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PROCEEDINGS

OF THE

California Academy of Sciences

FOURTH SERIES

Vol. XXVI

SAN FRANCISCO
PUBLISHED BY THE ACADEMY
1948-1950

CONTENTS OF VOLUME XXVI

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVI, No. 1, pp. 1-22, text figs. 1-12 June 28, 1948

THