to move at the rate of 300 to 1000 feet per hour in the channel but no movements have been measured in the basins.

## SUMMARY

1. A periodic, quantitative study was made in a newly dredged boat channel to determine whether or not succession occurs in the subtidal benthic environment.
2. There was no indication that the settlement of an earlier assemblage of animals was necessary for the settlement of a subsequent one.
3. Variations in the population were noted. The principal species were grouped according to: (1) those that reached a peak in number of specimens then decreased, (2) those that showed fluctuations, possibly seasonal, (3) those that reached a plateau, and (4) those that apparently are still increasing in numbers of specimens present.
4. The relationship between the amount of water circulation and its effect upon benthic animals in boat basins and channels was discussed.

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# NOTES ON THE LIFE HISTORIES OF TWO SOUTHWESTERN PHALAENID MOTHS

JOHN ADAMS COMSTOCK
Del Mar, California

## LACINIPOLIA QUADRILINEATA (GROTE)

This small and contrastingly marked moth was described by Grote in 1873, as *Mamestra 4-lineata*, from "California."

Very little has been published concerning its life history, and I have no record of adequate illustrations.

Dyar published a brief description of the larva in 1898, from material supplied by Koebele, "Los Angeles County, food plant not stated."

Crumb, in 1956, p. 135, gave an excellent description of the mature larva, compiled from material obtained in Arizona, and recorded its range as California, Arizona, New Mexico, Nevada and Oregon. His food plant records were given as "taken among dead leaves and other plant debris about clover, *Haplopappus heterophyllus*, and other herbs." This suggests a sweeping operation rather than beating specific plants.

During June of this year (1962) I did some extensive beating of *Adenostoma fasciculatum* H. & A., (Chamise) in Del Mar, California. Among other captures I took two larvae that were new to me. These were drawn, measured, and carefully noted. Later they pupated, and when they finally emerged, proved to be *Lacinipolia quadrilineata*. As this moth was coming in to black light at the time, I confined several females, and secured numerous eggs. This made possible the following notes.

### EGG

Hemispherical, the base flattened, and top rounded, with a clearly defined micropyle. Height, 0.5 mm. Diameter at base, 0.75 mm. The walls are covered with from 25 to 30 ridges which arise at the base and run towards the margin of the micropylar depression. Some of these ridges end considerably short of this margin. Others fuse with their nearest neighbor. The majority reach the edge of the micropylar depression.

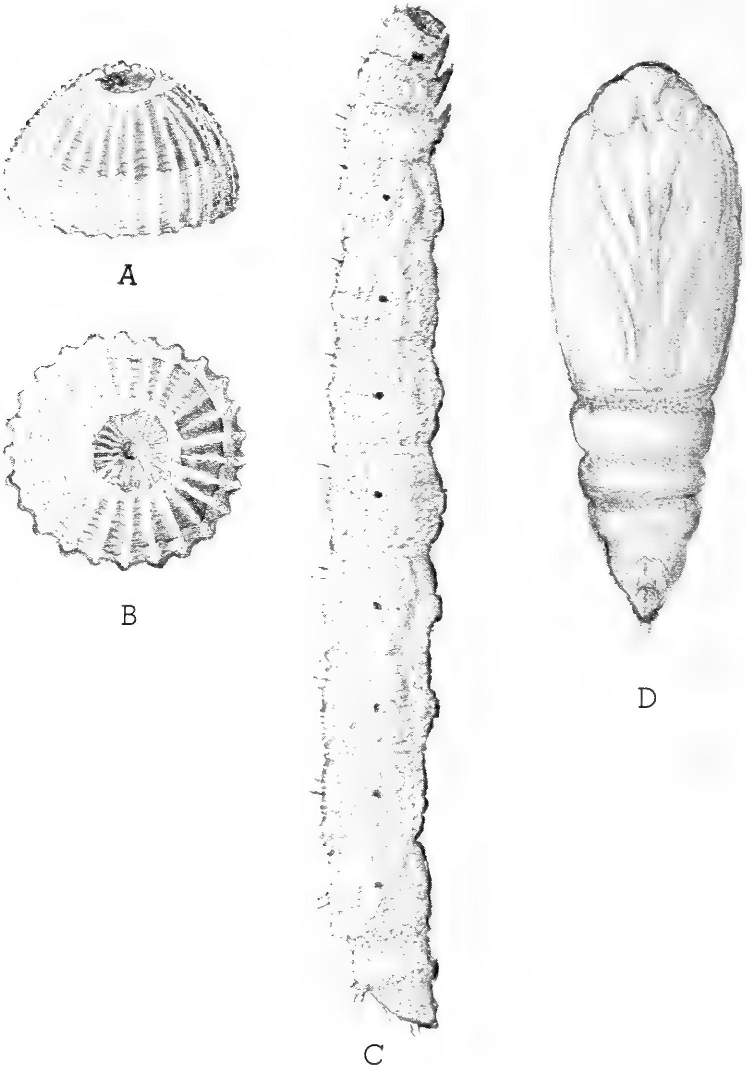

*Figure 1.* The egg. mature larva and pupa of *Lacinipolia quadrilineata.* [A. egg. lateral aspect, tipped forward slightly to show micropyle. Enlarged × 40; B. egg. superior aspect, enlarged × 40; C. mature larva, lateral aspect, enlarged × approx. 5; D. pupa, ventral aspect, enlarged × 7.] Reproduced from colored drawing by the author.

The micropyle proper is a small crater-like structure in the center of this depression. Radiating from it are numerous fine ridges. These join the raised margin and help to form an elevated circlet along with the large ridges that converge on the outer wall. All of these ridges are white, and are topped with pearly nodules. The troughs between them are comparatively deep, and their floors are crossed transversely by low lines or ridges.

The color of the egg when first laid is a pale yellow-green. Later the ground color changes to cream, with a large irregular patch of salmon-red on the floor of the micropylar depression, and a wide circlet of the same color covering most of the upper half of the egg. Some examples show a wider distribution of this salmon-red band.

The egg is illustrated as Figure 1, A and B.

## MATURE LARVA

Regularly cylindrical throughout most of the body, with tapering anterior segments and cauda. Length, 25 mm.

Head; width, 2.75 mm. Color, dark gray, with brown and blackish mottling. It is retracted into the first segment when the larva is at rest, resulting in only a small portion showing, as recorded in the illustration, Figure C.

Body; dull mottled gray throughout. There is a suggestion of a longitudinal middorsal line, topped throughout its length by minute white spicules. A dorso-lateral line of the same character is also present, the latter being paired.

The spiracles are very small, but are black, and therefore conspicuous.

The entire body is covered by minute spiculiferous points that are lighter in color than the ground on which they rest, and hence give the larva a frosted appearance.

Near the dorso-lateral paired line there is a row of white setae, (two to each segment). A similar row of shorter setae occurs supraspiracularly. The remaining setae are still shorter, and are black.

The legs are gray with a tinge of yellow, and are heavily covered with short setae. The prolegs are concolorous with the body, and the crochets are brown.

The larva is sluggish in its movements at all times.

The two larvae pupated June 27 and 28 in a fragile cocoon on the floor of the rearing jar.

### PUPA

Length, 11.5 mm. Width through center, 4 mm. Color, red-brown, with a darker brown on the segmental junctures of the abdomen and the caudal tip.

The head is evenly rounded, and the eyes large and protruding. The maxillae extend to the wing margins, and the antennae terminate about .5 mm. short thereof.

The surface texture is smooth and glistening, except for the slightly granular surface of the eyes and the punctate surfaces of the caudal margins of the movable segmental junctures on the abdomen. The spiracles are concolorous with the body and relatively inconspicuous. The cremasteric tip bears two long thin spines without recurved tips.

The pupa is illustrated as Figure D.

## AUTOGRAPHA BILOBA (STEPHENS)

This striking moth, which is illustrated in Holland's Moth Book on Plate XXVIII, figure 24, and which has been shifted about in various genera, such as *Plusia*, *Phytometra* and *Autographa*, has received scant attention in the literature, so far as its life history is concerned.

It ranges throughout the Americas from Canada to Argentina, and its larvae feed on several plants of economic importance, yet I have failed to find any worthy illustrations of its early stages in the literature.

The larva is a rather general feeder, having been reported on lettuce, cabbage, tobacco, alfalfa, parsnip, clover, thistle and *Collinsia*. Apparently it is seldom abundant, in contrast to others of our pest insects. I have only taken a single example at Del Mar during many years of collecting. Fortunately this lone specimen was a female who rewarded me with a fine cluster of eggs.

The most complete account of the species' metamorphosis was published in 1882 by French. Hampson, in 1913, briefly mentioned French's paper. Rosewall, in 1922, listed one of its food plants, and in 1956 Crumb published pertinent facts concerning its larva, seasonal occurrence and range. My notes supplement and amplify these previously published records, and add illustrations.

Eggs from the single female collected at Del Mar, April 6, were laid April 8, and hatched April 19 to 23, 1962. The young larvae made egress at the side of the egg, leaving the shell intact. They immediately took to lettuce.

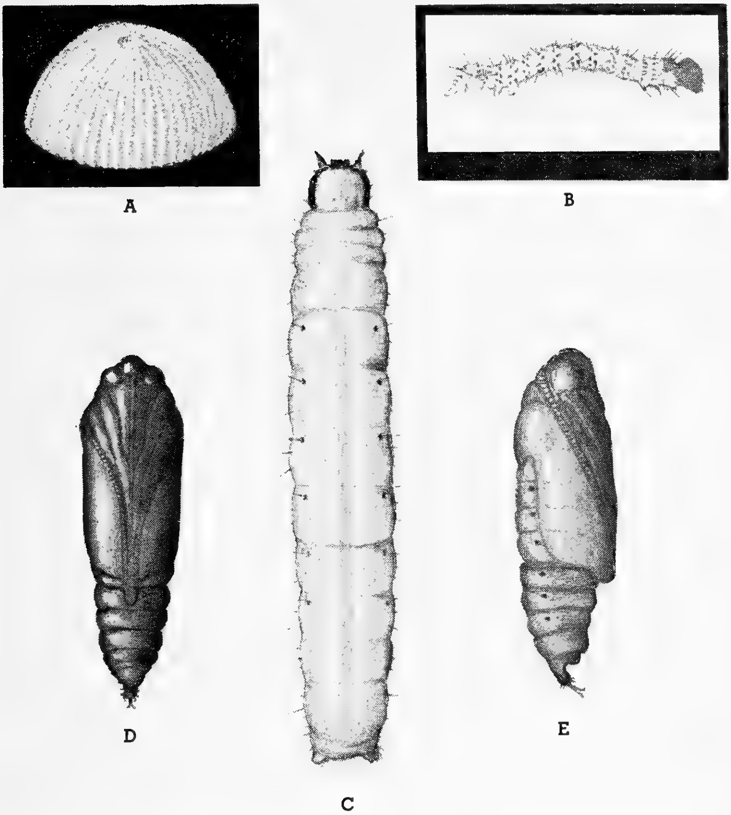

*Figure 2.* Early stages of Autographa biloba (Stephens). [A. egg, lateral view, slightly tipped to show micropyle, enlarged × 46; B. first instar larva, lateral aspect, greatly enlarged; C. mature larva, dorsal aspect, enlarged × 4; D. pupa, ventral aspect, (black phase) enlarged × 3; E. pupa, lateral aspect (olive green phase), enlarged × 3.] Reproduced from colored drawing by the author.

## Egg

Hemispherical, the base flat, the top well rounded and the small micropyle deeply depressed. Color, glistening white. The surface is covered with vertical ridges, approximately 40 to 42 in number, each topped with a row of minute pearly nodules. Many of the ridges coalesce in the upper portion of the egg. There are apparently no horizontal striae between the ridges.

The basal diameter of the egg is 0.60 mm. and the height 0.35 mm. The micropyle is relatively small and depressed.

The egg is pictured as Figure 2 A.

### FIRST INSTAR LARVA

Body cylindrical, constricted on segmental junctures, translucent, with a slight tinge of yellow. The length of larva was not noted.

The head is black, larger than first segment, and measures 0.4 mm. in width. A prominent black scutellum occurs on the prothoracic segment.

The body is thickly covered with relatively long black setae, each arising from a black papillus. These papillae occur in transverse rows across each segment, arranged in zig-zag lines. The two pairs of prolegs and the anal pair are concolorous with the body. The true legs are dark. Ecdysis on April 19 to 23, 1962. Figure 2 B illustrates this instar.

### SECOND INSTAR

Length of body, 3 mm. Head width approximately 0.5 mm. Ground color, translucent light green. The dark setae arising from black papillae are still present. The head is translucent light green; ocelli, black, and mandibles tipped with brown.

From this point on, the rate of growth and time of ecdysis varied so widely that specific instars were not noted. One intermediate stage is recorded.

### LARVA OF 11 MM. LENGTH

Body width, 2.1 mm. Head width, 2.3 mm. Ground color of head and body, light green. A narrow darker green longitudinal middorsal stripe is present, bordered laterally by three narrow pale white stripes on the first three or four segments, becoming obsolete posteriorly. A similar stigmatal line runs the length of the body. Suprastigmatally on the 4th to 8th segments a black papillus bearing a white seta is a noticeable feature. There are numerous white setae scattered over the body, each arising from a white papillus. The legs are black, and the prolegs concolorous with the body.

### MATURE LARVA

Length, fully extended, 22 mm. Body width through center, 4.5 mm. Head width, 2.3 mm. Our illustration of the larva (Fig. 2 C) appears foreshortened, due to the resting habit with the central segments arched upward.

The ground color of the head and body is light green. The head is glistening green except for a conspicuous black margin around the cheeks and across the mandibles. The ocelli are black on this black margin. The bases of the antennae are green and the terminal segments black. The body is cylindrical and plump. A dark green longitudinal middorsal band extends the length of the body. In some examples this is less clearly defined. Lateral to this dark green band is a wide whitish band, somewhat mottled in a few examples. This fuses laterally with the green ground color. A faint longitudinal stripe runs immediately superior to the spiracles. The latter are white centered, with narrow brown rims. Superior to this there is a line of black nodules, one to a segment placed above each spiracle. These are not always present, particularly in the caudal and thoracic areas.

The legs are black, and the prolegs concolorous with the body. The crochets are dark brown. Numerous white setae, arising from minute white papillae occur sparingly over the body. There is also a heavy vestiture of minute white hairs, discernible only under high magnification.

The larvae began spinning loosely woven white transparent cocoons on May 5, 1962. By May 16 all had pupated.

## Pupa

Length, 16 mm. Greatest width through the patagia, 5 mm. When first formed the color is dark olive-green. This gradually darkens to a uniform shiny black.

The eyes are prominent and bulging. The wing tips and antennae form part of an overhanging bulge extending caudalward over the fifth abdominal segment. In the green stage the spiracles are clearly distinguishable as brown ovals, with narrow dark brown rims. In the black phase they show as brown pits, surrounded by a brown shading.

The cremaster is a stubby prominence, rounded at the tip. It bears two relatively long straight spines with recurved tips, and at the base of these there is a cluster of very small red-brown recurved hooklets. These features are shown in the two drawings of the pupa as Figure 2 D and E.

The first imago appeared May 22, and a pair emerged May 23, 1962. Progressive hatchings followed thereafter.

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# THE EARLY STAGES OF *PERO MACDUNNOUGHI* CASSINO AND SWETT (LEPIDOPTERA, GEOMETRIDAE)

John Adams Comstock
Del Mar, California

The species of *Pero* commonly occurring around Los Angeles and in the area southward to the Mexican border was long mislabeled *Pero peplarioides* in local collections. This was prior to the issuance of the McDunnough paper of 1949, and that of Rindge in 1955. These two papers clarified the mix-ups in our southern California Peros in proving that our so-called *P. peplarioides* was actually *Pero macdunnoughi* C. & S., and that the real *peplarioides*, properly called *P. occidentalis peplarioides* (Hulst) was a southern Rocky Mountain species.

A correction will therefore have to be made as to my paper of 1930, containing notes on the (presumed) life history of *Pero peplarioides*, as this should refer to *P. macdunnoughi*.

This paper was somewhat sketchy, in addition to its incorrect designation of the species. Recent rearings of *macdunnoughi* in San Diego County (type locality, San Diego) would seem to justify a more thorough account of its metamorphosis.

The moth has come to light continuously from April to late September of this year (1962), and larvae have been beaten from *Adenostoma*, *Lonicera* and *Rhamnus crocea* Nutt. It has been reared on Privet and Broom, and reported on "Pyrocanthus." Probably it is a general feeder on many vines and bushes.

Females lay readily in captivity, depositing their eggs indiscriminately. Frequently these are laid in rows on the edges of leaves or on the netting of the jar cover. They are usually laid on their sides.

## Egg

Suboblongate, slightly flattened at one end and rounded at the other. Length, 1 mm. Width, 0.6 mm. The color is olive-green at the base, shading to straw at the rounded end. The surface is covered with minute hexagonal cells with very low side walls, discernible with high magnification but appearing to be granular under a low powered lens. The egg is pictured in lateral aspect on Fig. 1 A.

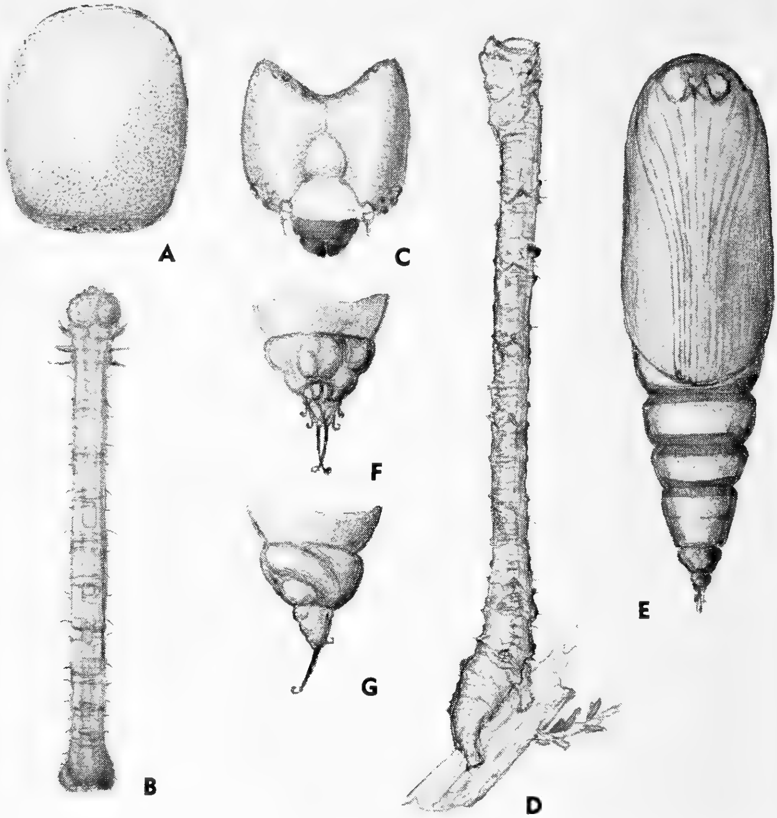

*Figure 1.* Early Stages of *Pero macdunnoughi* Cassino and Swett. [A. egg, lateral aspect, enlarged × 30; B. first instar larva, dorsal aspect, enlarged × 17; C. head of mature larva, enlarged × 9; D. larva, penultimate instar, lateral aspect, enlarged × 4; E. pupa, ventral aspect, enlarged × 4¼; F. and G. cauda and cremaster, ventral and lateral aspects, enlarged × 20.] Reproduced from water color painting by the author.

## First Instar Larva

Length, 4 mm. Head width, 0.45 mm. Width of body through 5th abdominal segment, 0.3 mm.

The head is markedly bilobed. Its color is orange-yellow. The ocelli are black. See Fig. 1 B.

The first two thoracic segments taper outwardly toward the head and the caudal segments widen to 0.4 mm. The body is translucent. and soiled yellow in color. There is a faint suggestion of a middorsal longitudinal paired gray stripe, shaded a lighter gray internally. The caudal area is orange-yellow. The setae are relatively long and dark.

## PENULTIMATE INSTAR

Length, 25 mm. Width through 5th abdominal segment, 1.8 mm.

Head; width, 1.75 mm. Subquadrate, tapering toward mouth parts. The crown is accented by triangulate points supero-laterally. The outer margin is black, the face and front speckled brown, and the labia white. The mandibles are dark brown, streaked with black. See Fig. 1 C.

The body is mottled dark and light gray, speckled with black. There are red-brown patches on the lateral surface near each segmental juncture. On the 5th segment there is a large black warty tubercle, placed substigmatally, (one on each side). This protrudes ventrally. There are numerous small black papillae scattered over the body, each giving rise to short black setae. The larva is a perfect camouflage, mimicking a gray twig. It is illustrated on Figure 1 D.

## FINAL INSTAR

Length, 45 mm. Head width, 2.5 mm. The appearance is similar to penultimate instar except that the triangulate patches in front of each segmental juncture on the lateral surface are black, without a trace of the former red-brown coloring. From the upper angle of each triangle a black ridge extends upward and over the dorsum, and a similar ridge extends downward across the venter. There is also a ridge running longitudinally, in line with the spiracles. This is topped by a narrow black line. The spiracles are gray, with black margins, and narrow black central slits. The legs and prolegs are mottled black and gray. Most of the setae are black, and arise from black nodules. Those on the last caudal segment are gray. There is considerable variation in the stippling and spotting of individuals.

## PUPA

Length, 17 mm. Width through center, 5.5 mm. Color, dark brown, shading to black on eyes, segmental junctures and cauda. Texture, smooth, except for the posterior margins of the movable segmental junctures, which are pitted.

The maxillae and antennae reach to the wing margins. The spiracles are slightly darker than the ground color, and are relatively inconspicuous. The anterior portion of the pupa is evenly rounded.

The cremaster is the most distinctive feature. It is composed of a lobulated pyramidal element from which arise two stout shafts that taper to recurved tips. These cross over each other. There are also two short recurved hooklets on each side. The shape of the last caudal elements is complicated, and difficult to describe. It is best defined by the accompanying illustrations on Figure 1 E, F and G.

Three aspects of the pupa were shown in my paper of 1930, Plate 13.

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BULLETIN OF THE SOUTHERN CALIFORNIA
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# FUNCTIONAL MORPHOLOGY OF THE EXTERNAL APPENDAGES OF *EMERITA ANALOGA*[1]

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## INTRODUCTION

The sand crab, *Emerita analoga* (Stimpson), is the only species of the family Hippidae recognized from the western coast of the United States. Its distribution extends from Washington (Banner and McKernan, 1943) to Chile (Schmitt, 1935). The closely related species, *Emerita emerita* (Linn.), ranges from Baja California southward. In the family Albuneidae there are two species. The larger is *Blepharipoda occidentalis* Randall and the smaller *Lepidopa myops* Stimpson.

*Emerita analoga* is by far the most numerous. It inhabits the sandy beaches of southern California, and may be found there in great numbers. Anyone who has visited the seashore in this vicinity may have observed the many small "v" shaped channels which the water follows in the outwash of the waves. In the daytime under ordinary conditions this is the only visible indication of the presence of these animals other than an occasional discarded skeleton. The tiny ripples are created as the water rushes over the extended flagella of the antennae. As "soft-shelled" crabs they are dug up or dredged by fishermen who recognize them as good bait for surf fish. Because individuals in the hard- and soft-shelled conditions are found living together, there has arisen the erroneous popular idea that they are different species.

Common as these creatures are, not a great deal has been written concerning their anatomy or morphology. Most of the investigations conducted upon *Emerita analoga* have dealt with their habits, life history, and ecology. An article by MacGinitie (1938) gives an excellent account of their movements and mating habits. Weymouth and Richardson (1912) too were concerned with the ecology and habits of the crabs. Mead's work (1917) dealt chiefly with move-

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[2] Department of Zoology.

ments. Many of his experiments were conducted with animals not in their natural environment, and therefore the conclusions he reached are subject to critical examination.

## METHODS

Data were collected on the sand crab, *Emerita analoga*, both by direct observation and photographic technique. The animals used in these studies were kept in small, individual glass tanks provided with six inches of sand covered with water.

Normal behavior was studied, including swimming, digging, and feeding. Observations were then made where appendages were removed singly, in pairs, and in various combinations.

The photographic equipment used was a sixteen millimeter Arriflex with 25, 50, and 150 millimeter lenses. The animals were photographed ventrally, laterally, and dorsally at 24 frames per second. High speed photography, 50 to 250 frames per second, was used to better understand the use of external appendages. Time lapse photography, 1 to 10 frames per second was used for studying the action of the antennae during feeding.

## OBSERVATIONS

Between the high- and low-water marks *Emerita analoga* is most abundant. Some individuals have been found several feet beyond low water but they are not numerous and probably do not remain there for any great length of time. Occasionally these animals have been found above the reach of the waves, but in such cases they were deeply buried and not very active. They had undoubtedly advanced with a previous high tide and were then trapped by a rapid ebb. Upon observation after the next high tide, it was found that practically all of the stranded individuals had made their way back to lower levels.

The area that is covered by the wash of the waves is the favored locality for the sand crabs. Since this area is constantly being shifted by the variation of the tides, the animals are found to advance and retreat periodically. This movement has certain characteristics which are of interest and are quite readily observed.

During the period of high tide, the population of the zone farthest inshore is dominated by males. Seaward, the males decrease in relative number so that at the outermost limit of the waves the sexes are practically equal or slightly in favor of the females. Still farther seaward beyond the wash, there are more females than males. At low tide these conditions are reversed; the females are most abundant at the shoreward limits of the waves and the males at the seaward limits. A single male, however, does not migrate the entire distance; the group movement gives rise to the observed conditions. Experiments using marked animals have indicated that many of the males which occupy the zone at the lower limits of the wash of the waves during low tide move inshore at high tide so that they are still at the lower limits of the waves. Likewise the males at the shoreward limits during low tide make up most of the population at the highest reach of the water at high tide.

In the course of the studies upon population movements, several different habitats have been observed. At Venice, California, a large area of gently sloping beach is shielded from the sun by piers, the pilings of which aid materially in reducing the force and errosive effect of the waves. In this relatively quiet shaded environment the sand crabs were found to be more numerous than on any of the uncovered beaches. A different type of habitat is found on the open, exposed beaches which make up most of the shoreline. This type may further be subdivided according to whether the seaward slope is steep or gentle. When steep, the errosive effect of the waves is relatively more pronounced. There is much shifting in the surface sands, thus creating an extremely unstable substratum. As the slope of the shore increases, the wave-washed zone becomes more narrow, thereby reducing the area which the sand crabs inhabit. On the gently sloping shores, the wave-washed zone is much broader and the errosive effect is relatively weak. Since *Emerita analoga* live under all of these variable conditions, many of their habits must be interpreted with consideration for the special environment they inhabit. Table 1 illustrates the distribution of sexes with varying slope and tide conditions.

TABLE 1

Distribution of the sexes of *Emerita analoga* at high and low water.

| | | Zones at high tide | | | Zones at low tide | | |
|---|---|---|---|---|---|---|---|
| Station | | In-shore | Middle | Off-shore | In-shore | Middle | Off-shore |
| 1 | Males | 39 | 42 | 18 | 27 | 22 | 27 |
| | Females | 11 | 37 | 25 | 40 | 29 | 17 |
| 2 | Males | 29 | 31 | 11 | 20 | 18 | 35 |
| | Females | 10 | 21 | 33 | 32 | 27 | 24 |
| 3 | Males | 13 | 15 | 11 | 7 | 10 | 15 |
| | Females | 3 | 17 | 17 | 19 | 19 | 12 |
| 4 | Males | 24 | 21 | 15 | 4 | 13 | 19 |
| | Females | 7 | 20 | 26 | 12 | 17 | 9 |
| 5 | Males | 15 | 29 | 23 | 10 | 17 | 22 |
| | Females | 2 | 31 | 28 | 11 | 28 | 13 |

At Stations 1 and 2 the beach was very gently sloped and entirely shaded by a wide pier. Because of the resistance of the pilings, the force of the waves was greatly diminished. At Station 3 the beach was steep, uncovered, and exposed. Stations 4 and 5 were similar to Station 3 except that the slope was gentle. Each entry in the above table represents the average of eight counts made as nearly simultaneous as possible. A screen twenty-four by twenty inches was used to collect the sand crabs.

The normal habitat of *Emerita analoga* presents factors which are both advantageous and disadvantageous to the animals. In their particular zone they are almost without competition except for the occasional appearance of one of the Albuneidae mentioned before. Their food consists of microplankton which is brought to them by the waves. The constant wash of the water makes it unnecessary for them to perform their own pumping as many other plankton feeders are obliged to do. Their task is simply to sift the organisms from the water.

Among the disadvantages of the environment are the difficulties which the animals meet in maintaining their position on an unstable substratum and escaping the shock of the waves. They protect themselves by burrowing into the sand, and by this means also hide from predators such as birds and fish. At the same time, the sand crab must be able to get sufficient food and oxygen from the water.

As might be expected, this unusual mode of life has resulted in striking modifications of the typical decapod anatomy.

## ANATOMY

*Carapace*. The somites of the head and thorax of *Emerita analoga* are fused with one another in the usual way. The whole cephalothorax is covered by a heavily calcified carapace. It is found that the membranous dorsal body wall is not united with the carapace but only closely applied to it. This is especially evident in the posterior portion where by careful dissection one part may be separated from the other without much difficulty.

In the course of collecting the sand crabs, a series was taken from La Jolla to Monterey, California, with most of the work being done on specimens gathered near Santa Monica.

The carapace (Fig. 2) is ovate and measures 15-30 mm. in length in the adult female and between 10-22 mm. in the adult male. The width in the female ranges from 9-23 mm. and in the male from

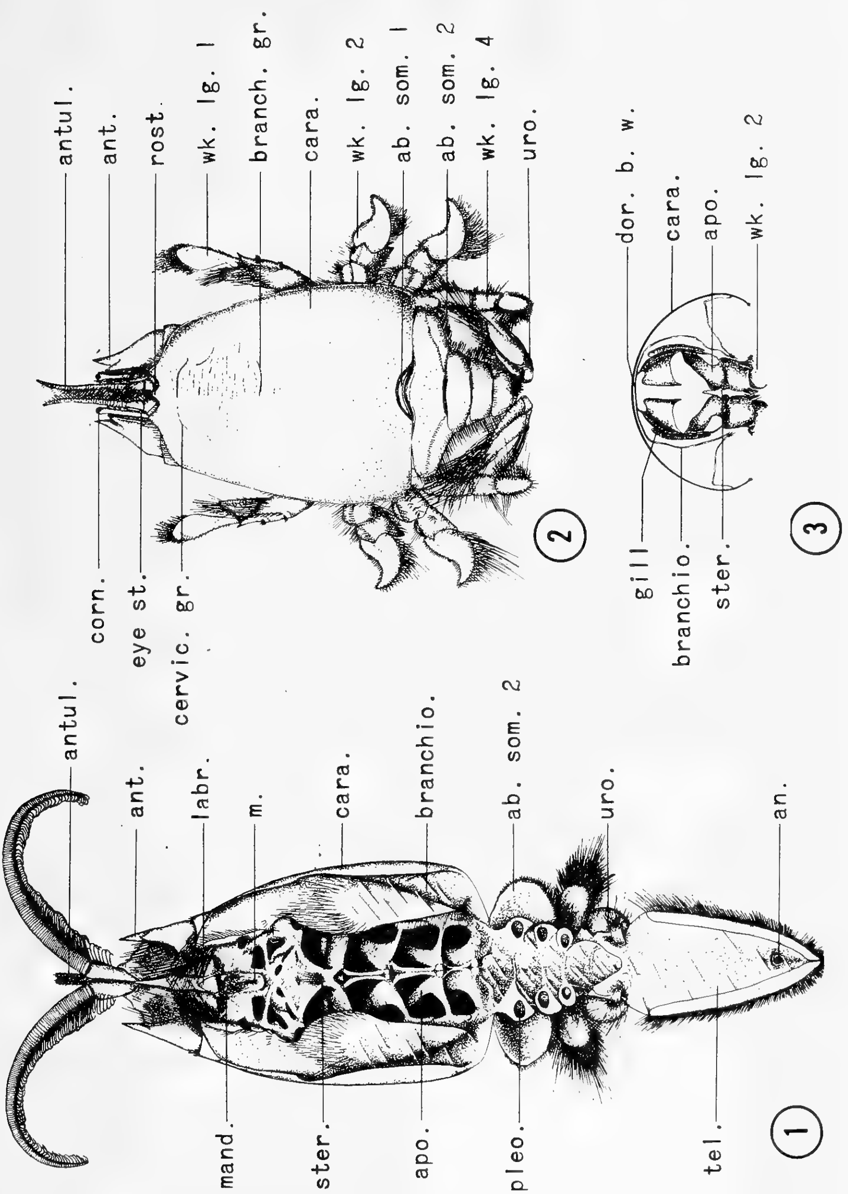

Fig. 1, ventral view of *Emerita analoga,* with the appendages removed and the abdomen extended. x 2; fig. 2, dorsal view of *Emerita analoga.* x 2; fig. 3, transverse section between the second and third walking legs. x 2.

8-17 mm. In a series of individuals of either sex it is found that the relation of the width to the length of the carapace is quite variable. Two specimens measuring the same in length may vary as much as 4 mm. in width. Measurements of the carapace of an average female would be about 16 mm. in width and 22 mm. in length; the male would be about 10 mm. in width and 14 mm. in length.

The carapace is strongly convex, with its lower margin overlapping the sterna and covering the basal joints of the walking legs (Fig. 3). The branchiostegites (Figs. 1 and 3) of *Emerita analoga* have the outer layer of the pleural fold strongly calcified. The part of the fold which lies next to the gills is not calcified but appears as a thin transparent membrane. The rostrum is much reduced and is present only as a short, blunt, median projection. On either side of it is a lateral process from the carapace. These are only slightly longer than the rostrum, but more rounded. They overlie the uncalcified part of the eye stalks and probably serve to protect them from injury. On the anterior half of the carapace are two conspicuous transverse grooves, the anterior one being the cervical groove and the posterior one, the branchial groove. There are numerous smaller grooves which become less distinct laterally and posteriorly. That part of the carapace adjoining the first abdominal tergum is quite smooth.

The posterior part of the carapace is noticeably wider than the anterior, giving the animal a streamlined appearance. This shape may be of use in cutting down the drag of the water if the animal happens to be digging in during the outwash of the wave. Once buried, this same shape may serve as a wedge to give the crab a firmer position.

*Terga of Abdomen.* The abdomen (Fig. 2) is distinctly segmented and flexible. It is tapered posteriorly, ending with the telson which is a rather narrow triangular structure. The telson and the sixth segment are bent under the body when at rest, and in the case of an oviferous female serve to cover and protect the eggs. The tergum of the first segment is a small crescent shaped piece which occupies a rounded notch in the posterior edge of the carapace to which it is partially fused. In addition there is a tough tissue which attaches the first tergum firmly to the ventral side of the carapace. The terga of the remaining segments are convex, covering their respective sternum and the basal joints of the abdominal appendages. The second abdominal somite is four to five times broader than long and is characterized by large winglike pleura. The anterior margin of the tergum is almost straight but the posterior edge has a curved sinus into which the tergum of the third somite fits. The third, fourth, and fifth terga are similar in form

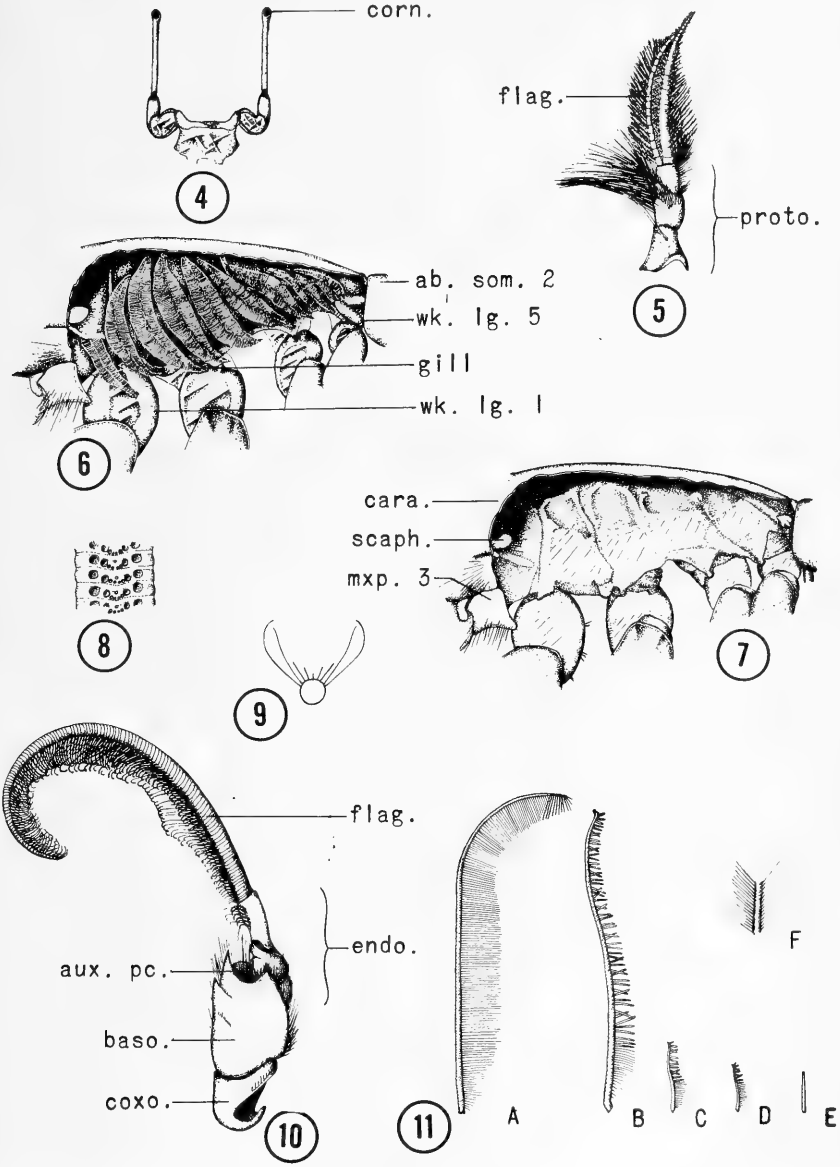

Fig. 4, eye stalks. Dorsal view. x 3; fig. 5, antennule, left. Lateral view. x 3; fig. 6, gill chamber of *Emerita analoga.* Lateral view, with carapace and branchiostegite removed. x 3; fig. 7, same as above with the gills removed to show the calcification of the lateral body wall. x 3; fig. 8, several annuli from the flagellum of the antenna. The hairs have been removed to show their points of attachment. x 12; fig. 9, diagrammatic transverse section through the flagellum of the antenna. x 3; fig. 10, antenna, left. Lateral view. x 3; fig. 11, hairs from the antenna. Lateral view. x 12 [A. outer row; B. second row; C. third row; D. fourth row; E. median row; F. portion from the first or outer row hair, looking into the trough between the barbs].

but much smaller in size than the second. The tergum of the sixth somite is as long as broad and has a wide rounded lobe which extends posteriorly and articulates with the telson.

*Sterna.* The sterna in the region of the thorax are reduced to bars between which the walking legs are attached. The succeeding sterna are joined to each other by a median bar. From each sternum there extend inward two apodemes. These afford a certain degree of rigidity to the body as well as providing attachment of the extrinsic muscles of the legs. Those sterna to which the mouth parts are fastened form a more continuous plate (Fig. 1) although some parts of it are very slightly calcified and may on first observation give the impression of transparent membranes.

The sterna of the abdominal region are calcified around the points of junction with the pleopods, but otherwise, except for thin transverse bars, appear only as transparent membranes through which the intestine may be seen. The amount of calcification and the width of these bars vary in different individuals. The length of time since changing the shell is a significant factor. The ventral surface of the telson is membranous except for a narrow calcified border. The structure of the telson will be taken up in more detail in a later section.

The sterna of the abdomen are rarely exposed to any extent and do not afford a vulnerable spot as might be the case in animals which characteristically swim by flexing the abdomen. In the normal position, the tip of the telson reaches the base of the first pair of walking legs. It shields the under side of the body against abrasion while the animal is burrowing.

*Eyes.* The eye stalks of *Emerita analoga* have four segments, the terminal (fourth) one being the longest and most slender and bearing at its enlarged tip the cornea (Fig. 4). Near the basal end of the third segment there is a small round opening covered by a delicate transparent membrane and bordered proximally by a tuft of long hairs. The function of this opening was not determined. Part of the second segment and its articulation with the third segment are very thinly calcified. It is this region which is covered above by the lateral-anterior projections of the carapace. The muscles and articulations of the eye stalks are so arranged that movement is almost entirely in the sagital plane. Lateral movement of the stalks is limited to about two millimeters.

The elevation and lowering of the eyes have been noted while watching these creatures in their normal environment. When the crab is at rest and not actively feeding, the eye stalks protrude above the sand about two-thirds the length of the terminal segment. The cornea is so situated that there is vision in all directions, thus apparently making it possible to observe the approach of enemies with the minimum exposure of the body. However, visual stimulation, such as the approach of foreign objects does not usually cause any eye movement or other reaction unless there is actual contact with some part of the animal itself. The slightest touch upon the stalks or the antennules causes the eyes to be flattened against the sand, and an impact in the proximity will produce the same reaction. This leads one to suspect that visual-muscular coordination is not as well developed as might be expected.

*Antennules.* The antennules consist of a protopodite of three segments to which are attached two flagella (Fig. 5). The lateral one is the longer and is made up of thirty-five to forty-five short annuli. Two distinct rows of hairs approximately at right angles to each other extend from the dorsal and ventral sides of the flagellum. The ventral row is continuous for the whole length but the dorsal row may stop five or six annuli from the end. The median flagellum is shorter and consists of sixteen to twenty-one annuli. It also bears two rows of hairs approximately at right angles with each other. The hairs are rather spinulose in nature but do possess a few short barbs. The exact character of the hairs of the antennules has been observed to be somewhat variable between different individuals.

The opening for the otocyst occurs on the dorsal side of the coxopodite. It is encircled by a row of short spinulose hairs. On the second segment of the protopodite there is a short lateral process, the appendicular scale, which is characteristically covered with long plumulose hairs. The distal segment of the protopodite is slightly compressed laterally. There are dense rows of spinulose hairs on the dorsal and ventral surfaces.

The functioning of the antennules is an important factor in the ability of the sand crab to maintain a respiration water supply while buried. This will be described later in the discussion of respiration. The hairs from each flagellum of the two antennules interlock forming a rectangular channel down which water flows. Sand or other large particles are strained out so that a minimum of foreign material reaches the gill chamber.

*Antennae.* The protopodite of the antenna has the usual two segments, the second of which is enlarged and provided with three prominent spines on its distal border (Fig. 10). The coxopodite bears the opening for the green gland. The endopodite is composed of a peduncle of three large segments and a long flagellum of numerous small annuli (165-185 in an adult female). The division of the peduncle into three segments allows a wide range of movement. Immediately below and lateral to the basal segment of the endopodite there is another small segment which articulates distally with the second segment of the endopodite and proximally with the basopodite.

From each of the annuli of the flagellum arise nine hairs arranged in longitudinal rows so that they form a "v" shaped trough. The two outer rows are made up of hairs which are long, slender, and curved sharply inward at their distal ends. The inner rows become successively shorter, with the median unpaired row being the shortest of all (Fig. 11a-e). The long hairs of the outer rows have two lines of numerous fine barbs perpendicular to the main stem and at an acute angle with each other so that they form a small "v" shaped trough (Fig. 11f). The hairs forming the second row are stouter and have short, stubby barbs arranged quite irregularly. Near the base of the hair, the barbs are longer and much more slender. The rest of the inner rows are made up of hairs which are similar in structure but smaller in size.

The hairs of the median row are spine-like and have no barbs. The hairs of the flagella are specialized for filtering out the food. As the water flows into the trough between the hairs and the barbs, the stout inner rows remove the larger particles in suspension and allow the rest to pass on to the slender outer rows. These, with their many fine branches, complete the filtering. By taking up so much of the force of the water and removing large particles, the strong inner rows of hairs protect the outer ones from being broken or pushed apart.

This arrangement of the parts is of particular significance in relation to the function of the flagella. As mentioned before, *Emerita analoga* uses plankton for its source of food, and the antennae are the means for securing these small organisms. As a wave washes in the antennae are extended. The movement of the water through the hairs of the flagella as the wave flows out causes the small particles to be collected. From time to time the antennae are whipped downward and wiped off by the mouth parts. This action has been observed to be repeated as many as eight times during a single wave. The two flagella are not brought down simultaneously, but separately and with no definite alternation. The act of lowering the flagella includes a rotation of 180° in that part in such a way that there is constantly a pressure into the trough of hairs, thus keeping the collected food from being washed away.

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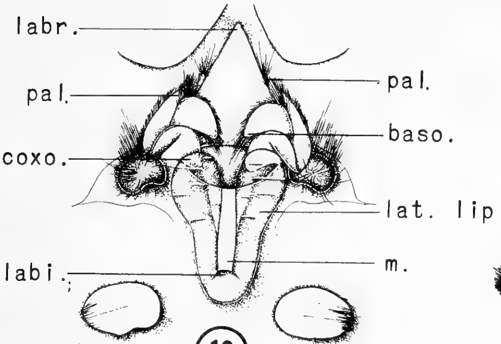

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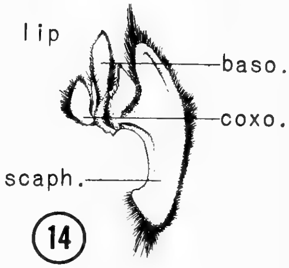

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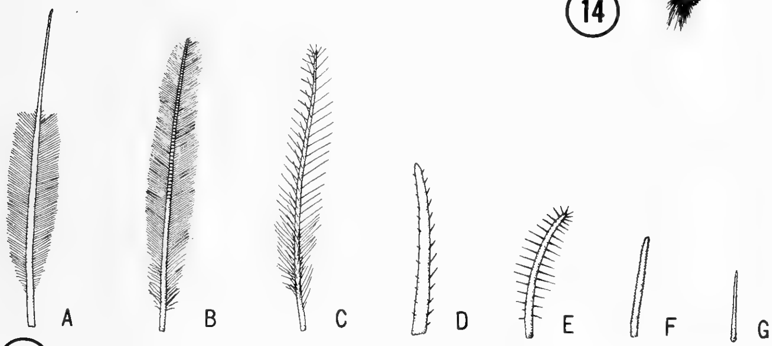

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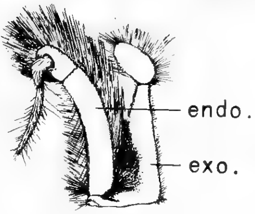

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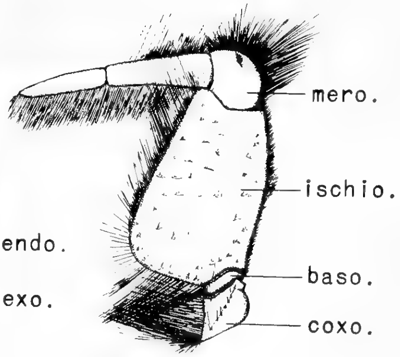

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Fig. 12, first maxilla, left. x 3; fig. 13, mouth and mandibles. Ventral view. x 8; fig. 14, second maxilla, left. x 3; fig. 15, different types of hairs found on *Emerita analoga.* x 12 [A. from the scaphognathite; B. from the endopodite of the uropod; C. from the margin of the telson; D. from the dactylopodite of the first walking leg; E. from the antennule; F. from the coxopodite of the first maxilla; G. from the meropodite of the first walking leg]; fig. 16, first maxilliped, left. x 3; fig. 17, second maxilliped, left. x 3; fig. 18, third maxilliped, left. x 3.

When the animal is not feeding, the antennae are folded together and coiled up under the protecting cover of the third maxillipeds. In such a position only the two segments of the protopodite and the basal segment of the peduncle are visible. The hairs of the flagella are turned toward the center of the coil. Practically the whole flexion necessary for this movement takes place in the articulation between the distal segment of the protopodite and the peduncle and in the segments distal to this. The three spines of the basopodite point anteriorly. This provides a barbed armor for the rest of the antenna as well as for the eye stalks which lie adjacent.

*Mouth.* The oral opening (Fig. 13) is a longitudinal slit about two millimeters in length by one-half a millimeter in width, leading into a slightly larger esophagus. In life, the surrounding tissue is colored deep red. The mouth is bordered laterally by raised membranous structures upon the inner surface of which there are usually found a series of wrinkles covered by small hairs. The labium is continuous with the lateral folds at the posterior end of the mouth. The labrum is a large, conspicuous, triangular flap. It is situated a short distance anterior to the mouth. It is quite thick and tough but is not at all calcified. The anterior border of the mouth is formed by a thin membranous fold which extends backward from the base of the labrum. Between the labrum and the sternum, and attached to the latter, are two palps. They are derived from an anterior fold of the epistome. Each bears a few long plumulose hairs at its apex. On either side of the mouth is a rounded elevation from which arise a large number of plumulose hairs. The homology of these structures was not determined.

*Mandibles.* Each mandible consists of two small uncalcified segments and a large palpus (Fig. 13). The proximal segment is frequently fused along its median edge with the raised margin of the mouth. The lateral portion of the basal segment gives rise to the large flattened palpus which extends forward enfolding the posterior-lateral edges of the labrum. The palpus is bordered by a fringe of plumulose hairs. The distal segment of the mandible is broad and flat. It is produced medianly into a blunt rounded point upon which are a few long hairs. The mandible may be able to create a slight current but it would be insignificant compared to the action of the other mouth parts. The absence of masticatory apparatus is what would be expected in correlation with the sand crab's exclusive diet of plankton.

*First maxillae.* The first maxillae (Fig. 12) are composed of a protopodite and a small, palpus-like endopodite. The coxopodite lies median to the basopodite and immediately ventral to the mouth. It is a thin uncalcified lamella bordered by rather stiff hairs. It is connected with the basopodite by a narrow, crescent shaped extension of the base. The median proximal portion of the coxopodite is produced into a pointed process from which arise a dense fringe of long plumulose hairs. The basopodite is composed of two parts. The distal segment is approximately the same width as the coxopodite but it is longer and bears a tuft of long spinulose hairs at its extremity. The proximal segment is narrow and curved. It terminates in an expanded, knob-like base. Very long plumulose hairs extend from the convex surface of the basal segment. The endopodite is a small pointed lobe arising laterally from the basopodite.

*Second maxillae.* The second maxillae (Fig. 14) exhibit practically the same structure as the first. The coxopodite is divided into two lobes, the median of which is similar in form to the coxopodite of the first maxilla. The lateral lobe is a narrow, finger-like projection with a few hairs at its tip. The basopodite and endopodite are both quite similar to those of the first maxilla but somewhat larger. The hairs of the endopodite are restricted to a few scattered ones on the median edge, while on the basopodite, they form a complete fringe around the margin. The exopodite, as in other decapods, forms the scaphognathite. In *Emerita analoga* this structure is rather short and broad. It barely reaches into the gill chamber (Fig. 6). Around the lateral, convex edge there is a row of plumulose hairs (Fig. 15a) which increase in length toward both extremities. The function of the scaphognathite in regard to respiration will be discussed later.

*First maxillipeds.* The first maxillipeds (Fig. 16) are thinly calcified and are quite flexible. The protopodite is reduced to a single small segment which articulates with the single segment of the endopodite and with the exopodite. The epipodite typical of other decapods is entirely missing in the sand crab.

The exopodite has two segments. The proximal one is flat and elongated, with a truncate distal end and a widened base. A series of short plumulose hairs border the lateral margin. A long lobe arises on the median edge. The terminal segment of the exopodite is broad, flat, and bluntly pointed. It is so articulated that it is able to create a current by a flapping action. The long plumulose hairs with which it is armed are curved and give the greatest force in the anterior to posterior sweep. This is a striking modification from the typical structure of the exopodite. Here the flagellum is replaced by a paddle which is part of the respiratory mechanism.

The long endopodite is ventrally convex so that a movement of this part performs a scooping effect. The lateral and terminal margins are edged by long plumulose hairs which are so arranged and curved that in action they pass the food on toward the mouth. Near the base of the endopodite there is a tuft composed of a few long plumulose hairs which reach almost to the end of the lobe. The entire convex ventral surface is covered by many short hairs.

*Second maxillipeds.* The second maxillipeds (Fig. 17) of the sand crab also have the protopodite reduced to a single, very small segment which articulates with the exopodite and with the endopodite.

The endopodite has four segments, the first of which is by far the longest. All of the parts of the endopodite are better calcified than those of the exopodite, but they do not approach the rigidity found in the third maxilliped. The second segment is short and articulates with the third by a joint which is not terminal but located on the flat surface. The possible movements which this allows are similar to those of a ball and socket joint. The third segment is small and cylindrical. The terminal segment is also cylindrical but quite elongated. The two distal parts are covered by long plumulose hairs scattered over their whole surface. The two proximal segments have long plumulose hairs forming a dense fringe along their borders.

The exopodite consists of two segments, both of them being thin, flat, and very lightly calcified. The proximal one is about three times the length of the distal, and has a broad base articulating with the protopodite at its median edge. From the wide base the proximal segment of the exopodite tapers to its articulation with the distal segment. The latter is flat and oval. It has a row of plumulose hairs along its edge which are much longer than those on the basal segment. The exopodite of the typical decapod possesses a long flagellum which in the sand crab is replaced by a broad paddle. This is correlated with the adaptation of this part for its function in the respiratory mechanism. The distal, oval segment lies in the channel carrying water to the gills. It is able to move in an arc at right angles to its flat surface, thereby creating a current which passes through the gill chamber.

The second maxillipeds function also as a part of the feeding apparatus. The endopodite assists in moving the food toward the mouth. The long hairs serve to wipe the collected food from the flagella of the antennae as they are drawn over the mouth. The third maxillipeds also participate in this function. When an antennal flagellum is whipped down, it is enclosed between the second maxillipeds. The long tufts of hairs on the second segments of the endopodites of each appendage interlock medially and against this the flagellum moves. The two distal segments lie over the flagellum. After the movement of the antenna is completed, each endopodite moves laterally so that the hairs no longer interlace. They then take up the function of passing the food along toward the mouth.

*Third maxillipeds.* The third maxillipeds (Fig. 18) of *Emerita analoga* lack an exopodite. The endopodite has only four segments in place of the usual five. The two segments of the protopodite are small, the basopodite being transversely linear to the ventral surface while the coxopodite is subrectangular. Along the median borders of each grow dense tufts of long plumulose hairs. The basopodite is joined immoveably with the ischiopodite. The latter is a broad, flat structure having a prominent longitudinal ridge on the dorsal surface. This is the main axis of the segment at either end of which the meropodite and basopodite articulate. The ventral surface of the ischiopodite is covered by scattered groups of short blunt hairs arising from shallow grooves. There are long plumulose hairs on the median and lateral borders, those on the former being two to three times longer than those on the latter. The meropodite is much smaller in size than the ischiopodite. Its anterior-lateral margin is rounded and possesses a large tuft of long and short plumulose hairs. The articulation between the ischiopodite and meropodite is such that a flexion of this joint causes the distal segments to be hidden behind the broad shield of the ischiopodite. When the animal is at rest this is the typical position. The two terminal segments are narrow and elongated. They bear a number of rows of long and short plumulose hairs along their median edges.

Since the third maxillipeds are the most exterior of the mouth parts, they form a protecting shield. They are much heavier and more strongly calcified than any of the other parts. When food is brought down by the antennae, the broad ischiopodites of the third maxillipeds form a chamber relatively free from currents in which the rest of the mouth parts can transport the food to the oral opening.

*Walking legs.* The first walking legs (Fig. 19) do not have chelae. The seven segments of the leg are reduced in *Emerita analoga* to six by the fusion of the basopodite with the ischiopodite, as is true for most Reptantia. The carpopodite and the propodite have spines which assist the crab in getting a strong foothold. The surface of all the segments are more or less marked by shallow grooves from which short blunt hairs arise. The broad flattened dactylopodite is modified to give a large area for contact with the substratum. It is bordered by long and short stiff plumulose hairs (Fig. 15d). The function of the first legs

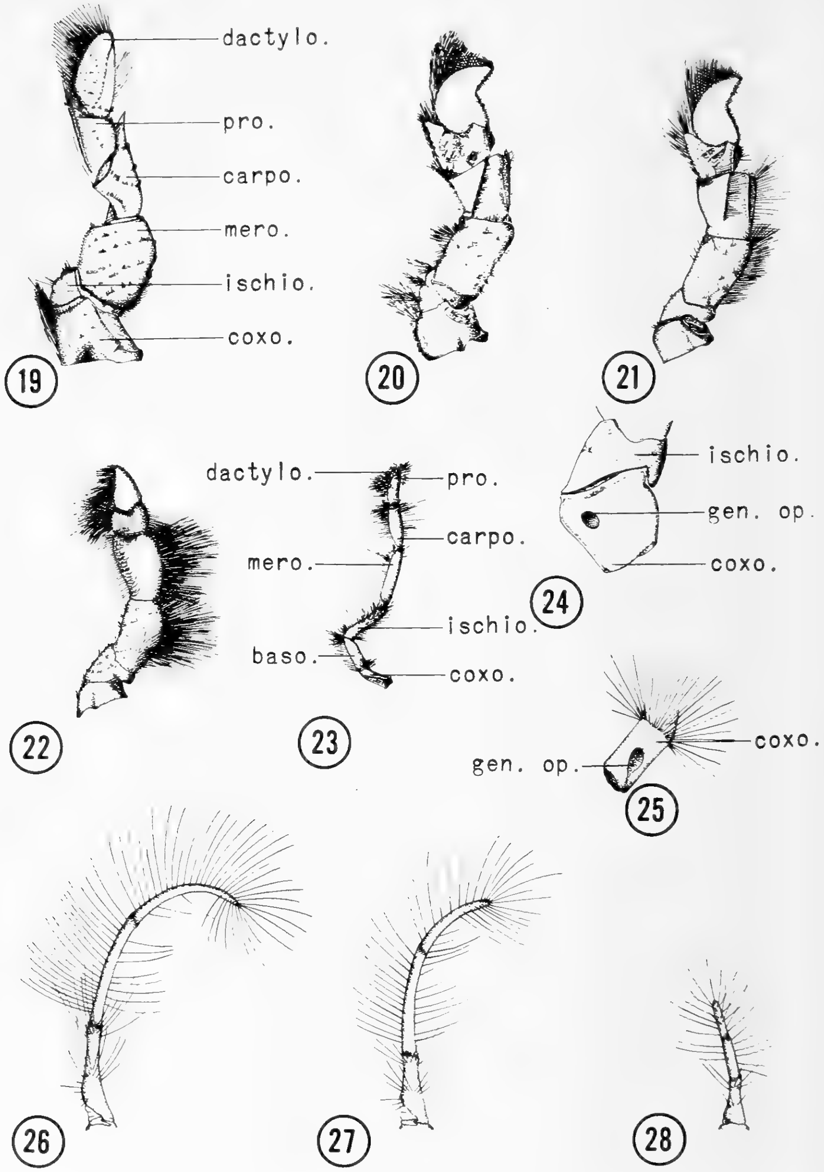

Fig. 19, first walking leg, left. Lateral view. x 2; fig. 20, second walking leg, left. Lateral view. x 2; fig. 21, third walking leg, left. Lateral view. x 2; fig. 22, fourth walking leg, left. Lateral view. x 2; fig. 23, fifth walking leg. Lateral view. x 2; fig. 24, protopodite of the third walking leg of a female, showing the genital opening. x 4; fig. 25, coxopodite of the fifth walking leg of a male, showing the genital opening. x 4; fig. 26, pleopod from the second abdominal somite. x 3; fig. 27, pleopod from the third abdominal somite. x 3; fig. 28, pleopod from the fourth abdominal somite. x 3.

in walking, as well as in digging, is to push. As the animal burrows into the sand or moves along the beach, the spines dig in and hold. The flat terminal segment may be turned laterally so that it presents the greatest surface against the sand when pushing.

The second walking leg (Fig. 20) also has the basopodite fused with the ischiopodite. The propodite retains a sharp projection but the carpopodite does not. The dactylopodite is broad, flat, and modified as a hook. The function of the second legs is to assist with the actual digging when the crab starts to burrow. The terminal segment is really a scoop with which sand is removed from under the animal and thrown out anteriorly.

The third walking leg (Fig. 21) is a replica of the second in all the major details. There are a few less hairs on the segments, but this character varies in different individuals. The dactylopodite is slightly narrower than that of the preceding appendage. The use of this leg is the same as that of the second. In the females, the genital opening is found on the coxopodite (Fig. 24).

The fourth legs (Fig. 22) have the same segmentation as the third. There are no spines on any of the parts. The dactylopodite is not a hook. It is flat and sub-triangular, terminating in a blunt point. The hairs on the fourth legs are relatively longer and more numerous than on any of the other legs. Although the function of the fourth walking legs is digging, their operation is quite characteristic. The leg is turned in such a way that the two terminal segments act as scoops and push the sand out sideways. This is in contrast to the second and third legs in which the dactylopodite is dug in and used as a hook in a posterior-anterior direction. Judging by the relative amount of sand which each appendage throws, the hooks are apparently more efficient.

The fifth walking legs are long and filiform (Fig. 23). They possess the seven segments typical of the decapod leg but the basopodite and ischiopodite show indications of fusion. The protopodite and the dactylopodite form a sharply toothed chela which is surrounded by a dense tuft of barbed hairs. In its usual position this leg is not visible externally. It is folded back under the branchiostegite and lies against the gills (Fig. 6). When fully extended, it reaches as far anteriorly as the posterior end of the scaphognathite. One of the functions of the fifth leg is to keep the gills free of foreign materials, especially sand. There is not any other structure or appendage which is adapted for this work.

In the males the opening of the genital pore is on the coxopodite (Fig. 25). It can readily be located by the genital papilla. Aside from the function of removing debris from the gills, it has been observed that the male crabs make use of the fifth legs in placing the sperm ribbons. It has also been observed that the fifth legs are used by the females in arranging the newly laid eggs on the pleopods.

*Pleopods.* The females have three pairs of uniramous pleopods (Figs. 26-28) on the second, third, and fourth abdominal somites. The first and fifth do not have any appendages. The first and second pairs of pleopods are more than twice as long as the third pair. They are cylindrical and filiform, and are composed of three nearly equal segments. This is in contrast to the biramous, multiarticular pleopods of the typical decapod. On the sand crab, these appendages are sparsely covered with hairs, the proximal ends of which are expanded to fit into cup shaped sockets. During the breeding season the egg mass is attached to the pleopods by a tough transparent substance. The eggs are arranged in branched strings which are held together by the same cuticle-like covering. The males of *Emerita analoga* have no pleopods.

*Uropods.* The uropods (Figs. 1 and 2) on the sixth abdominal somite have a long basal segment and two large terminal lamellae. The protopodite is slightly broader at its distal extremity than at the base. Along its lateral margin there are a series of long and short plumulose hairs. The exopodite consists of two segments, the proximal one being very small. The terminal segment is approximately twice as long as broad. It is flattened and oval in outline. Along the anterior margin there are several rows of coarse spinulose hairs while at the extremity there are longer plumulose hairs. On some individuals jointed hairs (Fig. 15b) are not uncommon. The endopodite is about three times as long as broad and is armed with hairs in a similar manner to the exopodite.

Although the sand crabs in their natural environment do not swim to any extent, the uropods perform the function of propelling the animal when that is necessary. The broad, oval shape of the terminal segments is adapted for swimming as well as for burrowing in the sand.

*Telson.* The telson is triangular in outline (Fig. 1) and in the adult female about twice as long as broad. It has a median shallow sinus on its proximal edge by which it is articulated with a rounded lobe from the tergum of the sixth abdominal segment. A short groove extends posteriorly from either side of the sinus. Lateral to the sinus the base of the telson is attached to the protopodites of the uropods. The dorsal surface of the telson is convex and is bordered by a slightly raised, narrow rim which bears a series of short plumulose hairs. Around the margin and extending to the tip are several rows of long barbed hairs (Fig. 15c). The ventral surface of the telson is practically flat and almost entirely uncalcified except for a narrow band around the edge. The anus opens in a small depression about one fourth of the way back from the tip.

The telson exhibits a small degree of sexual differentiation. In males it is proportionately smaller and narrower than in females. Also the fringe of hairs which is so conspicuous on the female telson is usually quite sparse on the male.

## HABITS

*Burrowing*. Under usual circumstances the act of digging into the sand is a relatively short one. However, the coarseness and firmness of the sand, the amount of water present, and the size of the animal all affect the time. Unless the animals are purposely dug up and placed on the surface, burrowing is rarely observed in the daytime. At night when the crabs are much more actively moving about, the burrowing process can be frequently seen.

In all cases observed under normal environmental conditions, *Emerita analoga* has been found to enter the sand backwards with its anterior end pointing seaward. Movement on the surface and while swimming is also rear end foremost. The direction of burrowing is obliquely downward. This method has quite obvious advantages. Because the food of these animals is found in the greatest amount in the water, it is necessary that the mouth and food capturing devices be located near the surface. In order to see, the eyes must protrude above the sand. The antennules must have access to a supply of fresh water for the gills.

In the normal habitat, the process of digging is always the same and is usually accomplished while the wave is covering the beach. Often an animal which is dug up and placed on the surface will wait for the next wave to come in before it disappears under the sand.

The uropods beat rapidly in an anterior-posterior direction. The hairs of the terminal segments are so arranged that they exert the greatest force in the posterior to anterior sweep. The action of these parts serves to stir up the sand on the bottom and mix it with the water; rather than actually scooping out a hole, they merely make a more fluid region into which the animal pushes. The second, third, and fourth pairs of walking legs are adapted for actually digging. It is with the aid of these parts that the animal is able to bury itself in hard, compact sand. The terminal segment of the second and third pairs are modified as hooks, and the fourth pair has flattened terminal segments. These legs are so jointed that they are able to perform a powerful scooping action. In the still water of an aquarium, the little puffs of sand are seen to be thrown out as the crab disappears. The first pair of walking legs is used for pushing. The end segment is flattened and there are spines on the fourth and fifth joints, all of which give the leg a strong purchase. Digging is continued until only the eyes and the tips of the antennules are visible. When the crab is completely covered, the first legs and the third maxillipeds push against the side of the burrow, thus making an open space under the anterior end of the animal. This cavity is filled by the water used in respiration.

It has been determined that the rate of burrowing increases as temperature decreases. The optimal temperature range for both sexes is 20 to 25 C, but females are better able to withstand temperature extremes (Jeanette Hanby, personal communication).

*Reproduction. Emerita* shows a distinct annual breeding cycle, as determined by plotting the percent of the monthly sample of females bearing eggs against months of the year. The ovigerous period extends from April to October, reaching a maximum in July when 80% of the population was ripe.

Incubation period for animals in the laboratory is between 29 and 32 days. It is not certain if *Emerita* berries more than once during the breeding season (Boolootian, *et al.*, 1959).

*Gills and respiration.* The gill chambers of *Emerita analoga* are covered by the branchiostegites, which may be removed to expose the gills (Fig. 6). There are eight pleurobranches and, at the level of the first walking legs, ventral half only of a ninth. All of the gills are phyllobranchiae. They are all attached at about the same level on the body wall, well above the articulation of the legs. They probably did not all arise as pleurobranchs but without knowledge of the development it is difficult to class them otherwise.

The method of obtaining the supply of water for respiration shows marked differences from that used by typical decapods. Since the animal is usually buried under a layer of sand, it is necessary to transport the water from the surface down to the gill chamber. One of the most obvious specializations found in *Emerita analoga* is that the direction of flow of the respiratory current is from anterior to posterior instead of in the posterior-anterior direction typical of other decapods. Calman (1909) states in regard to the respiratory current, "as a rule it sets from behind forward, though it appears that in some cases, especially in decapods which burrow in sand or mud, the direction of the current is periodically reversed. . . . The flagella of the antennules in some Hippidea and of the antennae in the Corystidae form a long exhalent (or inhalent) siphon." Weymouth and Richardson (1912) have noted the reversal of the respiratory current in *Emerita analoga,* while similar observations were made by Garstang (1896, 1897) on *Corystes* and *Portumnus*. However, examination of the arrangement of the hairs and the articulation of the joints involved in creating the current would seem to indicate that for *Emerita analoga* the anterior-posterior flow is the usual one. Many observations on buried animals have shown but a few exceptions. Only when the individuals were forced to remain above the surface did they exhibit a periodic reversal of the direction of the respiratory current. It was found that sand crabs in a laboratory aquarium show this change of direction much more frequently than do animals in their natural environment.

When the sand crab is at rest the tips of the antennules protrude above the surface of the sand. Upon close observation the in-going current may be seen by noting the movement of the fine particles in the surrounding water. This water travels down the rectangular channel formed by the hairs of the antennules. The function of the antennules in this manner is similar to that of the siphons of the burrowing molluscs. Both are used to carry fresh surface water to an animal living in the substratum.

As the current leaves the antennules, it passes into a channel between the branchiostegite and the body wall. In this passage lives the scaphognathite of the second maxilla which drives the water on toward the gills. The exopodites of the first and second maxillipeds are also located in this channel and have a similar function. They both have broad terminal segments which are articulated in such a way that they are able to perform a sweeping motion. This would give the water an additional push in the direction of the gills. After passing over the gills, the current of water continues posteriorly and emerges from under the carapace.

The fifth pair of walking legs which are folded inside the gill chamber have a function in cleaning the gills. When specimens were opened for examination, a number of grains of sand were frequently found lodged in the filaments. The chelae of the fifth legs are capable of prehension and might be used for picking out the sand and any other material which might be present.

## SUMMARY

The sand crab, *Emerita analoga* (Stimpson), inhabits the sandy beaches in the zone covered by the wash of the waves. This environ-

ment, while largely free from competing species and supplying a plentiful amount of food in the form of plankton, requires a considerable degree of adaptation. The shifting substratum makes it difficult to maintain a firm and stable position and there is danger from the shock of the waves and from predatory animals. In order to escape these hazards, the sand crab is able to burrow rapidly. The first four pairs of walking legs and the uropods are modified for this function. The antennae are adapted for filtering food from the water and transporting it to the mouth while the animal remains buried. The constant wash of the waves makes it unnecessary for these crabs to maintain a current of water to bring in food as other plankton feeders are required to do. The direction of the respiratory current of water has been changed from that of other decapods and flows from anterior to posterior. The antennules form an inhalent siphon. There are many other less conspicuous modifications which aid the sand crabs in taking advantage of their environment as well as in overcoming the disadvantages.

## ABBREVIATIONS

| | | | |
|---|---|---|---|
| *ab. som. 1* | first abdominal somite | *gill* | gill |
| *ab. som 2* | second abdominal somite | *ischio.* | ischiopodite |
| *an.* | anus | *labi.* | labium |
| *ant.* | antenna | *labr.* | labrum |
| *antul.* | antennule | *lat. lip* | lateral lip |
| *apo.* | apodeme | *m.* | mouth |
| *aux. pc.* | auxiliary piece | *mand.* | mandible |
| *baso.* | basopodite | *mero.* | meropodite |
| *branch. gr.* | branchial groove | *mxp. 3* | third maxilliped |
| *branchio.* | branchiostegite | *pal.* | palpus |
| *cara.* | carapace | *pleo.* | attachment of pleopod |
| *carpo.* | carpopodite | *pro.* | propodite |
| *cervic. gr.* | cervical groove | *proto.* | protopodite |
| *corn.* | cornea | *rost.* | rostrum |
| *coxo.* | coxopodite | *scaph.* | scaphognathite |
| *dactylo.* | dactylopodite | *ster.* | sternum |
| *dor. b. w.* | dorsal body wall | *tel.* | telson |
| *endo.* | endopodite | *uro.* | uropod |
| *exo.* | exopodite | *wk. lg. 1* | first walking leg |
| *eye st.* | eye stalk | *wk. lg. 2* | second walking leg |
| *flag.* | flagellum | *wk. lg. 3* | third walking leg |
| *gen. op.* | genital opening | *wk. lg. 4* | fourth walking leg |
| | | *wk. lg. 5* | fifth walking leg |

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# FOSSIL ARTHROPODS OF CALIFORNIA. NO. 25. SILICIFIED LEAFHOPPERS FROM CALIFORNIA MOUNTAINS NODULES

W. Dwight Pierce[1]

It is with great pleasure that I present the studies of a series of silicified jassid (cicadellid) leafhoppers, Order Homoptera, all extracted by acids (formic and hydrochloric) from Miocene calcareous petroliferous nodules collected in the Calico Mountains, San Bernardino County, California, by Allison R. Palmer, Mrs. Laura Rouse, Mr. and Mrs. Samuel Kirkby, Mrs. Dara Kuznetzoff (as Dara Shilo), Mr. and Mrs. John Gibron, Sr., and Dr. Donald Weissman.

The nodules were found at twelve sites on two sides of the mountain mass and probably represent quite a range in age, as there is over 300 feet difference in altitude, although the tilting of the strata reduces the value of present altitude. However, other evidences indicate sites Gibron 4 and U.S. 19057 to be the oldest. They are all Miocene.

For comparison of location and approximate altitude I have tabulated the material (Table 1). The collection sites are in SE and SW quarters of Section 23, and SW quarter of Section 24, R.1.E., T.10.N.; and in NE quarter Section 19, and SW quarter Section 18, R.2.E., T.10.N., a distance of 2¼ miles east and west, and about 1 mile, north and south.

The classification of the Jassidae is very confusing inasmuch as each authority has used a different system of group classification. The head shows tremendous differences, due to the movement of the epistomal suture, the frons, and the antennae and ocelli. The group has been called by various family names, but I have chosen to follow as nearly as possible the system of Evans (1946-1947).

Hitherto, the few fossil leafhoppers reported have been compressed by pressure of volcanic ash, or aquatic deposits. The fossils from the lake-bed nodules formed in volcanic areas are unique, in that they are three-dimensional, siliceous replicas of the insects, often still containing traces of the petroleum that was evolved by catalytic action from their tissues. As the silica is colloidal, the preservation of form is perfect, and in several specimens even the form of the brain and nervous system is clearly outlined.

The first specimen found was described and illustrated by Palmer

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TABLE I

SOURCES OF THE LEAF HOPPER MATERIAL

| Quarter, Section and Range | Site | Specimen | Nodule No. | Altitude | Collector of Nodule | Species |
|---|---|---|---|---|---|---|
| S.W.23.1 | Gibron 4 | H1704 | | 2415± | Gibron | *Miochlorotettix gibroni* ♂ paratype |
| S.E.23.1 | (G.1) LA115 | H1820 5743 | | 2415± | Gibron | *Miochlorotettix gibroni* ♂ paratype |
| S.E.23.1 | (G.1) 115 | H1561 | | 2415± | Gibron | ♀ |
| S.E.23.1 | (G.1) 115 | H1567 | | 2415± | Gibron | *Miochlorotettix gibroni* ♂ paratype |
| S.E.23.1 | (G.2) 116 | H1431 | | 2400 | Gibron | |
| S.E.23.1 | (G.3) 117 | H1940 | | 2415± | Gibron | *Miochlorotettix gibroni* ? |
| S.W.24.1 | 19057 | 5076 | | 2420 | Gibron | nymph |
| S.W.24.1 | 19057 | (H20) 5278 | | 2420 | Gibron | *Miochlorotettix gibroni* allotype |
| S.W.24.1 | 19057 | (H21) 5279 | | 2420 | Gibron | *Miochlorotettix gibroni* |
| S.W.24.1 | 19057 | (H22) 5280 | | 2420 | Gibron | *Miochlorotettix gibroni* |
| S.W.24.1 | 19057 | (H23) 5281 | | 2420 | Gibron | *Miochlorotettix gibroni* |
| S.W.24.1 | 19057 | (H26) 5283 | | 2420 | Gibron | *Miochlorotettix gibroni* holotype |
| S.W.24.1 | 19057 | (H60) 5296 | | 2420 | Gibron | *Miochlorotettix gibroni* |
| S.W.24.1 | 19057 | (H70) 5299 | | 2420 | Gibron | *Miochlorotettix gibroni* |
| S.W.24.1 | 19057A | H785 | | 2400 | Gibron | |
| S.W.24.1 | 19057A | H899 | | 2400 | Gibron | *Miochlorotettix gibroni* ? |
| S.W.24.1 | 19057A | H1801 | | 2400 | Gibron | *Miochlorotettix gibroni* ? |
| S.W.24.1 | 19057B | H1354 | | 2410 | Gibron | |
| S.W.24.1 | 19063 | (H1216a) 5745 | | 2500+ | Gibron | *Miomesamia juliae* holotype |
| S.W.24.1 | | H1216b | | 2500+ | Gibron | *Miochlorotettix gibroni* ? |
| S.W.24.1 | 19064b | US NM 561985 | | 2500 | Palmer | *Euscelis palmeri* |
| S.W.24.1 | LA 38 | 854 | 10263C | 2700 | R. Kirkby | fragment |
| N.E.19.2 | 12 | 1312 | 2201 | 2700 | Shilo | *Protochlorotettix calico* ♀ holotype |
| N.E.19.2 | 17F | 3723 | 28805 | 2700+ | L. Rouse | *Phlepsius weissmanae* ♂ holotype |
| N.E.19.2 | 17 | 2142 | 11806 | 2700+ | L. Rouse | *Protochlorotettix calico* impression |
| N.E.19.2 | KX42b | 5787 | 18799 | 2700+ | S. Kirkby | *Miochlorotettix kirkbyi* |
| N.E.19.2 | KX14 | 5788 | | 2660 | S. Kirkby | *Miochlorotettix kirkbyi* |
| S.W.18.2 | 42 | 2491 | 10528 | 2750 | Weissman | nymph |
| 4 quarter Sections | 15 Sites | 28 Specimens | | 2400-2750 | 7 collectors | 6 species |

(1957), but he did not give it a name, because of the absence of a male specimen. In paleontology one cannot wait until we find all diagnostic characters before we assign a name to a species, even though the generic position must later be changed, because we need a "handle" for it. I am, therefore, assigning a name to his specimen, naming it in his honor, and have reproduced his drawings so that the species can be readily compared to the others found in the nodules.

These are the first leafhopper fossils preserved by silica replications, and they are truly remarkable fossils. The clear transparent nature of some of them makes it very difficult to correctly interpret all characters.

Leafhoppers are not aquatic, although they may visit and breed upon aquatic plants growing out of the waters; hence, we might consider these insects as accidentally preserved, probably being drowned by the downfall of volcanic liquids or gases.

There are six distinct species in the series and by the figures it can be seen that they are readily separated by the face, the anterior outline of the head, the shape and proportions of frons, and clypeus. Two of the species, *gibroni* and *kirkbyi* are unusual in the arching of the prothorax due to a greatly enlarged scutellum, and both of these and *calico* show a complete median division of the sternal segment preceding the female genitalia. Nine of the specimens are assigned to one species, *gibroni*, although there is considerable variation in head measurements.

Specimens 5279 and 5787 are interesting in that the brain has been differently crystallized and hence is quite apparent in the clear head.

In Table 2 are listed the measurements for comparison; and these are to form part of the descriptive data.

### Order HOMOPTERA Leach 1815
### Family JASSIDAE (Cicadellidae)
### Subfamily EUSCELINAE
### Tribe EUSCELINI

Palmer (1957) described and figured a female leafhopper, which Dr. David A. Young considered to belong to the genus *Deltocephalus* s.s., based on size and general appearances.

However, DeLong (1926) states: "In regard to venation proper, the normal and apparently constant condition in the *Deltocephalus* wing is a series of three anteapical cells, with a costal cell beyond the outer anteapical cell." In those wings in which two cross veins intervene between the first and second sectors there are two discal cells, three anteapical cells, and five apical cells.

Palmer's leaf hopper has only one cross vein and consequently two discal and two anteapical cells, plus the five apical cells. For this reason I feel that the fossil must belong to one of the genera in which its type of wing venation is known to exist, as: *Euscelis*, *Eutettex*, *Chlorotettix*, *Thamnotettix*, *Phlepsius*, and *Paraphlepsius*.

We have three other characters to assist in the elimination: (1) short, broad vertex, not excessively angulate; (2) wide face, with frons broad at base, narrowing to clypeus, which is one-half as wide as frons at base, and with clypeus wider at apex than base; (2) last sternal segment (7th) of female broadly roundingly emarginate, exposing basal parts of valves and valvifers, and with pygofer at base no wider than the emargination.

All three of these characters are to be found in *Euscelis deceptus* Sanders, *E. parallelus* (Van Duzee), *E. striolus* (Fallen), and *Thamnotettix mellus* Sanders.

Inasmuch as Palmer describes his species as having head slightly convex in profile, it seems to fit better into *Euscelis* than *Thamnotettix*, and hence it is here tentatively placed in the genus *Euscelis*.

### Genus *Euscelis* Brullé

### **Euscelis palmeri,** new species

(Figures 6, 7, 19, and 20)

*Holotype:* USNM 561985, the specimen figured and described by Dr. Allison R. Palmer (1957), without name, but placed tentatively in *Deltocephalus*. It is with pleasure that I assign it the species name *palmeri*. I repeat his description, adding in parentheses points derived from his drawings.

*Type locality:* Site 19064b, U.S.G.S. Cenozoic locality, SW ¼ Sect. 24, R.1.E. T.10.N., Calico Mts., San Bernardino County, California.

*Description:* Female. Length about 3.2 mm. Crown slightly produced forward, sharply rounded anteriorly in dorsal aspect, slightly convex in profile; median length about three-fifths width between eyes. (Face with proportions of width to length as 23: 18; posterior margin of eyes at about middle line of facial length; posterior margin of face a curve enclosing genae and clypeus. Frons a little more than twice as wide at apex as at base. Clypeus one-half wider at apex than at base. Lorae not completely defined. Antennae inserted between eyes and frons opposite middle of frons).

Forewing with discal cells undivided; cross vein dividing costal area originates from (near base of) anteapical area; proximal parts of claval veins not preserved; (basal cells, three; discal cells, two; costal cell, one; anteapical cells, two; apical cells, four).

Femur with two distal pairs of spines, and a single more proximal spine arranged on knee. Anterior spines in each pair seem more slender than posterior spines.

Seventh sternite with broad median indentation in its posterior margin that is flat at its anterior end except for a small centrally located notch. This segment has been pulled forward in fossil to expose first valvifers of ovipositor, and between these, smooth basal parts of first valves. Posterior to these, basal parts of pygofer overlap slender basal parts of third valves. Surfaces of third valves and pygofer granular. Pygofer also bears strong spines on its posterior half. Tips of third valves extend posteriorly beyond apex of pygofer. (Three dorsal segments are visible beyond the pygofer).

## **Miochlorotettix,** new genus

Leafhoppers with typical deltocephaline form, but with prothorax strongly arched forward; and scutellum occupying the arch, as well as extending back between the wings to about the same distance as it extends forward.

At first sight it was thought this might be a deformity of the prothorax, but identical thorax and scutellum has been found in all specimens.

It is placed tentatively near *Chlorotettix*, because of the genitalia.

## **Miochlorotettix gibroni,** new species

(Figures 1, 2, 15, 16, and 17)

*Type locality:* Crystallized fossil leafhoppers, extracted by hydrochloric acid from calcareous Miocene nodules from Calico Mountains, SW ¼ Section 24, R.1.E., T.10.N., San Bernardino Co., Calif., from site 19057 U.S.G.S. Cenozoic locality, collected and extracted by Mr. and Mrs. John Gibron, Sr., of Campbell, California.

*Types:* Holotype: ♂ specimen 5283 (Gibron H26); allotype ♀, 5278 (Gibron H20); paratypes 5279 (Gibron 21), with tip of abdomen broken, but probably male; 5296 (Gibron H60) head and thorax only; 5280 (H22); 5281 (H23); 5299 (H70), all from U.S. Geol. Site 19057; also, 5743 (H1820), H1561, H1567 from Gibron Site 1, near camping site on Mule Cañon Drive; H1431 from Gibron Site 2,


1a.

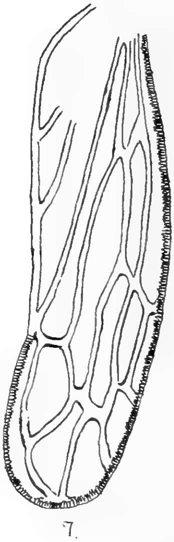

1.


2.


4.


1b.


5.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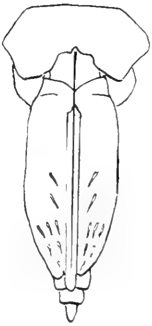
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across the hill on Phillips Drive side; H1704 from Gibron Site 4 farther west. Other specimens, labeled with (?) are Gibron's H1940, H899, H1801, and H1216b. Types mounted in balsam, deposited in Los Angeles County Museum Collection; all other material in personal collection, John Gibron, Sr.

*Description:* Measurements of all specimens given in Table 2.

Male. Smaller than female. In the holotype the body is complete, with antennae; one anterior leg with femur and tibia; fragment of median leg; one entire posterior leg.

The face is ¾ as long as wide; frons wider than clypeus, which is more or less quadrate. Antennae with broad basal segment; second segment more than twice as long as wide; third joint elongate, slender.

The prothorax is strongly arched forward, and the concavity of the arch is occupied by the anterior half of the scutellum.

Gibron's specimen H1704 is a dry mounted male attached on a slide by gum tragacanth. It has the six legs mostly intact and has been studied by illumination, comparative measurements being made of the lengths of the various leg segments using spaces in ocular micrometer, 52 spaces=1 mm.

COMPARATIVE MEASUREMENTS OF THE LEGS

| leg element | | front legs | middle legs | hind legs |
|---|---|---|---|---|
| coxa | | 8 | 13 | — |
| trochanter | | 11? | 3 | — |
| femur | | 30 | 25 | 30 |
| tibia | | 15 | 20 | 62 |
| tarsus (entire) | | 14 | 15 | 33 |
| tarsus | I | 5 | — | 18 |
| | II | 6 | — | 10 |
| | III | 6 | — | 10 |

The legs are armed with many long spines. The tarsal joints are attached before the apex of the preceding joint, and each is terminated by two pulvilli.

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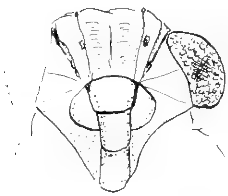
*Figure 1. Miochlorotettix gibroni,* ventral view of ♂ 5283.

a. Same. Antenna, ♂ 5283.

b. Same. Caudal segments and hind tibio-tarsus, ♂ 5283.

*Figure 2. M. gibroni,* caudal segments, ♀ 5279. *Figure 3. Protochlorotettix calico,* side view, ♀ 1312. *Figure 4.* Same, caudal segments, ♀ 1312. *Figure 5. Miochlorotettix kirkbyi,* caudal segments, ♀ 5787. *Figure 6. Euscelis palmeri,* caudal segments, after Palmer. *Figure 7.* Same, wing, after Palmer.



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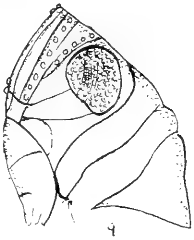

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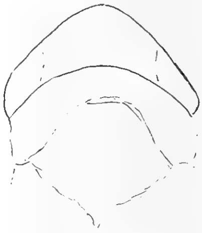

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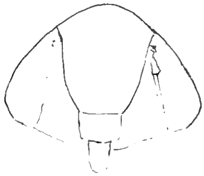

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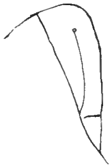

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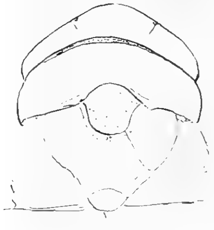

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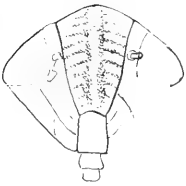

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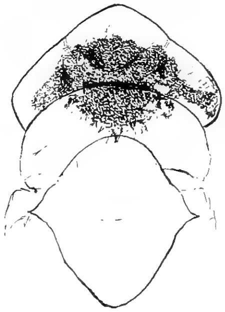

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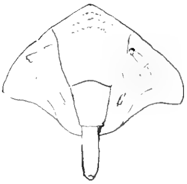

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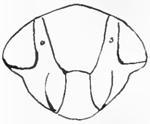

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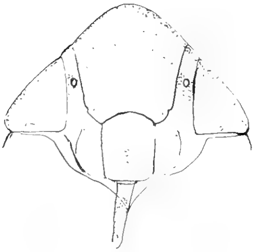

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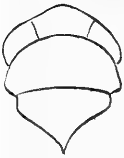

20.

Female. The allotype is larger than the holotype male but has the same shaped head, and the scutellum occupying the arch of prothorax. The specimen is broken in two parts and mounted in balsam.

This specimen is interesting in the preservation of the brain, which is not crystallized in the same manner as the rest of the body. This is a great white mass extending the width of the base of the head, with long arms reaching into the eyes dorsally with two large lobes separated by a lower median area, and from the lobes extend a pair of fine nerves to the anterior margin to indicate the position of ocelli. The under and posterior part of the brain occupies the facial portion.

The female genitalia also set this species aside among the Jassidae, in that the last ventral segment is completely divided at base into two lobes, broad at base, and acute at apex. The ovipositor extends beyond the pygofer.

The paratypes have the head, thorax, and scutellum of identical pattern as described above.

### **Miochlorotettix kirkbyi,** new species
(Figures 5, and 10-12)

*Holotype:* ♀ specimen 5787 collected by Samuel Kirkby in NW ¼ NE ¼ Section 19, R.2.E., T.10.N., Calico Mountains, and dissolved from nodule 18799, Site 42B, altitude close to 2700 feet.

This specimen is placed in the new genus *Miochlorotettix* because of the greatly enlarged scutellum displacing the prothorax forward; and also the complete division of the sternite preceding the female genitalia, with two separate sternal lobes as in *gibroni* and *calico*. However, it differs in the frontal curvature of the head being not as sharply angled as *gibroni;* side profile wider than *gibroni* or *calico;* face quite distinct from all four species included in this paper.

Length 3.68 mm., which is shorter than the ♀s of *gibroni* or *calico*.

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*Figure 8. Miomesamia juliae*, face, 5795. *Figure 9.* Same, side view of head, prothorax and scutellum, 5795. *Figure 10. Miochlorottetix kirkbyi*, face, 5787. *Figure 11.* Same, side view of face, 5787. *Figure 12.* Same, dorsal view of head, prothorax and scutellum, 5787. *Figure 13. Phlepsius weissmanae*, face, 3723. *Figure 14.* Same, dorsal view of head, prothorax and scutellum, 3723. *Figure 15. Miochlorotettix gibroni*, face, ♂ 5283. *Figure 16.* Same, dorsal view of head, prothorax and scutellum showing brain, ♀ 5278. *Figure 17.* Same, dorsal view of head, prothorax and scutellum. *Figure 18. Protochlorotettix calico*, face, ♀ 1312. *Figure 19. Euscelis palmeri*, face, after Palmer. *Figure 20.* Same, head, prothorax and scutellum, after Palmer.

## Genus **Protochlorotettix,** new genus

This genus is close to *Chlorotettix*, and has a normal triangular scutellum, but the last sternal segment is completely divided into two plates as in *Miochlorotettix*, which however, has the scutellum extending forward into the prothorax.

### **Protochlorotettix calico,** new species

(Figures 3, 4 and 18)

*Holotype:* specimen 1312, balsam slide mount, crystallized female, acid extracted by W. D. Pierce from blue-gray nodule, No. 2201, found by Dara Shilo, May 11, 1956, on blue-gray mine dump (LACMIP 359) altitude about 2700 feet, on lot 13, from NE ¼ Section 19, R.2.W., T.10.N., Calico Mountains, San Bernardino County, California.

*Description:* Length 4.88 mm. This fine crystallized female still shows traces of color. The remarkable replacement of the tissues by the silica has preserved even the reticulate and granulate surface sculpture of head, legs and abdomen.

Its measurements are compared in Table 2 with the specimens of *M. gibroni*.

It differs from *Euscelis palmeri* by much more angulated projection of vertex; clypeus quadrate; seventh sternite posteriorly divided into two lobes; last dorsal segments surpassed by pygofer and valves; the last segment shorter. While having several characters similar to *Euscelis deceptus*, it differs from that species also in the more angulate head.

The head (Figures 3 and 18), is strongly arched at a 90° angle (measured from tip of front to outer corners of eyes), though apically rounded. Ocelli on parietals between eyes and frons on the anterior edge of the vertex. Antennae fossae ventral, obovate, on parietal strips between eyes and frons, about middle of eyes. Frons slowly narrowed to a distinct notch, then suddenly narrowed to width of clypeus; marked with six transverse bands as in *Euscelis ovatus* and *deceptus*. Clypeus oblong, almost the same width throughout as in *Euscelis deceptus*. Rostrum elongate, about as long as clypeus. Lorae not well defined, but probably terminate at the frontal notches. Genae apically acute.

The legs are not complete. Front coxae widely separated. Middle and hind coxae practically contiguous.

The abdomen (Figures 3 and 4), has pygofers and valves sur-passing the last two dorsal segments. The last dorsal is a small palpiform segment not twice as long as wide.

The seventh ventral segment is divided at base to form two acute lobes, exposing the first valves and valvifers of the base of the pygofer, and the narrow parallel lined third valves. These valves exceed the length of the pygofer.

While a little color and a very fine surface granulation is visible, there are no setae present on the pygofer.

Internally the alimentary canal is visible.

In addition to the type, specimen 2142, on nodule 11806, collected by Mrs. Laura Rouse in NE ¼ Section 19, is a surface impression from which good latex molds disclose the dorsal form of the male leafhopper with dimensions as given in Table 2.

TABLE 2
DIMENSIONS OF FOSSIL LEAF HOPPERS

| Species | Specimen No. | Sex | Total Length mm. | Head Length Dorsal mm. | Head Width mm. | Face Length mm. | Frontal Angle ° |
|---|---|---|---|---|---|---|---|
| *Phlepsius weissmanae* holotype | 3723 | ♂ | 3.5 | 0.16 | 0.80 | 0.88 | 95° |
| *Miochlorotettix gibroni* | 5283 | ♂ | 3.76 | 0.29 | 0.86 | 0.72 | 90° |
| holotype | 5279 | ♂ | 3.60 | 0.25 | 0.98 | 0.88 | 92° |
| | 5281 | ♂ | 4.44 | 0.28 | 0.88 | 0.84 | 90° |
| | 5299 | ♂ | 4.68 | — | — | 0.92 | — |
| allotype | 5278 | ♀ | 4.96 | 0.38 | 1.00 | 0.73 | 91° |
| | 5280 | ♀ | 4.80 | 0.40 | 0.88 | 0.88 | — |
| | 5296 | | — | 0.19 | 1.05 | 0.88 | 90° |
| | 5743 | | 2.8+ | 0.14 | 0.98 | 0.80 | 92° |
| | H1704 | ♂ | 3.60 | — | 0.96 | 0.96 | — |
| | 1567 | ♂ | 3.36 | 0.21 | 0.88 | 0.88 | — |
| | 1801 | ♂ | 4.00 | 0.327 | 0.96 | 0.903 | — |
| ? | 1216b | | — | 0.48 | 1.04 | 0.88 | — |
| ? | 5787 | ♀ | 3.68 | 0.28 | 0.92 | 0.86 | 90° |
| *Miochlorotettix kirkbyi* | 5788 | ♀ | 3.04 | 0.192 | — | 0.96 | — |
| *Protochlorotettix calico* holotype | 1312 | ♀ | 4.88 | — | — | 1.32 | 90° |
| impression | 2142 | ♂ | 3.60 | 0.16 | 0.88 | — | 90° |
| *Miomesamia juliae* | 5745 | | 4.45 | 0.31 | 1.05 | 1.12 | 90° |

### Genus *Phlepsius* Fieber

### **Phlepsius weissmanae**, new species

(Figures 13 and 14)

*Holotype:* Crystallized male extracted from Miocene nodule 28805. Specimen 3723, collected by Mrs. Laura Rouse, and extracted by Mrs. Ruth Weissman and writer. From Site 17F, Lot 333, NE ¼ Section 19, R.2.E., T.10.N., Calico Mountains, San Bernardino County, California. Named in honor of Mrs. Weissman in acknowledgment of her great help for several years in these studies.

*Description:* Size: 3.5 mm. Head length: 0.16 mm., width 0.80 mm., face length: 0.88 mm.

Color: although crystallized, the brown pattern of face markings and thoracic and abdominal sclerites makes this an unusual specimen.

Head anteriorly broadly rounded, not extending much beyond the eyes. From dorsal aspect the median length of head is less than half the distance between the eyes. Eyes minutely granulate.

Face elongate, about as long as wide. Frons broad at vertex; gradually narrowed to clypeus, almost twice as long as eyes, marked with ten transverse colored bars which are interrupted on median line but mutually connected in two longitudinal stripes; two and one half times as long as clypeus.

Antennae between eyes and frons at about middle of eyes; three basal joints of right antenna present.

Oscelli minute, on anterior margin at corner of eyes.

Mandibular and maxillary plates or genae diagonal from eyes to clypeus. Lorae outlined by curved line from tip of clypeus to frons. bisecting the diagonal mandibular and maxillary plates.

Labium divided into two segments.

### Tribe *Platymetopiini*

A very unusual insect was extracted by John Gibron, Sr., which is unfortunately, not whole, as it lacks the posterior part of the abdomen; the legs, except their basal segments; and the right eye, which has been cleft off. Still, as it is so different from any of the other leafhopper material it should be discussed.

Classification in the Jassidae is very difficult, but species with large protuberant eyes are rare. The presence of the ocelli on the anterior margin, and the sharp marginal profile of the head place the specimen in Euscelinae, the tribe being Platymetopiini, according to J. W. Evans 1947, or Mesamiini, according to P. W. Oman 1934.

## Genus **Miomesamia,** new genus

Face wide; eyes prominent, large, strongly facetted, and only slightly emarginate on lower side facing lorae. Dorsal outline very much as in *Ulopa reticulata.*

Profile sharp angulate, with ocelli on the anterior margin each terminating a ridge, the frontal suture, which passes the antennae and originates at the epistomal suture.

Frons quadrangular, wider at apex than base, medianly depressed, rests on epistomal suture, in front of which the beak is in three parts: postclypeus, preclypeus, and labium. At the sides of the clypeus are the somewhat swollen lorae and the genae. Antennae set at the sides of the frontal sutures, opposite the upper corner of the eyes. The parietals between frons and eyes wide and longitudinally ridged, and along the ridges are rows of round pits, probably originally setigerous.

Crown of head depressed.

### **Miomesamia juliae,** new species

*Type:* specimen 5795 (Gibron #1216), extracted from nodule by hydrochloric acid, by John Gibron, Sr., collected at U.S. Geol. Serv. Site 19067, in SW ¼ Section 24, R.1. E., T.10.N., Calico Mountains, by Mr. Gibron, and named in honor of Julia Gibron.

*Description:* Length of specimen 3.2 mm. Probable total length about 4.45 mm. Length of head above 0.31 mm.; width of head 1.05 mm.; length of face 1.12 mm.

Before the final mounting of the specimen considerable petroleum was drawn out into the balsam.

## AN UNIDENTIFIED LEAF HOPPER

A more fragmentary specimen (859 from nodule 10263), consisting of a crystallized thorax, one anterior and one posterior wing, from a nodule found by Mrs. Ruth Kirkby at Site 38 (LACMIP 386), in the southeast ¼ southwest ¼ Section 24, R.1.E., T.10.N., in the Cañon south of that in which *D. palmeri* was found. The fragment measures 6.0 mm., and is hence different from either of the preceding, but as it has no diagnostic characters, cannot even be assigned to a genus.

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# A CONTRIBUTION TO THE BIOLOGY OF THE GRAY GARDEN SLUG[1]

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## Introduction

The gray garden slug, *Deroceras reticulatum* (Müller), is a pest of considerable economic importance in fields and gardens of the Pacific Northwest. The mild winters and generally moist springs of western Oregon are particularly favorable to the growth and reproduction of this introduced species. Control by the use of standard metaldehyde baits has not been satisfactory under all conditions of weather, or when certain crops or horticultural practices are involved. Toxicological studies have been hampered by the difficulty in maintaining a laboratory culture of test animals. This paper documents some aspects of slug biology and describes techniques developed during an attempt to rear the gray garden slug under laboratory conditions.

## Parasites of Slugs and Their Control in the Laboratory

Most workers have had to depend for their test animals on field-collected slugs which usually are abundant only in the fall and spring. Several workers (Meggitt, 1916; Lovett and Black, 1920; Reynolds, 1936; Kozloff, 1956a, 1957) reported that they could not keep slugs alive in the laboratory long enough to do comprehensive studies. Sivik (1954) reported a technique for obtaining eggs from slugs by confining them in wooden boxes containing moist soil and covered with gauze, but he did not state how long he could maintain a healthy stock culture. This method was tried, but high mortality occurred within a two week period. A modified version of this technique, however, was used in subsequent studies as a standard method of rearing slugs for limited lengths of time. Plastic boxes (refrigerator vegetable crisper

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[1] Approved for publication as technical paper number 1479, Oregon Agricultural Experiment Station. Part of a thesis presented in partial fulfillment of the requirements for the degree of Master of Science in Entomology at Oregon State University. Accepted for publication January 2, 1963.

[2] Now with the Research Department, Niagara Chemical Division, Richmond, California.

[3] Associate Professor of Entomology.

chests), provided with two screen-covered ventilation holes in the cover and a layer of moist soil or vermiculite, proved to be convenient containers for this purpose.

Examination of the bodies of dead and dying slugs in the rearing boxes revealed the presence of fungi, bacteria, nematodes, and protozoa. Steam sterilization of the soil in the containers failed to reduce the slug mortality, indicating that these organisms were being introduced into the boxes with the field-collected slugs themselves. It was not the purpose of this study to determine the pathogenicity of the parasitic organisms found, but to seek ways of eliminating them as possible causes of slug mortality.

The fungus associated with dead slugs was identified as a species of *Fusarium*. A fungus found attacking slug eggs, and preventing their development, was identified as a species of *Arthrobotrys*. To suppress spread of the fungi and bacteria in the rearing containers, water containing 200 parts per million of Agri-mycin 100 (streptomycin 15% and terramycin 1.5%)[4] combined with 200 parts per million of captan fungicide (N-trichloromethylthio tetra-hydrophthalimide) was added to the soil. The transfer of bacteria and fungi from eggs to newly hatched slugs was prevented by dipping the eggs in an aqueous solution containing the same amount of Agrimycin 100 and captan. This procedure also prevented bacterial and fungal growth during the incubation period of the eggs.

Slug mortality continued in the rearing containers, however, and the dead and dying slugs were found to be infested with nematodes and protozoa which had apparently not been eliminated by the above mentioned treatment. The nematodes, determined as *Rhabiditus* c.f. *lambdiensis* Maupas, *Panogrolaimus* spp., and *Diplogaster* spp., were usually found beneath the mantle of the slugs and when present in large numbers, were occasionally observed protruding from the dorsal surface or in the respiratory orifice. All stages of the nematodes could be found in slugs at any one time and were also observed free-living in the soil of the rearing containers. Transfer of protozoa and nematodes from the parent slugs to their offspring can be accomplished by way of the eggs. Both nematodes and protozoans were observed on the moist surfaces of the eggs. Attempts to sterilize the eggs with chemical solutions, however, were not successful. Egg proteins were apparently denatured at very low concentrations of various alcohols and of other chemicals tested.

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[4] Obtained from Charles Pfizer & Co., Inc., Brooklyn 6, N.Y.

A treatment which was effective in eliminating the nematodes from the infected slugs themselves rather than from the eggs was developed. Juvenile slugs were freed of their nematode parasites by confinement on a special agar-base medium over a two-week period of time. The complete medium was compounded by combining three separate fractions. The first fraction consisted of agar, 20 grams, combined with Bel-Ais salt mixture, 100 milliliters, in 200 milliliters of water. The second was a mixture of powdered skim milk, 50 grams; dextrose, 200 grams; and bacto-yeast extract, 10 grams; in 400 milliliters of water. The third fraction consisted of boiled potatoes, 200 grams, in 400 milliliters of water, of which only the extract was used. These three fractions were autoclaved separately at 15 lbs. per square inch pressure for 25 minutes. Agri-mycin 100, 2.68 grams, and methyl-p-hydroxybenzoate[5], 0.375 grams (or a final concentration of 0.025%), were added after the autoclaving process. The fractions were then thoroughly mixed. At a concentration of .05% of methyl-p-hydroxybenzoate, there was approximately 45% mortality, mostly of young slugs. At .025%, all stages of slugs survived. Although slugs fed readily on this medium, they gradually lost weight during the two week period. Following treatment they were transferred, for other studies, to lettuce leaves in the plastic crisper-chest rearing boxes.

To further test the effectiveness of methyl-p-hydroxybenzoate, nematodes were isolated from the slugs and placed in petri dishes containing the above mentioned medium. All nematodes were dead after five hours exposure. Nematodes in check plates, containing the nutrient media without the methyl-p-hydroxybenzoate, increased in size and numbers over a period of several days.

The protozoan, identified as *Tetrahymena limacis* (Warren), was not eliminated by the methyl-p-hydroxybenzoate treatment. Protozoa and nematodes were usually found together in individual slugs, but one form would dominate the other in numbers. When the nematodes were eliminated from the slugs by the treatment mentioned above, the number of protozoans increased greatly. Although Kozloff (1957) noted that these protozoans inhabited the slug's digestive gland primarily, they appeared to be present not only in the various internal organs, but in the subcutaneous tissue as well. According to Kozloff (1956b), a gray garden slug is able to support a large population of *T. limacis* without the slug's normal biological activities being disrupted. Kozloff concluded that *T. limacis* is not very pathogenic. A

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[5] Obtained from Eastman Kodak Co., Rochester, N.Y.

closely related species, *Tetrahymena* (*Paraglaucoma*) *rostrata* (Kahl) Corliss, is a histophagic parasite of enchytreid worms, however, and infection results in the death of the host (Stout, 1954). If we accept Kozloff's conclusions regarding *T. limacis*, we would expect greater longevity from the nematode-and-fungus-free slugs in the rearing containers. Actually, the slugs did live several weeks longer than previously, but mortality was still heavy. Moribund and dead slugs were found to be heavily infested with the protozoans. The protozoan parasites could not be controlled by the methyl-p-hydroxybenzoate treatment, and since they appeared to be pathogenic, new treatments were sought for their elimination from the slug cultures.

Cleveland (1925) was successful in eliminating protozoa from termites by subjecting them and their hosts to pure oxygen pressures. A modified version of Cleveland's method was tested against *T. limacis* in the gray garden slug. It was found, however, that an oxygen pressure of 42 psi for 16 hours caused 40% slug mortality without freeing the survivors of the protozoan parasites. Even though eradication of this parasite from its host was not accomplished, slug cultures were maintained long enough to collect considerable information on slug biology under laboratory conditions.

## Oviposition and Egg Viability

Various parasites, a limiting factor in the rearing of slugs, were found to be excreted in the feces. Early in the investigation, slugs were placed in plastic crisper-chests on screen trays to facilitate sanitation by washing the excrement through the screen at various intervals of time. The water remaining in the bottom of the chests maintained a

TABLE 1

Oviposition record for five sexually-mature slugs on soil at each of five different saturation percentages.

| Observations | Numbers of eggs laid at saturation per cents of | | | | |
|---|---|---|---|---|---|
| (one day intervals) | 10 | 25 | 50 | 75 | 100 |
| 1st | 0 | 0 | 32 | 41 | 0 |
| 2nd | 0 | 0 | 48 | 72 | 0 |
| 3rd | 0 | 45 | 62 | 36 | 0 |
| 4th | 0 | 0 | 0 | 51 | 41 |
| 5th | 0 | 56 | 23 | 0 | 0 |
| Totals | 0 | 101 | 165 | 200 | 41 |

high humidity, but the slugs would not lay eggs under these conditions. When the screen layer was replaced with a layer of damp soil, however, the slugs readily deposited egg masses.

The range of soil moisture content favored for oviposition was investigated in the laboratory utilizing information from the above observations. Oven-dried sandy loam soil was placed in jars and the moisture levels adjusted to 10, 25, 50, 75, and 100 per cent saturation (as determined by the method of Richards, 1954). Mature slugs from screen-bottomed plastic crisper-chests were placed in the jars of soil for oviposition. Results of the trial (Table 1) indicated that a soil moisture content of approximately 75% was most suitable for oviposition. Carrick (1942) came to a similar conclusion and stated further that normal egg development will not take place in soils below 10% saturation, nor in soils close to 100% saturation. In the field, egg masses of *Deroceras reticulatum* are usually deposited in cavities of the damp soil in the top three inches. According to Karlin and Naegele (1960), eggs of *D. reticulatum* can withstand complete submergence for at least four days without affecting normal development. The selection by slugs of soil for oviposition substantially below 100% saturation would tend to place most egg masses in locations not saturated for long periods during the rainy western Oregon winters.

The incubation period for *D. reticulatum* eggs has been reported to range from about 15 to 96 days (Taylor, 1907; Hawley, 1922; Carrick, 1938; Lovett and Black, 1920; and Binney, 1878). Approximately 3000 eggs, deposited in the laboratory within a 24 hour period, were observed at a constant temperature of 20°C. The minimum period for incubation was 11 days, with a maximum of 21 and a mean for 60 groups of 50 eggs each of 15.5 days. These observations on the variation in development time can be extended to include the development of eggs from a single clutch. Rarely do all the eggs of a single egg mass deposited by one slug hatch on the same day. It was further observed that eggs of a single clutch that remained unhatched 12 days after the initiation of hatching, failed to develop. Microscopic examination of these remaining eggs revealed the absence of the sperm body described by Carrick (1938) as characteristic of fertile eggs. In some clutches approximately half of the eggs were found to be infertile.

During embryonic development, slug eggs exhibit an increasing ability to withstand extremes of temperature. When first laid, the egg is very susceptible to freezing and to temperatures higher than 22°C. Eggs containing embryos which have almost completed their development can withstand a temperature of 0°C for several days, and after-ward resume development when placed at higher temperatures. This fact facilitates the storage of eggs in refrigerators for long periods of time. In the present study, approximately 1000 eggs in the advanced stage of development, kept in a refrigerator at 4°C for seven months, commenced hatching within 24 hours after removal to room temperature.

The eggs of *D. reticulatum* will desiccate and the embryos die unless contact is maintained with a moist surface. There are reports in the literature of eggs being completely desiccated for weeks (Lovett and Black, 1920), or even for years (Binney, 1878), and on exposure to moisture again, these eggs regained their spherical form and resumed normal development. Carrick (1942) remarks that these reports are too fantastic for credence. In this study, several thousand eggs were allowed to desiccate in petri dishes, and were kept in this condition at room temperatures for five months. At the end of this period, when water was added to the filter paper in the dishes, the eggs rapidly regained their original form and turgidity, but no embryonic development took place during a two-month observation period. Similar results were obtained by Carmichael and Rivers (1932) in desiccation studies on the eggs of *Limax flavus*.

## Growth Rates at Constant and Fluctuating Temperatures

Slug activity in the field is associated with conditions of high humidity and this association has led to an assumption that activity is in some way induced by damp conditions. Crozier and Pilz (1923) showed, however, that the speed of locomotion of *Agriolimax campestris* Binney varied directly with temperature. Dainton (1943; 1954) showed that certain changes in temperature, not conditions of high humidity, induced locomotor activity. In her experimental work, in which she employed a more or less gradual alternation between two constant temperatures, she showed that activity was sharply stimulated by falling temperatures below about 21°C and by rising temperatures above 21°C. Activity subsided as soon as the temperature was maintained constant at any level. Temperature changes in the reverse direction had no such effect. As at constant temperature, activity was low when the temperature was rising toward 21°C or falling from above this value. Dainton assumed that increased acquisition of food necessarily accompanied increased locomotor activity.

It was of interest in this study to determine whether a substantial increase in growth rate could be induced by certain defined temperature conditions, since rapid production of mature slugs from eggs was of importance. Most experimental investigations on the effect of temperature on the rate of development of an organism are conducted with a series of constant temperatures. Constant temperatures are rare in nature and field slugs are certainly exposed to almost constantly fluctuating temperatures due to diurnal and seasonal changes, as well as to non-periodic changes in weather. In view of this fact, and to test Dainton's assumption regarding increased feeding associated with increased locomotor activity, a series of experiments were conducted to compare growth rates of *D. reticulatum* at both constant and fluctuating temperatures.

A system for constantly fluctuating the temperature of a rearing chamber was devised by utilizing a Fenwal differential expansion thermal switch activated by a pair of metal arms attached to the rotating disc of a 24 hour electric timer. After the desired maximum and minimum temperatures had been preset, this mechanism produced one full cycle of continuous temperature change in a 24 hours period by activating a Cenco refrigerating incubator.[6]

The growth rates of newly hatched slugs were studied by placing one-day-old individuals under a constant temperature of 20°C. An equal number of slugs were subjected to fluctuating temperature conditions of 17° to 24°C (approximately 0.6°C change per hour).

The results after 45 days (Table 2) showed no marked differences in mean weights of the slugs under the two temperature conditions. The test also demonstrated the great variation in growth rates possible for individual slugs. Some individuals exhibited practically no growth during this period, since in 100 observations of newly hatched slugs, the mean weight had been found to be 1.8 milligrams, the same

TABLE 2

Comparison of weight increases of immature gray garden slugs reared under two sets of temperature conditions for 45 days.

| | Constant Temperature (20° C.) | Fluctuating Temperatures (17°-24° C.) |
|---|---|---|
| Mean (of 60 slugs for each condition) | 24.8 mg. | 26.1 mg. |
| Maximum | 83.8 mg. | 73.0 mg. |
| Minimum | 4.4 mg. | 1.8 mg. |

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[6] Central Scientific Company, Chicago, Illinois.

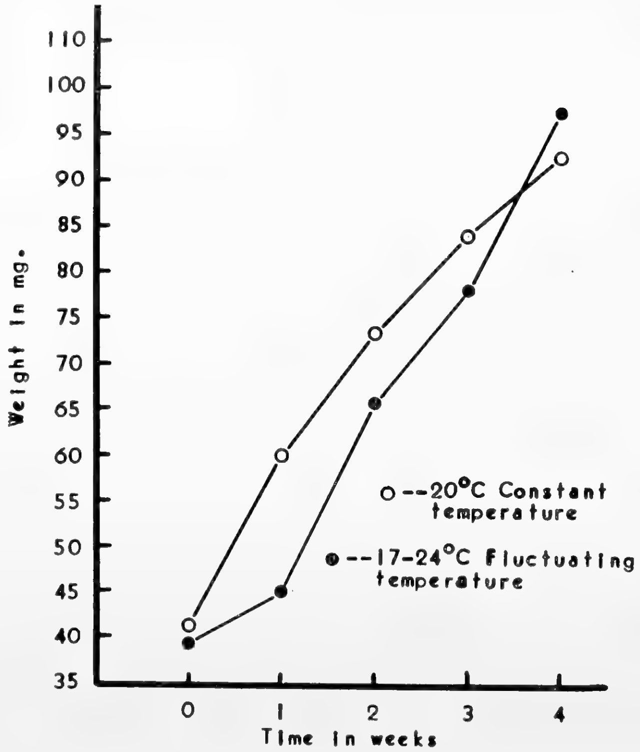

*Figure 1*. Comparison of growth rates of immature slugs under constant and fluctuating temperature conditions.

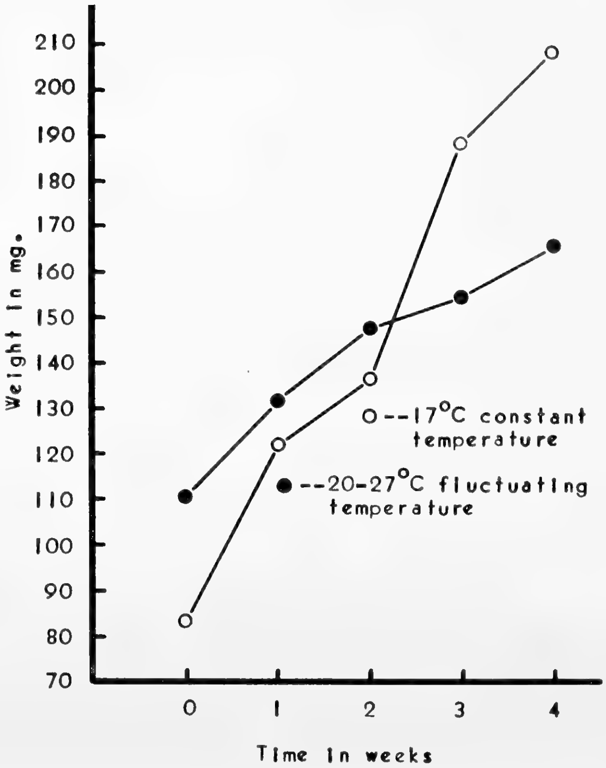

*Figure 2*. Comparison of growth rates of immature slugs under low constant and high fluctuating temperature conditions.

weight as the minimum found under the fluctuating temperature conditions of this experiment.

In another trial of the same temperature conditions, very similar results were obtained. The weights of slugs used in this second trial, and in further studies, were 25 milligrams or greater because of the difficulties encountered in handling smaller individuals. The results from weekly weighings (Fig. 1) again showed that growth rates under the two temperature conditions were not markedly different. However, the slugs under the fluctuating temperature conditions were observed to be active more of the time and their food consumption during the 4 week test period was noticeably greater.

A third comparison of growth rates was made in which 40 immature slugs were placed under fluctuating temperatures of 20° to 27°C and an equal number under a constant temperature of 17°C. Mean weights of the slugs were recorded on a weekly basis for four weeks.

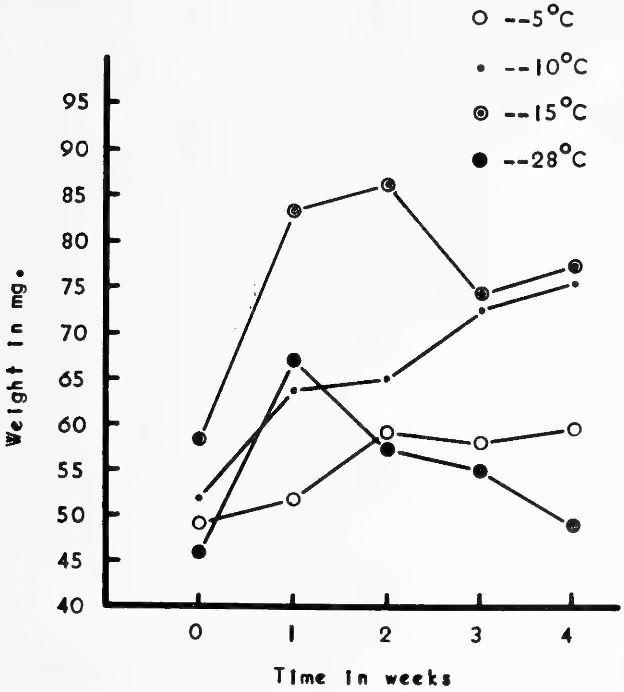

*Figure 3.* Comparison of growth rates of immature slugs under four different constant temperatures.

The results (Fig. 2) indicated a more rapid growth rate for the slugs maintained at a constant temperature, in spite of the fact that the more active slugs under the higher and fluctuating temperature condition consumed almost twice as much food as their counterparts at 17°C. It was concluded that, while the subjection of slugs to fluctuating temperatures increased their activity and food consumption (as indicated by Dainton, 1954), this procedure was not promising as a means for obtaining rapid maturation of slugs in laboratory cultures.

Growth rates of slugs at four different constant temperatures were also studied. Twenty-five slugs were placed in each of four temperature controlled cabinets which were held constant at 5°, 10°, 15°, and 28° C, respectively. The mean weights of the slugs were recorded

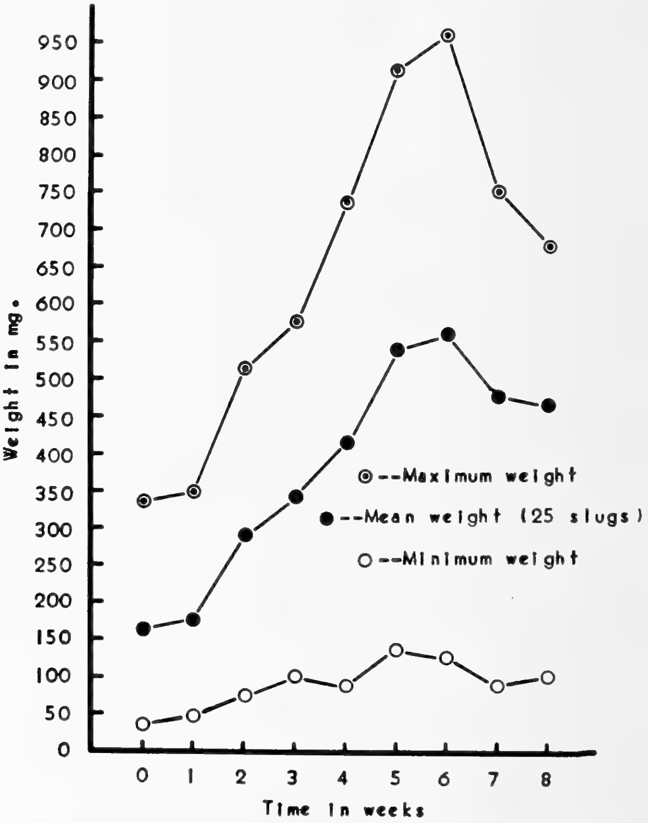

*Figure 4.* Variation in weight-gain by 25 4-month-old slugs held in a fluctuating temperature cabinet at 17° to 24° C for eight weeks.

over a four week period. The results obtained (Fig. 3) showed that the slugs at the temperatures of 10° and 15°C were of almost comparable weight after the third week. The growth rate was somewhat low at 5°C. The slugs at 28°C decreased in weight after an initial increase.

The experimental animals displayed great individual variation in growth rates in the above observations. To study this variation, a random sample of 25 4-month old slugs was placed in a cabinet at fluctuating temperatures of 17° to 24°C. An ample supply of food (lettuce leaves) was available at all times. The slugs were weighed individually at weekly intervals over an eight week period. The maximum, minimum, and mean weights were plotted for comparison (Fig. 4). These results, and those shown in Table 2, indicate the tremendous growth rate variations which can occur in a slug population from eggs hatched on the same day. The reason for the decrease in weight after the sixth week (Fig. 4) is not known.

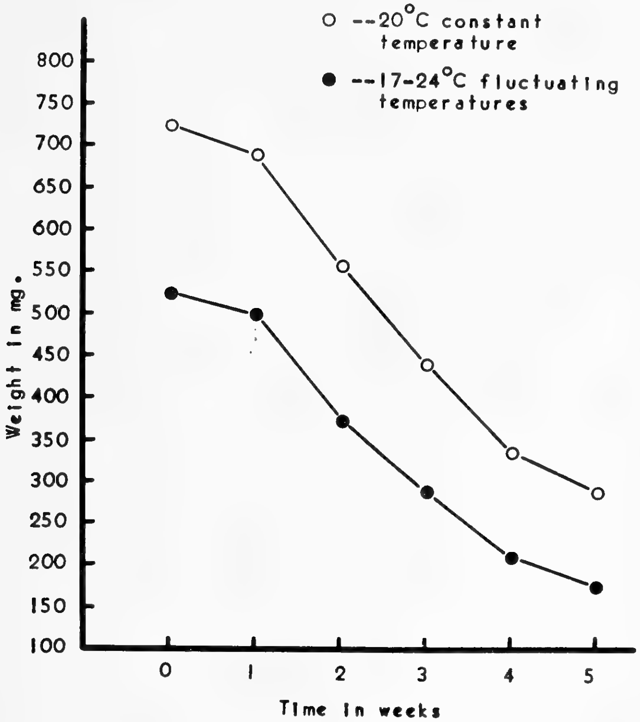

*Figure 5.* Comparison of weight-loss by starving slugs under constant and fluctuating temperature conditions.

## STARVATION STUDIES

Immature slugs can withstand extended periods without food, providing other conditions are favorable. Lovett and Black (1920) reported keeping nine slugs for one month without food. To test tolerance to starvation, five groups of ten one-week old slugs were placed in jars containing moist, unwashed river sand at a constant temperature of 20°C. Water (containing the previously mentioned antibiotics to suppress fungal and bacterial growth) was added occasionally to maintain moist conditions. Slug mortality in these jars was not complete until after a five month period.

The effects of starvation on mature slugs was also investigated, but in this case, the loss in weight under two temperature conditions was studied. Field-collected slugs were fed on lettuce for one week, then

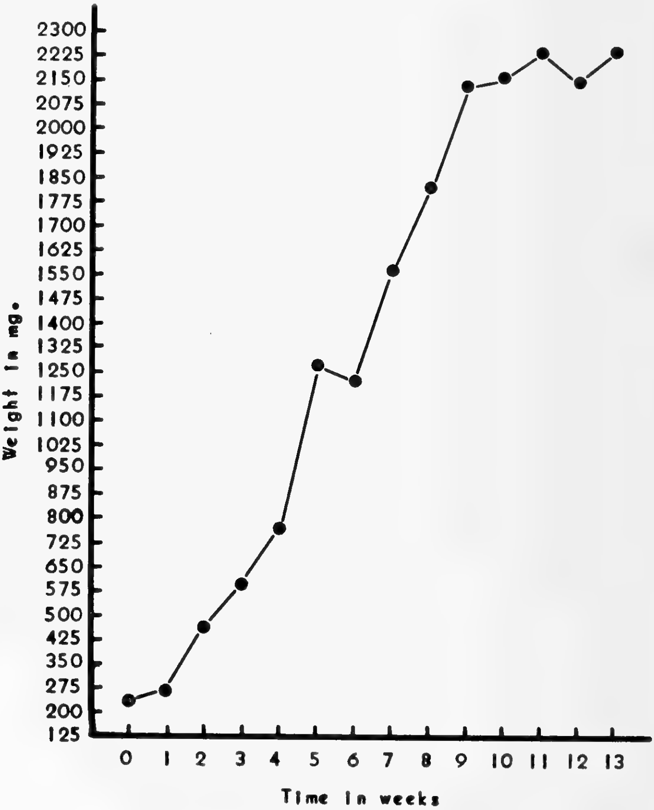

*Figure 6.* Growth record of a single slug, reared from the fourth to the seventh month of life in a fluctuating temperature cabinet at 17° to 24° C.

divided into two groups of ten each. One group was kept at 20°C and the other at a 17° to 24°C fluctuating temperature. The slugs were weighed individually at weekly intervals and the mean weights plotted after five weeks (Fig. 5) when mortality from disease terminated the experiment. The results showed a steady decline in weight under starvation conditions with the rates of weight loss (slopes) under the different temperature conditions being approximately equal. This situation was unexpected, since the slugs under the fluctuating temperature conditions exhibited the increased locomotor activity similar to that observed in previous experiments.

## MATURATION PERIOD

General observation of gray garden slugs in the field shows that sexual maturity is reached considerably ahead of maximum growth. The length of time required to attain maximum size naturally varies with environmental and other conditions, and may or may not coincide with the total length of life. The published accounts of longevity of *D. reticulatum* are fairly consistent, ranging from 18 months to two years (Taylor, 1907; Lovett and Black, 1920; Theobald, 1895; Cook, 1895; and Hawley, 1922). No mention of the weight of the mature specimens of this species, however, was found in the literature.

The ultimate size attainable by this species was indicated in one trial on the effects of fluctuating temperatures, in which a single specimen survived for 13 weeks. This slug was reared in a 17° to 24°C fluctuating temperature cabinet and was weighed weekly from the time it was four months old until its death three months later. The results (Fig. 6) indicated that the slug reached maturity when 6 months of age, weighing approximately 2.2 grams, at that time. The mature specimen measured 50 millimeters long and 9 millimeters wide when extended, a size considerably larger than that normally seen in fields of western Oregon.

## ACKNOWLEDGMENTS

The assistance of the following persons during the course of this study is gratefully acknowledged: Dr. G. Dallas Hanna and Dr. A. G. Smith, of the California Academy of Sciences, San Francisco, for confirmation of our identification of *Deroceras reticulatum* (Müller); Dr. E. N. Kozloff of Lewis and Clark College, Portland, Oregon, for the identification of the protozoa; Dr. H. J. Jensen and Dr. Donald Murphy of the Botany and Plant Pathology Department, O.S.U., for identification of the nematode parasites; and Dr. Mathew Nadakavakaren of the Botany and Plant Pathology Department, O.S.U., for classifying the fungi.

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# SURF-RIDING BY THE CALIFORNIA GRAY WHALE

Notice of the ability of cetaceans to utilize forward wave motion and to surf-ride is of interest to workers in the field of hydrodynamics as well as animal behavior.

This ability has been reported in the small odontocete delphinids *Tursiops truncatus* (Montagu) and *T. gilli* Dall. For the former, the report was made by Caldwell and Fields (J. Mamm., 40: 454, 1959) and Norris and Prescott (Univ. Calif. Publ. Zool., 63: 300, 1961), and for the latter by Norris and Prescott (*loc. cit.*). These reports showed that the same individuals repeated the performance several times, indicating that the surf-riding was not an accidental encounter but a self-reinforcing form of play behavior.

We now report similar behavior by the large mysticete, *Eschirichtius glaucus* (Cope), the California gray whale.

Although both Scammon (The marine mammals of the north-western coast of North America etc., 1874, p. 24) and Caton (Amer. Nat., 22: 510, 1888) referred to extensive play by this species in the breakers along the outer coast of Baja California, they made no specific mention of surf-riding.

The following behavior has been reported to us by Robert V. Bell, leader of a party of salvage divers who spent seven weeks in Baja California in the spring of 1958. They were anchored just south of Magdalena Bay in the channel which divides Santa Margarita and Cresciente Islands. Just west of the latter was a large area of shoal water and the divers were anchored about 50-60 yards from these shoals.

The divers reported that almost daily during the seven-week period they watched gray whales riding the breakers coming in over the shoal. The divers were particularly interested in the behavior and agreed among themselves at the time that the whales were surf-riding "just as a man would"; *i.e.*, just in front of the crest of the waves.

The whales engaging in the activity were adults. It was not noted, however, whether the same individuals rode more than once.—DAVID K. CALDWELL and MELBA C. CALDWELL, *Los Angeles County Museum, Los Angeles 7, Calif.*

# MOLLUSCS FROM PACIFIC NORTHWEST ARCHAEOLOGICAL SITES, 2. WASHINGTON: 45-CA-30, A COASTAL SHELLMIDDEN IN THE OZETTE AREA

Robert J. Drake

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## Introduction

Site 45-CA-30 was excavated over a period of six weeks in the summer of 1961 (Borden 1962: 611); it is located in the Olympic National Park near the northwest corner of Washington (see Fig. 1-D) near Ozette in Clallam County. It was investigated under the direction of Richard D. Daugherty of Washington State University with support from the National Park Service by means of a grant.

In May of 1962, the reported upon mollusc and barnacle samples from the 45-CA-30 excavations were submitted for study and report, accompanied by a profile plan of the small shellmidden and a regional location map. A letter from Stanley J. Guinn (dtd. 30 May 1962) contained a description of the site and an account of molluscan remains in relation to factors of its stratigraphy.

45-CA-30 was shown, by the excavations of 1961, to have been a specialized habitation location apparently occupied primarily for sea mammal hunting from late prehistoric into postcontact times. "Whale and seal bones were especially abundant." The midden was stratified, of about 5 feet in depth, and made up of animal remains and fire broken rock. The greater portion of the recovered artifacts was harpoon parts and composite fishhook portions. (Borden 1962: 611).

Size of the shells, as seen in the midden deposit to lessen toward the top, seemed to reflect the greatest change over time. Alteration of form of a particular species was not evident. The main shell components were of clams and mussels; limpets, chitons, barnacles, seaurchins, and snails being less frequent. There were less deposits of limpets, barnacles, chitons, seaurchins, and snails in the upper levels; clam and mussel shells, however, persisted. (*in litt.*, 30 May 1962, Stanley J. Guinn).

## Processing and Study

Upon receipt, the material was processed as a study unit in a program of investigation of animal remains from archeological sites. The assignment of reference numbers (usually referred to as "permanent study

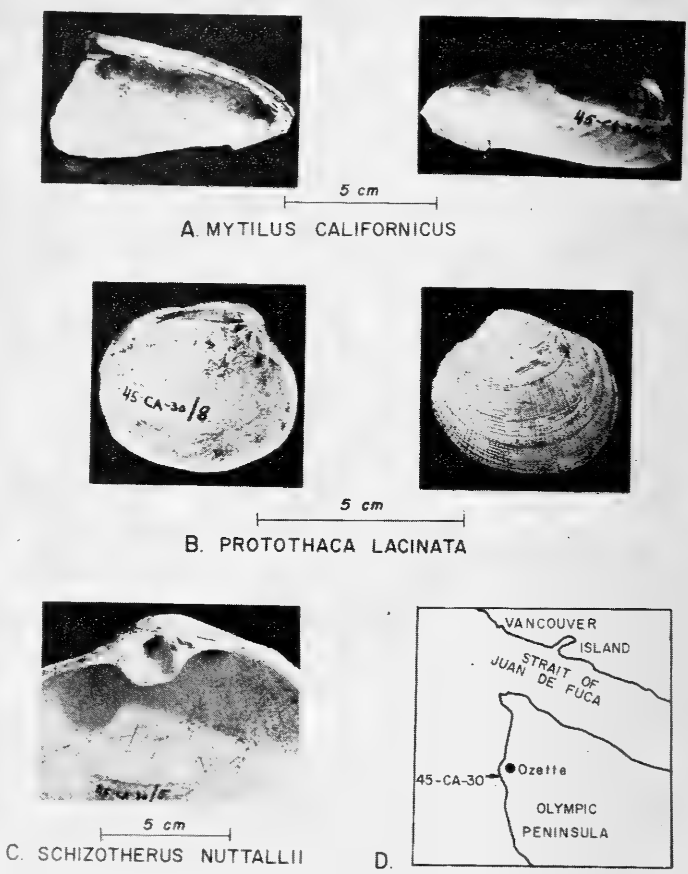

FIG. I MARINE BIVALVES & SITE LOCATION

*Figure 1.* Marine bivalve shells from site 45-CA-30, Washington; location of site.

numbers") of the shells was unnecessary as each lot had been numbered and invoiced before shipment. Therefore, references to samples follow the numerical designations in the records of the Department of Anthropology of Washington State University. The shells and barnacles were returned to the Department of Anthropology at Pullman.

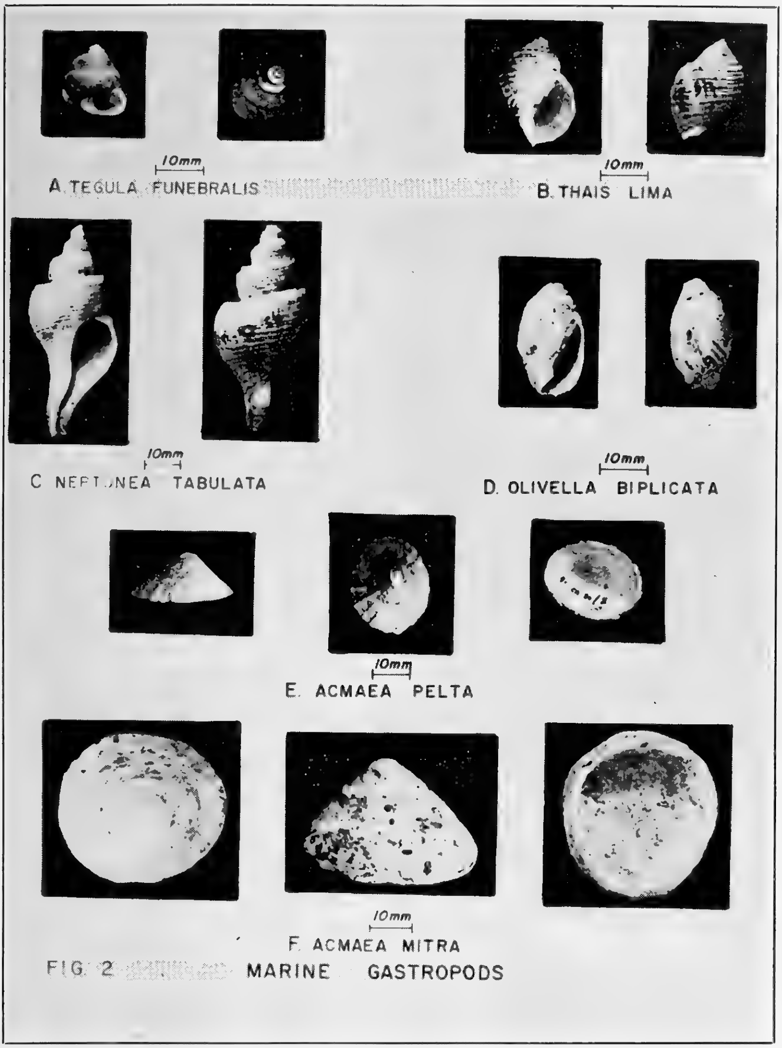

*Figure 2.* Marine gastropod shells from site 45-CA-30, Washington.

## Marine Bivalve Shells

*Protothaca lacinata* (Carpenter), 1864; (45-CA-30/8)—Fig. 1-B.
References:
Morris 1952: 47-48; pl. 11, fig. 6.
Palmer 1958: 96-97.

Remarks:
Lives near shore, probably mostly in shallow water.

*Mytilus californicus* Conrad, 1837; (45-CA-30/11)—Fig. 1-A.
Reference:
Morris 1952: 20; pl. 6, fig. 10.
Remarks:
Lives mostly in the tidal zone.

*Schizotherus nuttallii* (Conrad), 1837; (45-CA-30/5)—Fig. 1-C.
Reference:
Morris 1952: 57; pl. 17, fig. 1.
Remarks:
Lives buried in mud in the tidal zone.

## Marine Gastropod Shells

*Tegula funebralis* (Adams), 1854; (45-CA-30/14)—Fig. 2-A.
Reference:
Morris 1952: 81; pl. 22, fig. 8.
Remarks:
Lives in the tidal zone.

*Thais lima* Gmelin, 1791; (45-CA-30/11)—Fig. 2-B.
Reference:
Morris 1952: 119; pl. 28, fig. 10.
Remarks:
Lives near shore, probably mostly in shallow water.

*Neptunea tabulata* (Baird), 1863; (45-CA-30/17)—Fig. 2-C.
References:
Oldroyd 1927 (vol. 2, pt. 1): 227-228; pl. 18, fig. 4.
Morris 1952: 126; pl. 29, fig. 11.
Remarks:
Probably lives near shore and mostly in shallow water, but occasionally deeper than the tidal zone.

*Olivella biplicata* (Sowerby), 1825; (45-CA-30/16)—Fig. 2-D.
Reference:
Morris 1952: 134; pl. 30, fig. 20.
Remarks:
Lives in sand in the tidal zone.

*Acmaea pelta* Eschscholtz, 1833; (45-CA-30/2)—Fig. 2-E.
Reference:
Morris 1952: 71; pl. 19, fig. 7.
Remarks:
Lives in the tidal zone.

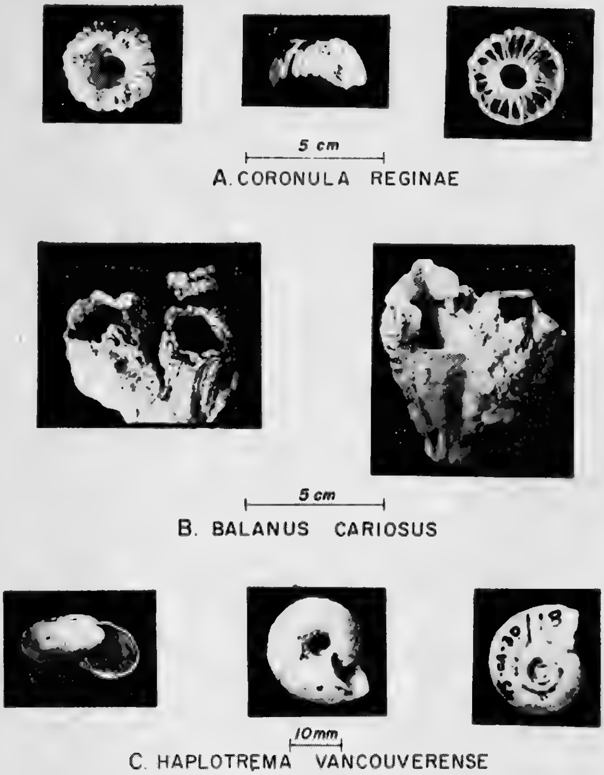

FIG. 3 BARNACLES & TERRESTRIAL GASTROPOD

*Figure 3.* Barnacles and terrestrial gastropod shell from site 45-CA-30, Washington.

*Acmaea mitra* Eschscholtz, 1833; (45-CA-30/6)—Fig. 2-F.
Reference:
Morris 1952: 71; pl. 19, fig. 4.
Remarks:
Lives in the tidal zone.

## BARNACLES AND TERRESTRIAL GASTROPOD SHELL

*Coronula reginae* Darwin, 1854; (45-CA-30/42)–Fig. 3-A.
References:
Darwin 1854: 419-421; pl. 15, fig. 5.
Cornwall 1955a: 54-55; illu.
Cornwall 1955b: 43-44, fig. 35.
Remarks:
Lives on whales, mostly killer whales.

*Balanus cariosus* (Pallas) 1788; (45-CA-30/12)–Fig. 3-B.
References:
Darwin 1854: 273-275; pl. 7, fig. 3a.
Pilsbry 1921: pl. 20, figs. 3, 6.
Cornwall 1955a: 22 (illu., fig. 6 on p. 15).
Cornwall 1955b: 26-28; fig. 19.
Remarks:
Lives mainly on rocks in or near the tidal zone.

*Haplotrema vancouverense* (Lea), 1839; (45-CA-30/18)–Fig. 3-C.
Reference:
Pilsbry 1946: 221-225.
Remarks:
Lives on land in the general Coast Conifer Forest habitat.

## DISCUSSION

*Tegula* shells were "found in clusters as though they had been dumped from a container of some sort." *Tegula* is utilized as a foodstuff yet; along the central California coast, they are collected in pails for boiling for stews.

The shell of the limpet *Acmaea mitra* (Fig. 2-F) had some bryozoan incrustation in its interior; this would indicate the shell being again in marine water after the animal had been removed by man or other predator.

Reagen (1917: 17-20) offered a pioneering trilogy for gross chronological precontact cultural change in the Ozette-Makah territory. He mentions oyster shells being an important part of the molluscan remains in the sites of the general area, especially for what he then considered older and oldest periods. Therefore, presence and/or absence of oyster shells in 45-CA-30, and related sites, intimate some connection with cultural change related to environmental change in different portions of the Olympic Peninsula, and perhaps concurrently. This suggests the possibility that changes of relatively few feet in shoreline oscillation, perhaps over a lengthy period of time, could bring about enough habitat alteration to seriously distort the food gathering economy.

## MARINE MOLLUSCS AND BARNACLES

The 3 bivalve and 6 gastropod molluscs are tidal-zone or close to shore (and probably also shallow water) forms. One barnacle, the *Balanus*, would probably be found attached to rocks within tidal limits when it lived. If many specimens of the other barnacle, the *Coronula*, were found in the site, their presence would give additional argument for a sea mammal hunting phase for the aboriginal beach living location.

## TERRESTRIAL GASTROPOD

*Haplotrema vancouverense* is a species distributed from southeastern Alaska to northern California and eastwardly in places to the northern Idaho region. It has been found in aboriginal sites in southwestern British Columbia along with landsnails of three other genera: *Allogona*, *Monadenia*, and *Vespericola*. (An evaluation of landsnail remains in British Columbia sites will be the third in the series including the present report.) In 45-CA-30, *Haplotrema* is reported as "found only in sparse layers and always on top of other snails" (*in litt.*, S. J. Guinn, 30 May 1962). It is not known if terrestrial snails were used as food by prehistoric Indians of the Pacific Northwest; they are being currently studied as remnants of the background biotas surroundings man's record in archaeology. Eventually detailed studies of nonmarine molluscs in sites (with possible controlled sampling-excavation) and including other biological remains similarly considered will supplement a body of indications, some most subtle but still interlocking, for changes in past environments.

## ACKNOWLEDGMENTS

Dr. Richard D. Daugherty and Mr. Stanley J. Guinn of the Department of Sociology and Anthropology of Washington State University kindly provided the archaeo-zoological material for site 45-CA-30. Drafting was by Mrs. Maureen A. Douglas and record-typing was by Miss A. C. Templeton of the Department of Zoology of U.B.C.; I did the photography. This report represents one of several such evaluations supported by Grant G24475 from the Anthropology Program of the National Science Foundation, 1962-1963.

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# ATTRACTION OF INSECTS TO EXUDATES OF *VERBESINA ENCELIOIDES* AND *IVA AMBROSIAEFOLIA*

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We have called attention previously to the attraction of insects to exudations from the stems of *Senecio longilobus* Benth. (thread-leaf groundsel), a species of composite containing alkaloids highly toxic to livestock but not yet shown to be significantly so to insects (Linsley and Cazier, 1962). Among the insects attracted to the exudate were tenebrionid and lagriid beetles; braconid, multillid, pompilid, sphecoid and vespoid wasps; and various Diptera, including *Sarcophaga.* The dominant species from the standpoint of size and continuity of presence on the plant during the period in which it was under observation, was the large, black, heavy-jawed longicorn beetle, *Stenaspis solitaria* (Say). One or more males were present almost continuously and usually also females as partners in mating pairs. Both sexes chewed on the surface of injured areas and lapped up exuding liquids. It was not clear whether or not they were responsible for the primary lesion. After extensive feeding, the beetles often appeared logy, especially the females, and commonly sat on leaves or stems for some time before flying away.

In the summer of 1962, at a site one mile east of Douglas, Cochise County, Arizona, an opportunity was afforded to make a few observations on the attraction of insects to exudates from injuries in two additional species of composites, *Verbesina encelioides* and *Iva ambrosiaefolia.* Both plants were growing in and next to a shallow burrow excavation on the upper slope leading into drainage dyke and in each case the primary lesions were produced by the large scarab beetle, *Cotinis palliata.* In late July a female of the long-horned beetle, *Dendrobias mandibularis,* was observed chewing on an uninjured stem of *Verbesina* but she failed to produce a primary lesion. Attempts to artificially produce exuding lesions on the stems of *Verbesina* by cutting or scraping were unsuccessful as the tissue dried too rapidly and none of the plants with scarab lesions died during the period of these observations. The latter was probably because the stems were not girdled by the lesions.

Adults of *Cotinis palliata* are notorious for their injury to fruits, especially figs, peaches and grapes. According to Nichol (1935), in the hot climate of southern Arizona, ripe fruit which is attacked will be fermenting by the following day, and the beetles return and feed till it is entirely consumed. They also follow fruit injury by Gila woodpeckers and other birds. He states that when they attack a whole skinned fruit, they utilize the clypeal horn to break the surface, since the mouthparts are not suitably developed for tearing the epidermis. They leave a sickening odor where they have been feeding as well as a greasy excrement. He found both sexes feeding during all of the daylight hours, but mostly between 10 AM and dusk. Broken watermelons are especially attractive to *Cotinis* and have been used in orchards as traps. During the breeding season the diet is varied with pollen from sorghums, maise, grasses, and various herbs and shrubs. Nichol experimented with various fermenting baits—those containing sour milk or grape or peach juice and water being the most attractive of those tested.

### *Verbesina encelioides* (Cav.) Benth. & Hook.

This species, one of the crown-beards, is an erect, many-branched annual, with numerous flowerheads, canescent stems, and a large taproot. It was the dominant plant for a distance of several hundred yards along the excavation, the majority of individuals ranging from 4 to 6 feet in height. However, injured plants were limited to about a dozen specimens in a group of 75-80 examples growing in an area about 10x24 feet square. Feeding by large scarabs (*Cotinis palliata*) at the base of plants near the ground level, or less commonly on branches in the middle of the plant, was noticed in mid-July. The resulting lesions produced white exudates for a period of two or three weeks that were attractive to a wide range of insects. Nevertheless the attraction was selective and by no means representative of the fauna present in the immediate area. Aside from *Cotinis*, the most conspicuous of the insects attracted were large, yellow and black long-horned beetles (*Dendrobias mandibularis*), large blue mud wasps (*Chlorion aerarius*), large red spider wasps (*Cryptocheilus severini*), and large black ground beetles (*Calosoma*). These species were aggressive and belligerent toward one another in varying degrees and thus exhibited varying degrees of dominance in different combinations.

Males of *Dendrobias mandibularis* were seen feeding on the exudate as early as July 23, 1962, but sustained observations on their activity were not possible until August 16, 1962. At 7:10 AM (air temperature: 79° F), a male was observed feeding at a lesion in nearly horizontal stem toward the middle of a plant, in the company of two *Cotinis* and various small flies, wasps and beetles (for hourly counts of the composition of the feeding aggregations, see Table II). He was joined shortly by a female which flew in. The male immediately engaged her in copulation, holding her alongside the pronotum with the long, broad, front tarsi, the middle and hind legs remaining on the substrate. While the female continued to feed, the pair was rushed repeatedly by a female *Chlorion* which the male fought off with the antennae and front tarsi.

At 8:16 AM the female stopped feeding and broke off copulation, flying off after a few moments of preening and cleaning the mouthparts. Thereupon the male returned to feeding, fighting off wasps and larger beetles belligerently but largely ignoring the smaller insects. The arrival of a third *Cotinis* immediately precipitated a battle with the scarabs butting each other and the cerambycid. The latter was at disadvantage when butted from behind and was knocked off the branch several times, only to fly directly back and resume battle. In head-to-head combat *Dendrobias* and *Cotinis* were more or less stalemated, but when the former approached from behind he succeeded in pushing each of the scarabs off the branch and keeping them away.

At 10:14 AM, a second (smaller) female *Dendrobias* flew in and started to feed. As previously, the male engaged her in copulation, which continued until 11:25 AM, when she flew off and attached herself to the underside of a leaf of a *Verbesina* plant about 25 feet distant. Once again, the male became very belligerent toward all of the larger insects then present. At 11:52 AM (air temperature 93° F) the male left the stem and crawled to the underside of a leaf and hung up in the shade. The next morning, and each morning during the following week the male *Dendrobias* returned to the exudation site and dominated it, being joined from time to time by females. One morning, two mating pairs were present but when copulation was complete and the females had left, the first male succeeded in chasing away the second.

As has been emphasized previously (Linsley, 1959), the olfactory sense is well developed in Cerambycidae. Beeson and Bhatia (1939) and others have recorded the rapid response of *Hoplocerambyx spinicornis* (Newman) to the fresh sap of *Shorea robusta*, to which adults fly over considerable distances. They have been attracted over a measured quarter of a mile within five minutes, flying upwind. The males precede the females in flying to a trap tree, to which as many as 465 adults have been attracted in a single day, 836 over a period of several days.

Little is known of the food habits of adult *Dendrobias mandibularis*. Schwarz (1904) reported that the species is especially fond of printers' ink and sometimes obliterates the large letters on posters of theatrical performances, etc., which are pasted on walls and fences. More details on this habit and data on the chemical nature of the ink and glues involved would have been of interest in relation to the above observed behavior. Chemsak (1958) recorded the attraction of large numbers of individuals of both sexes to watermelon rinds in trash barrels (a sample contained 32 males and 34 females). Among these were two females of the longhorned beetle *Eustromula validum* (LeConte) all that were seen. Watermelon is attractive to other insects, including bees (Bohart, 1950) and, as mentioned above, the scarab *Cotinis*. *Dendrobias* have been collected as they were feeding on the exudate of *Salix* sp. at Holtville, California (Cazier & Ross) and on the sap of *Baccharis sarothroides* in Sabino Canyon, Arizona (Bradt & Cazier) where they were found in association with another Cerambycid, *Stenapsis verticalis*, which was feeding on the same injuries. In late June, 1950, a number of *D. mandibularis* were collected from the blossoms of *Yucca elata* at Don Luis, Arizona (Cazier), but no feeding observations were made. They were taken singly and in copulation on these flowers.

At the ground level sites, the *Cotinis* and *Calosoma* were dominant, usually ignoring attacks from *Chlorion*, which was dominant in the absence of the larger beetles. A maximum of five *Cotinis* were found feeding at a single lesion at the same time on *Verbesina* and six *Calosoma* were feeding on or were in the immediate vicinity of a lesion on *Iva*. Although the smaller insects were often dislodged in battles between the larger forms, they flew or crawled back immediately and apparently would not leave until satiated. At the time when the sample reported in Table I was collected, most of the ground level lesions were drying up, and the residual species composition was not fully representative of the total group attracted.

## TABLE I

### Numbers and kinds of insects feeding at hourly intervals from exudations from base of *Cotinis*-injured *Verbesina encelioides* during morning of August 16, 1962*

| *Insects* | *8:30* | *9:30* | *10:30* | *11:30* |
|---|---|---|---|---|
| *Sarcophaga prohibita* (Diptera, Sarcophagidae) | 4 | 2 | 3 | 3 |
| *Calosoma peregrinator* (Coleoptera, Carabidae) | 2 | 2 | 1 | |
| *Aeolus mellillus* (Coleoptera, Elateridae) | 2 | 1 | | |
| *Statira* sp. nr. *pluripunctata* (Coleoptera, Lagriidae) | 1 | | | |
| *Dasymutilla gloriosa* (Hymenoptera, Mutillidae) | 1 | 2 | | |
| *Dasymutilla klugii* (Hymenoptera, Mutillidae) | 1 | | | |
| *Notogramma purpurata* (Diptera, Otitidae) | 1 | 2 | | 1 |
| *Chlorion aerarius* (Hymenoptera, Sphecidae) | | 2 | 1 | 1 |
| *Euxesta* sp. (Diptera, Tephritidae) | | 2 | 1 | |
| *Polistes major castaneicolor* (Hymenoptera, Vespidae) | | 1 | | |
| *Priocnemioides t. texanus* (Hymenoptera, Pompilidae) | | 1 | 2 | 1 |
| *Dasymutilla chrysocoma* (Hymenoptera, Mutillidae) | | 1 | | |
| *Polistes fuscatus centralis* (Hymenoptera, Vespidae) | | | 2 | |
| *Largus cinctus* (Hemiptera, Pyrrhocoridae) | | | 1 | 1 |
| *Asterocampa leilia* (Lepidoptera, Nymphalidae) | | | 1 | |

*Among the insects observed at the exudations of this plant during the week prior to August 17 but not represented in the above samples were: *Carpophilus lugubris* (Coleoptera, Nitidulidae), *Cotinis palliata* (Coleoptera, Scarabaeidae), *Euphoria fascifera* (Coleoptera, Scarabaeidae), *Megacyllene antennata* (Coleoptera, Cerambycidae), *Dendrobias mandibularis* (Coleoptera, Cerambycidae), *Opius sanguineus* (Hymenoptera, Braconidae), *Zonosemata vittigera* (Diptera, Tephritidae) and several undetermined small flies (Diptera).

## TABLE II

### Numbers and kinds of insects feeding at hourly intervals from exudations from *Cotinis*-injured stem near middle of plant of *Verbesina encelioides* during morning of August 16, 1962 (7:20 a.m. air temperature: 80° F.)

| *Insects* | *7:20* | *8:20* | *9:20* | *10:20* | *11:20* |
|---|---|---|---|---|---|
| *Algarobius prosopis* (Coleoptera, Bruchidae) | 6 | 4 | 2 | | |
| *Centrinaspis hospes* (Coleoptera, Curculionidae) | 4 | 2 | 6 | 1 | |
| *Cotinis palliata* (Coleoptera, Scarabaeidae) | 2 | 3 | 1 | | |
| *Dendrobias mandibularis* (Coleoptera, Cerambycidae) | 2 | 1 | 2 | 2 | 1 |
| Undet. small flies (Diptera) | 2 | 5 | 4 | 2 | 2 |
| *Priocnemioides t. texanus* (Hymenoptera, Pompilidae) | 1 | | | 1 | |
| *Chlorion aerarius* (Hymenoptera, Sphecidae) | 1 | 1 | 2 | | |
| *Opius sanguineus* (Hymenoptera, Braconidae) | 1 | 1 | | 2 | |
| *Sarcophaga prohibita* (Diptera, Sarcophagidae) | | 1 | 2 | | 1 |
| *Asterocampa leilia* (Lepidoptera, Nymphalidae) | | | 2 | | 1 |
| *Cryptocheilus severini* (Hymenoptera, Pompilidae) | | | 1 | | 1 |
| *Rygchium guerrero* (Hymenoptera, Vespidae) | | | 1 | 2 | 1 |
| *Zonosemata vittigera* (Diptera, Tephritidae) | | | 1 | | |
| *Dyscrasis hendeli* (Diptera, Otitidae) | | | | 1 | |
| *Euptoieta claudia* (Lepidoptera, Nymphalidae) | | | | 1 | |
| *Notogramma purpurata* (Diptera, Otitidae) | | | | | 1 |

The following insects were found feeding on exudates of *Verbesina* between July 23, 1962 and August 21, 1962:

Order Hempitera

Family Pyrrocoridae

*Largus cinctus* (Herrick-Schaeffer)— widely distributed in southwestern United States and northern Mexico. Adults reported to feed on berries and fruits.

Order Lepidoptera

Family Nymphalidae

*Asterocampa leilia* (Edwards)—Known from Texas to southern Arizona and Mexico.

*Euptoieta claudia* (Cramer)— occurring in southern United States, Mexico and Central America.

Order Coleoptera

Family Carabidae

*Calosoma (Camedula) peregrinator* Guérin-Méneville—Ranging from New Mexico to southern California. Adults known to feed on cutworms and other caterpillars.

Family Elateridae

*Aeolus mellillus* (Say)—Southwestern United States. Adults nocturnally active and attracted by light.

Family Lagriidae

*Statira* sp. nr. *pluripuncta* (Horn)—Representative of a large genus of nearly 450 described species in the American tropical and subtropical regions, of which six occur in southwestern United States, three in eastern and central United States.

Family Scarabaeidae

*Cotinis palliata* (Gory)—A common species of Mexico and the southern United States; injurious to fruits, etc. (see above).

*Euphoria fascifera* LeConte—A rarely encountered species known from Baja California, northwestern Mexico and southern Arizona.

Family Cerambycidae

*Dendrobias mandibularis mandibularis* Serville—Ranging from Baja California and the mainland of Mexico to southern Texas, New Mexico and Arizona.

*Megacyllene antennata* (White)—Baja California and northern Mexico to Texas, New Mexico, Arizona and southern California.

Family Bruchidae

*Algarobius prosopis* (LeConte)—Occurring from Texas to southern California, northern Mexico and Baja California.

Family Curculionidae

*Centrinaspis hospes* (Casey)— Our material is all from southern Arizona, Sonora and Chihuahua.

Order Diptera

Family Sarcophagidae

*Sarcophaga prohibita* Aldrich—Described from Kansas and widely distributed in southwestern United States.

*Protodexia hunteri* (Hough)—A western North American species repeatedly reared from grasshoppers (Aldrich, 1916).

Family Otitidae

*Notogramma purpurpata* Cole—A rare species described from the Gulf of California.

*Dycrasis kendeli* Aldrich—Known to us only from a few examples from Texas.

Family Tephritidae

*Euxesta* sp.

*Zonosemata vittigera* (Coquillett)—A fruit fly living in the fruit of *Solanum elaeagnifolium* (Cazier, 1962).

Order Hymenoptera

Family Braconidae

*Opius sanguineus* (Ashmead)—A species widely distributed in eastern North America. Locally a parasite of the larvae of *Zonosemata vittigera* (above), a *Solanum* fruit fly (Cazier, 1962).

Family Multillidae

*Dasymutilla chrysocoma* Mickel—Our material is all from Arizona.

*Dasymutilla gloriosa* (Saussure)—A species of the desert areas of southwestern United States and northern Mexico.

*Dasymutilla klugii* (Gray)—Also a species primarily limited to southwestern United States and northern Mexico.

Family Vespidae

*Polistes fuscatus centralis* Hayward—Occurring in the southwestern United States, northern Mexico, and Baja California.

*Polistes major castaneicolor* Bequaert—Our material is all from southern Arizona and New Mexico and northern Mexico.

*Rygchium guerrero* (Saussure)—Western Texas to southern Arizona, northwestern Mexico and Baja California.

Family Pompilidae

*Priocnemioides texanus texanus* (Cresson)—Our material is from southwestern United States and adjacent areas of northern Mexico.

*Cryptocheilus severini* Banks—Widely distributed in lower regions of central and southern United States and northern Mexico.

Family Sphecidae

*Chlorion aerarius* Patton—A widely distributed North American wasp.

*Verbesina encelioides* var. *exauriculata* occurs from Kansas to southwestern United States and northern Mexico. According to Blake (1951) it is said to have been used by the Indians and white pioneers for boils and skin diseases. The Hopi are also reported to bathe in water in which the plant has been soaked to relieve the pain of spider bite.

Heal, Rogers, Wallace and Starnes (1950), in tests with various insects, found that aqueous extracts of the flowerheads and of the stems, leaves, and flowers were very toxic to American cockroaches when injected into the blood stream, but German cockroaches and milkweed bugs were unaffected after immersion in the extract. Alcohol, petroleum ether, and chloroform extracts of the whole plant were toxic to black carpet beetle larvae but not to German cockroaches, milkweed bugs, confused flour beetles, and larvae of the webbing clothes moth and *Aedes* mosquitoes. The related *V. virginica* Linnaeus, in the form of powdered stems and leaves did not prove toxic to southern armyworms, mealworms, and southern beet webworms (Bottger and Jacobson, 1940) nor larvae of the European cornborer (Jacobson, 1953). However, the last author found combined petroleum ether, ethyl ether, chloroform, and alcohol extractives toxic to codling moth larvae but not houseflies. No evidence of toxicity was observed among the insects feeding on the exudates from the *Verbesina* lesions. However, their behavior suggested an overwhelming response to the attractiveness of the exudate.

### *Iva ambrosiaefolia* Gray

This plant, one of the marsh elders, of which about fifteen species are known—all North American, is a shrub-like herb with inconspicuous green flowers. In the site under study, individuals were widely scattered along the wash among the dominant *Verbesina encelioides*. Only a few exhibited *Cotinis* injuries, but these were overrun with insects of many kinds. The most prominent of these was a plant about 4 ft. high and 5 ft. in diameter.

The following insects were observed on a plant exuding liquids from *Cotinis* injuries:

Order Hemiptera
  Family Pyrrocoridae
    *Largus cinctus* (Herrick-Schaeffer) (See above)

Order Neuroptera
  Family Mantispidae
    *Climaciella occidentis* (Banks)

Order Coleoptera
  Family Carabidae
    *Calosoma (Camedula) peregrinator* Guérin-Méneville (See above)
  Family Lagriidae
    *Statira* sp. nr. *pluripuncta* (Horn) (See above)
  Family Nitidulidae

*Carpophilus lugubris* (Say)—The widespread and notorious "dusky sap beetle" which has long been known to be attracted to fermenting and decaying plant materials. On sweet corn plants, sites injured by other insects are very attractive to adults and infestations increase when damage by other insects is present (Harrison, 1962).

Family Scarabaeidae
*Cotinis palliata* (Gory) (See above)

Family Cerambycidae
*Megacyllene antennata* (White) (See above)

Order Diptera

Family Asilidae
*Beameromyia macula* Martin—Our material is all from southeastern Arizona.

Family Sarcophagidae
*Sarcophaga prohibita* Aldrich (See above)
*Protodexia hunteri* (Hough) (See above)

Family Lauxaniidae
*Camptoprosopella* sp.

Family Otitidae
*Notogramma purpurata* Cole (See above)

Family Tephritidae
*Euxesta* sp.
*Zonosemata vittigera* (Coquillett) (See above)

Order Hymenoptera

Family Mutillidae
*Dasymutilla chrysocoma* Mickel (See above)
*Dasymutilla gloriosa* (Saussure) (See above)
*Dasymutilla nogalensis* Mickel—Our material is all from southern Arizona and northern Mexico.

Family Vespidae
*Polistes fuscatus centralis* Hayward (See above)
*Polistes major castaneicolor* Bequaert (See above)

Family Pompilidae
*Cryptocheilus severini* Banks (See above)
*Hemipepsis ustulata ustulata* Dalbohm—Central and southern United States and Mexico
*Priocnemioides texanus texanus* (Cresson) (See above)

Family Sphecidae
*Chlorion aerarius* Patton (See above)

## TABLE III

Numbers and kinds of insects found at hourly intervals at exudations at base of *Cotinis*-injured *Iva ambrosiaefolia* during morning of August 19, 1962

| *Insects* | *7:15* | *8:15* | *9:15* | *10:15* | *11:* |
|---|---|---|---|---|---|
| *Calosoma peregrinator* (Coleoptera, Carabidae) | 6 | 7 | 7 | 4 | 2 |
| *Cotinis palliata* (Coleoptera, Scarabaeidae) | 4 | 4 | 5 | 5 | 5 |
| Misc. small flies (Diptera) | 4 | 6 | 9 | 7 | 10 |
| *Statira* sp. nr. *pluripunctata* (Coleoptera, Lagriidae) | 3 | 3 | 1 | 1 | 1 |
| *Hemipepsis u. ustulata* (Hymenoptera, Pompilidae) | 3 | 2 | 1 | 3 | 1 |
| *Chlorion aerarius* (Hymenoptera, Sphecidae) | 3 | 4 | 4 | 2 | 3 |
| *Carpophilus lugubris* (Coleoptera, Nitidulidae) | 2 | 2 |  |  |  |
| *Dasymutilla gloriosa* (Hymenoptera, Mutillidae) | 2 | 1 |  | 1 |  |
| *Sarcophaga prohibita* (Diptera, Sarcophagidae) | 2 | 1 | 2 | 2 | 1 |
| *Cryptocheilus severini* (Hymenoptera, Pompilidae) | 1 | 2 | 1 | 1 | 1 |
| *Polistes fuscatus centralis* (Hymenoptera, Vespidae) | 1 | 3 | 2 | 2 |  |
| *Dasymutilla nogalensis* (Hymenoptera, Mutillidae) | 1 |  |  |  |  |
| *Beameromyia macula* (Diptera, Asilidae)* | 1 | 1 | 1 | 1 | 2 |
| *Climaciella occidentis* (Neuroptera, Mantispidae)* | 1 |  |  |  |  |
| *Megacyllene antennata* (Coleoptera, Cerambycidae) |  | 1 | 1 | 1 | 1 |
| *Priocnemioides t. texanus* (Hymenoptera, Pompilidae) |  | 1 | 1 |  |  |
| *Polistes major castaneicolor* (Hymenoptera, Vespidae) |  | 1 | 1 |  | 1 |
| *Dasymutilla chrysocoma* (Hymenoptera, Mutillidae) |  | 1 | 1 |  |  |
| *Zonosemata vittigera* (Diptera, Tephritidae) |  | 1 | 2 |  | 1 |
| *Camptoprosopella* sp. (Diptera, Lauxaniidae) |  | 1 | 1 |  |  |
| *Largus cinctus* (Hemiptera, Pyrrhocoridae) |  | 1 | 1 | 1 | 1 |
| *Euxesta* sp. (Diptera, Tephritidae) |  |  | 1 |  |  |

*Neither of these species was observed to feed on the exudate, but their presence on t
plant suggests the possibility that they may have been attracted by the secretion.

*Iva ambrosiaefolia* occurs from western Texas to southern Arizona and Northern Mexico, blooming from May to October. The stems are pubescent and the plant aromatic, but we have been unable to find reference to its toxic properties, if any. The related *I. xanthifolia* Nutt., according to Blake (1951), induces dermatitis in some persons after contact, and the pollen is a cause of hay fever. Heal, Rogers, Wallace and Starnes (1950) applied extracts of the upper parts, leaves, and flowers of this last species and of *I. axillaris* Pursh. and *I. frutescens* Linnaeus to German and American roaches and to milkweed bugs, without toxic effect.

### PREDATORS UPON ATTRACTED INSECTS

During the course of these observations the remains of *D. mandibularis* and *C. palliata* were found in the early morning beneath the plants on which they had been seen feeding during the preceding day. Both species were observed at night on or near the exuding lesions and when these were near the ground the beetles evidently fell prey to some nocturnal species of rodent. What appeared to be mouse droppings were intermixed with the hard remains of the beetles. *C. palliata* was also found "sleeping" high up on *Conyza coulteria*, *Prosopis juliflora*, *Iva ambrosiaefolia* and *Verbesina encelioides*. *D. mandibularis* was found at night on the leaves and flowerheads of *Verbesina encelioides*. No remains of the third large beetle *(Calosoma)* were found although these beetles remained overnight near the lesions. Their repugnant odor or ability to run rapidly may account for their apparent immunity to rodent attacks.

## SUMMARY

(1) The attraction of various insects to exudates from living plants of *Verbesina encelioides* and *Iva ambrosiaefolia* was observed during July and August in southeastern Arizona.

(2) The primary lesions from which the exudates flowed were made by the scarab beetle *Cotinis palliata*.

(3) The exudates were selectively attractive and the assembled insects were not a representative cross-section of the immediate local fauna. About 30 species were observed at *Verbesina*, about 25 at *Iva*.

(4) The exudation sites were usually dominated by large insects which were antagonistic to one another. At various times and at various sites the dominant insect was the longhorned beetle *Dendrobias mandibularis*, or the scarab beetle *Cotinis palliata*, or the ground beetle *Calosoma peregrinator*, or the sphecid wasp *Chlorion aerarius*. Smaller insects were tolerated by these, but were frequently dislodged in battles between them.

(5) Insects remaining overnight at lesions near the ground were subject to predation—presumably by rodents.

## ACKNOWLEDGMENTS

The authors are indebted to Marjorie Statham, American Museum of Natural History, for the photographs which accompany this article. Insects were identified by Frank Cole, University of California, Berkeley and H. J. Reinhard, Agricultural and Mechanical College of Texas (Diptera), P. D. Hurd, University of California, Berkeley (Aculeate Hymenoptera), Paul J. Spangler, T. J. Spilman, and R. E. Warner, United States National Museum (Coleoptera), and R. L. Usinger, University of California, Berkeley (Hemiptera). Plants were identified by Margaret S. Bergseng, Herbarium, University of California, Berkeley.

*Figure 1 (upper).* Frothy exudate from base of *Cotinis*-injured plant of *Verbesina encelioides*, August 16, 1962.

*Figure 2 (lower).* Female of *Dasymutilla gloriosa* feeding on exudate.

*Figure 3 (upper).* Butterfly *(Asterocampa leilia)* feeding on exudations from base of *Cotinis*-injured plant of *Verbesina encelioides*. Background insects include the bug, *Largus cinctus*, and miltogrammine flies.

*Figure 4 (lower). Calosoma peregrinator* feeding on exudations.

*Figure 5 (upper).* Mating pair of *Dendrobias mandibularis*, the female feeding on exudates from *Cotinis*-injured mid-area of *Verbesina encelioides*, August 16, 1962. Background insects include *Sarcophaga prohibita* (large fly), *Centrinaspis hospes* (weevil), *Algarobius prosopis* (bruchid), and *Opius sanguineus* (braconid wasp).

*Figure 6 (lower).* Mating pair of *Dendrobias mandibularis* with newly arrived female on opposite side of stem feeding on exudates. Background insects include: *Sarcophaga prohibita* (large fly), *Protodexia hunteri* (small fly), and *Centrinaspis hospes* (weevil).

*Figure 7 (upper).* Female of *Megacyllene antennata,* newly arrived on *Cotinis*-injured *Verbesina* plant.

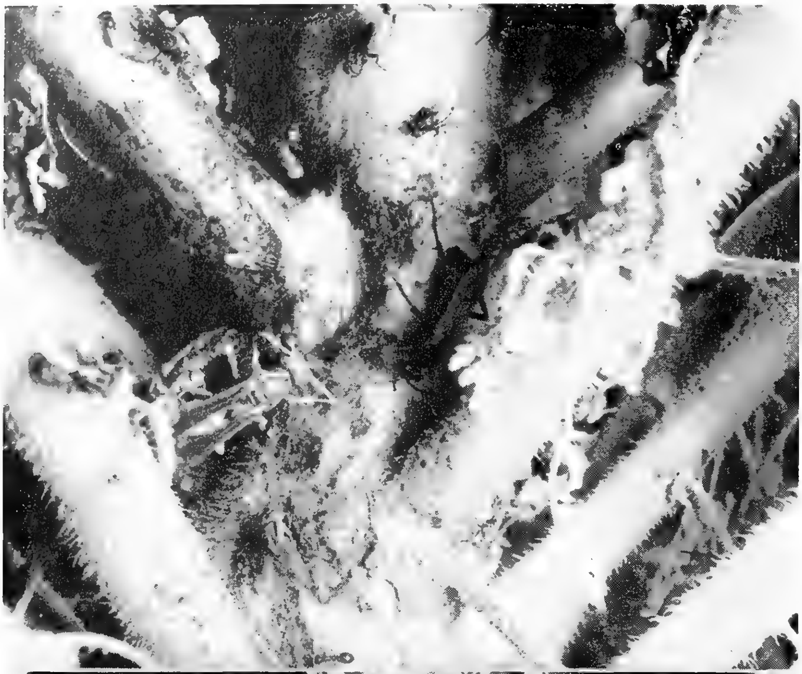
*Figure 8 (lower). Cotinis palliata* (scarab) and *Centrinaspis hospes* (weevil) feeding on exudates of *Verbesina encelioides.*

*Figure 9 (upper). Chlorion aerarius* feeding before attempting to displace mating pair of *Dendrobias mandibularis.* Background insects include *Sarcophaga prohibita* (large fly), *Protodexia hunteri* (small fly), *Centrinaspis hospes* (weevil), and *Euxesta* (tephritid fly).

*Figure 10 (lower). Chlorion aerarius* and *Dendrobias mandibularis* (male) feeding after the former had attacked mating pair (above) and chased off the female. Male longicorn, although feeding, adopted aggressive attitude toward *Chlorion* and ultimately chased it away.

*Figure 11 (upper).* Insects feeding at exudations at base of *Cotinis*-injured plant of *Iva ambrosiaefolia*, August 19, 1962. A butterfly (*Asterocampa leilia*), mud dauber wasp (*Chlorion aerarius*), and numerous flies, including *Sarcophaga prohibita* and *Protodexia hunteri*, are represented.

*Figure 12 (lower). Cotinis palliata* feeding at base of *Iva ambrosiaefolia*. Background insects include the fly *Sarcophaga prohibita*.



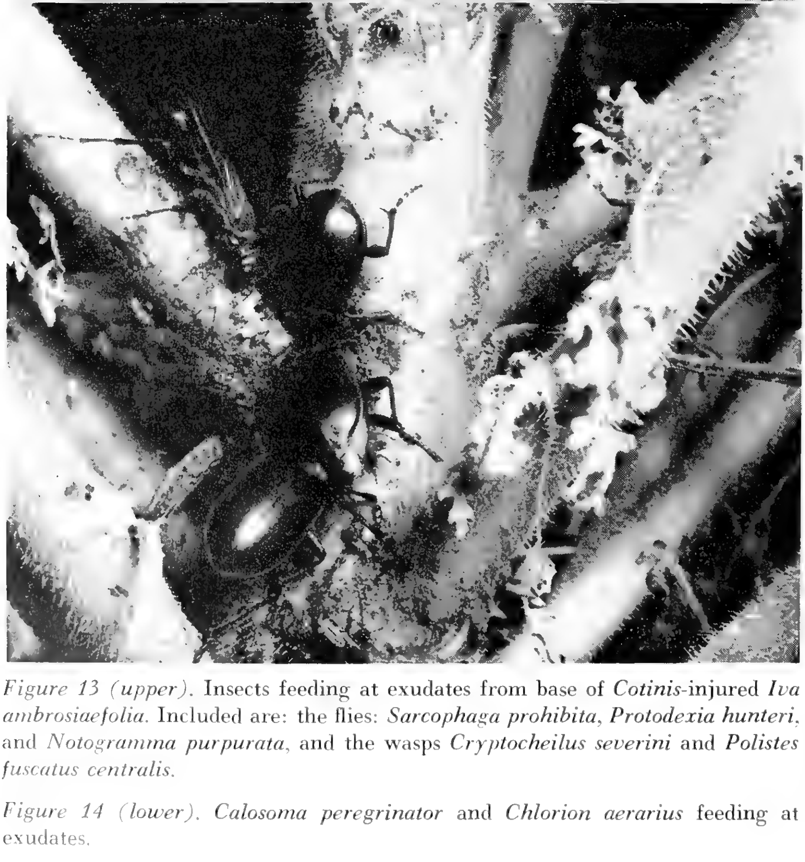


*Figure 13 (upper).* Insects feeding at exudates from base of *Cotinis*-injured *Iva ambrosiaefolia.* Included are: the flies: *Sarcophaga prohibita, Protodexia hunteri,* and *Notogramma purpurata,* and the wasps *Cryptocheilus severini* and *Polistes fuscatus centralis.*

*Figure 14 (lower). Calosoma peregrinator* and *Chlorion aerarius* feeding at exudates.

*Figure 15 (above).* *Cotinis palliata* feeding on stem *of Iva ambrosiaefolia*. August 19, 1962.

*Figure 16 (below).* Elytra of *Cotinis palliata* and rodent droppings beneath *Cotinis*-injured plant of *Iva ambrosiaefolia*, suggesting that the scarabs are subject to nocturnal predation by rodents.

*Figures 17 and 18. Polistes fuscatus centralis (above)* and *Climaciella occidentis (below)*, wasp and wasp-like neuropteron, on foliage of *Iva ambrosiaefolia*, August 19, 1962.

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# NOTES ON THE BARNACLE *LEPAS FASCICULARIS* FOUND ATTACHED TO THE JELLYFISH *VELELLA*

Several years ago while the Allan Hancock Foundation vessel *Velero IV* was occupying station 2792-54, about 7.2 miles WNW of Palos Verdes Point, San Pedro Channel, California, the surface of the sea was observed to be littered with floating barnacles. Two quarts of these, obtained by dip net, were preserved by the writer and brought back to the Foundation laboratory, where they were identified as *Lepas fascicularis* Ellis and Solander 1786, a well-known pelagic species. Further examination revealed that the barnacle float in most cases was attached to the underside of the float of *Velella* a pelagic jellyfish frequently encountered.

A review of the early literature reveals that this phenomenon was not unknown, though there have been no records since 1876. Darwin (A monograph on the fossil Lepadidae, 1851) discussed the cement glands and ball floats of *Lepas fascicularis* at great length and briefly mentioned the occasional attachment to *Velella*. Willemoes-Suhm (Philos. Trans. Roy. Soc., 167:131-154, 1876) in his work on the development of *Lepas fascicularis*, collected on the Challenger expedition between Japan and the Sandwich Islands, also mentioned that the cypris-like larvae attach to the dead floats of *Velella*. Though a few records of this peculiar phenomenon have been recorded in the past it is felt that a photograph which clearly shows the morphology and size of *L. fascicularis* and its position in relation to *Velella* will be of value since other published illustrations are lacking.

Frequently three or more barnacles have their peduncles imbedded in one common float. Of the twenty-one floats collected, with their numerously attached barnacles, sixteen definitely contained *Velella*, two more appeared to have *Velella*, and the remaining three were small single barnacle-float combinations which contained no visible traces of *Velella*. In attaching the cirriped larvae fasten to the under side of the *Velella* float. In the process of development they secrete a cement substance which forms a yellowish-tan vesicular ball ranging up to one-and-one-half inches in diameter. In most cases these balls were below the *Velella* float, leaving the chitinous concentric air chambers and erect sail exposed. In others, however, the cement ball passed over the basal portion of the float covering it along with the sail. The accompanying photograph (Fig. 1) shows five *Lepas fascicularis* attached to the under side of *Velella* (in the central mass). Of twelve additional barnacle "colonies" that were later found washed ashore at Pismo Beach, California, all contained small *Velella* imbedded in their floats.

*Lepas fascicularis*, however, is a truly pelagic animal which is not dependent on foreign floating material for its existence. When floating objects such as *Velella* are not present for attachment the barnacle secretes a ball of frothy material from its cement glands to keep it afloat.

The size of this ball is increased as the barnacle grows. In spite of its float *L. fascicularis* is like other barnacles in that it has no power of locomotion in the adult stage, and therefore is a victim of oceanic currents. The barnacle feeds on microscopic plankton and may in turn serve as food for larger marine animals.

The capitulum size of the *L. fascicularis* collected ranged from 24 mm. to 42 mm. in length, and from 8 mm. to 30 mm. in width. Another pelagic barnacle of smaller size, *Lepas anatifera* Linn., was also attached to the capitulum and floats of *L. fascicularis*.—Jens W. Knudsen, Dept. of Biology, *Pacific Lutheran University, Tacoma 44, Washington.*

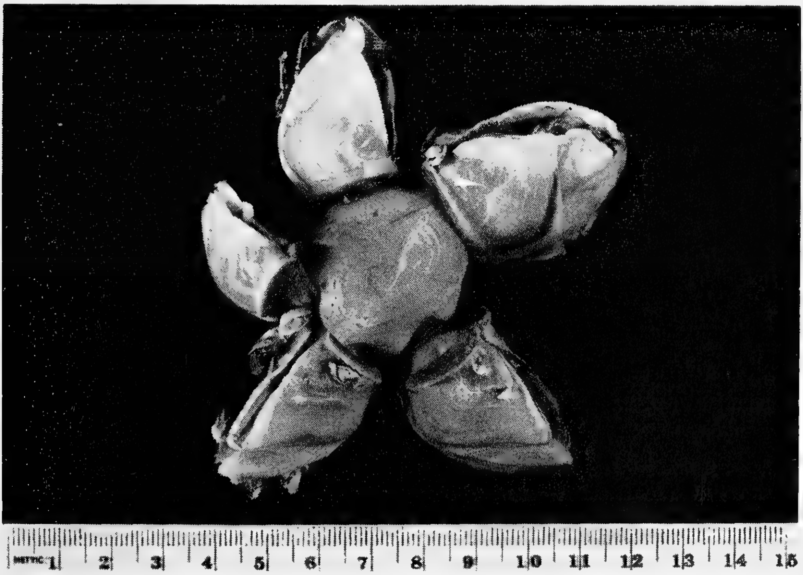

*Figure 1.* Five *Lepas fascicularis* are shown with their peduncles imbedded in a common float that is attached to the underside of the jellyfish *Velella. Velella* can be seen in the central mass characterized by the concentric rings of its air chambers and by the diagonal sail that extends from the lower left to the upper right-hand corner. Several specimens of *L. anatifera* are attached to *L. fascicularis.* Allan Hancock Foundation photograph.

# COMPARISON OF *BOCCARDIA COLUMBIANA* BERKELEY AND *BOCCARDIA PROBOSCIDEA* HARTMAN (ANNELIDA, POLYCHAETA)

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## Introduction

*Boccardia columbiana* and *B. proboscidea* are morphologically separable on only one recognizable characteristic; the first segment has a conspicuous notopodial setal fascicle in the first species and a greatly reduced one in the second species. *Boccardia columbiana* Berkeley (1927) first described from Vancouver Island, British Columbia, occurs in shaly rock where it drills galleries. *Boccardia proboscidea* Hartman (1940) first described from central and southern California occurs in minute burrows penetrating shale and limestone reefs. The descriptions of the two species are nearly identical morphologically and ecologically, differing mainly in geographical location, the first in latitudes 49° to 50° N, the second in 34° to 39° N. This geographical isolation has been eliminated, however, because *B. proboscidea* has been noted northward to Oregon (Hartman, 1944; Hartman and Reish, 1950) and Vancouver Island (Berkeley and Berkeley, 1950, 1952). Hartman (1940: 385) had suggested for *Boccardia proboscidea*, ". . . its range may extend north to Puget Sound, Wash."

Since 1927, *B. columbiana* had been reported only from the original locality; it is herein recorded south to central California. Its distribution overlaps that of *B. proboscidea* and their ranges are nearly identical. It is significant also that these species occur together in the shale-limestone and in non-shaly habitats.

## Purpose

*Boccardia columbiana* and *B. proboscidea* are similar in range, habitat, and morphology. It is the purpose of this paper to review similarities and emphasize the few differences in their morphology, range, and habitat. As an aid to identification, a key (see below) distinguishes all *Boccardia* species known from the Pacific coast of the United States and Canada.

[1] Fresno, California

## ACKNOWLEDGMENTS

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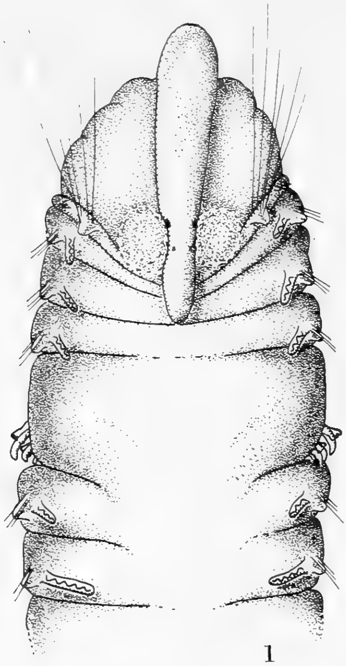
## MORPHOLOGY

*Boccardia* Carazzi, 1895, is a genus of Spionidae, Polychaeta, Annelida. It belongs to the polydorid spionids in which a modified fifth segment contains enlarged and specialized setae. A pair of palpi used in feeding is located anteriorly and branchiae begin on segments anterior to the modified fifth segment. Bidentate hooded hooks appear first in the neuropodium of segment 7.

*Boccardia columbiana* and *B. proboscidea* are similar in that they have a rounded prostomium; this with its caruncle extends back to the posterior margin of segment 3 (Figs. 1 and 2). Both species may have pigmentation laterally along the prostomium and at the edges of the palpal grooves. Branchiae are present on segments 2, 3, 4, –, 6, and 7 and posteriorly but the last few segments lack them. Hooded hooks begin on segment 7. Segment 5 is comparable in being well developed, larger than preceding and succeeding segments and modified. It lacks branchiae, anterior dorsal setae, and setal lobes, but has a double row of specialized setae (Figs. 3 and 4). They are of two kinds, a heavy falcate spine alternates with a bushy-topped spine (shown in original descriptions). Berkeley (1927, Pl. I, Fig. 6) showed an additional kind not found in any of the specimens examined by me. Its appearance suggests super-imposition of the two kinds of setae. No differences were found between the specialized setae of the respective species.

Late larval forms, early adults, and mature specimens have comparable lateral pigment spots on segments 7 and 8. These spots are located between notopodia and neuropodia; they are pronounced in younger forms and still visible on mature adults.

The two species are different in that adult *Boccardia columbiana* specimens have an average length of 12.0 mm. and a maximum of 15.0 mm.; adult *B. proboscidea* are more than twice as large, they measure 30.0 and 35.0 mm. In *B. columbiana* the first notopodium is well developed with many fine capillary setae spread out in a fan-shaped arrangement; their distal ends extend forward beyond the anterior limit of the prostomium and peristomium (see Fig. 1). The setae of segment 1 are best seen under reflected light and after the palpi have been removed from the specimen. In *B. proboscidea* the notopo-



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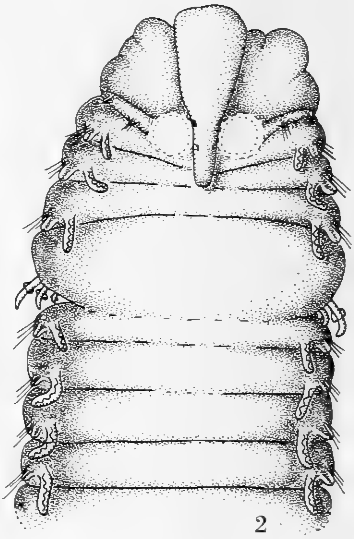

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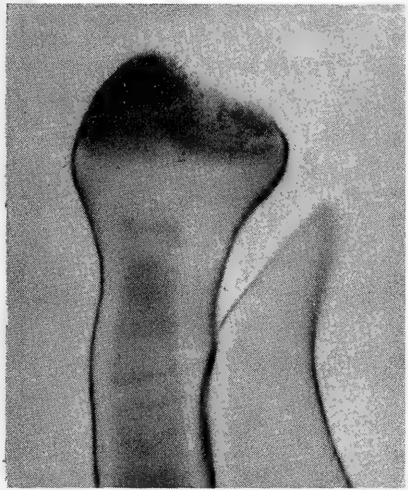
*Figure 1. Boccardia columbiana*, anterior end (x70)

*Figure 2. Boccardia proboscidea*, anterior end (x50)

dium is weakly-developed, it has only a few short setae and a small post-setal lobe; its neuropodium is also poorly developed (see Fig. 2).

Specimens of both species were taken from piling material at Cayucos, central California; they measured 6.0 to 8.0 mm. long. *Boccardia proboscidea* was more heavily pigmented in the region of the prostomium and also on the dorsal surface of segments 2 and 3. *Boccardia columbiana* showed only one of 11 specimens with a heavily pigmented prostomium and none had dorsal pigment on segments 2 and 3. Generally, the largest *B. proboscidea* from the piling material had the greatest amount of pigment; however, specimens (15.0 to 17.0 mm.) from the back bay marina mud in Morro Bay showed very little pigmentation even along the prostomium. The forms thus are similar in general pigmentation but the amount and distribution may vary between and within the species according to age, habitat, and possibly method of preservation. It has not been possible to ascertain a definite pattern of pigmentation for all members of either form.



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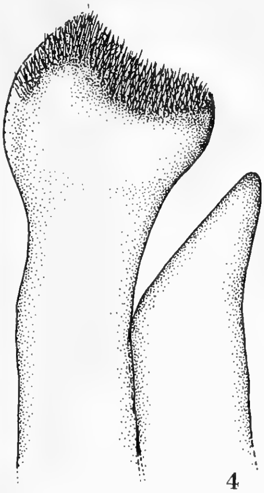

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*Figure 3. Boccardia proboscidea,* photomicrograph of modified setae of Segment 5 (x500)

*Figure 4. Boccardia proboscidea,* modified setae of Segment 5 (x500)

*Boccardia columbiana* is anteriorly attenuated with the peristomium tapered towards the tip of the prostomium. *Boccardia proboscidea* has a squared-off appearance with a broader, blunter peristomium. The appearance of the anterior end varies, however, and is more useful in comparing mature adult forms than younger stages.

## GEOGRAPHICAL AND ECOLOGICAL DISTRIBUTION

*Boccardia columbiana* has been reported previously from only British Columbia; its range is here extended to central California. *Boccardia columbiana* has been found at Monterey, Cambria, Cayucos, and Santa Barbara, all in California. Berkeley (1927) reported it usually boring in shaly rock. It is now reported in a number of habitats including sandy material in and on wood pilings, sand between barnacle tests on pilings, sand tubes in an algal holdfast from mid-tide (worms had penetrated and eroded the algae in many places), sponge from the underside of rock in low tide, between closely applied branches of the holdfast of a kelp, *Postelsia palmaeformis* Ruprecht, surface of rock in close spatial relationship with *Phragmatopoma californica*

(Fewkes), coralline algae (*Lithophyllum* sp.), and galleries bored in shells of several different kinds of gastropods.

*Boccardia columbiana* was found in *Tegula funebralis* (Adams) shells inhabited by *Pagurus samuelis* (Stimpson) and *Purpura foliata* Martyn and *Olivella biplicata* (Sowerby) inhabited by *Pagurus granosimanus* (Stimpson). It was also found in *Acanthina spirata* (Blainville) and *O. biplicata* inhabited by *P. samuelis*. In one specimen of *A. spirata* from Santa Barbara it was associated with two other polydorids, *B. proboscidea* and *Polydora ciliata* (Johnston); in an *O. biplicata* also from Santa Barbara it was associated with *Polydora commensalis* Andrews, *P. ciliata*, and *Polydora limicola* Annenkova. *Boccardia columbiana* also occurred in borings in shells of living *Diodora aspera* (Eschsholtz) and with *B. proboscidea* in *Jaton festivus* Hinds. It was further found that *B. columbiana* was present in *T. funebralis* shells inhabited by the gastropod itself, in empty shells, and in shells containing hermit crabs.

*Boccardia proboscidea* has been described from California, Oregon, and British Columbia. Its distribution is extended here only to other areas of California including Santa Barbara, Goleta, Cayucos, Fort Bragg, and Humboldt Bay. It occurred in sandstone reefs with pholids and sipunculids at Santa Barbara and in similar material at Goleta in the warm water of a high tide pool. At Fort Bragg it was found in crevices in graywacke sandstone as a co-habitant of narrow ledge tide pools with a copepod, *Tigriopus californicus* (Baker).

*Boccardia proboscidea* has also been found in soft sandy mud at Ballona Creek near Venice, Los Angeles County, and more recently from mud in the boat slips at Morro Bay and from mud flats of Humboldt Bay. It also was found in mucous tubes in sand at the base and among the branches of upright branching coralline algae, on the surface of intertidal rocks with *Phragmatopoma californica*, in holdfasts of *Macrocystis integrifolia* Bory and *Phyllospadix scouleri* Hooker, on the sandy bottom of inner Santa Barbara harbor in areas of considerable pollution, and at Cayucos and Santa Barbara from piling material which included *Balanus* spp. and *Mytilus* spp. as the dominant animals. At Goleta it was found at the base of large *Mytilus californianus* Conrad growth on the outer side of a rocky intertidal reef. Many specimens were found in pink coralline algae (*Lithophyllum* sp.) which encrusts intertidal rocks at Cayucos. *Boccardia proboscidea* erodes the algae in forming its tube or nestles in pockets between lamellae of the coralline where it gathers sand and silt. It may gather with other polydorids to form pockets of worms. *Boccardia columbiana* and *B. tricuspa*

Hartman are associates here; the former has the same habits as *Boccardia proboscidea* but the latter erodes and drills the coralline, producing cleaner burrows with no concentrations of associated sand and silt.

*Boccardia proboscidea* has also been found in gastropod shells inhabited by hermit crabs. It occurs with *Pagurus samuelis* in *Tegula funebralis* and *T. brunnea* shells at Cayucos, *Jaton festivus* and *Acanthina spirata* shells at Santa Barbara, and with *Pagurus granosimanus* in *Olivella biplicata* shells at Cayucos. Present with this species in *Tegula brunnea* was *Boccardia columbiana* and *Polydora ciliata.* In some cases *B. proboscidea* merely nestles in the damaged apex of the gastropod shells but in others it erodes and drills the shell material.

A living *Mytilus californianus* from rocks on the ocean side of the breakwater at Santa Barbara Yacht Harbor contained a *B. proboscidea* nestled in a pocket produced by a fracture between lamellae of the shell. The worm tube opened at the external edge of the shell following the spatial pattern characteristic of the blister worm, *P. websteri* Hartman, which occurs in oysters.

## SUMMARY AND DISCUSSION

*Boccardia columbiana* and *B. proboscidea* have been found in the Eastern Pacific at British Columbia in the north, and central California in the south and at intermediate localities. Both occur in sandstone crevices, piling material, algal holdfasts, coralline algae, surface of rocks with *Phragmatopoma californica,* and in gastropod shells. They occur in living gastropod shells, in shells inhabited by hermit crabs, and in empty shells. Thus, the worms do not have an obligatory commensal relation with the hermit crabs.

Although both species occur farther north in open surf regions, *Boccardia columbiana* is the dominant form in this habitat. *Boccardia proboscidea* was the dominant form in piling material from the quiet waters inside Santa Barbara Yacht Harbor. *Boccardia columbiana* has not been found in the sand-mud flat environment in which *B. proboscidea* flourishes at Ballona Creek, Morro Bay, and Humboldt Bay.

Morphologically the two species differ in the arrangement of setae of segment 1; this is the only characteristic consistently usable. Certain pigmentation patterns and the general aspect of the anterior end may be of use in preliminary sorting of mature adults, but in general the younger adults of *B. proboscidea* resemble more the features ascribed to *B. columbiana* than those of their own adults.

An unresolved problem of morphology associated with plankton studies is the determination of the stage in development at which the notosetae of segment 1 assume the adult appearance. If this occurs only at settling, free-swimming larval forms of the two species would be indistinguishable. *Boccardia columbiana* has not been investigated as to its development and larval characteristics. Hartman (1940, 1941) gave information on the development of *Boccardia proboscidea.*

Nine species of *Boccardia* are known from the north eastern Pacific; they comprise about two-thirds of the world's known species of the genus (Hartman, 1959: 375). Of the nine, six were originally described from this region. The north eastern Pacific, thus is unlike the Atlantic coast of the United States where members of *Polydora* are dominant and the central Pacific which has a greater representation of *Pseudopolydora* species. A key to the nine species of *Boccardia* is given below.

## Key to *BOCCARDIA* Species From The Northeastern Pacific

| | | |
|---|---|---|
| 1. | Modified 5th segm.—branchiae lacking ant. to Segm. 5 | 2 |
| 1a. | Modified 5th segm.—branchiae present ant. to Segm. 5 | *(Boccardia)* 3 |
| 2. | Neuropodial hooded hooks begin on Segment 7 | *Polydora* |
| 2a. | Neuropodial hooded hooks begin on Segment 8 | *Pseudopolydora* |
| 3. | Specialized setae of Segment 5—of one type | 4 |
| 3a. | Specialized setae of Segment 5—of two types | 6 |
| 4. | Anterior branchiae on Segments 2, 3, –, –, –, 7 | *Boccardia redeki* |
| 4a. | Anterior branchiae on Segments 2, 3, –, –, 6, 7 | 5 |
| 5. | Posterior notopodial hooks present | *Boccardia uncata* |
| 5a. | Posterior notopodial hooks absent | *Boccardia truncata* |
| 6. | Setae of Segment 5—Falcate and tridentate | *Boccardia tricuspa* |
| 6a. | Setae of Segment 5—Falcate and bushy-topped | 7 |
| 7. | Prostomium rounded | 8 |
| 7a. | Prostomium bifid | 9 |
| 8. | Notosetae of Segment 1– long, in fan-shaped group | *Boccardia columbiana* |
| 8a. | Notosetae of Segment 1– short, not so disposed | *Boccardia proboscidea* |
| 9. | Posterior hooded hooks mainly falcate | *Boccardia basilaria* |
| 9a. | Posterior hooded hooks bidentate | 10 |
| 10. | Notosetae present on Segment 1 | *Boccardia natrix* |
| 10a. | Notosetae absent on Segment 1 | *Boccardia polybranchia* |

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# NEW SPECIES OF *HYPERODES* JEKEL AND A KEY TO THE NEARCTIC SPECIES OF THE GENUS. (COLEOPTERA: CURCULIONIDAE)[1]

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## Introduction

In the course of an extended study of the weevils of the genus *Hyperodes*, the species described below were recognized as being new to science. I had planned to publish the descriptions of the new forms as a part of a longer paper on which work is not yet completed, but at the request of fellow workers, who wish to have the names available for reporting data of economic importance, I have decided to publish descriptions at this time. To facilitate studies by workers who may have to deal with members of this somewhat difficult group, I am also including a key to those species which have been encountered in North America north of Mexico.

## Abbreviations

The following abbreviations have been used in the present paper to indicate the locations of specimens examined:

(USNM) Collection of the United States National Museum
(ELS) Collection of Dr. E. L. Sleeper
(WDS) Collection of the author
(CU) Collection of Cornell University
(CARN) Collection of the Carnegie Museum
(HFH) Collection of Mrs. H. F. Howden

## Descriptions of New Species

### **Hyperodes wallacei,** new species

*Holotype:* Rostrum shorter than prothorax, stout, broad, flattened above; tricarinate, densely clothed with dull grayish-yellow scales, bearing four rows of short, stout, setae; underside with filiform scales, apex bearing a few long bristles. Antennae reddish brown, segments one and two of funicle subequal, the first stouter, other funicular segments moniliform, gradually becoming broader toward the club, all

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the segments with a few fine bristles; club oval, covered with fine dense pubescence, bearing scattered longer bristles; obscurely three-segmented. Scrobes deep, slightly widened posteriorly, upper margins impinging against upper edge of eyes. Head with many round and a few strap-shaped, yellowish metallic scales. Frontal fovea moderate, ocular lobes feeble. Prothorax wider than long, sides moderately rounded, slightly constricted at apex, densely clothed with yellowish brown scales which are minutely granulose; a median and two lateral vittae of paler scales, all these vittae rather vague and ill-defined; an indication of a depressed line, almost a sulcus, along median vitta; a scattering of short, stout, clavate setae on the disc of the prothorax. Scutellum oval, clothed with tiny, white scales. Elytra slightly emarginate at base, densely clothed with yellowish-brown scales, larger than those of prothorax; striae well-impressed, punctures deep, remote; intervals convex, even-numbered ones more so, these with a row of stout, clavate setae; apices of elytra separately rounded and prolonged. Pro- and mesothoracic sterna densely clothed with small filiform scales medially, giving way to round scales at the sides; metasternum with round scales laterally, glabrous medially, coarsely and densely punctate and with numerous fine hairs. Abdominal sternites coarsely punctured, with fine hairs arising from the punctures. Apex of last sternite of male not impressed. Legs rather densely clothed with round scales, sparsely pubescent; tibiae denticulate and setigerous within, with feeble mucro. Tarsi densely pubescent beneath, sparsely so above.

The female of this species is unknown.

*Notes and Discussion:* Holotype, male, (USNM), labelled as follows: "Dunellon, Fla., Jun. 12, 1939, Oman". One paratype, male, (CARN); three paratypes, males, (HFH); one paratype, male, (CU); two paratypes, males, (USNM); two paratypes, males, (ELS), labelled as follows: "Alachua Co., Fla.; 27-vii-54; H. V. Weems, Jr.; taken at light": Total length, 3.9 mm.; pronotal length, 0.9 mm.; pronotal width, 1.2 mm.; elytral width, 1.7 mm.;: "Monroe Co., Fla.; v-1-53; N. J. and E. L. Sleeper, Collrs.": Total length, 3.8 mm.; pronotal length, 0.8 mm.; pronotal width, 1.0 mm.; elytral width, 1.8 mm.; one paratype, male, (WDS), labelled as follows: "Swan Quarter, N. C.; vii-22-1953; W. M. Kulash; light trap". Total length, 3.7 mm.; pronotal length, 0.7 mm.; pronotal width, 1.0 mm.; elytral width, 1.5 mm. The range in total length for all specimens which I have had the opportunity to examine is from 3.7 mm. to 4.7 mm.

This species bears certain superficial resemblances to both *H. alter-*

*nata* and *H. annulipes*. and agrees in many respects with the published description of *H. peninsularis*. However, the short, stout beak of the present species is distinctive, as is the general habitus of the weevil itself, and I see no choice but to establish a new species for the individuals I have studied which seem to belong together in agreeing with the above description.

I am glad to have the opportunity to express my appreciation for the generous cooperation of Dr. George E. Wallace of the Carnegie Museum throughout the course of my studies on *Hyperodes* by dedicating this species to him.

*Specimens Examined:* (USNM) 3 (CU) 1; (HFH) 3; (ELS) 2; (WDS) 1.

*Distribution: Florida*—Dunellon; Gainesville; Miami; Paradise Key; Pensacola: Monroe Co.; Alachua Co.

*North Carolina:*—Swan Quarter.

*Biological Notes:* Taken in light trap at Swan Quarter, North Carolina by W. M. Kulash, also at light by H. V. Weems, Jr. in Alachua Co., Florida. Swept from grass by N. J. and E. L. Sleeper in Monroe Co., Florida.

It will be noted, as is true in many new species of insects, that not too much is known of the biology of this species, nor of the other species considered in this paper.

### **Hyperodes texana,** new species

*Holotype:* Rostrum shorter than prothorax, stout, flattened above, tri carinate, the median carina the strongest; densely clothed above with round scales, densest toward the base; four rows of erect, yellowish setae, two on each side of the median carina; anteriorly the round scales give way to dense, metallic, yellow, semi-recumbent, filiform ones; apex with a few strong bristles; ventral surface with fine pubescence. Antennae reddish brown, scape clavate, segments one and two of funicle subequal, the first stouter; remaining funicular segments moniliform, widening gradually toward the club, with fine pubescence and a few stronger bristles; club oval, finely pubescent, obscurely three-segmented; scrobes rather deep, slightly widened posteriorly. upper edge impinging against top of eye. Head densely clothed with yellow, metallic, strap-shaped scales; frontal fovea deep, receiving the median carina of rostrum. Prothorax wider than long, sides broadly rounded, densely covered with round, yellowish scales which are minutely granulose; a median and two lateral vittae of paler scales; disc of prothorax with scattered, rather short, slender setae; ocular lobes moderate; scutellum oval, covered with tiny white scales. Elytra moderately emarginate at base; densely scaly, the scales brownish yellow in color; striae well impressed, punctures deep, rather remote; intervals moderately convex, each with a row of short, slender, slightly clavate setae; tips of elytra conjointly rounded. Thoracic sterna densely scaly, both round and filiform whitish scales, restricted to the lateral edges of the metasternum; metasternum and abdominal sternites coarsely, densely punctured, and with fine, pale, sparse pubescence; last four abdominal sternites lighter in color; apex of last sternite of male with a vague, broad impression. Legs light reddish brown, sparsely pubescent; femora with a ring of yellowish scales distally; tibiae more strongly setose, with scattered round scales, denticulate and setigerous within, with rather a strong mucro. Tarsi densely pubescent beneath and with fine, pale, sparse pubescence above.

*Allotype:* Similar in almost all respects to the male holotype, the chief visible difference being that the apex of the last sternite of the female is deeply foveate and emarginate.

*Notes and Discussion:* Holotype, male, and allotype, female, (USNM). The two specimens are mounted on separate points on the same pin which also bears the following labels: "McAllen, Texas; III-2-45; Fraser & Ball; reared in parsley; 45-8847". Eight paratypes (USNM). One paratype, male, (WDS), labelled exactly as is the holotype and allotype. Total length, 4.5 mm.; pronotal length, 1.0 mm.; pronotal width, 1.2 mm.; elytral width, 1.8 mm. One paratype, female, (WDS), labelled exactly as is the male paratype. Total length, 4.3 mm.; pronotal length, 0.8 mm.; pronotal width, 1.1 mm.; elytral width, 1.8 mm. I have named this species in deference to the fact that most of the specimens I have examined have come from the state of Texas. It bears superficial resemblances to *echinata*, *sparsa*, and *rotundicollis*, but the male genitalia are distinct. The size range in specimens I have examined is from 4.0 to 4.7 mm. in total length.

*Specimens Examined:* (USNM) 108; (WDS) 2.

*Distribution: Louisiana*—Deeville; Violet; Chalmette; Meraux; New Orleans.

*Texas*—McAllen; Mission; San Juan; Weslaco; Santa Maria.

*Biological Notes:* This species has been reared from parsley at Violet, Louisiana; Deeville, Louisiana; and McAllen, Texas. It has been found in dill roots and stems at Mission, Texas, and on celery stems at San

Juan, Texas. It has been reared from carrot roots at McAllen, Texas, and was collected from dead egg-plants (leaves) at New Orleans, Louisiana. Miss Warner of the U.S. National Museum informs me (personal communication) that a species she determined as *Hyperodes texana* has been reported to be doing considerable damage to carrots in the lower Rio Grande Valley of Texas.

### **Hyperodes hoodi,** new species

*Holotype:* Rostrum shorter than prothorax, broad, stout, flattened above, tricarinate, the median carina strongest, densely clothed with round brownish scales and lighter colored filiform ones; four rows of slender, erect, rather inconspicuous setae; underside with stiff, yellow, hair-like scales, a few longer bristles at apex. Antennae reddish brown, segments one and two of funicle subequal, both slightly clavate, other funicular segments with numerous rather strong bristles; club slender, oval, clothed with fine pale pubescence. Scrobes deep, suddenly widened posteriorly, upper margins impinging against upper part of eye; frontal fovea deep, receiving the median carina of the rostrum. Head densely clothed with yellowish, strap-shaped scales. Prothorax slightly wider than long, sides broadly rounded, ocular lobes weak, apex slightly compressed; densely clothed with rounded dull-brown scales; a median and two lateral vittae of paler scales; setae sparse, slender, inconspicuous; scutellum oval, clothed with tiny white scales. Elytra emarginate at base; striae well-impressed, punctures deep, remote; intervals slightly convex, each with a row of slender, dark, semi-recumbent, inconspicuous setae; tips conjointly rounded; elytra densely clothed with dull-brown scales, mottled with patches of paler ones, all the scales minutely granulose. Thoracic sterna densely clothed with small, dirty-looking scales, giving way to round ones laterally on the metasternum. Abdominal sternites densely and finely punctured, with a fine, pale hair arising from each puncture; apex of last sternite of male not impressed. Femora sparsely haired, with a band of dull brownish scales distally; tibiae more densely setose, without scales, denticulate within. Tarsi densely pubescent beneath, with rather stiff, fine bristles dorsally.

*Allotype:* The apex of the last abdominal sternite of the female is marked with a broad, rather indistinct concavity. Otherwise the sexes are very similar.

*Notes and Discussion:* Holotype, male, in the collection of (USNM). The specimen bears the following label: "BRIT. AMER.". Allotype, female, (USNM), same label as the holotype. Seven paratypes, 5 males, 2 females, (USNM). One paratype, male, (WDS), total length, 4.7 mm.; pronotal length, 1.0 mm.; pronotal width, 1.2 mm.; elytral width, 1.9 mm.; same label as all other type material. I am unable to restrict the type locality at the present writing. Range is from 4.2 mm. to 4.9 mm. in total length.

This species resembles both *sparsa* and *echinata* in general habitus, but the male genitalia seem to prove conclusively that it is distinct.

It is with great esteem that I dedicate this species to my good friend and wise counselor in many a taxonomic difficulty, Dr. J. Douglas Hood of Cornell University.

*Specimens Examined:* (USNM) 9; (WDS) 1.

*Distribution:* "British America".

*Biological Notes:* Nothing is known of the biology.

### **Hyperodes dietrichi,** new species

*Holotype:* Body surface black and shining. Rostrum about as long as prothorax, tricarinate, the median carina strongest, coarsely punctured and rugose, slightly narrowed at middle, wider at base and apex; bearing long slender setae which are dark on the dorsal portion of the rostrum and light-colored and finer on the ventral surface; numerous fine, yellowish, recumbent, filiform scales scattered over the dorsal surface; a few long, pale bristles at apex; rostrum without round scales. Antennae reddish brown, the scape clavate, segments one and two of funicle subequal in length, the first stouter, remaining segments of funicle subequal, moniliform; club slender, oval, and covered with fine, short hairs, obscurely three-segmented; all the antennal segments bear scattered, rather strong bristles; upper margin of scrobe impinges against upper margin of eye; scrobes well-defined, scarcely widened posteriorly. Head coarsely, densely punctured, the punctures bearing very fine pale hairs; head without strong setae; frontal fovea profound, receiving median carina of rostrum. Prothorax with sides and base strongly rounded, slightly wider than long, apex slightly constricted; coarsely, confluently punctate, bearing many slender, recumbent hairs and numerous erect, slender, bristle-like setae; a vague median and stronger lateral vittae of yellowish round scales, the scales minutely granulose. Scutellum small, oval, covered with tiny pale scales. Elytra slightly emarginate at base; striae well-impressed, the punctures large and close-set; intervals slightly convex, each with a row of long, slender, bristly setae; elytra rather sparsely covered with pale yellowish scales, these thicker laterally and on the declivity; tips of elytra conjointly rounded. Thoracic sterna coarsely punctate. with sparse, small, dirty-yellow scales and numerous hair-like setae. Abdominal sternites rather coarsely punctured, bearing sparse. coarse pubescence, both punctures and pubescence finer on terminal segment; segments three and four narrow; apex of last ventral segment not impressed. Femora darker than tibiae, bearing sparse, fine, pale hairs; tibiae reddish brown, more heavily setose than femora, denticulate and setigerous within, with rather strong mucro, hind tibiae with a brush of long, flying hairs. Tibiae concolorous with tarsi, latter densely pubescent beneath.

*Allotype:* The female has at the apex of the last abdominal sternite a small, well-marked fovea and lacks the brush of long flying hairs on the hind tibiae. Other characters agree very closely with those described for the male.

*Notes and Discussion:* Holotype, male, (ELS, no. 73), labelled as follows: "San Magarita, C. Z., Panama"; "V-15-46"; "E. L. Sleeper, Collr." Total length, 3.2 mm.; pronotal length, 0.7 mm.; pronotal width, 1.1 mm.; elytral width, 1.6 mm. Allotype, female, (ELS). labelled the same as the holotype; total length, 3.3 mm.; pronotal length, 0.8 mm.; pronotal width, 0.9 mm.; elytral width, 1.4 mm. One paratype, female, (ELS), labelled as follows: "San Blas, Nayarit, Mexico"; "VII-14-60"; "R. B. Loomis and J. Maris, collectors." Total length, 3.2 mm.; pronotal length, 0.8 mm.; pronotal width, 0.9 mm.; elytral width, 1.4 mm. One paratype, male, (USNM), labelled as follows: "Mexico, II 13 45, Laredo, Tex."; "H. R. Cary, on orchid plant. 45-3653"; "Hyperodes sp., LLB '45." Total length, 3.5 mm.; pronotal length, 0.9 mm.; pronotal width, 1.1 mm.; elytral width, 1.6 mm.

I am unable to match my specimens with any of Champion's species, described in the "Biologia Centrali-Americana," nor with any form in the Nearctic fauna of the genus, so that I have little hesitation in considering this to be a new species. I am herein restricting the type locality to San Magarita, C. Z., Panama. I felt that it was wise to discuss the present species in this paper, along with the other, undoubted, Nearctic species, since it is very probably represented in other collections in the United States.

*Specimens Examined:* (USNM) 1; (ELS) 3.

*Distribution: Texas*—Laredo.

*Mexico*—San Blas; PANAMA—San Magarita, C. Z.

*Biological Notes:* Dr. Sleeper (personal communication) took the holotype and allotype on orchid flowers at San Magarita. The female paratype (ELS) was taken with blacklight apparatus at San Blas. The male paratype (USNM) was taken on orchid at Laredo.

It gives me great pleasure to dedicate this handsome species to my kindly mentor and good friend, Dr. Henry Dietrich of Cornell University.

## KEY TO THE NEARCTIC SPECIES OF *Hyperodes*

1\. Rostrum at least as long as or longer than prothorax .................. 2
1a. Rostrum shorter than prothorax, stout, flattened above ............... 15

2\. Second segment of funicle appreciably longer than the first, latter clavate, top-shaped ..................................................... 3
2a. Second segment of funicle at most only slightly longer than the first, the latter slender, but stouter than the second ......................... 5

3\. Prothoracic scales moderate in size; elytral setae inconspicuous ......... 4
3a. Prothoracic scales large; pronotum cribately punctured; elytral setae conspicuous ............................................. *cryptops*

4\. Prothorax sub-cylindrical, sides almost straight; scales not metallic *delumbis*
4a. Prothorax sub-orbicular, sides broadly rounded; scales of dorsum with metallic luster ........................................... *decepta*

5\. Alternate elytral intervals setose .................................. 6
5a. Each elytral interval with a row of setae, at least on the declivity ........ 8

6\. Elytral setae long, moderately clavate ............................... 7
6a. Setae short, strongly clavate, semi-recumbent ................ *annulipes*

7\. Prothorax with sides broadly rounded ....................... *alternata*
7a. Prothorax with sides almost straight; femora ringed with a band of large, ocellate, silvery-white scales ............................. *peninsularis*

8\. Vestiture rather sleek, smooth-looking; scales with metallic or pearly luster ...................................................... 9
8a. Vestiture rough; scales not metallic or nacreous ...................... 10

9\. Prothorax moderately rounded; scales with metallic luster ...... *hyperodes*
9a. Prothorax with sides very broadly rounded; scales of head, rostrum, and legs with pearly luster ..................................... *grypidioides*

10\. Large species; over 5 mm. in length ...................... *laramiensis*
10a. Smaller; less than 5 mm. ......................................... 11

11\. Prothorax with sides almost straight; ventral surface of abdomen densely scaly ...................................................... *vitticollis*
11a. Prothorax with sides broadly rounded; ventral surface of abdomen not covered with dense scales ........................................... 12

12\. Opaque; very dull and dark-colored; scales very rough-looking; setae very conspicuous ................................................ *horni*
12a. More shining, not as dull or dark; scales more smoothly arranged; setae not conspicuous ............................................... 13

13. Setae moderately clavate; head thickly clothed with small scales, paler than those of prothorax . . . . . . . . *montana*
13a. Setae slender, not clavate . . . . . . . . 14

14. Median vitta of prothorax composed of a double line of yellowish, rather shining scales . . . . . . . . *dorsalis*
14a. Median vitta obsolete . . . . . . . . *poseyensis*

15. Body clothed with squamiform scales; not pubescent on the dorsal surface 16
15a. Body clothed above with coarse pubescence . . . . . . . . 30

16. Upper edge of scrobe directed toward middle of eye . . . . . . . . 17
16a. Upper edge of scrobe directed toward top of eye . . . . . . . . 22

17. Elytral scales very tiny, not concealing the surface; surface very shining; elytral setae small, almost invisible . . . . . . . . 18
17a. Elytral scales not tiny; elytral setae conspicuous . . . . . . . . 19

18. Rugosities of rostrum with scattered punctures . . . . . . . . *lodingi*
18a. Rugosities smooth, impunctate . . . . . . . . *carinata*

19. Each elytral interval setose; elytra densely scaled . . . . . . . . 20
19a. Alternate intervals setose; elytra sparsely scaled . . . . . . . . *latinasa*

20. Frontal fovea absent . . . . . . . . *obtecta*
20a. Frontal fovea present . . . . . . . . 21

21. Elytral setae stout, dense, clavate . . . . . . . . *hirtella*
21a. Elytral setae slender, sparse, not clavate . . . . . . . . *echinata*

22. Surface of body very shining, not densely scaly; prothorax coarsely punctate; hind tibiae of male with a brush of long, flying hairs . . . . . . . . 23
22a. Surface densely scaly; prothorax with a granular appearance; male without a brush of long hair on the hind tibiae . . . . . . . . 24

23. Alternate elytral intervals setose; setae clavate . . . . . . . . *humilis*
23a. Each elytral interval setose; setae long, slender, bristle-like . . . . . . . . *dietrichi*

24. Alternate elytral intervals with setae; apex of each elytron separately prolonged . . . . . . . . 25
24a. Each interval setose; elytra conjointly rounded . . . . . . . . 26

25. Setae rather long, slender, slightly clavate; head clothed with filiform, yellowish scales . . . . . . . . *sparsa*
25a. Setae short, stout, strongly clavate; head clothed with both round and filiform scales . . . . . . . . *wallacei*

26. Setae long, slender bristle-like . . . . . . . . *novella*
26a. Setae shorter; body densely scaly . . . . . . . . 27

27. Prothorax with sides almost straight; setae stout, rather conspicuous; elytral intervals sub-costate . . . . . . . . *obscurella*
27a. Prothorax with sides broadly rounded; setae slender, inconspicuous; intervals at most moderately convex . . . . . . . . 28

28. Scales of head fine, hair-like, sparse . . . . . . . . *rotundicollis*
28a. Scales of head strap-like, dense . . . . . . . . 29

29. Color light yellowish-brown; prothoracic vittae conspicuous; elytral setae moderately strong . . . . . . . . *texana*
29a. Color dull, dark brown; vittae and setae inconspicuous . . . . . . . . *hoodi*

30. Pubescence very sparse; surface of body shining .................... 31
30a. Pubescence rather dense; surface of body dull, opaque ................ 32

31. Larger; median prothoracic carina strong .................... *anthracina*
31a. Smaller; median carina variable, never very strong, sometimes obsolete; scrobes not greatly widened posteriorly ....................... *porcella*

32. Prothoracic carina short, abbreviated before and behind ....... *maculicollis*
32a. Carina entire, linear ....................................... *californica*

## ACKNOWLEDGMENTS

It gives me great pleasure to acknowledge, in addition to the appreciation expressed above under the individual species, the generous encouragement and unstinting help of my colleagues of the Biology Department of Long Beach State College, particularly Dr. Elbert L. Sleeper, Dr. James H. Menees, and Dr. Richard B. Loomis. I am also most grateful to Dr. David K. Caldwell of the Los Angeles County Museum for his aid during the preparation of the manuscript of this paper for publication.

# NEW INFORMATION ON THE STRUCTURE OF PERMIAN LEPOSPONDYLOUS VERTEBRAE—FROM AN UNUSUAL SOURCE[1]

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## Introduction

Records of the variety of vertebrate fossils from given horizons and localities are frequently exaggerated in their proportions of large animals. Skeletal elements of very small vertebrates are much less commonly found in the usual prospecting and quarrying operations than are large, conspicuous elements. The reasons for this are obvious. Small, delicate elements are undoubtedly not readily preserved, especially during the deposition of coarse sediments; but an even more important reason is that the collector is likely to overlook the smaller elements in the usual field and laboratory procedures. This bias has been largely overcome in recent years through the development of various methods of washing and screening (see McKenna, 1962). Another solution of this problem has not been employed to the full extent of its possibilities; this method is the careful search for skeletal elements in coprolites.

This method has a number of advantages. First, coprolites are usually large enough to be easily seen and collected, and the collector's eyes do not have to be focused for small elements. Second, the predator or scavenger to whom the coprolite pertains has concentrated and associated the elements. This could provide a valuable means of acquiring more thorough knowledge of animals that are otherwise known from only scattered, isolated elements. Palaeoniscoid fishes, for example, are often known only from such remains, frequently only from scales. Coprolites packed with scales offer the opportunity to study variations in scale structure in individual fossil fishes. One can, of course, rarely be sure that any given coprolite represents only one meal, that is, one individual animal eaten, but consistent association of the same kinds of parts in a number of coprolites can lead to confidence that these parts represent one kind of animal.

Perhaps the most immediately interesting use of coprolites is in the search for new faunal elements. This report presents new information

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that was acquired in this way on the structure and occurrence of Permian lepospondylous amphibians.

## LEPOSPONDYL REMAINS IN A COPROLITE

The Welles quarry near Arroyo de Agua, Rio Arriba County, northern New Mexico is a locality from which parties from the University of California, Berkeley have obtained many well preserved parts of a number of vertebrates (see Langston, 1953). This quarry is in the Cutler formation and is of early Permian (Wolfcampian) age. The Welles quarry, along with two nearby quarries, seems quite clearly to be part of a lake deposit. Its fauna includes pleuracanth sharks, at least one kind of palaeoniscoid fish, several genera of labyrinthodont amphibians, the cotylosaur *Diadectes*, and two genera of pelycosaurian reptiles; there are also small pelecypods and a number of plants. In addition, there are a great number of coprolites, some of which were collected by a party from the University of California, Los Angeles in the summer of 1960.

The coprolites are of many sizes, from as small as 1 cm. long to larger than 11 cm. long. There are a variety of shapes: fusiform, twisted, irregular. Some consist of spirally wound laminae, some of irregularly arranged but faintly concentric laminae. Almost all contain hard parts of vertebrates. Some contain palaeoniscoid scales, often along with small bones and bits of bones. Some contain parts of teeth of pleuracanth sharks. Some contain only unidentifiable fragments of bones. One at least, UCLA VP 1648, contains among other items a small vertebra with a urodele-like haemal arch.

Before preparation was begun, this coprolite (No. 1648) was about 70 mm. long. It was somewhat flattened, with an elliptical cross-section of about 33 mm. by 13 mm. The ends and sides were rounded. A polished transverse section shows irregularly concentric lamination. There are many small, fragile bones scattered throughout the coprolite. These are difficult to prepare, but successful development of a selected few elements was carried out with the use of fine insect pins with points ground to sharp, beveled edges.

A number of vertebral parts are present. One is a fairly complete vertebra a little more than 3 mm. long from the anterior end of the centrum to the posterior end of the neural arch. The transverse diameter of the centrum is slightly less than 1 mm. near the anterior end. The neural arch is rounded above, and the neural spine is represented by only a faint ridge. The transverse process arises from the neural

*Figure 1.* A caudal vertebra found in a coprolite from the lower Permian of New Mexico. UCLA VP 1648. A, dorsal, B, right lateral, and C, ventrolateral views. In the ventrolateral view, only the right side and distal end of the haemal arch can be seen. Unshaded areas represent matrix. x20.

arch in a broad base whose center lies about 1 mm. posterior to the front end of the centrum; it extends directly laterally for about 0.5 mm., narrowing to a single costal articulatory facet slightly less than 0.5 mm. in diameter. The structure of the sides and bottom of the centrum is not clear. Much of the anterior part of the neural arch is missing, and a natural cast of the relatively large neural canal is thereby exposed. On the right side, it can be seen that the neural arch broke away from the centrum along a smooth line that curves lateralwards near the anterior end of the vertebra. This smooth line of parting is shown also by a centrum—lacking the neural arch completely—elsewhere in the coprolite. This indicates the presence of a neurocentral suture.

The most interesting element in the coprolite is the caudal vertebra illustrated in Figure 1. The centrum of this vertebra is about 3 mm. long; the posterior zygapophyses were damaged in preparation, but the distance from the anterior edge of the prezygapophyses to the posterior edge of the postzygapophyses, about 3.5 mm., was measured prior to the damage. The neural arch is swollen to an almost circular cross-section, greater in diameter than the centrum except at the ends of the vertebra. The neural spine is only a slight ridge, commencing about midway along the neural arch and becoming more prominent posteriorly. The dorsal part of the neural arch flares gently to become broader from side to side in the regions of the zygapophyses. The prezygapophyses have horizontal, slightly concave articular facets and are connected to one another via a semicircular notch. As may be seen in the illustration, the right prezygapophysis was chipped along its lateral edge in preparation. Because of breakage, details of structure of the postzygapophyses cannot be described. The smooth concavity of the intervertebral notch for the spinal nerve can be easily made out on the right side between the postzygapophysial area and the centrum. There is no costal facet; presumably this vertebra occupied a fairly far posterior position in the caudal series. Faint traces of the neurocentral suture can be seen, especially near the anterior end. The lateral surfaces of the centrum, unlike the surfaces of the neural arch, are not swollen; a cross-section midway through the centrum would show flat sides. The centrum is somewhat pinched midway in its length and flares at either end to a width approximately equal to that of the neural arch. The ventral surface of the centrum is a broad, shallow trough. Passing away insensibly from the ventrolateral edges of the centrum is a haemal arch. The base of this arch is broad and extends farther anteriorly along the centrum than it does posteriorly; the distal end of the arch is narrower and lies about midway along the length of the centrum.

The caudal vertebra that has been described is very similar to caudal vertebrae in living urodeles. Taking a caudal vertebra of a urodele as, say, *Cryptobranchus* for comparison, the only differences are that in *Cryptobranchus* there is a short neural spine jutting posterodorsally beyond the postzygapophysial area and there is a spike-like posteroventral continuation of the haemal arch. The latter difference may not be real; on the ventral surface of the rounded distal end of the haemal arch of the vertebra in the coprolite can be seen a small area of breakage that may indicate the former presence of such a spike-like distal process.

There are other elements besides vertebrae in the coprolite. These include at least one rib that seems to have both capitular and tubercular facets. There are also a number of what appear to be limb bones and parts of limb bones. One of these seems to be half of a propodial, broken away from the missing half at the narrow waist of the shaft, presumably about midway in the length of the original bone. The preserved half is about 4 mm. long, is about 1.4 mm. thick near its articular end, and is about 0.6 mm. thick at its broken end.

The general similarity of all the various vertebral parts in the coprolite to one another and the general fitness in size of all the elements to one another make it seem likely that they all came from one animal.

## Discussion

Romer (1945) has classified the urodeles and apodans (gymnophionans) along with a number of highly problematical groups of Carboniferous and Permian vertebrates as members of the amphibian subclass Lepospondyli. The order Microsauria, in particular, has presented thorny problems in phylogeny. The microsaurs have been considered variously as possible relatives of the urodeles, of the apodans, and of at least the captorhinomorph suborder of cotylosaurian reptiles (see Vaughn, 1962). The major uniting feature of the Lepospondyli is the presumed common possession of "lepospondylous" vertebrae that arise, as in living members of the subclass, by direct formation of the centra through ossification around the notochord with little or no preformation in cartilage. The lepospondylous vertebra shows no sign of the division into intercentral and pleurocentral parts that characterizes the labyrinthodont amphibians and that is still evident in the vertebrae of reptiles and even mammals, although Williams (1959) feels that the centrum of the living lepospondyls can be equated with the major central element, the pleurocentrum, of living amniotes.

In labyrinthodont amphibians, reptiles and mammals, the haemal arches (chevrons) of the caudal region are outgrowths of intercentra. In urodeles, contrariwise, the haemal arches are outgrowths of the centra and there is no sign of intercentra. It is known that such a "central" haemal arch was present also in the members of the Carboniferous and Permian lepospondylous order Nectridia, an order that includes the well known *Diplocaulus*, but the nectridian haemal arch is quite different from that of urodeles in that the distal portion is long from front to back and flattened from side to side, usually with vertical fluting along the sides; frequently, the nectridian haemal arch is constricted at its base, so that it is fan-shaped in lateral aspect. In nectridians the neural arch in the caudal region looks much like the haemal arch, the total effect being a flattened tail that was obviously of use in sculling locomotion. Except for its "central" position, the haemal arch of the vertebra in the Welles quarry coprolite is not at all like that found in nectridians; it is very much like that seen in living urodeles.

To date, the only lepospondyl of any kind reported from the Permian of New Mexico is the microsaur *Pantylus*, and this is known from only a single mandible found at the Anderson quarry near Arroyo de Agua (Langston, 1953). This is in marked contrast to the number of lepospondyls found in approximately contemporaneous lower Permian deposits in northcentral Texas, whence are known: two genera of Nectridia, a genus of the Lysorophia, and a half dozen genera of the Microsauria, among them *Pantylus* (Romer, 1950a, 1960). The very small size of the vertebrae in the coprolite from the Welles quarry makes it seem highly unlikely that they might pertain to *Pantylus*. Further, Williston (1916) reported caudal vertebrae with *intercentral* haemal arches found in close association with parts of three skulls of *Pantylus* in Texas. As Romer (1950b: 640) has noted, "If the caudal vertebrae figured by Williston are actually those of *Pantylus* they are of considerable theoretic interest in bearing haemal chevrons." The theoretic interest stems from the intercentral position of the chevrons, a condition that would tend to remove microsaurs from the close relationship they have been thought to have with the other orders classified under Lepospondyli. It must be noted, however, that Case (1929) failed to find any trace of intercentra in *Ostodolepsis*, presumably closely allied to *Pantylus*, and that there is no good evidence for intercentra in other microsaurs. Steen (1938) reported poorly preserved intercentral haemal arches in one specimen of the Pennsylvanian microsaur *Microbrachis*, but, as Romer (1950 : 633) has remarked, "Since . . . they do not appear in other individuals of this or in related forms, and since some confusion with caudal ribs is not impossible in a small and poorly preserved specimen, judgment may be suspended on this feature."

Granted that the evidence for intercentral haemal arches in microsaurs is not good, neither is there any reason for believing that they had "central" haemal arches; indeed, there is some indirect evidence that they did not have such arches. Gregory, Peabody and Price (1956) studied microsaurian skulls and postcranial parts from the lower Permian fissure deposits near Fort Sill, Oklahoma. The bones in these deposits are rarely found in articulation, and referral of isolated vertebrae to any particular genus or even larger group is difficult. The microsaurian atlas seems to be represented by several strikingly urodele-like specimens (*op. cit.:* 43) The dorsal vertebrae that seem to belong to microsaurs differ from those of urodeles in that the transverse processes arise from near the front of the neural arch and bear only one articular facet, in that there is a neurocentral suture, and in other, less obvious ways. In these same fissure deposits were found a number of caudal vertebrae that were referred to the microsaur *Cardiocephalus* with "great hesitation" (*op. cit.:* 46-47) because "The only features that distinguish these from known caudal vertebrae of [the cotylosaur] *Captorhinus* are their smaller size and the absence of any trace of the transverse fissure permitting autotomy of the tail. . . ." Nevertheless, in spite of the uncertainty in identification of these vertebrae, it must be noted that no caudals were found with any trace of "central" haemal arches. For this reason, as well as the caution prompted by Williston's report of intercentral chevrons in *Pantylus*, it would seem to be unwise at this time to suppose that the vertebrae in the Welles quarry coprolite represent a microsaur.

This leaves us with no known order to which the vertebrae in the coprolite may be confidently assigned. That these vertebrae are of a basically lepospondylous nature would seem to be clear from the nature of the haemal arch. Of the groups of Paleozoic lepospondyls besides microsaurs: (1) in the Nectridia, as has already been pointed out, the haemal arches look quite different, and nectridian vertebrae do not have a neurocentral suture; (2) there is no evidence of haemal arches in lysorophians, in at least *Lysorophus* and *Megamolgophis* the neural arch is composed of two separate lateral halves, and the limbs in these animals were apparently much reduced (3) aistopods were limbless and had ribs with peculiar processes quite unlike the ribs seen in the coprolite. Of living lepospondyls: (1) in the vertebrae of apodans the transverse processes are placed far forward on the neural arch, but there are special "infrazygapophyses" that provide additional articulatory surfaces along the ventral parts of the centra, and besides, caudal vertebrae are almost nonexistent in the apodans and when present do not have haemal arches; (2) the vertebrae of urodeles are nectridian-like in the placement of the transverse process midway along the centrum and in that the transverse process usually is inclined posteriorwards and has two articular facets; (3) neither apodan nor urodele vertebrae have neurocentral sutures, but this, as Gregory, Peabody and Price (*op. cit.*) point out, may not be significant. The known vertebrate fauna of the Permian is, of course, probably only a small sample of the fauna actually living at that time, and the sampling error is undoubtedly even greater when only the smaller forms are considered. It is entirely possible that the animal represented in the coprolite belongs to some lepospondylous group otherwise unknown. It may also represent a much-modified variant of one of the known Paleozoic groups. It may even be seen eventually to help corroborate the opinion of Gregory, Peabody and Price that the urodeles were derived from nectridian-like forms, but fossils of connecting forms are needed to establish this.

Even if we put aside the problem of ordinal assignation of the form represented by the bones in the coprolite, this animal is still of considerable interest in that it shows such a strikingly urodele-like haemal arch in the Permian, in that it adds to our picture of the early Permian fauna of New Mexico, and in that it demonstrates the possible rewards of diligent search for skeletal elements in coprolites.

## ACKNOWLEDGMENT

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# PROCEEDINGS OF THE ACADEMY

The Southern California Academy of Sciences met nine times during the fiscal year 1962-1963. Eight of these meetings were held in the Auditorium at the Los Angeles County Museum, and the Annual Meeting was at the University of Southern California. The section on Earth Sciences held several meetings at different schools in the area.

The following talks were given at the monthly meetings. The Botany Section, on September 21, 1962, presented Dr. D. Foard of U. C. L. A. who spoke on the "Developmental Anatomy of the Camellia Leaf." The Invertebrate Zoology Section was in charge October 19, 1962, when Dr. Irwin M. Newell, Univ. Calif., Riverside, gave a talk "Biology and Systematics of the Giant Red Velvet Mites of the Desert." On November 16, 1962, the Experimental Biology Section presented Dr. Richard M. Straw, of Los Angeles State College, who discussed "Cytomegalovirus (Human Salivary Gland Virus) in Tissue Culture Cells." The Vertebrate Zoology Section heard Dr. Charles A. McLaughlin of the Los Angeles County Museum talk on "The Mammals of Chad, Africa," January 18, 1963. Professor Emma Lou Davis, U.C.L.A., reported on the "Migration of the Prehistoric Mesa Verdes Peoples," sponsored by the Anthropology Section, on February 15, 1963. The Earth Sciences Section presented Dr. Theodore Downs of the Los Angeles County Museum, who talked about the "Fossil Vertebrates of the Anza-Borrego Desert," on March 15, 1963. The Junior Academy on April 19, 1963, presented three students who discussed their studies.

The newly elected Board of Directors and Advisory Board met on May 3, 1963, to hear reports and elect officers for 1963-1964.

The third Annual Meeting was held at the University of Southern California, on May 18, 1963. More than 120 persons attended the Scientific Sessions, including a special symposium with eight papers, and the general session with 18 papers in four sections. The student participants were judged for two student prizes which were presented at the Annual Dinner for the first time.

The papers presented were: Symposium "Adaptation to Cold" Dr. Harry Sobel, Chairman and organizer. 1. "Some Comparative Aspects of Cold Acclimation in Birds and Mammals." Dr. Rowand R. J. Chaffee (speaker) and Dr. Wilbur W. Mayhew, University of California, Riverside. 2. "Fatty Acid Metabolism in Cold Exposure and Cold Acclimation." Dr. Edward Masoro, University of Washington, Seattle. 3. "Some Physiological Aspects of Cold Acclimatization." Dr. John

Patrick Mehan, University of Southern California. 4. "Physiological Role of Brown Fat." Dr. Robert E. Smith, University of California, Los Angeles. 5. "Progressive Reduction of Low Temperature Induced Fibrillation Point by Hypothermia Exposure." Dr. Dale L. Carpenter, Marquart Corporation. 6. "Profound Hypothermia in the Rabbit." Dr. David Norman, North American Aviation. 7. "Changes in Guinea Pigs Exposed Continuously to Temperatures of 2-4°C for One Year." Dr. Harry Sobel, Veterans Administration Hospital, Sepulveda. 8. Dr. G. S. Bajwa, Institute for Biological Research, Culver City, presented histological findings.

General Session papers:

Studies on the *Mytilus edulis* community in Alamitos Bay, California: Development and destruction of the community. Donald J. Reish, Long Beach State College.

Evolutional Trends in the Chonotrichida (Protozoa, Ciliata). John L. Mohr, H. Matsudo, and Y. M. Leung, University of Southern California, and V. L. Gregory, California Polytechnic College, Pomona. (Presented by Mohr)

An Ecological Study of the Green Lynx Spider Population of Northwestern Florida. Donald C. Lowrie, Los Angeles State College.

Fortuitous Appearance of Two Exotic Fishes in the California Fauna. Carl L. Hubbs, Scripps Institute of Oceanography.

The University of Southern California Antarctic Program and Some Preliminary Results of Work in the Bransfield Strait. Hugh H. Dewitt, University of Southern California.

Evolution in the Viperfish *Chauliodus* sp. Jules Crane, Cerritos College.

New Information on the Structure of Permian Lepospondylous Vertebrae—from an Unusual Source. Peter Vaughn, University of California, Los Angeles.

Heavy Machinery in Archeology. Ruth D. Simpson, Southwest Museum.

The Transition of Isopods from a Marine to a Terrestrial Habitat. Gary J. Brusca, University of Southern California.

Studies on the Ecology of Planktonic Foraminifera and Radiolaria off the Southern California Coast. Richard Casey, University of Southern California. (Co-winner of student award)

Water balance of the Florida Mouse. Daniel S. Fertig, University of Southern California.

Metabolic Aspects of Temperature Regulation in Lepidoptera. J. E. Heath, University of California, Los Angeles, and P. A. Adams, University of California, Santa Barbara. (Presented by Heath)

Some Investigations in Cinephotographic and Microphotographic Techniques. William R. Stanley, and Wm. J. Bruff, Cerritos College. (Presented by Stanley)

Comparative Osteology of the Plethodontid Salamander Genus *Aneides*. David B. Wake, University of Southern California. (Co-winner of student award)

Winter-time Biota of the Pacific Coast Lagoons of Central Baja California, Mexico. Robert Eberhardt, Lockheed-California Company.

The late Miocene Mammal Fauna from Camp Creek, Nevada. J. R. Macdonald, Los Angeles County Museum.

Pleistocene Lake Panamint, Panamint Valley, California. Thomas Clements and Lydia Clements, University of Southern California. (By title only)

Late Pleistocene Bird Fossils from the Channel Islands, California. Hildegarde Howard, Los Angeles County Museum.

Seventy-five members and guests attended the Annual Dinner Meeting which was held at the Faculty Center, University of Southern California. Dr. Herbert Friedmann, Director, Los Angeles County Museum, presented a talk on "Aspects of Evolution in a Genus of Crested Cuckoos."

Fellows elected to the Academy were announced at the Annual Dinner. They were: Mr. Cyril F. Dos Passos, Mendham, New Jersey; Dr. Herbert Friedmann, Los Angeles; and Dr. Laurence M. Klauber, San Diego.

Co-winners of the student awards were Mr. Richard Casey and Mr. David Wake, both of the University of Southern California. Each received a first prize of $35.00, presented at the Annual Dinner.

Dr. Theodore Downs, retiring president, relinquished the gavel to the incoming president Dr. Richard B. Loomis. Appreciation to Dr. Downs was expressed for a successful and outstanding two years in office.

Thanks were extended to Dr. Jay M. Savage, Chairman of the Local Committee, and to other faculty members and graduate students in the Department of Biology, University of Southern California, for their help in conducting a successful Annual Meeting.

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The 1921 issues are: Vol. XX, No. 1, April; Vol. XX, No. 2, August; Vol. XX, No. 3, December.

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# BULLETIN OF THE
# Southern California Academy of Sciences

LOS ANGELES, CALIFORNIA

VOL. 62 OCTOBER-DECEMBER, 1963 PART 4

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BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

VOL. 62 OCTOBER-DECEMBER, 1963 PART 4

# AN EXPERIMENTAL STUDY OF THE ECHOLOCATION ABILITY OF A CALIFORNIA SEA LION, *ZALOPHUS CALIFORNIANUS* (LESSON)

WILLIAM E. EVANS[1] AND RUTH M. HAUGEN[2]
Lockheed-California Company, Burbank, California

## INTRODUCTION

It has been well established that dolphins, specifically the Atlantic bottlenose dolphin (*Tursiops truncatus*), are endowed with an extremely efficient biological "sonar" system (McBride, 1956; Schevill and Lawrence, 1956; Kellogg, 1958, 1959; Norris, Prescott, Asa Dorian and Perkins, 1961). During several cruises of the Lockheed-California Company Research Vessel Sea Quest early in 1962, another marine mammal, the California sea lion, *Zalophus californianus* Lesson, was observed to produce at least five different types of sounds under water during what appeared to be feeding and investigating activities. A sonagram of one of the more characteristic of these sounds is presented in Figure 1. The waveform of these sounds and the behavior associated with their production was indicative of some form of echolocation. However, the possible presence of various unobserved delphinids, which are known to be sound makers, *e.g.*, the Pacific Pilot Whale, *Globicephala scammoni* and the Pacific whitesided dolphin, *Lagenorynchus obliquidens*, (Schevill and Watkins, 1962), in the immediate area made the positive identification of these sounds as being of sea lion origin tenuous. However, these field observations were recently verified by the observation of underwater sound production by various captive pinnipeds (Poulter, 1963; Schevill, Watkins and Ray, 1963).

In order to further verify these observations, especially in reference to the use of these sounds for echolocation, the following series of tests was conducted.

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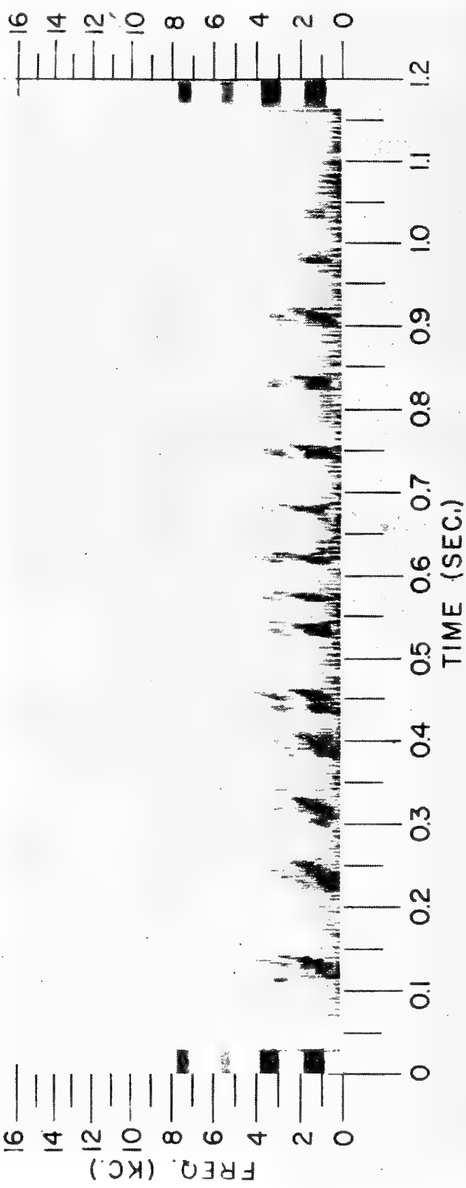

*Figure 1.* Sonogram of one of several underwater sounds produced by a California sea lion *Zalophus californianus* (Lesson). This sound was recorded at a location 1000 yds. off of Santa Barbara Island, California.

1. A single captive California sea lion was monitored during various types of activity to evaluate its underwater sound production capability.
2. The same animal was trained to retrieve objects made of a chemically inert material. It was determined whether or not sound was used in conjunction with the detection and retrieval of these objects under various conditions of visibility.
3. The same animal's vision was completely suppressed by blindfolding and its navigation and target detection capability observed.

## PROCEDURE

The experimental animal, a one year old female California sea lion, was maintained in a circular steel tank, 26 feet in diameter, 9.5 feet deep, with a capacity of approximately 40,000 gals. An 8-foot wide work platform used for animal training occupied one side of the tank. Although this facility was capable of handling sea water, fresh water was used to simplify maintenance.

*Training and Tests.* The sea lion used in this study was placed in the laboratory tank on December 18, 1962. At the time of procurement she had been in captivity three weeks and would eat dead fish. Other than this small degree of taming she was essentially untrained.

From the time of her initial introduction into the tank her sounds were periodically monitored using a Massa, M-115 hydrophone, Massa, M-185 hydrophone power supply and amplifier, and a Clevite Ordnance Type O, hydrophone and a specially constructed preamplifier. All signals were recorded on a Vega, 4-channel tape recorder at a tape speed of 7.5 ips. In addition, the animal's underwater behavior was observed through four, 23-inch underwater viewing ports.

Rings made of ⅜ inch plastic tubing, 6.5 inches in diameter and filled with air were used for the retrieval targets. These were easy for the animal to pick up, and would produce a good echo return. Each ring was weighted with lead shot to make it sink. The weight was placed at one point on the circumference of the ring so that it would stand up-right on the bottom of the tank.

The animal was trained to accept the test rings on her training stand at first, then retrieve them from the floor of the training platform. She then progressed to water, retrieving floating rings and then finally submerged rings. During the water retrieval phase of the training, records were kept of her retrieval time, and search pattern. All initial trials were monitored acoustically.

During the retrieval training, several problems were encountered in the animal's behavior that affected final handling techniques. At first the sea lion would watch the target rings, jumping into the water as soon as the target was thrown. Not only was insufficient time allowed for the ring to sink to the bottom of the tank, but also the animal could see exactly where the ring was thrown and no search was necessary. To offset this problem, the trainer held the animal's attention by feeding her pieces of fish while another experimenter threw the rings into the water. However, the sea lion then began to respond to the sound of the ring hitting the water. Consequently, it was necessary to employ "false targets." As the trainer was supplying the animal with small bits of food, talking to her, and putting her through various simple tricks (*e.g.*, shaking hands), the other experimenter would splash the water by repeatedly throwing in a ring and pulling it out by means of an attached string. Thus, responses to false targets were not rewarded. However, still another anticipatory response was to occur. When the experimenter stopped splashing water, the sea lion went after the sinking ring. By splashing water for a few trials without throwing in a target, this undesirable behavior was eliminated.

The possibility of changes in retrieval time from trial to trial as a function of the food consumed during the trials was considered and checked. During one training session, using floating rings, the retrieval times of the initial trials were of the order of 6 seconds. By the 40th trial, retrieval time had slowed to 20-40 seconds as the animal appeared "bored or distracted." However, during the 50th through the 80th trials, retrieval times were again in the 5-8 second range. There was no noticeable "time" or "food" effect during the test sessions. On a test day, the animal generally had been fed only a few fish prior to the tests. The maintenance diet was approximately 7.5 pounds of mackerel, squid, or white bait per day.

When the underwater target retrieval behavior was well established, a series of daylight and night test trials was run. The final handling technique was as follows. The sea lion was positioned on her training stand with her back to the water. The trainer fed her small fish (white bait), talked to her, and put her through simple tricks. Simultaneously another experimenter splashed the water with a false target ring. During the splashing, the target ring was thrown into the water. After the target ring had sunk to the bottom of the tank, (approximately 15 sec.), the trainer was signaled. The trainer then sent the sea lion into the water by the verbal command "go find it." The time interval from the animal's entrance into the water until exit onto the platform with the ring was considered the "retrieval time." Upon retrieving successfully, the sea lion was first rewarded with a fish, the words "good Penny," and then given the command to mount her training stand were she was given another fish before the next trial.

The position of the target ring in the tank was varied from trial to trial. A grid painted on the bottom of the tank was provided for ease of visual monitoring of the ring position and the animal's search pattern. A *successful retrieve* was one in which the animal brought the ring with her when she emerged from the water onto the platform. If unsuccessful, she was sent again. If repeated unsuccessful attempts were made, the sea lion was guided to the correct spot by throwing another ring, turning on the lights, etc. Each test consisted of 10 retrievals. Constant sound and visual monitoring was maintained throughout all tests.

The same procedure was followed for both daylight and night trials. However, during night trials, tests were run with overhead floodlights in the on and off positions. With one 500-watt overhead floodlight on, the ambient level directly above the surface of the water ranged from 0.75 to 1.00 foot candle, as measured with a Weston model 756 illumination meter. During the "lights off" phase, measurements made with the sensing element of the meter placed against the underwater viewing ports and on the platform directly above the surface of the water indicated ambient light levels of 0.03 to 0.05 foot candle. During this phase of the test the available light consisted mainly of skylight. These levels were measured with approximately 80% cloud cover. Most night tests were made under 100% cloud cover, and hence slightly lower illumination.

Under dark conditions it was apparent that the animal was not forced to rely entirely on echolocation, if it did indeed possess such a capability. Therefore, attempts were made to completely suppress the animal's vision with blindfolds in a fashion similar to that demonstrated by Norris, *et al*, (1961), with the Atlantic bottlenose dolphin. Unfortunately, we could not take full advantage of the blindfolding technique since latext suction cups would not adhere to the fur of a sea lion in the same fashion as to the smooth skin of a dolphin. After several failures with cloth hoods and plastic goggles, a 3-inch wide, elastic bandage, 36 inches long, proved to be a successful blindfold. This device was wrapped around the animal's neck, over her eyes, and under her muzzle in a double thickness, completely blocking light from her eyes, yet not impeding her capability for eating on land or in the water or for barking in air.

The animal was equipped with a harness and tow line that allowed her removal from the tank in the case she became completely disoriented or displayed some violent fright response.

The animal was accustomed to the blindfold and to the harness separately through the method of successive approximations. She first learned to rub the folded blindfold material with her nose and chin, then to have the material rubbed over her head. Next, she accepted the blindfold being laid over her head and then over her eyes. Finally, she allowed it to be wrapped around her head and tied. She was occasionally given pieces of food during the operation and responded to the words "good Penny" by opening her mouth for food. The sea lion readily entered the water on command, wearing the blindfold wrapped, but not tied, slipped it off and returned. Upon a command, she would then retrieve the blindfold for her trainer. Acceptance of the harness was similarly accomplished. The animal first learned to push the leather with her nose, then to put her head through it. Next she learned to present the handler with her flipper to allow the harness to be fitted. She accepted both the blindfold and the harness calmly and patiently with no display of anxiety. Swimming was not impeded by the harness. However, when pressure was exerted on the tow line by the handler, the animal appeared to be very emotional. She then strained in the harness, dashed about, "porpoised" out of the water, and refused to return to her work stand. Some emotional holdover appeared occasionally in the trials immediately following. Throughout the course of these tests the animal did not adjust to being restrained by the line. The complete harnessing and blindfolding procedures are illustrated in Figure 2.

## RESULTS

*Underwater Sound Production.* After several days of monitoring, it became apparent that this particular California sea lion was considerably less vociferous than a single Atlantic bottlenose dolphin observed under similar conditions (Evans and Prescott, 1962). During the second week of monitoring, at 1640 hours, the animal was observed to produce several bursts of broadband pulses while swimming unimpeded a few inches off the bottom of the tank, approximately 15 minutes after a feeding session. These sounds were similar to those presumably produced by the California sea lion in its natural environment. This type of sound production behavior was observed again on subsequent days and was usually accompanied by the same slow swim-

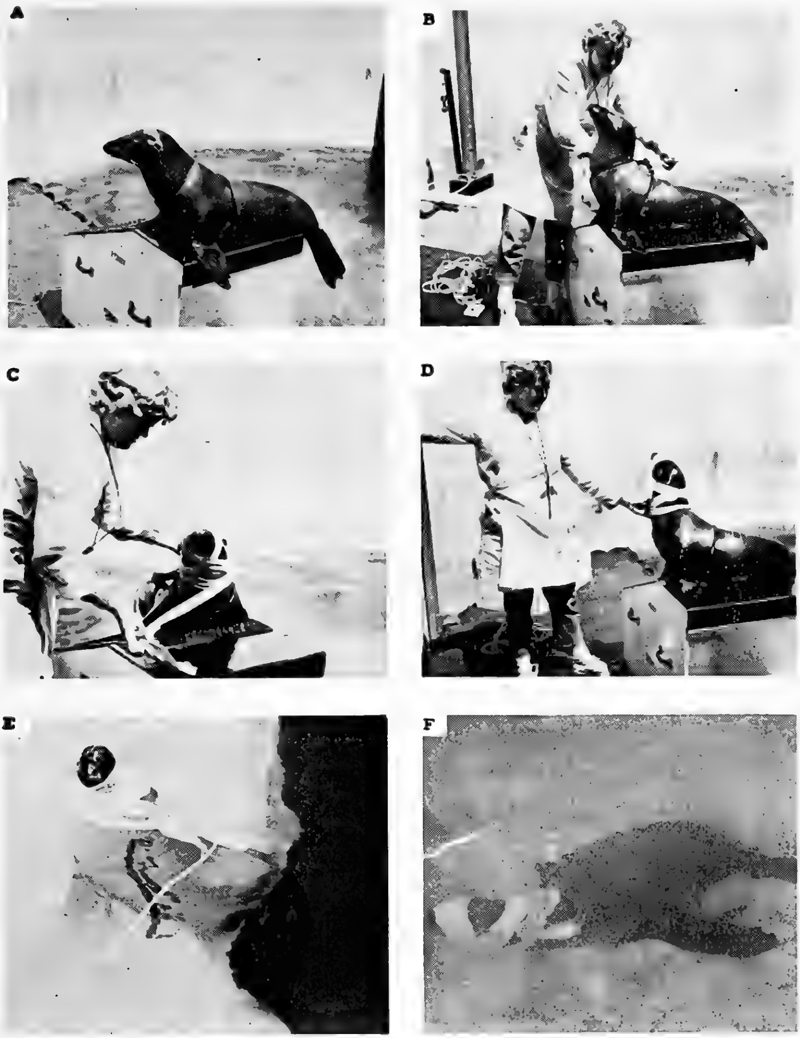

*Figure 2.* Various steps in the harnessing and blindfolding of a California sea lion, *Zalophus californianus* (Lesson).

ming, bottom searching behavior, 15 to 20 minutes after a feeding. As observed by Poulter (1963) and Schevill, Watkins and Ray (1963) the signals produced by this animal were similar in some ways to clicks or pulses produced by delphinids while echolocating. However, in all of the pulse series we have observed, the sounds were produced in bursts, rather than in long trains of pulses as are commonly produced by the bottlenose dolphin. In addition, the signals produced by this sea lion (Fig. 3A) had very little energy above 6 Kcps and none above 8 Kcps, while in those produced by Atlantic bottlenose dolphins (Fig. 3B) maintained in the same test tank during the early part of 1962, considerable high frequency energy was present. No double pulse structure, as observed by Poulter (*op. cit.*) was noted.

*Retrieval Tests.* A total of 25 trials was run under the dark condition (0.03-0.05 foot candle); 18 of these were successful retrievals. The experimental animal produced no sound during any of these trials. The retrieval time during the "lights on" condition, ranged from 5 to 11 seconds with an average time of 8 seconds. During the dark condition the times ranged from 5 to 22 seconds, with an average time of 15 seconds. The search pattern used during all test conditions consisted of a series of continuous loops. The search pattern was more complex during the completely dark condition. There was a consistent tendency for the animal to "check" initially the area of the last successful find.

*Blindfold Test.* When given the command to enter the water for the first blindfold test the animal showed no hesitation. She leaped from her training stand into the water, and surfaced in the center of the tank (Fig. 2E). When tossed food, she oriented toward the sound of the splash, but made no attempt to retrieve the food if it was further than 2 feet from her mouth. However, food that touched her face or vibrissae was quickly consumed. Occasionally she submerged, sinking slowly to the bottom and rising to the surface to breathe. During this first trial, when the animal was called back to her training stand, she swam quickly and directly toward her handler, colliding with the edge of the platform. She then submerged, floated slowly to the surface, and refused to attempt to emerge from the water again. All of her movements were slow and deliberate. In order to remove the animal from the water, slow and gentle pressure was applied to her leash, pulling her toward the platform. She was then fed pieces of fish as her handler unfastened the blindfold. With visual orientation restored, the animal voluntarily came out of the water to her training stand. She produced no discernible sound during any portion of this test. The animal's behavior during the second blindfold test was similar to that of the initial trial, including the lack of sound production. During both of the blindfold tests, the animal seemed to prefer staying in the water, and at the end of the second test was removed under protest.

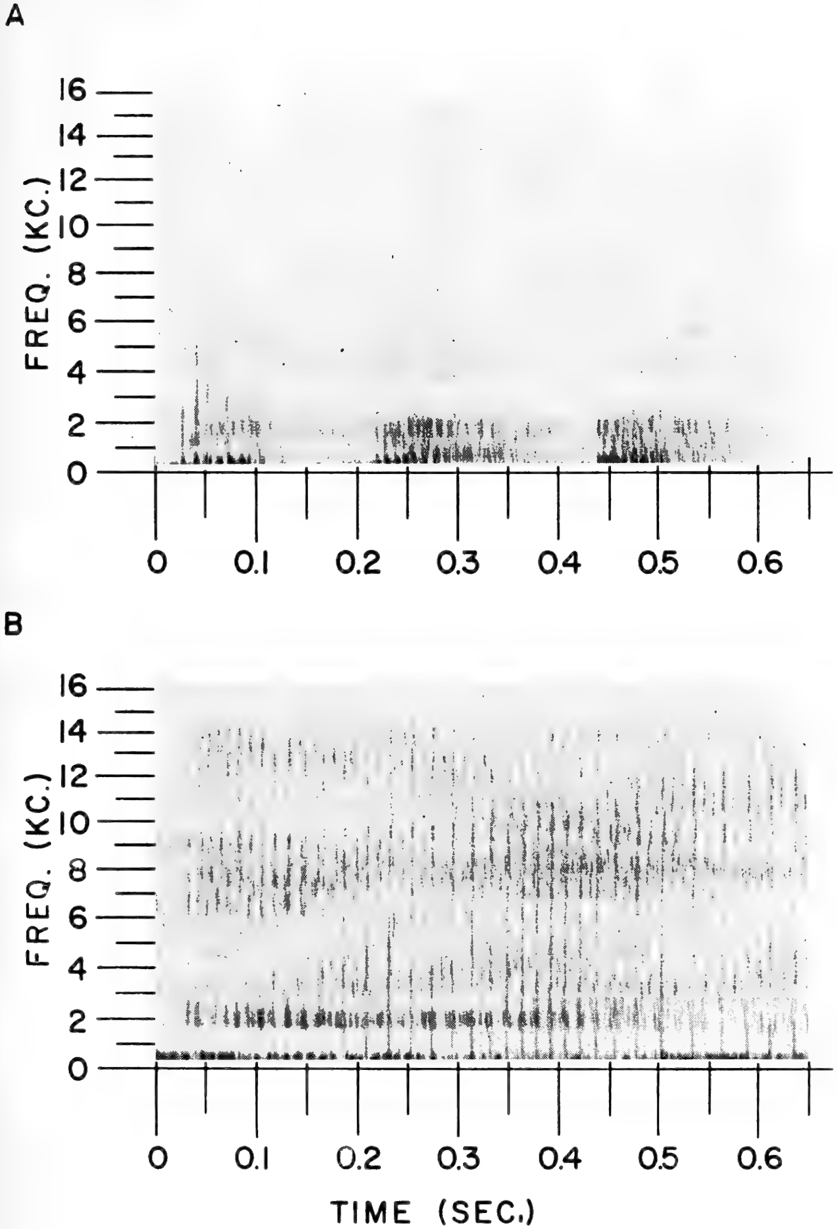

*Figure 3.* A. Sonagram of clicks produced underwater by a California sea lion maintained in a test tank at the Lockheed-California Company, Burbank Facility. B. Sonagram of a train of echolocation clicks produced by an Atlantic bottlenose dolphin maintained in the same test tank the previous year.

These results, in contrast to those of Norris, *et al.* (1961) with *Tursiops*, indicated that a total loss of vision seriously impaired the sea lion's navigation and food-finding ability. With continued training it is possible that some adaptation to this undoubtedly stressful situation might occur. However, it was apparent in these tests that suppression of the visual sense constituted a more serious problem for the sea lion than it did for the blindfolded dolphin.

## Discussion

The results of this series of tests do not support the theory that the California sea lion has a well-developed echolocation ability (Poulter, 1963). However, much insight into search behavior, sound production and the visual capabilities of the California sea lion has been gained. Also, the techniques developed, and the state of training of the animal used, should make it possible to define accurately the various parameters of sea lion target detection behavior, whether they are visual, acoustic, or both. The possibility that an echolocation capability is a learned behavior, should not be overlooked.

## Summary and Conclusions

1. A single, captive California sea lion, *Zalophus californianus* (Lesson), was observed to produce series of short duration, broadband sounds, underwater, while apparently searching for food. These sounds appear to be similar to the "clicks" used by the Atlantic bottlenose dolphin for echolocation signals.
2. The sea lion in captivity does not produce underwater sounds nearly as frequently as the bottlenose dolphin, under similar conditions.
3. Under conditions of darkness (ambient light level, 0.05 foot candle) the sea lion can successfully find and retrieve air filled plastic rings, 6.5 inches in diameter from 9.5 feet of water, without producing sound.
4. A method was devised to blindfold successfully a California sea lion. When blindfolded, the sea lion's ability to find food and navigate was seriously impeded.

## Acknowledgments

We wish to thank Messrs. W. W. Sutherland, R. G. Biel, and J. J. Dreher of the Lockheed-California Company for their assistance in monitoring during the tests, and Messrs. Arthur Thomas and David H. Brown, Marineland of the Pacific Oceanarium, for invaluable suggestions on handling and caring for the experimental animal. Also we wish to thank Dr. K. S. Norris, Department of Zoology, University of California, Los Angeles, Dr. D. K. Caldwell, Los Angeles County Museum, Dr. W. E. Schevill, Woods Hole, Oceanographic Institution, and Melba C. Caldwell, University of Southern California for their constructive comments on this manuscript.

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THE NUMBER OF CONENOSE BUGS, *TRIATOMA*, INFECTED BY ONE ENGORGEMENT ON A MOUSE WITH *TRYPANOSOMA CRUZI*. In order to test the capacity of one small rodent to infect *Triatoma p. protracta* (Uhler) with trypanosomes, a ♂ 11.5 gm. *Mus musculus*, Expt. 226, was inoculated intraperitoneally on Feb. 1, 1960, with 0.05 ml. of sodium citrate solution containing the No. 1 dropping of a recently-fed 5th instar *Triatoma* nymph from Griffith Park, Los Angeles (Wood, Exper. Parasitol., 10:356-365, 1960.) This clear fecal droplet revealed numerous metacyclic *Trypanosoma cruzi* Chagas. Tail blood samples of the mouse were negative for trypanosomes 14, 16, and 18 days after inoculation. Five trypanosomes were seen on the 22nd day and one on the 23rd day after inoculation in single drop samples.

Experimentally infected rodents have been used many times for transferring trypanosomes to *Triatoma* (Wood, *loc. cit.*). No attempt was made here to restrict these bugs to a specific area of the rodent for feeding. All bugs were released at the same time in the immediate vicinity of the mouse which was confined to a wire cylinder in a circular plastic dish, 15.5 cm. in diameter and 7 cm. deep. On the 23rd day, two sets of bugs were fed on the experimental mouse. The first set of 11 *Triatoma* (3 ♂, 5 ♀, 3 fifth instar nymphs) were placed with the white mouse for 2 hours. The adults fed to capacity but the 5th nymphs were ⅓ full. These bugs were purposely removed to prevent further decrease of blood volume in the mouse. They were examined for trypanosomes one month later and all except 1 ♂ were positive, an infection rate of 81.9%.

The second set of 28 *Triatoma* (9 third and 9 second instar nymphs) were allowed to feed at random until death of the mouse. Twenty-four contained blood at the time of removal. These bugs were also examined for trypanosomes after one month. Twenty-three or 82.1% were infected including 8 third and 15 second instar nymphs.

Since the size and weight of an important California reservoir rodent, *Peromyscus truei gilberti* (J. A. Allen), is similar to that of *Mus musculus*, this experiment indicates the percentage of insect vectors that could ingest *Trypanosoma cruzi* during two feedings. This high rate of replacement of infected bugs and continued susceptibility of *Triatoma* to infection would explain the widespread distribution and continuous recurrence of Chagas' trypanosome in native reservoir rodents and hematophagous bugs as demonstrated by field sampling (Wood, Bull. So. Calif. Acad. Sci., 41:61-69, 1942. Amer. J. Trop. Med., 23:315-320, 1943; Bull. So. Calif. Acad. Sci., 49:98-100, 1950;

Wood and Wood, Amer. J. Trop. Med. and Hyg., 10:155-165, 1961) throughout the southwestern United States.—Sherwin F. Wood, *Life Sciences Department, Los Angeles City College, Los Angeles 29, California.*

# BIRDS AND INDIANS IN THE WEST

Loye Miller

University of California, Davis

From time to time during the previous ten years I have been asked to identify the bird remains taken from Indian middens in western America during careful explorations by trained anthropologists. In addition there have come to hand numerous bones retrieved by the casual digger (including myself) who was inspired only by a simian or juvenile curiosity. It seems worth while now to survey and draw together the results of these studies as an addition to the splendid work done by Howard (1929) on the great "Shell Mound" at Emeryville on the east shore of San Francisco Bay—a site now blotted out by the relentless wheels of civilization called "Progress."

My own studies have focused carefully upon middens located widely as follows: The Dalles, Oregon; several shell-heaps on Puget Sound, Washington; four sites along the Missouri River in North Dakota; Wilson Butte Cave, Birch Creek Valley, and Weiss Rock Shelter in Idaho; Iron Gate site in Siskiyou Co., California; San Nicolas Is. and shore sites along the southern California coast. These sites represent a great variety of terrain as well as a great variety of Indian tribes—each with its special language, food habits, totems, intra-tribal organization and religious beliefs. The avian remains from the middens of Oregon, Washington, North Dakota and Wilson Butte Cave, Idaho have been previously recorded (Miller, 1957, 1960, 1961, and Gruhn, 1961, respectively). Those from the Birch Creek Valley and Weiss Rock Shelter sites in Idaho are discussed herein.

## Acknowledgments

More recently much aid and encouragement have come to me from the staffs of the Museums at Idaho State College at Pocatello, Idaho; the Peabody Museum of Harvard University at Cambridge, Mass.; the University of Oregon at Eugene, Ore.; and the University of California at Berkeley. Dr. C. S. Cressman, Dr. Earl H. Swanson, Dr. Alden H. Miller, Dr. W. Wood, Dr. B. Robert Butler, and Dr. Ruth Gruhn all have rendered especial service and are extended my sincere thanks.

## PREVIOUSLY UNPUBLISHED AVI FAUNAS

### Weiss Rock Shelter (Idaho County, Idaho)

*Buteo jamacensis*, Red-tailed Hawk, femur and humerus. These two bones represent a large *Buteo* (probably a single individual and a female). They are not *B. regalis*, being too heavy shafted and short. Both are much abraded at the ends giving a first impression of having been gnawed by small rodents. On close examination, however, the humerus shows on the palmar aspect of the area between the bicipital and the deltoid attachments some rectilinear scratches, two of which cross each other and are followed by two parallel lines to fortuitously produce the Roman numeral XII. Other lines on both sides of the deltoid crest strongly suggest that a very fine pointed instrument had been used to remove the crest. Furthermore on the anconal face opposite the distal end of the deltoid crest a hole 10.2 x 6.5 mm. in size, has been made. A few faint scratches are discernible at the antero-distal margin of this hole. The impression in my own mind is that an attempt had been made to produce a whistle but the plan had been abandoned before completion. I have examined such whistles from other middens but they are generally made from the ulna of longer winged birds. A 3 mm. hole appears in the shaft of the femur which I can not explain though how it could have been made by accident without breaking the shaft is a mystery. No tool marks appear on the femur. Both bones show weathering to greater extent than any other specimen in the collection.

*Falco sparverius*, Sparrow Hawk. Humerus and tibia are the only bones of this species retrieved thus far and fortunately their preservation is excellent. The left humerus lacks a few chips from the deltoid crest, the right tibia lacks the proximal ¼. The bones show no weathering and are but lightly stained. Rich color of the tail feathers of this little falcon may have appealed to the Indians as ornaments.

*Dendragapus obscurus*, Dusky Grouse. This grouse is the most prominent bird in the collection and the majority of the bones are beautifully preserved. Specimens vary in color from "old ivory" to a warm golden brown. Both sexes of adults and two stages of immaturity are represented. In the John Day Basin of Oregon I found this species quite abundant in sage country with scattered low junipers among gently rolling hills. It is surprising that only two of the nine bones are definitely from young birds.

*Pedioecetes phasianellus*, Sharp-tailed Grouse. This grouse is represented by a single tarsus, presumably of a female bird. Both ends are broken but it closely corresponds except for size with an old male, the only recent skeleton available. This grouse is smaller and definitely more slender legged than *Dendragapus*. There appears no possibility of confusing the tarsi of the two birds.

*Otus asio*, Screech Owl. An incomplete ulna is assigned to the Screech Owl after repeated check and re-check under the lens. Only the proximal ⅔ remains and the olecranal process is missing. The size, curvature, intermuscular lines and facets so far as preserved correspond with those of a female specimen of *O. asio bendirei* from central California. The fascinating thing about this specimen is that a tiny round hole has been drilled in the shaft on the concave (radial) side. This hole is less than 1.5 mm. in diameter and appears perfectly round with smooth edges. The distal end of the specimen does not appear to have been broken. I am confident that it was purposefully cut as was done in removing the olecranal process at the proximal end. Was the skilled artisan endeavoring to produce a tiny whistle? Several of the whistles examined from other Indian middens had been made from the ulnae of long winged species (e.g. *Grus*), the shaft and the olecranal process had been cut in similar fashion and the hole located on the concave aspect of the shaft. Whatever his purpose the Indian did a skillful bit of work.

*Asio otus*, Long-eared Owl, tibia and humerus. Two species of the genus *Asio* might be expected to occur at times in the area of Weiss Rock Shelter. Isolated and broken bones of unknown sex of these two owls are difficult to assign specifically. The tibia is fortunately quite nearly perfect so it is assigned with confidence to the species *A. otus*. The other specimen is a badly broken humerus which is assigned with less confidence to the same species. The Long-eared Owl seems the species most likely to be found in country not too far from the rock shelter. In my own field experience it has been met in fair numbers in sage-juniper country as well as in localized timber along streams that cut through semi-desert areas.

*Colaptes cafer*, Red-shafted Flicker, two humeri and tarsus. The tarsus and one humerus are practically perfect and are readily identifiable. The second humerus, #42,436, is less perfect but corresponds in such characters as are preserved although the shaft is slightly heavier, a difference assigned to age or sex of the individual. The congeneric

Yellow-shafted Flicker is less likely to occur in this region and comparison of humeri of specimens of the same sex from the two species showed a stouter shaft in the Red-shafted Flicker. It seems proper therefore to consider *C. cafer* as the species represented. Although I have known the Flicker to serve as a food item for a number of Caucasians and certainly could appreciate such an interest on the part of an Indian, I feel that the feathers of this beautiful bird may have had an even stronger influence in making it one of the species occurring frequently in the bird lists from Indian middens.

*Corvus corax*, Raven, coracoid. This practically perfect bone is the only representation of this species which occurs in so many other middens and cave deposits. It is wide-ranging in open arid country where it commonly uses rocky outcrops for nesting sites. The single bone came from a mature individual.

*Corvus branchyrhynchos*, Common Crow, pelvis, humerus, ulna. The Crow is less commonly seen in open country than is the Raven but two and probably three individuals are represented in the collection. I feel that a sizable assembly of broad leaf trees furnished attraction for these gregarious birds somewhere within reach of the Indians of Weiss Rock Shelter. Audubon in his Missouri River Journal, speaks of certain tribes of Indians along the River as using the crow for food. Such use may explain the abundance of its bones in this Idaho midden.

*Pica pica*, Magpie, nine bones. I assume that the Magpie here represented is the widely occurring Black-billed species since our only other species, the Yellow-billed Magpie, is so closely restricted to limited areas and habitats in central California west of the Sierra Nevada. Constant osteological differences between unassociated bones of the two species have not been recognized.

Only one other species, the Dusky Grouse, is represented in such great numbers and no immature specimens have been found. Furthermore, I have found the adult Magpie a wary bird and quite able to take care of himself unless his curiosity be excited. I am impressed by the Indians' ability in capturing numbers of the birds. The species may have had a varied appeal—as food, as pets, as a source of attractive feathers or as a tribal totem.

*Turdus migratorius*, American Robin. A single bone, a complete tibia represents this species that, during one or another season of the year may be found in any type of environment below the limit of trees from the arctic to Mexico. Furthermore it may occur, at times, in great numbers during the non-breeding season. Its plump body would have been an acceptable food item at the camp fire of any group. Its rarity and its perfect preservation are the chief interests attached to this specimen.

*Sturnella neglecta*, Western Meadowlark. Like the Robin, this full bodied bird may have added an acceptable item to the Indians' bill of fare. Its presence indicates open country though not necessarily a permanent meadow. Semi-arid country with annual grass dotted with low, perennial bushes may be inhabited by Meadowlarks.

## *Birch Creek Valley* CAVE OR ROCK SHELTER
(ca. 125 NNE of Pocatello, Idaho

*Anseriformes*, a single coracoid of a medium sized duck represents this order. Seemingly the water birds played a very small part in the life of the Indians of this area. There must have been no still water or marshes of any size within hunting range, else their arts, crafts, ceremonials or nutrition would have included some species of water bird in greater numbers.

*Falconiformes*, a complete and a broken coracoid may have come from the same individual of *Falco columbarius*, the Pigeon Hawk, which alone represents the raptorial order. In none of the Indian middens previously studied have I failed to find some large species of raptor; eagles, hawks, falcons and even vultures. The Birch Creek environment surely provided several species of these birds. Did they have no attraction for the Indians? With what plumes did they feather their shafts? Grouse feathers are too strongly curved. Crows are a bit too small for efficient use and large waterfowl seem not to have been available.

*Galliformes*, one's first impression is that the whole domestic economy of the Birch Creek Indians centered about the grouse family and that the only grouse was the Sage Hen. Closer study, however, shows that two other grouse and a quail (*Oreortyx*) played a minor part for the Galliformes.

*Dendragapus obscurus*, Dusky Grouse, is represented by three humeri, one femur, one tibia, one tarsus and two coracoids. The male humerus is very closely like that of the female Sage Hen, but the shaft is stouter and the distal articulation with the forearm operates around a more oblique axis, *i.e.* the ulnar condyle and the entepicondyle are extended more distally than the radial condyle. Similarly the femora are much alike except that *Dendragapus* shows a greater degree of pneumaticity in the great trochanter when viewed from the anterior face. This grouse is found in open timbered country and pine forest today, contrasting with the Sage Hen of the treeless sage.

*Centrocercus urophasianus*, Sage Hen. This grouse is the dominant bird of the entire collection. Forty six (46) humeri, equally divided between male and female, are identified with confidence whereas other skeletal elements are strangely in the minority—skull 1, sternum 1, scapula 1, fibula 1, tarsus 1, femur 2, sternum 2, tibia 7, metacarpus none at all. There are a few ulnae present, but they are so badly mutilatted that they can be assigned merely to "grouse." Why are the ulnae broken away at both ends while many of the humeri are quite perfect? Seven (7) coracoids are assignable to "grouse," but only two are assigned with confidence to *Dendragapus* and none to *Centrocercus*.

The super-abundance of this species emphasizes the openness of Birch Creek Valley and the presence of zeric vegetation.

*Bonasa umbellus*, Ruffed Grouse. Three grouse metacarpi, perfectly preserved, check perfectly with this small grouse. No other bone in the entire collection, however, is thus assignable, nor are there other Western grouse known to me with which they could be confused. They came from adult birds of both sexes.

Presence of Ruffed Grouse remains in these small numbers suggest a limited amount of stream-side tangle of water loving trees, brush and vines.

*Oreortyx picta*, Mountain Quail. A single coracoid is the sole representative of this species. It is found today in ecologic association with *Dendragapus* rather than with the open country dwelling *Centrocercus*.

### *Strigiformes*

*Asio otus*, Long-Eared Owl. There are two bones in the collection which are assigned to the owls. One is the distal end of a humerus, the other an almost complete tarsus of a bird scarcely out of the nest. Both are assigned to the species *A. otus;* the Short-Eared Owl, *Asio flammeus*, is very closely similar but in general it is slightly larger. It must be admitted that the specific assignment may be in error.

Long-Eared Owls today may be found breeding in mesquite desert, pine clad mountain canyon or willow thickets along river courses.

The bird's presence here holds little interest except to raise the question "why?" The immaturity of the bone suggests that a young bird may have been captured and brought in by a child or by a medicine man. It may even have been held in captivity for a while or used in ceremonial rites. Some Pacific Coast tribes consider the owls as incarnations of nocturnal spirits of mystic powers.

### *Passeriformes*

The remainder of the collection is assigned with a fair degree of confidence to this order though some of the badly broken bones could be those of the flicker, a species so often found in Indian middens. Many of the most delicate little bones are as perfectly preserved as though prepared by a skillful technician. These latter, I feel confident, reached Birch Creek in the stomachs of owls, to be later cast up unbroken and beautifully cleaned, as pellets of fur, feathers and bone. The owls, however, seem to have used the area only as temporary roosts since they left none of their own bones as record. (*Asio* does not inhabit caves or rock shelters.)

The owls can scarcely be held responsible, however, for the presence of the wing bones of certain larger passerines which could not be swallowed whole but would have been partially dismembered.

*Corvus brachyrhynchos*, Common Crow. The crow is represented by seven of the characteristic carpometacarpi and by no other bone. Certainly no owl could swallow the terminal joint of a crow's wing (owls do not pluck their prey). This species must have been brought in by man and, though divers Indian tribes are reported to have used the crow as food, the presence of wing bones only is suggestive of ritual or decoration as the purpose served in this case.

For some strange reason these segments of the crow's wing are all broken at either or at both ends though the slender metacarpal III may be well preserved. Also the size of some may reach that of a female *C. cryptoleucus* although that species shows positive divergence in osteological characters. Possibly the crow's primary feathers were used by the arrow marker for want of better. This might account for fracture of the metacarpus in chopping off and bringing home only the wing-tips.

*Pica pica*, Black-billed Magpie. Like the crow, the magpie has been found in many of the Indian middens of the west. I have ascribed its presence to the Indians having used its striking plumage in ornamentation or having kept it as a pet. Two humeri, one metacarpus and a questionable ulna represent it in the Birch Creek collection.

Smaller passerines. Quite a few of the bones mentioned above as probable remnants of "owl pellets" are left nameless. Classification within the order is based so largely upon characters not registered in the single and unassociated bone that I feel much uncertainty as to even the family represented. An error once registered upon the printed page can never be erased. Therefore, silence seems to be indicated.

## AGE OF MIDDENS

Materials from many areas that have passed through my own hands represent the birds presumably assembled by Indians who had not yet come under the influence of Caucasian man; *i.e.*, he was himself a "natural species" of wild creature among wild creatures—more or less omnivorous but, when possible, in the main a carnivore. Unlike the bear, wolf or cougar, however, he had a primate brain that set him quite apart from his fellow creatures. His aesthetics, religion, ceremonials, his social organizations, interest in pets or games, craftsmanship in clothing, housing, weapon-making and I know not what else, all had an influence upon the accumulation of bird bones aside from his mere desire for food, though the latter may have loomed large.

The time represented in these accumulations extends from the near present back into that nebulous borderland between the Pleistocene and the Recent. At least the horse, camel, mammoth and ground sloth survived long enough to "shatter lances" with the big brained bipedal immigrant from the Old World. Carbon 14 dating accomplished thus far extends the period back some 10,000 to 12,000 years (Butler, 1962)

In only one case so far have I found an extinct species of bird in the midden collections. Among 9,000 bird bones there was a single bone of *Coragyps occidentalis* from the Dalles, Oregon. Other extinct species have been reported by my colleagues from caves in New Mexico and Texas, but the actual association with man has not yet been established.

The association of the extinct Diving Goose (*Chendytes*) with man in the coastal zone of Southern California is also uncertain thus far (see Howard, 1949:24). The California Condor (*Gymnogyps californianus*), so near extinction but so widely known in late Pleistocene, is extremely abundant in the midden at the Dalles, Ore. on the eastern side of the Cascade Range. The Whooping Crane (*Grus americana*) is but sparsely represented in middens of North Dakota. Notably absent from the Dakota middens are the Passenger Pigeon (*Ectopistes migratorius*) and the Carolina Parakeet (*Conuropsis carolinensis*) although Audubon records the latter within a very few miles of the Dakota site.

Aside from the Condor, no species of bird has been identified in these studies at a site outside its present day range.

## ARTIFACTS

The almost ivory-like texture and the highly pneumatic nature of certain groups make the bird's bone attractive to the Indian for several purposes. The long bones of deer and mountain sheep approach the fine texture of bird bone and I have seen large awls made of them, but for more delicate sewing the bird bone serves best. In the North Dakota middens there were well polished awls made from Swan: ulna 1, Eagle: ulna 2, radius 4, tibia 1; Crane: radius 1; and Horned Owl: humerus 1. The eagle bones were particularly desirable, it would seem, because of the lesser degree of pneumaticity. These bird awls were, I imagine, used in the making of finer clothing and headdresses out of thin skins of small mammals and birds.

This same fine texture and pneumaticity made the long bones of birds useful in fashioning beads and as counters in certain games. The radius of larger birds, when cut into segments, made beads already perforated for stringing. The fine texture would appeal to the sense of touch.

The best Indian "whistle" I have seen was made from the ulna of a crane (*Grus canadensis*). Both ends had been removed and a smooth hole cut near the proximal end on the concave (radial) side. Within the cavity of the bone, just below this hole, a partial plug had been skillfully modeled to direct a blast of air out through the hole and produce a musical tone of great purity closely approximating that of the California Pigmy Owl (*Galucidium gnoma*). Fortunately the artisan had used a somewhat asphaltic matrix which had not been removed by subsequent ground waters so his skillful handiwork had been preserved. The length of this whistle was 6½ inches. Another ulna from this same midden (on San Francisco Bay Shore) had been squarely cut at one end though it was irregular at the other. Unfortunately the plug, if ever present, had not been preserved; but if a thumb closed the rough end, one could blow across the smoothly-cut end and produce a good tone much as a small boy would blow across an empty cartridge case or a pill bottle. This bone was 2½ in. long. This midden yielded several other fragments of long bone that might have been designed for making into whistles by a specially music minded craftsman.

Men (or women) of all times and tongues have yielded to the attraction of the feather. Even the bird himself seems in some species to be appreciative of his own colorful clothing. The Indian was no less susceptible than his kinsman in Hawaii, Africa, New Guinea (or New York). So he decorated his headdress, his medicine bag, his quiver and I know not what else with feathers. To this aesthetic sense I ascribe the presence of several species of bird remains we find in Indian middens. Of course the feather itself may have long ago disappeared, though there are exceptions (I have seen the gaudy feathers of macaws preserved for centuries in the dry air of Peru). Sooner or later certain of the species might have become totemic either to a tribe or to a clan within the tribe. This might lead to a tabu on the one hand or to the ritual consuming of its flesh, blood or heart on the other hand.

Mrs. Joseph Grinnell gives me an interesting account of her husband's parents' experience during the 1870's in the midwest. Father Grinnell was government physician to the Indians in Indian Territory. Wild Turkeys abounded in the timber along the water courses whence they were frequently brought in the doctor's game bag to the kitchen door. Mother Grinnell went into the back yard to pluck them. There she often found eager little brown hands thrust between pickets of the fence to clutch the colorful feathers but never could the Indian be induced to touch any of the meat. It was tabu to the Indians of that area. Indians of the cliff-dweller culture kept turkeys in captivity for the sake of their feathers, it is reported, rather than as a source of food. Powell, in his account of exploration in the Colorado River Basin, figures an eagle cage built and used by Hopi-land Indians. I saw a magpie kept in a cage by a wandering tribe of Indians in Death Valley, California. What but its plumage could have been the attraction in this case?

I feel that attractiveness of their plumage may account for the presence of Sparrow Hawk, Flicker, Magpie and perhaps Crow in many of the middens that I have examined. It has been reported that the scalps of the Acorn-eating Woodpecker in California and the Ivory-billed Woodpecker of the Mississippi Valley were used within historic time as a medium of exchange between tribes. I am inclined to credit the report.

The wing feathers of large raptors, waterfowl or even the Raven probably found use in the fletching of arrows. Skins of pelicans made warm body covering. The fluffy plumes of the Rhea, held together by plant fibre made a light and comfortable blanket for the native of the Argentine pampa. Altogether the bird's feather was an important item of interest to the Indian. To me it explains the presence of certain bones in the refuse heaps. Among some ten thousand bird bones examined, I have seen but two or three that suggested contact with fire. Possibly these Indians, like some Esquimaux, ate the bird raw.

## Ritual

The owl was sacred to Pallas Athena; the Romans ascribed great significance to the movements of birds. No less seriously did the American Indian look upon a wide variety of birds. This aspect of ethnology warrants a volume in itself. Only surmise is left us in the work with midden remains. How tantalizing and how exciting to the imagination! The Indians, more than likely, brought with them from the Old World a "rootstock" of belief or superstition from which there grew through the ages, along with the evolution of linguistic or even physical characters, a whole "botanical garden" of beliefs, rituals, tabus, totems and heraldry. The picture is so kaleidoscopic today that I ventured only suggetsion in the discussion of certain species.

## Fragmentation of Bones

Three papers have previously appeared regarding my own study of the bird remains from middens (Miller, 1957, 1960, 1961). In each of these comment was made on the high degree of breakage. This continues to puzzle me. Mammal bones were supposedly cracked to retrieve the yellow marrow from the cavity. Bird bones are small and in relatively few species is there even a small amount of fat to be found —certainly not enough to encourage an Indian to crack the dense and very hard tarsus of an eagle or a condor. Yet seldom are these bones found unbroken.

Trampling by bare or moccasined feet would merely press the bone into the soft matrix of the midden. Bone-chewing habits of the dog family would tend to concentrate upon the ends of the bone where articular cartilages and synovial membranes add flavor. Furthermore the bone would be abraded instead of merely broken. Excavation of the Dalles midden uncovered almost no canid material whereas the breakage of bird bone there was most marked.

On San Nicolas Is. off Southern California, dog remains of two strains were extremely abundant; yet in the extensive middens there breakage of bird bone was at the minimum. The Birch Creek middens in eastern Idaho show less of this breakage than does any other mainland midden that I have studied. To me it seems to be the result of human activity, a force sometimes quite powerful, that was purposefully applied. But what was the purpose? Was it ritual? In the case of the Sage Hen from Birch Creek midden, which was presumably a food item in the main, many of the long bones were almost perfect.

## SUMMARY AND DEDUCTIONS

1. Birds were of definite interest to the Indians though that interest may have varied greatly.
2. The interest may have been in its flesh as a food item; in its feathers for ornament, for flectching the arrow, for warmth in clothing, for symbolism; in its bone for making awls, beads, counters or whistles; as a tribal or clan totem; religious or ceremonial sacrifice; as a pet; Tabu probably loomed large.
3. The bird fauna retrieved from a midden varied with geographic location, with local ecology, with climatic changes at the same site.
4. Only one bone out of many thousand represents an extinct species. Only one species, the condor, was found outside its present day range.
5. In some cases mineralization had begun.
6. Maximum age was 10,000 to 12,000 years.
7. Bones from most middens were highly fragmented. This phenomenon was not explained.
8. Owls or falcons may have added some bones to a midden.
9. Falcons, Ravens and Cliff Swallows may have nested in some of the caves.

TABLE I.

Bird remains identified from middens of Western Indians.

| x = present<br>sp. = species | Emery-ville, Calif. (Howard, 1929) | Dalles, Oregon (Miller, 1957) | Puget Sount, Wash. (Miller, 1960) | Missouri R., N. Dakota (Miller, 1961) | Wilson Butte, Idaho (Gruhn, 1961) | Weiss Rock, Idaho | Birch Creek, Idaho |
|---|---|---|---|---|---|---|---|
| Gaviidae | x 3 sp. | — | x 2 sp. | — | — | — | — |
| Podicipedidae | x 2 sp. | — | x 2 sp. | — | x | — | — |
| Diomedeidae | x | — | — | — | — | — | — |
| Pelecanidae | x 2 sp. | — | x | x | — | — | — |
| Phalacrocoracidae | x 3 sp. | x | — | — | — | — | — |
| Ardeidae | x | — | — | x | — | — | — |
| Threskiornithidae | x | — | — | — | — | — | — |
| Anatidae | x many sp. | x 2 sp. | x many sp. | x 3 sp. | x | — | x 1 sp.<br>— |
| Cathartidae | x 2 sp. | x 3 sp | — | — | — | — | — |
| Accipitridae | x +4 sp. | x 2 sp. | x 2 sp. | x 3 sp. | — | x | x |
| Falconidae | x 3 sp. | x 2 sp. | — | — | x | x | x 3 sp. |
| Tetraonidae | x | — | x | x | x | x 2 sp. | x 1 sp. |
| Phasianidae | — | — | — | — | x | — | — |
| Gruidae | x | — | x | x 2 sp. | — | — | — |
| Rallidae | x 2 sp. | x | — | — | x | — | — |
| Charadriidae | x 2 sp. | — | — | — | — | — | — |
| Scolopacidae | x 6 sp. | — | x | — | x | — | — |
| Recurvirostridae | x | — | — | — | — | — | — |
| Phalaropidae | x | — | - | — | — | — | — |
| Laridae | x | x ? sp. | x | — | — | — | — |
| Alcidae | x 3 sp. | — | x | — | — | — | — |
| Columbidae | — | — | — | — | x | — | — |
| Tytonidae | x | — | — | — | — | — | — |
| Strigidae | x 2 sp. | x | x | x | x | x 2 sp. | x |
| Picidae | — | — | — | — | x | x | — |
| Hirundinidae | — | — | — | — | x | — | — |
| Corvidae | x 2 sp. | x 3 sp. | x | x 2 sp | x | x 3 sp. | x 2 sp. |
| Turdidae | — | — | — | — | — | x | — |
| Icteridae | — | — | — | — | x | x | — |
| Fringillidae | — | — | — | — | x | — | — |

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# CONTRIBUTIONS FROM THE LOS ANGELES MUSEUM–CHANNEL ISLANDS BIOLOGICAL SURVEY. 37[1].

# BRACHYDONT DESMOSTYLIAN FROM MIOCENE OF SAN CLEMENTE ISLAND, CALIFORNIA.

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The twelfth expedition of the Los Angeles County Museum's Channel Islands Biological Survey visited San Clemente Island, Los Angeles County, California, for one week during February, 1941 (Comstock, 1946: 100). On the last day of the stay, three teeth and a bone fragment of an extinct mammal were collected by the party, possibly in the vicinity of Wilson Cove on the northeast end of the island. These teeth represent a comparatively rare brachydont desmostylian.

Desmostylians were large, supposedly amphibious mammals which inhabited both the east and west margins of the North Pacific Ocean during the Miocene Epoch. There were probably a number of different types, but the best known and one of the most widely distributed genera, *Desmostylus*, is still considered by many to be a poorly known mammal, and its relationship to other desmostylian species can only be regarded as tentative. Each cheektooth of desmostylians is made up of a number of columns that are joined at the base. In *Desmostylus*, the height of the columns is great and the base of the crown is not enlarged, but in two other genera, *Cornwallius* and *Paleoparadoxia*, the columns are relatively shorter and the base of the crown may or may not form a predominant part of the tooth.

The following abbreviations are used in this report: CIT, California Institute of Technology collections now in the Los Angeles County Museum; LACM, Los Angeles County Museum; PMBC, Provincial Museum of British Columbia; and UCMP, Museum of Paleontology, University of California, Berkeley.

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[1] All of the previous contributions from the Channel Islands Survey have appeared irregularly in this Bulletin, beginning in 1939.

### Order DESMOSTYLIA Reinhart, 1953
### Family **Paleoparadoxidae** Reinhart, 1959[2]
### *Paleoparadoxia* sp.

*Material.* Four specimens are represented in the collection: LACM 4371a, a nearly complete cheektooth; LACM 4371b, crown and portion of the root of a premolar embedded in a bone fragment showing portion of an adjoining alveolus; LACM 4371c, a bone fragment with the basal end of a tusk in place; and LACM 4371d, an indeterminate bone fragment (Fig. 1a-i).

*Collector.* The specimens were collected by Jack C. von Bloeker, on 22 February 1941.

*Locality.* LACM fossil vertebrate locality 1164: "Wilson Cove, north of airport, San Clemente Island, Los Angeles County, California." This information is from the original label; no further data are available. Neither Mr. von Bloeker (the collector) nor Mr. George P. Kanakoff (who accompanied Mr. von Bloeker on the collection date) can remember specifically collecting the specimens. Mr. von Bloeker thinks that they were collected near the pier at Wilson Cove on the above date, but Mr. Kanakoff believes that they may have been collected elsewhere on the island by U.S. Navy personnel. The rock adhering to the specimens was a light brown, medium-grained sandstone composed of angular to subangular clasts of volcanic rock. Rocks of similar lithology were not located by Mr. Jere H. Lipps and me during a search at Wilson Cove on 5 September 1961. The specimens may not have come from Wilson Cove.

*Formation and Age.* Olmsted (1958) indicated that the unnamed Tertiary sedimentary rocks exposed on the island are middle Miocene in age. However, he stated (p. 65) that the rocks at Wilson Cove contain "phosphatized Foraminifera that are questionably of early Miocene age."

*Descriptions.* The four specimens hereinafter described may have come from a single collecting station, and possibly from a single skeleton since they were apparently collected in limited time, are from unduplicated parts of a skeleton, all have the same patina, similar weath-

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[2] Designated "Family Paleoparadoxia" by Reinhart (1953), but was a *nomen nudum* until 1959 when the typical genus (*Paleoparadoxia* Reinhart, 1959) was proposed and characterized.

ering marks, and had the same type of matrix adhering to them before preparation.

**Cheektooth.** The nearly complete cheektooth (LACM 4371a) lacks the entire root system, and also the pulp cavity wall for about one quarter of its circumference. The columns are reduced in size compared to the underlying inflated crown. There are four main columns, with a group of three accessory columns at each end and at least two (possibly three, one may have occupied a lateral broken area) small columns between the large pair of main columns (see Fig. 1a). The columns are set upon a crown which is laterally inflated and bulbous, and which has thin walls ventrally. The columns converge toward the center of the crown, and each has a small protuberance of dentine at the top. No wear is evident on any column. A well defined cingulum runs nearly the length of the tooth on one side and seemingly gives rise to an additional incipient lateral cuspule on one end (Fig. 1c). A ventral view into the pulp cavity (Fig. 1b) discloses seven indentations that can be directly correlated with columns (or groups of columns) of corresponding relative size directly above (as in *Desmostylus*; VanderHoof, 1937: 182). The pulp cavity itself is exceptionally large —if the tooth were not broken, exposing a cross-section of relatively thin enamel and thick dentine, it might be thought to be the cavity

TABLE 1

Measurements in millimeters of crowns of cheekteeth of brachydont desmostylians. Comparative measurements taken from VanderHoof, 1942; Hay, 1924; and Clark and Arnold, 1923.

| Specimen | Maximum length | Maximum width | Maximum height of crown |
|---|---|---|---|
| *Paleoparadoxia* sp. | | | |
| LACM 4371a | — | 28.0 | 26.5 |
| UCMP 45274 | 23.2 | 18.0 | 16.0 |
| UCMP 63981 | 20.0(?) | — | 13.0 |
| *Paleoparadoxia tabatai* | | | |
| UCMP 40862 | 33.0 | 25.4 | 20.0 |
| UCMP 32076 | 35.4 | 25.4 | 16.2 |
| *Cornwallius sookensis* | | | |
| PMBC 486 (holotype) | 33.0 | 24.0 | 16.0 |
| PMBC 491 | 48.5 | 34.0(?) | 23.0 |
| UCMP 32682 | — | 28.0 | 14.0 |
| UCMP 36079 | — | 24.0 | 26.5 |
| UCMP 36078 | 36.0 | 27.5 | 17.5 |

occupied by dentine (see cross-sections in VanderHoof, 1937: fig. 14; Hay, 1923: fig. 4; Hay, 1924: fig. 1). The ventral border of the pulp cavity as preserved is laterally constricted midway from the ends of the tooth, which suggests that the tooth may have been double rooted. The dentinoenamel junction was probably about 10 mm. below the bases of the columns. At the base of a major column (on the broken end of the tooth) the enamel is 2 mm. thick. Fine circumferential striae (the surface expression of the enamel prism groups of VanderHoof, 1937: 182; and "Schreger's stripes" of Reinhart, 1959: 98) are distinguishable on the base of the crown and the columns. Somewhat larger vertical striae are distributed around the tooth in the region between the base of the crown and the base of the columns. A waterworn cheektooth (UCMP 64116) found with another tooth referred to *Paleöparadoxia* at UCMP locality V5555 in late Miocene rocks at Santa Cruz, California (Mitchell and Repenning, 1963) closely resembles LACM 4371a in having a well inflated crown base with columns that converge sharply inward. Dr. Tadao Kamei (*in litt.* 25 November 1962), basing his conclusion on a drawing, thinks that LACM 4371a is a left lower third molar.

**Premolar.** The premolar (LACM 4371b) is embedded in a badly eroded fragment of bone. The remnant of the root of another tooth slopes toward the premolar at an angle of 25°. The root of the premolar is oval in cross-section and is solid. The crown of the tooth is thickly enameled. The crown has very small pits irregularly distributed over its surface, but these pits may be due to weathering phenomena. On the tip of the crown is a tear-drop shaped opening in the enamel which exposes dentine (Fig. 1d). On one side of the crown (Fig. 1e) is a small, flat wear surface. On the side of the crown nearest to the second root fragment is a pronounced bulge accentuated by a small, irregular pit above it. On the edge of the tooth opposite this bulge is a small indentation which may be a second wear surface. There is a well marked separation between the enamel of the crown and the dentine of the root. Dr. Tadeo Kamei (*in litt.* 25 November 1962), basing his conclusion upon a drawing, thinks that LACM 4371b is a right first premolar, but that it could be either upper or lower.

**Tusk.** The fragment of bone containing the basal tusk fragment (LACM 4371c) is poorly preserved, but some information can be derived from it. No sutures are evident on the bone. It is dense except for the area at the base of the pulp cavity of the tusk, where it is perforated by numerous large nutrient foramina. Only a portion of one

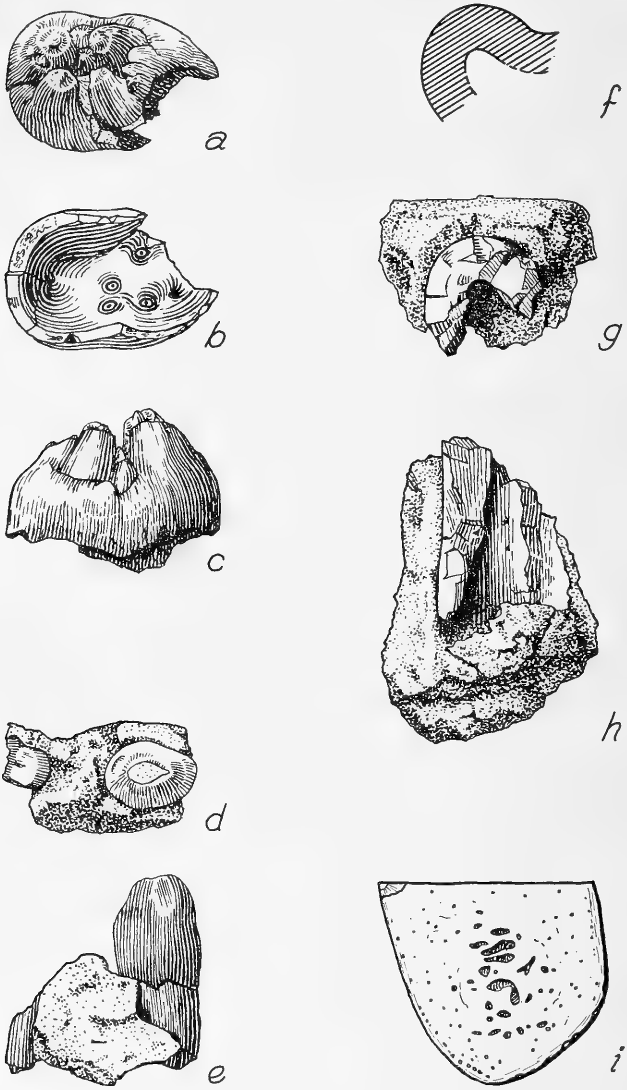

*Figure 1.* Fragmentary teeth and bones of *Paleoparadoxia* sp. from Miocene of San Clemente Island, California. All views ⅔ natural size except *i* which is 1⅓ natural size. *a*—occlusal, *b*—bottom, and *c*—side views of cheektooth LACM 4371a; *d*—occlusal and *e*—side views of premolar LACM 4371b; *f*—diagrammatic cross section, *g*—anterior, and *h*—side views of tusk fragment LACM 4371c; and *i*—cross-section of indeterminate bone fragment LACM 4371d (which has been ground flat on two sides).

side of the tusk is preserved. In anterior view, it is evident that the tusk was not perfectly round. In Figure 1g, the dark shading to the right of the tusk fragment denotes an area from which most of the tusk is broken away, but where a thin veneer of dentine still adheres to the alveolar wall. The curvature indicates a wider tusk with a sulcus or groove on one side (Fig. 1f). The walls of the tusk itself are thick three centimeters anterior to the basal end, but are reduced in thickness posteriorly to a sharp-edged margin at the end. The pulp cavity is funnel-shaped, tapering rapidly anteriorly (Fig. 1h).

**Bone fragment.** On the most convex border of the indeterminate bone fragment (LACM 4371d) there are numerous interconnecting shallow sulci which run along the axis of the bone. The broken surfaces of this bone were cut and polished on a lap wheel to better observe the microstructure (Fig. 1i). The bone is quite dense. The sections show the characteristic pachyostoseal condition (*sensu* McLean and Urist, 1961: 226) that VanderHoof found in *Desmostylus* and which I believe to be characteristic of the order Desmostylia (Mitchell, *In press*). The Haversian canals are distributed regularly throughout the region between the cancellous portion and the distinct circumferential lamellae. In the center, the cancellous portion is characterized by lacunae of small diameter separated by thick-walled trabeculae.

TABLE 2

Measurements in millimeters of teeth of *Paleoparadoxia* sp. (LACM 4371) from Miocene of San Clemente Island. See Table 1 for measurements of cheektooth (LACM 4371a).

| | |
|---|---|
| LACM 4371b, premolar: | |
| Greatest diameter of root | 16.5 |
| Least diameter of root | 12.0 |
| Height of crown | 21.0 |
| Maximum width of crown | 16.0 |
| Estimated least diameter of adjacent root | 8.0 |
| LACM 4371c, tusk fragment: | |
| Greatest diameter as preserved | 23.0 |
| Greatest diameter of pulp cavity as preserved | 15.0 |
| Greatest thickness of dentine wall | 9.0 |

*Remarks.* These San Clemente Island specimens are herein referred to *Paleoparadoxia* and not to *Cornwallius* because the cheektooth (LACM 4371a): 1. although fitting the original generic diagnosis of *Cornwallius* ("low-crowned teeth furnished with a strong tuberculated cingulum" of Hay, 1923: 107), has a "strong tuberculated cingulum" that is not in fact diagnostic, or even present, in teeth of *Cornwallius* but is characteristic of *Paleoparadoxia* (Mitchell and Repenning, 1963); 2. has vertical striae around the base of the crown, similar to more pronounced striae in a specimen referred to *Paleoparadoxia tabatai* by Reinhart (1959, specimen UCMP 40862); and 3. unlike teeth referred to *Cornwallius* has a prominent swollen crown base.

The *Paleoparadoxia* sp. specimens (LACM 4371; the "brachyodont desmostylid" of Mitchell and Lipps, *In press*) represent some of the earliest collected (1941) identifiable vertebrate fossils from the Tertiary of San Clemente Island other than the "mammalian bones" of Olmsted (1958: 64) and undetermined fish scales (Smith, 1898: 490). Mr. J. H. Lipps and I recently collected many fossils of marine vertebrates which are still under study (Mitchell and Lipps, *In press*).

*Paleoparadoxia* is circum-North Pacific in distribution, and ranges from early to late Miocene in age (Mitchell and Repenning, 1963). In the eastern North Pacific, *Paleoparadoxia* is known from west-central California (Reinhart, 1959: 95, specimens UCMP 40862 and 32076; and Mitchell and Repenning, 1963: , specimens UCMP 45274 and 63981), possibly from southern California (Reinhart, 1959: 99, specimen LACM 1352), and from San Clemente Island (this report) which is the southernmost known occurrence in this area. Teeth referred to *Cornwallius*, a genus which is restricted to the early Miocene of the eastern North Pacific, have been found in Alaska (Byers, 1959: 289; Drewes, *et al.*, 1961: 606), in British Columbia (Cornwall, 1922; Clark and Arnold, 1923), and the eastern side of Baja California (VanderHoof, 1942). Fossils of *Paleoparadoxia* may ultimately be found over as great a latitudinal range as fossils of *Cornwallius* in the eastern North Pacific.

Ijiri and Kamei (1961: 27) stated that "*Paleoparadoxia*, like *Desmostylus*, is aquatic (marine) herbivorous . . ." and may be "omnivorous grazing." Yabe (1959) reported that both "*Cornwallius*" (= *Paleoparadoxia, sensu* Mitchell and Repenning, 1963) and *Desmostylus* have been found in the same beds in Japan. *Paleoparadoxia* and *Desmostylus* have been found together in the Santa Cruz area of California also (Mitchell and Repenning, 1963).

## SUMMARY AND CONCLUSIONS

Three teeth and a bone fragment referred to *Paleoparadoxia* sp. are described from early or middle Miocene deposits on San Clemente

Island, Los Angeles County, California—this is one of the few North American locality records of this genus, and one of the first identifiable vertebrate fossils reported from the Tertiary of San Clemente Island.

One of the tusks of *Paleoparadoxia* sp. was not round in cross section but had an obvious sulcus on one side.

Pachyostosis occurs in bones referred to *Paleoparadoxia* sp.

## Comparative Material

The following specimens were examined: *Cornwallius sookensis*- UCMP 36078, 36079, and 32682, PMBC 491 (cast), PMBC 486 (cast); *Paleoparadoxia*- UCMP 40862, 32076, 45274, 63981; Cf. Paleoparadoxid- LACM 1352. This last specimen (LACM 1352) from LACM locality 1084 was incorrectly referred to as "CIT 857" by Reinhart (1959: 99-101).

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This paper is part of the results of a study by Mr. J. H. Lipps and myself on the paleontology and geology of San Clemente Island (see Mitchell and Lipps, *In press*). It is published as a Los Angeles Museum-Channel Islands Biological Survey contribution because the specimens were collected in 1941 by that Survey.

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# NOTES ON THE OVA OF SIX CALIFORNIA MOTHS

John Adams Comstock

Del Mar, California

In the spring and early summer of 1962 there was an unusual number and variety of moths that came to light in Del Mar, California. Many of these were noted for the first time in this locality. Ova were obtained from several species, some of which were reared to maturity and notes have been published on their life histories. A few could not be reared farther than the first instar because their food plants were unknown. The majority of ova were infertile, but drawings were made as a preliminary step to further study.

It seems advisable to record six of these ova since little or no mention of them occurs in the literature.

## **Autographa (Pseudoplusia) californica** Speyer

Figure 1A.

This common moth, known as the "Alfalfa Looper," was present in its characteristic abundance, at black light. The reason ova were secured was that no illustration of the egg has been found in easily available literature.

OVUM. (Laid May 4 and 5, 1962). Eggs were deposited singly in the rearing jar. Color, yellow. Form, hemispherical, the base flattened, the top well rounded, and the center depressed by a minute micropyle.

There are approximately 32 prominent ridges running from base to micropyle, but many of these fuse with others or become obsolescent in the upper third of the egg. The ridges are topped with rows of large round "pearls." There are no apparent cross striations running horizontally between the ridges. The floor of the micropyle is pitted.

The larva is an "omnivorous feeder on herbs, except grasses." The moth ranges along the west coast from Canada to California, and eastward to Colorado.

Owing to the large number of published records of the life history of this common pest, only a few selected bibliographical references are given at the end of this paper, namely: Comstock (1930: 25, pl. 9); Crumb (1956: 258 f.); Dyar (1890: 14); Essig (1913: 161); Hampson (1913: 540 f.; pl. 238, fig. 5); Lembert (1894: 46); and Okomura (1962: fig. 45).

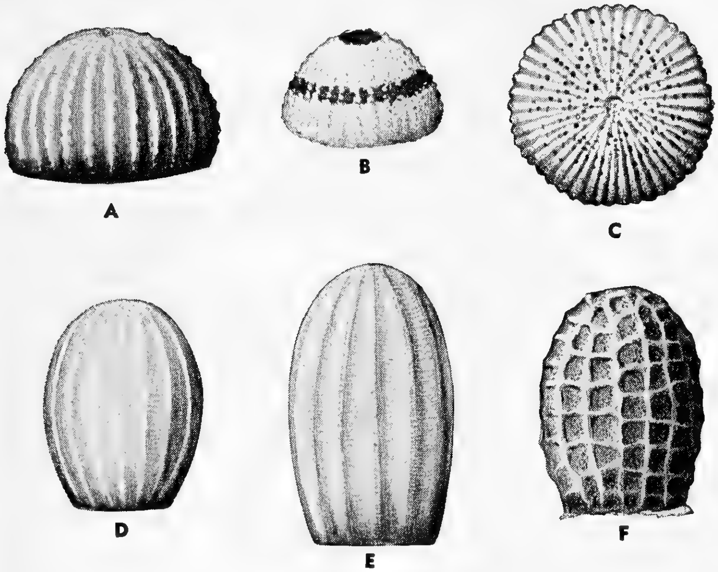

*Figure 1.* Ova of six moths., figures greatly enlarged. Reproduced from water color drawing by the author. Ova: A, *Autographa californica*; B, *Aseptis genetrix*; C, *Zale lunata*; (top aspect); D, *Pherne subpunctata*; E, *Sericosema simularia*; F, *Pterotaea agrestaria.*

## **Aseptis genetrix** (Grote)

### Figure 1B.

This noctuid moth was described by Grote (1878: 237) as *Hadena genetrix* from material obtained by Dr. James S. Bailey in "Nebraska, Colorado and Nevada." Dr. McDunnough, in 1937, made it the genotype of "*Aseptis*." It ranges from western Canada through Washington to Arizona, and eastward through Utah to Nebraska.

Its larva has been described by Dyar (1898: 320) and Hampson (1908: 139 f.).

Specimens taken in Del Mar on April 10, 1962, enable me to describe and illustrate the egg. Captive females deposited their eggs singly and indiscriminately in the rearing jar.

OVUM. Hemispherical, the base flattened. Diameter at base, 0.7 mm. Height, 0.5 mm. Color, glistening white. The majority have a circlet of yellow blotches around the upper one-third, and similar color in the micropylar depression, as shown in the illustration (Fig. 1B.).

The surface bears about 30 elevated ridges running vertically from base toward micropyle, each topped with a line of pearly nodules.

The eggs proved to be infertile. The larval food plant is reported to be *Adenostoma fasciculatum* H. & A.

## **Zale lunata** (Drury)

Figure 1C.

Synonymy male *edusa* Drury, *putrescens* Guer.

This member of the *Catocalinae* ranges through all states east of the Rocky Mountains except the Dakotas and Montana. In the west it has been reported from California through Oregon to Washington. Several forms or varieties have been named.

The larva has been described many times by various writers, but I cannot locate any illustrations of the egg.

Forbes (1954) reports it as "a general feeder on trees and shrubs," specifically listed are cherry, maple, plum, willow, oak, blackberry, raspberry, salmonberry, wisteria, rose and pyrocantha.

The species is not common in Del Mar, but a single female was taken May 7, 1962. This specimen laid a few eggs the following day, one of which served for illustrating. Subsequently (May 11) the eggs hatched.

OVUM. Spherical, with a flattened base and well rounded top. Width, 0.75 mm. Height, 0.5 mm. Color, bright green when first laid, changing later to cream, with a suggestion of dull green on the upper portion and with brownish spots sprinkled over the surface, as shown in the illustration. There are approximately 45 ridges running from the base toward the micropyle. Many of these fuse or become obsolete in the upper portion of the egg. These ridges are topped with minute nodules. The micropyle is relatively small; its white floor is deeply depressed and is covered with small hexagonal cell walls.

Notes were made of the first instar larva, largely for comparison with French's (1882) description of the same stage.

FIRST INSTAR LARVA. Length, average about 5 mm. Body cylindrical and elongate, the head slightly wider than the body segments.

Body, yellow, with a slight greenish tinge; legs and prolegs of the same color. There are two pairs of functional prolegs in addition to the anal pair. No distinguishing lines or marks occur on the body surface, but small black papillae are distinguishable, scattered over the body and head. These bear minute black setae.

This is a very active larva, but a sluggish feeder. It eats small patches from the surface of leaves of both willow and oak.

In view of the thorough coverage of remaining stages by many authors, no further notes were made.

Nine references in the literature are helpful in the discussion of this species: Behr (1870: 28); Beutenmuller (1901: 192); Crumb (1956: 293); Forbes (1954: 350 f.); French (1882: 130 f.); Guenee (1852: 13 f., pl. 2); Hampson (1913: 223 ff., fig. 56); Lintner (1888: 58); and Packard (1870: 229).

## **Pherne subpunctata** (Hulst)

Figure 1D.

This species was named by Hulst (1898) as *Metanema subpunctata*. His brief description recorded it from "California" with no date, collector, or type locality designated.

I published a brief note on the egg and first larval instar in 1955, but no illustration was included. We have no information of its range, but presume it may turn up in Arizona and Baja California, as it is apparently a lower sonoran zone species.

Nothing is known of its food plant. I offered young larvae *Rhus*, *Eriogonum* and *Ceanothus* in 1955, and again in 1962 tried several local plants without success.

I include herein an illustration of the egg, and an amplified description made from specimens taken in late June of 1962. The very brief note on the first instar larva previously published will have to suffice for the present.

OVUM. Oval, the base flattened and the top evenly rounded. Height, 0.95 mm. Horizontal diameter through the center, 0.7 mm. (the measurements given in 1955 were in error). When first laid the color is deep cream with the white lines of the vertical ribs showing in strong contrast.

At the base a circlet of raised points marks the origin of the vertical ridges. There are from 16 to 20 of these and the edges thereof are topped with a line of minute rounded tubercles. The troughs between these ridges are crossed by striations corresponding in position and numbers to tubercles of the vertical ridges.

The flattened base of the egg is irregularly pitted. The micropyle is not clearly defined, and is restricted by the terminations of the vertical ridges. This gives a roughened and crowded effect.

The majority of the eggs were regularly oval, but a few tended toward elongation.

Two references are helpful in the study of this species: Hulst (1898: 218); and Comstock (1955: 105).

### **Sericosema simularia** (Taylor)

Figure 1E.

This is a rare moth in the San Diego-Del Mar area, but is probably more common in the environs of Pasadena, California, the type locality.

It was described as *Enemera simularia* by Taylor (1906: 190 f.) from specimens collected by Fordyce Grinnell. Nothing has been published on its life history, range, or food plant.

We confined a female taken at Del Mar May 4, 1962, which laid 17 eggs, none of which hatched. In late June and early July, additional specimens were captured and generously added to our "clutch." As with the others, none hatched, though apparently fertile. All were retired for the winter but, unfortunately, without the moisture and temperature of their natural environment. This year (1963) they are apparently dead, but show dark bodies internally. This suggests that, normally, the embryo overwinters in the egg.

OVUM. Elongate-oval, very flat at the base and evenly rounded at the top. All were laid singly on their sides. Length, from base to rounded top, 1.0 mm. Width through center, 0.5 mm. Color, bright green.

The surface is covered by 12 or 13 longitudinal ridges, running from base to micropyle, with no fusion or discontinuance at their ends. The spaces between the ridges have low striae, placed close together, running at right angles to the main ridges. Each of the latter is topped by a row of very minute brownish nodules. The micropyle is small and irregular, faintly pitted, and not deeply depressed.

### **Pterotaea agrestaria** (Grossbeck)

Figure 1F.

This geometrid moth was first described in 1909, as *Cleora agrestaria*, by John A. Grossbeck, from material originating in Monterey and San Diego Counties. Apparently most of his specimens were collected by George H. Field, pioneer lepidopterist of San Diego.

A group of eggs laid May 8, 1962, showed, typically, the following characteristics:

OVUM. Width, 0.4 mm. Height, 0.8 mm. Form, ovoid, with a flattened base, an evenly rounded top, and no formed micropyle. Color, at first salmon-red, fading later to a lighter shade. The eggs were laid singly on their sides, not on their flattened bases.

There are from 12 to 14 longitudinal ridges running from base to rounded top. Horizontal ridges of equal height, from 7 to 9 in number, run at right angles to the longitudinal ridges. This gives a pattern of irregular squares and hexagons with deeply depressed and pitted floors. All of the ridges appear to have hyaline edges which show white in cross lighting.

The base appears to possess a ragged membrane suggesting that, in a state of nature, they may be laid with their flattened bases on a surface to which they may be adherent. These features are brought out in the illustration (Fig. 1F.).

It should be mentioned that a second batch of eggs obtained May 25, 1962, showed a considerable number that were more elongate and subcylindrical than the typical oval examples of the first lot.

None of the eggs hatched. We were prepared to feed the larvae on *Adenostoma fasciculatum* H. & A., as this was reported (*in litt.*) by Noel McFarland as the food plant.

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# A STUDY OF THE ZYGOPINAE (COLEOPTERA: CURCULIONIDAE) OF AMERICA NORTH OF MEXICO, I.[1]

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While engaged in a study of the genus *Cylindrocopturus* Heller of the subfamily Zygopinae, it became increasingly obvious that there was a need for a study of the whole of the Zygopinae. This is the first of three papers on this group.

The author is indebted to numerous individuals for aid on the papers, especially: Drs. Fred Truxal, Charles Hogue, and Mr. Lloyd Martin of the Los Angeles County Museum for making material and library facilities available; Miss Rose E. Warner (now Mrs. T. J. Spilman) for aid in studying material at the United States National Museum (USNM); Dr. Barry D. Valentine for information on the type material at the Museum of Comparative Zoology (MCZ), Harvard; and Dr. William D. Stockton for aid with the manuscript. Acknowledgment is made to National Institute of Health, research grant AI-3407 (Richard B. Loomis, Principal Investigator), for aid in studying material first hand in northwestern Mexico. In addition to the above abbreviations the following have been used: ELS=E.L. Sleeper Collector, (ELS)=E.L. Sleeper Collection, FDPI=Entomological Collection Florida Department of Plant Industry, and OSU=Ohio State University.

## KEY TO THE GENERA OF ZYGOPINAE IN THE UNITED STATES

1. Pygidium exposed; (Fig. 1) .................. 5. *Peltophorus* Schoenherr
1a. Pygidium completely concealed; (Fig. 7) .......................... 2
2. Abdomen horizontal throughout (Fig. 4); eyes approximate on the front; humeri not obliquely truncate ........................................ 3
2a. Abdomen ascending rapidly distally (Fig. 6); eyes and humeri variable. .................................................................. 4
3. Femora minutely toothed; antennae stout with well developed club; body densely scaly; elytral striae coarse .................. 3. *Acoptus* LeConte
3a. Femora not toothed; antennae very slender, the club small; body subglabrous above; elytral striae fine ............................ 4. *Psomus* Casey

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[1] Contribution #23 to the knowledge of the Curculionoidea.

[2] Biological Science Paper #9, Long Beach State College.

4\. Pectoral channel extending over the mesosternum, occasionally ending in the metasternum, channel clearly limited laterally by a raised ridge or carina (Fig. 10) .................................................. 5

4a. Mesosternum not excavated, apex of rostrum free (Fig. 3) .............. 7

5\. Femora minutely or moderately toothed .......... 1. *Lechriops* Schoenherr

5a. Femora unarmed .................................................. 6

6\. Mesosternum and anterior margin of metasternum deeply impressed or excavated by pectoral channel (Fig. 10) .............. 2. *Eulechriops* Faust

6a. Mesosternum with a pectoral channel indicated only by a feeble concavity and prominent lateral carinae, metasternum not impressed, the latter inclined in front ........................ 7. *Cylindricopturinus*, new genus

7\. First two segments of funicle little different in length; second never more than one and one-half times as long as first .......................... 8

7a. Second segment of funicle very long, more than twice as long as the first ........................................... 8. *Copturus* Schoenherr

8\. Mesosternum flat, slanting, non-carinate laterally 6. *Cylindrocopturus Heller*

8a. Mesosternum very feebly concave, carinate laterally between meso-and metacoxal cavities .................... 7. *Cylindrocopturinus*, new genus

## 1. *Lechriops* Schoenherr

*Lechriops* Schoenherr 1826, p. 306. Type species *Rhynchaenus sciurus* Fabricius.

*Piazurus* LeConte 1876, p. 259. (Not Schoenherr, 1826)

*Gelus* Casey 1897, p. 667. Type species *Cryptorhynchus oculatus* (Say)

This genus occurs in North and Central America and northern South America as well as on some of the islands of the West Indies.

### KEY TO THE SPECIES OF *Lechriops* OF AMERICA NORTH OF MEXICO

1\. Prothorax about twice as wide as long; common sutural spot of elytra not conspicuous; elytra much wider than prothorax; total length 1.7 mm. .... ............................................ *subfasciata* (LeConte)

1a. Prothorax normally slightly wider than long (varying from 5:5 to 5:8) never more than one and one-half times wider than long; common sutural light spot of elytra very conspicuous ..................................... 2

2\. Elytra but little wider than prothorax; outline more elongate, slender (Fig. 5); elytra noticeably longer than wide (measurements of length down sutural line); total length 2.0-3.5 mm.; width 1.2-1.6 mm. .................. ..............................................*californica* (LeConte)

2a. Elytra much wider than prothorax; outline more robust ((Fig. 7); elytra but little longer than wide .......................................... 3

3\. Smaller, 3.0-3.2 mm.; elytral suture with a prominent light spot near middle; pronotum with a conspicuous pattern of pale brown scales; east of the continental divide south into Mexico and Central America ....... *oculata* (Say)

3a. Larger, 3.5-4.5 mm.; elytral suture with a prominent light spot and sutural line from declivity to apex; pronotum without pattern of lighter scales at middle; (Fig. 7); Arizona ........................ *grisea*, new species

### *Lechriops subfasciata* (LeConte)

*Piazurus subfasciatus* LeConte 1876, p. 260. Type locality: "New York, Mr. Guex," type in MCZ.
*Gelus subfasciatus* (LeConte), Casey 1897, p. 668.
*Lechriops subfasciata* (LeConte), Blackwelder 1948, p. 47.

This species is still known only from the unique type, which may represent an introduced species from an undetermined Latin American Country.

### *Lechriops californica* (LeConte)
Figure 5

*Piazurus californicus* LeConte 1876, p. 260. Type locality: "Calveras, California," type in MCZ.
*Gelus californicus* (LeConte), Casey 1897, p. 668.
*Lechriops californica* (LeConte), Blackwelder 1948, p. 47.

*Distribution*. Rather abundant in western United States and northern Mexico. Specimens are at hand or have been seen from southern Oregon, Utah, Nevada, California, Arizona, New Mexico, Baja California Norte, Sonora, and Chihuahua. It is limited to areas of pine growth, being, however, infrequently encountered on pinyon pine (*Pinus cembroides* var.). It is very abundant on *P. ponderosa* and *P. jeffreyi* throughout all of the range of this weevil. The larvae and pupae have been encountered beneath or in the bark of *P. jeffreyi* in southern California and Baja California Norte.

### *Lechriops oculata* (Say)

*Cryptorhynchus* Say 1824, p. 308. Type locality: "Inhabits Missouri," here restricted to St. Louis, Missouri, type lost.
*Lechriops oculatus* (Say), Heller 1895, p. 14.
*Gelus oculatus* (Say), Casey 1897, p. 668.
*Lechriops oculata* (Say), Blackwelder, 1947, p. 879.

*Distribution*. Generally distributed throughout North America east of the Rocky Mountains and the Sierra Madre Oriental. Its range in Canada is undetermined, but examples are at hand from Quebec, Ontario and Manitoba. Numerous examples have been seen from Mexico and Guatemala.

This species has been taken on *Quercus* spp., *Hicoria* sp., *Sassafrass sassafrass* L., *Fraxinus* spp., *Fagus grandifolia* Ehrh., *Viburnum* spp., and *Crataegus* spp.

### **Lechriops grisea,** new species
Figures 6 and 7

*Holotype.* USA., Arizona, Cochise Co., Chiricahua Mtns., Rucker Cyn., VIII-10-59, 7000', type no. 74, (ELS).

*Male.* Length 3.3 mm., width 2.0 mm.; elongate-oval; black with antennae and tarsi reddish brown; head and basal third of rostrum sparsely clothed with oval, black and white scales, vertex of head with scattered seta-like scales in punctures, prothorax with overlapping oval, yellowish-white scales on sides, a few black and brownish seta-like scales on disc, elytra moderately clothed with black, brown, white and yellowish white scales, the latter in patches at base of elytra and on apical half of sutural intervals.

Rostrum nearly three times as long as wide at base (11.5:4), nearly six times as long as width at antennal insertion (11.5:2), as long as the prothorax (11.5:11), sides convergent from base to antennal insertion, parallel sided thence to apex, in lateral outline strongly arcuate; coarsely, rugosely punctured and with a prominent median carina in basal third, apical two-thirds smooth, sparsely, very finely punctured; mandibles feebly bidentate. Antennal insertion at basal third of rostrum, scape shorter than the first two segments combined, not attaining base of rostrum; funicle with first two segments longer than remainder combined (ratio 1.3:2.2:.8:.6:.5:.5:.6), sparsely clothed with fine setae. Club oval-acuminate, basal segment constituting nearly half club length (1:.5:.2:.4), sparsely clothed with fine setae. Head continuous with rostrum, depressed but not foveate between the eyes, dorsum closely punctured with only the vertex without punctures, vertex strongly alutaceous, front narrow, the eyes separated by only one-third width of rostrum at antennal insertion, eyes finely granulate.

Prothorax wider than long (11:15.3), widest just before base, sides convergent from base to apex, apex tubular but not constricted, ocular lobes absent, base bisinuate, apex emarginate; disc closely, coarsely punctured, each with a subclavate scale, punctures of sides coarse, but obscured by vestiture, each with a large oval overlapping scale, disc

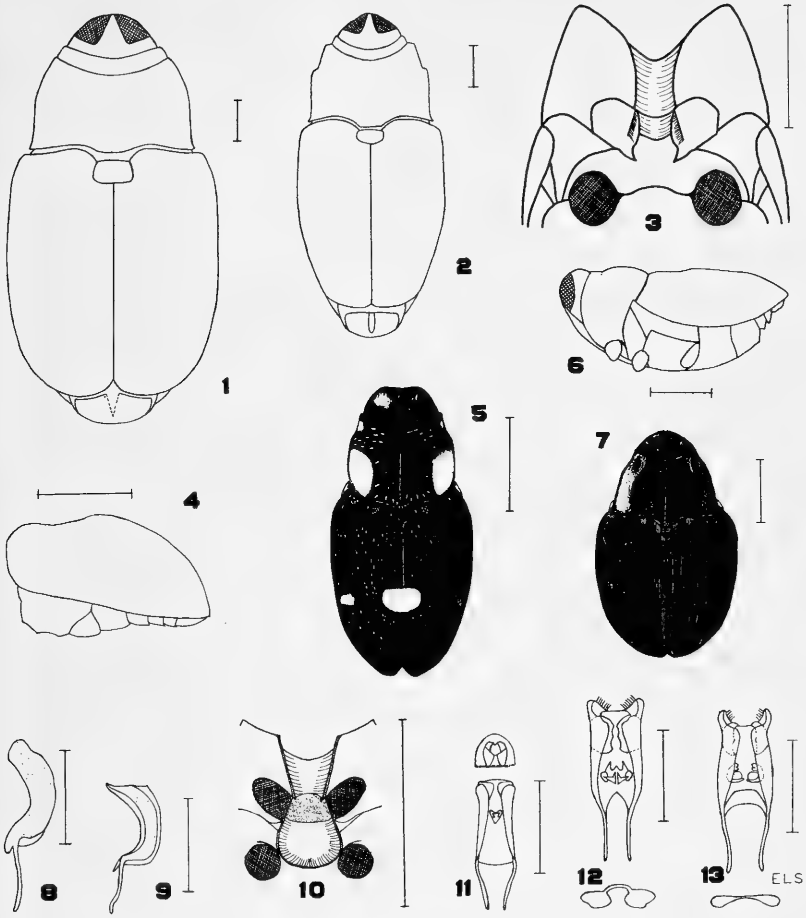

*Figure 1.* Outline of *Peltophorus polymitus seminiveus* (LeConte). *Figure 2.* Outline of *Peltophorus adustus* (Fall), male. *Figure 3.* Outline of pro- and mesosternum of *Copturus floridanus* (Fall). *Figure 4.* Lateral outline of elytra and sternites of *Acoptus suturalis* LeConte. *Figure 5. Lechriops californica* (LeConte). *Figure 6.* Lateral outline of *Lechriops grisea*, new species. *Figure 7. Lechriops grisea*, new species, holotype. *Figure 8.* Lateral outline of aedeagus of *Peltophorus polymitus suffusus* (Casey). *Figure 9.* Lateral outline of aedeagus of *Peltophorus adustus* (Fall). *Figure 10.* Outline of pro- and mesosternum of *Eulechriops minutus* (J. E. LeConte). *Figure 11.* Dorsal outline of aedeagus of *Peltophorus adustus* (Fall). *Figure 12.* Dorsal outline of aedeagus of *Peltophorus polymitus seminiveus* (LeConte) with outline of dorsal part of tegmen. *Figure 13.* Dorsal outline of aedeagus of *Peltophorus polymitus suffusus* (Casey) with outline of dorsal part of tegmen. Line = 1 mm.

carinate from base to apical fourth. Scutellum prominent, small, rounded, punctured and alutaceous.

Elytra only slightly longer than wide (12.5:11.1); humeri rounded off not prominent, but slightly wider than base of prothorax; sides strongly arcuate from base to apex, apices feebly emarginate; disc feebly convex, feebly depressed behind the scutellum; striae narrow, deep, with rectangular punctures, each separated by a narrow transverse carina, each puncture with a recurved subclavate seta, striae seven and eight not attaining base; intervals flat with close, deep, confusedly placed punctures each with a broad clavate scale.

Sternal side densely clothed with oval, white, rarely overlapping scales, which are for the most part appressed, each originating in a coarse puncture, area between punctures strongly alutaceous on abdominal sternites 3-5, on remainder of venter feebly alutaceous. Prosternum and mesosternum as in other species, metasternum concave between mesocoxae; intercoxal process very broad and truncate; abdominal sternites 10.5:4:1.5:2:3, first very long and with an oval concavity longitudinally at middle, second abruptly bent upward along posterior margin, apex of fifth truncate. Legs clothed with white appressed oval scales. Front coxae with a backward projecting tooth. Femora linear, compressed, all prominently unguiculate externally, the posterior pair mucronate internally. Tarsi elongate, as long as the tibiae, first two segments slender, clothed with prominent white seta-like scales, third broadly bilobed, naked, glabrous above, densely pilose beneath, fourth slender with inconspicuous reddish brown setae, ratio lengths of segments of hind tarsi 4.5:1.6:1.6:2.5. Claws slender.

*Allotype.* Female, 4.25 mm., width 2.4 mm., differing from the male only in the less concave first abdominal sternite and having the fifth sternite rounded apically.

*Other localities.* USA, Arizona, Cochise Co., Huachuca Mtns., Parker Cyn., 6500', VIII-12-59, ELS, (ELS).

*Type material.* Holotype, allotype, 1 ♀ paratype all with the same data, 2 ♂ ♂ paratypes, from Parker Cyn. The ♀ paratype from the type locality deposited in the Entomological Collections, Los Angeles County Museum, remaining type material in (ELS).

*Biology.* All of the examples from Parker Cyn. were taken while beating oak, where they were observed feeding on leaf petioles. One example from the type locality was also observed on oak.

This species may be separated readily from the other species known from the United States by its larger size and the prominent sutural spot and line. the latter being very conspicuous. It does not compare favorably with any of the material described in the Biologia Centrali-Americana nor any known species from northern Mexico.

### 2. *Eulechriops* Faust
### Figure 10

*Eulechriops* Faust 1896, p. 91. Type species *Eulechriops erythroleucus* Faust.

*Zygomicrus* Casey 1897, p. 667. Type species *Eccroptus minutus* J. E. LeConte.

This genus is distributed from northeastern United States to northern South America. Three species were previously listed in the literature from America north of Mexico. One of these species is here referred to a new genus, leaving *E. minutus* (J. E. LeConte), from the United States and *E. sobrinus* (Horn) from the Cape Region of Baja California Sur. The undescribed forms will be the subject of a future paper now in preparation.

All of the United States forms are associated with various species of *Quercus*.

### 3. *Acoptus* LeConte
### Figure 7

*Acoptus* LeConte 1876, p. 264. Type species *Acoptus suturalis* LeConte, the type in MCZ.

*Homogaster* Provancher 1877, p. 530. Type species *Homogaster quebecensis* Provancher, location of type unknown, a synonym of *A. suturalis*, according to Blackwelder and Blackwelder, 1948: 47.

A monotypic genus with the single species, described from "New York," distributed in the United States and Canada east of the Rocky Mountains, and in extreme northeastern Mexico.

In eastern United States this has been taken from *Quercus* spp., *Cercis canadensis* L., *Hicoria* sp., and *Platanus occidentalis* L.

### 4. *Psomus* Casey

*Psomus* Casey 1892, p. 458. Type species *Orchestes armatus* Dietz, type in MCZ; *Psomus politus* Casey, type in USNM, a synonym of *O. armatus*; Fall 1913, p. 64.

A single species occurs in the United States and Canada east of the

Rocky Mountains, and three species are known from Central America.

*P. armatus* (Dietz) is frequently associated with green ash (*Fraxinus lanceolata* Borck. and F. *americanus* L.) It is uncommon in collections. It is most frequently collected in June.

## 5. *Peltophorus* Schoenherr

*Peltophorus* Schoenherr 1845, p. 451. Type species *Peltophorus polymitus* Boheman.

This genus is restricted to arid areas of the United States and Mexico. The type locality for *P. polymitus polymitus* Boheman is "Mexico, Villa Alto in Oaxaca." In the United States three kinds are known from western Texas, New Mexico and Arizona.

### KEY TO THE KINDS OF *Peltophorus* OF AMERICA NORTH OF MEXICO

1. Prothorax with sides parallel in basal two-thirds to three-fourths (Fig. 2); abruptly subrectangular constricted in apical third; pronotum coarsely, cribrately punctured, their edges forming longitudinal ridges in some examples . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *adustus* (Fall)

1a. Prothorax with sides convergent from base to apex with a feeble apical constriction (Fig. 1); pronotum coarsely punctured, with a few punctures coalescent, their edges never forming prominent longitudinal ridges . . . . . . . . . 2

2. Range, southwestern Texas; dorsum of body with black, white and brown scales; punctures of elytral striae large, encroaching upon intervals; fifth ventral abdominal sternite without a prominent spot of scales each side of middle; aedeagus as in Figs. 8 and 13 . . . . . . . . . . *polymitus suffusus* (Casey)

2a. Range, southern Arizona and southwestern New Mexico; dorsum of body with black and white scales; punctures of elytral striae no wider than striae; fifth abdominal sternite with a prominent spot of black scales each side of middle; aedeagus as in Fig. 12 . . . . . . . . . *polymitus seminiveus* (LeConte)

### *Peltophorus adustus* (Fall)

Figures 2, 9 and 11

*Zygops adustus* Fall 1906, p. 61. Type locality "Arizona," here restricted to Arizona, Pima Co., Santa Rita Mtns., Lower Madera Cyn., type in MCZ.

*Distribution.* Moderately abundant in the Santa Rita, Huachuca and Chiricahua Mtns., in southern Arizona, and at Rodeo, New Mexico. Nearly all examples examined were taken from *Agave palmeri* Englm.

### *Peltophorus polymitus suffusus* (Casey)
Figures 8 and 13

*Zygops suffusus Casey* 1892, p. 459. Type locality "Texas (southwestern)" here restricted to Texas, Jeff Davis Co., Ft. Davis, type in the USNM.

*Peltophorus polymitus suffusus* (Casey), Blackwelder 1947, p. 881.

*Distribution.* Texas: Davis Mtns., VII-2-40, V-9-41, VII-17-46, VI-29-49, DJ & JN Knull, (OSU); Chisos Mtns., VII-17-46, DJ & JN Knull, (OSU); Val Verde Co., V-13-46, DJ & JN Knull, (OSU); Sanderson, VI-15-56, D. G. Genung, (ELS, FDPI).

### *Peltophorus polymitus seminiveus* (LeConte)
Figures 1 and 12

*Zygops seminiveus* LeConte 1884, p. 31. Type locality "Arizona," here restricted to Arizona, Cochise Co., Ft. Huachuca, type in MCZ.

*Peltophorus polymitus seminiveus* (LeConte), Blackwelder, 1947, p. 881.

*Distribution.* Arizona: Many records from the Santa Rita, Huachuca, Chiricahua, Pinal, Santa Catalina, Dragoon and Patagonia Mtns., May through September. Common in several species of *Agave* including *A. palmeri.*

### *Cylindrocopturus* Heller

*Cylindrocopturus* Heller 1895, p. 56. Type species *Zygops quercus* Say 1831, p. 20.

*Paratimorus* Heller 1895, p. 58. Type species *P. ganglbaueri* Heller.

*Copturodes* Casey 1897, p. 667. Type species, none designated, *Zygops quercus* Say, by present designation.

*Gyrotus* Casey 1897, p. 668. Type species *Gyrotus minutus* Casey, by monotypy, *new synonmy.*

The genus occurring throughout the United States and Canada (except for northwestern United States and Western Canada), southward to Argentina. Thirty species occur in Baja California and America north of Mexico. Forty-three species are known from the New World. The species of this genus will be treated in subsequent papers.

The designation of *Zygops quercus* Say as type species of *Copturodes* Casey was necessary in order to establish its synonomy with *Cylindrocopturus. Z. quercus* seemed the logical choice inasmuch as it is also type species of *Cylindrocopturus* and it was *Z. quercus* and forms related to it that were treated in the 1897 paper, for the most part.

After a study of many examples of *G. munitus* and comparing this species with numerous examples of *Cylindrocopturus* from Mexico I have come to the conclusion that there is no characteristic that will set *Gyrotus* apart from *Cylindrocopturus*. The pronounced modification of the prothorax in the region of the postocular lobes used by Casey for a major characteristic is repeated in varying degrees in many species of *Cylindrocopturus* from Mexico. The other characteristics grade into or are shared in varying degrees with members of that genus found in the United States. As a result of the synonymy *G. munitus* Casey must now be known as *Cylindrocopturus munitus* (Casey), *new combination.*

### 7. **Cylindrocopturinus,** new genus

*Type species Eulechriops pictus* Schaeffer, here designated.

Rostrum as in *Lechriops;* first two segments of funicle subequal; eyes large, separated by less than one-fourth the width of the rostrum at the point of antennal insertion; prothorax moderately bisinuate at base, without indication of ocular lobes or modification thereof; scutellum conspicuous, round; elytra deeply and conspicuously striate. completely concealing pygidium from above; mesosternum feebly concave, metasternum feebly convex, not exacavated, mesosternum carinate laterally between pro- and mesocoxae, apex of rostrum resting free; abdominal sternites ascending rapidly distally in lateral outline.

This genus is differentiated from the other North American forms by the characteristics pointed out in the key, particularly in having the non-excavate metasternum and the lateral elevations on the mesosternum which form a pectoral channel. *Lechriops* has the femora armed with a very small to moderately large tooth and the pectoral channel extending into the metasternum. *Eulechriops* has unarmed femora as in this genus but differs in the deep excavation of the metasternum. *Cylindrocopturus* has no indication of a pectoral channel on meso- or metasternum.

### **Cylindrocopturinus pictus** (Schaeffer). new combination

*Eulechriops pictus* Schaeffer 1908, p. 219. Type locality "Huachuca Mtns., Arizona," type in the USNM; Sleeper 1954, p. 182.

A rather rare and without doubt the prettiest of our Zygopinae from the United States. known only from the mountains of south central

Arizona. Specimens have been examined from the Santa Rita, Huachuca, and Patagonia Mountains.

A single example was beaten from *Quercus arizonica* in Madera Canyon of the Santa Rita Mtns. in July.

## 8. *Copturus* Schoenherr

*Copturus* Schoenherr 1826, p. 302. Type species *Rhynchaenus lamella* Fabricius.

*Coptorus Schoenherr* 1826, p. 302. (Error in spelling.)

This genus is represented in America north of Mexico by a single species found only in southeastern United States. The genus ranges generally southward to Argentina. More than 156 species have been described.

### **Copturus floridanus** (Fall), new combination

Figure 3

*Piazurus floridanus* Fall 1906, p. 61. Type locality "Florida (Key Largo and Elliots Key)," here restricted to Key Largo, type in MCZ.

This species is frequently encountered in Florida in Dade and Monroe Counties particularly on the Keys, and in Cuba.

In Florida it was taken by beating miscellaneous vegetation on Key Largo, and in Matheson Hammock. It has also been taken on *Swietenia mahogoni*.

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# THEODORE PAYNE

1872 - 1963

With the passing of Theodore Payne on May 6, 1963, the Southern California Academy of Sciences lost one of its most active members and the last surviving Charter Member.

Mr. Payne was born in Northamptonshire, England, June 19, 1872. As a small boy he was always fond of flowers and had a small garden of his own. At the age of 12, he was sent to Ackworth School in Yorkshire where he joined a natural history society. His special choice, from the first, was botany, and while at this school he became secretary of the botanical section, made a collection of pressed plants for which he was awarded the first prize, and became active in conservation and horticulture.

After leaving Ackworth, he was apprenticed for three years to the firm of John Cheal & Sons, Lowfield Nurseries, Crawley Sussex, to learn the nursery and seed business, a vocation which was to become his life-long career.

In the spring of 1893 he decided to come to California. On June 3rd, as he neared his 21st birthday, he sailed for New York and arrived in Los Angeles, June 28th. Shortly after arriving here he secured a position as gardener to Madame Helena Modjeska, the famous Polish actress, at her country estate, "Forest of Arden," Santiago Canyon, Orange County, where he remained for two and one half years.

He then entered the employ of the Germain Fruit Company (now Germain Seed Co.) in April, 1896, and was placed in charge of their flower, tree and palm seed department. While with this firm, he also handled much of the correspondence pertaining to technical information and prepared all their catalogues.

Mr. Payne, having decided to go into business for himself, resigned from the position with the Germain Fruit Company in 1903 and bought the Hugh Evans Nursery then located at 440 South Broadway. Two years later he moved his business to 345 S. Main Street, and subsequently bought a nursery at 33rd and Hoover

Streets which he used for growing-grounds. He maintained his nursery at the Main Street address until 1922, when he purchased 10 acres of land fronting on Los Feliz Blvd., and moved the nursery to that location. Here, he continued his nursery, growing mainly native trees, shrubs, and wild flowers, until he retired in June, 1961, at the age of 90.

As a seed and plantsman, Mr. Payne has contributed a wealth of information about the nature of plants, the growing of cuttings, and the germination of seeds: particularly of native plants. Many of the plants that dot our orchards, parks, highways, and landscaped homes, passed through his hands.

Early in his career, he made a study of the Eucalyptus and when the Eucalyptus boom occurred about 1907, he soon became the headquarters for these seeds in the United States. Between 1911 and 1913 he sent out hundreds of pounds of these seeds to Central and South American and European countries.

When Mr. Payne first came to California he was impressed with its native flora. With deep regret, he saw the wild flowers rapidly disappearing from the landscape. He decided, then early in his career, to awaken interest in the native flora and began growing wild flowers and native plants. To further the interest in beautiful native plants for home gardens, he sowed wild flower seeds in a vacant lot in Hollywood, and in several such lots in Pasadena. He secured from Walter Raymond, of the Raymond Hotel in Pasadena, a plot of ground on the hotel site and sowed it with wild flower seeds: the following spring his efforts resulted in a profusion of wild flowers. His first wild flower catalogue, of many that were to follow, was a modest little booklet published about 1906.

In 1915, Mr. Payne was commissioned by the City Council of Los Angeles to plant wild flower beds in Exposition Park. This "wild flower garden" consisted of 5 acres and was planted with native trees, shrubs, perennial plants, bulbous plants, and a large area of annual wild flowers. In all, the garden contained 262 species, the whole being a reproduction of a natural landscape; each specimen was labeled with its botanical and common name.

In 1919, and later, Mr. Payne did landscape work in addition to his nursery work. He landscaped a number of estates in the Santa Barbara area, Ojai, Los Angeles, Pasadena, and elsewhere; the largest was the 140-acre estate of Mrs. Lora J. Knight in Montecito. Among the native plants that he planted there in quantity were 121 Monterey Pine and 30 pounds of seed of the "Blue-eyed Grass." He kept 10 men on this place to maintain and cultivate the plants and made 2 trips each month to supervise their work.

During this period, shortly after the commencement of work on the Knight's estate, Mr. Payne formed a landscape architects partnership with Ralph D. Cornell and for 5 years, during their association, they completed some interesting developments including Torrey Pines Park and Occidental College.

In 1926, he was requested by Mrs. Susanna Bixby Bryant to help her select a site on her ranch in Santa Ana Canyon for a native botanic garden. The Rancho Santa Ana Botanic Garden was founded the following year. Mr. Payne served on its advisory council for over 20 years, until the time the Garden was moved to Claremont.

During his career in horticulture, Mr. Payne introduced into cultivation in California between 400 and 500 species of wild flowers and native plants and made them available for general use. He wrote many articles on native plants, acquainting readers with the desirability of these plants for home gardens, and gave talks in nearly all the towns in southern California on "Preserving the Wild Flowers and Native Landscape of California."

Mr. Payne received a number of honors and awards for his outstanding achievements in horticulture and in recognition of his work in conserving the native flora of California. He held a number of memberships in botanical societies, nature conservation groups, and horticultural societies. He was a charter member of several organizations. He held one honorary life membership, one honorary membership, four life memberships, and was Fellow of the Royal Horticultural Society of England. He served as president of several horticultural, arboricultural, wild flower and nurseryman's associations.

The County of Los Angeles and the County Department of Parks and Recreation honored Mr. Payne by setting aside a plot of ground, consisting of 320 acres, near Llano in the Mohave Desert as a wild flower sanctuary. This was dedicated as the *Theodore Payne Wildlife Sanctuary* on January 28, 1961. In 1958, Mr. Payne began the development of a 5-acre site in the Descanso Gardens as a wild flower garden, planting 23 species of conifers, 14 groups of other trees, 92 kinds of shrubs, 8 perennial plants, and seeds of 39 species of wild flowers. The dedication of this garden was held in the spring of 1959, at which time Mr. Payne was presented a scroll from the California State Legislature and another from the Los Angeles County Board of Supervisors in recognition of his work in conserving the native flora of California.

In addition to this activity in the many organizations to which he belonged, he was an active member of the Southern California Academy of Sciences for the greater part of his life; only in the past several years, as age and declining ill health came upon him, did he become less active. He first became a member in 1898, and in May 1907, at the time the Academy was incorporated, he became a charter member. In May, 1918, he was elected secretary of the Botanical Section and for many years thereafter served in this capacity. He was elected to the Board of Directors on June 20, 1920 where he served for about 30 years, later serving on the Advisory Board. He was President of the Academy from May 1932 to May 1933. Already a Fellow, he was made an Honorary Life Member of the Academy in May, 1957.

Mr. Payne will always be revered by all who knew him for his many kindnesses and for his wise and patient nature, for his love of flowers and the California native plants. Many who came to him for information about plants or to chat with him, whether amateur or professional horticulturalist or botanist, left richer in knowledge and with great respect for a wonderful man. He was never too busy to share his time, his knowledge of botany, and his experiences in growing native plants.

As his life was nearing to a close, he saw one of his hopes being realized—that of a foundation devoted to the purpose of perpetuating the knowledge and conservation of California native plants and the growing of these plants for the home garden and roadside planting. This organization, "The Theodore Payne Foundation for Wild Flowers and Native Plants," was named in his honor.

A final honor given Mr. Payne, posthumously, was the "Man of the Year" award for 1963 by the California Garden Clubs, Inc. Although Mr. Payne received many similar honors, he was a modest man and never allowed pride in these things to overshadow his devotion to love for wild flowers and his service to mankind.

A Memorial Fund in the Southern California Academy of Sciences and in the Theodore Payne Foundation has been established in his honor. Many friends have contributed and are still contributing to these funds.

BONNIE C. TEMPLETON
Los Angeles County Museum

# SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

## Volume 62, 1963

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## BULLETIN OF THE SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

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PROCEEDINGS, 1896 to 1899. Six numbers—Vol. 1, Nos. 1 to 6.

MISCELLANEOUS BULLETINS issued under the imprint of the Agricultural Experimental Station, 1897 to 1907. *Ten numbers.*

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Began issue with Vol. 1, No. 1, January, 1902. Issued ten numbers in 1902; nine numbers in 1903, 1904, 1905; three numbers in 1906. Issued two numbers annually from 1907 to 1919, both inclusive (except 1908—one issue only). Issued four numbers (January, May, July and October) in 1920.

The 1921 issues are: Vol. XX, No. 1, April; Vol. XX, No. 2, August; Vol. XX, No. 3, December.

The 1922 issues are: Vol. XXI, No. 1, March; Vol. XXI, No. 2, September.

The 1923 issues are: Vol. XXII, No. 1, March; No. 2, July.

The 1924 issues are: Vol. XXIII, No. 1, January-February; No. 2, March-April; No. 3, May-June; No. 4, July-August; No. 5, September-October; No. 6, November-December.

From 1925 to 1961, including volumes XXIV to 60, three numbers were published each year. Beginning with volume 61, four numbers will be published each year.

## MEMOIRS

Vol. 1, 1938. Vol. 2, Part 1, 1939. Vol. 2, Part 2, 1944. Vol. 3, Part 1, 1947.
Vol. 3, Part 2, 1949. Vol. 3, Part 3, 1956.

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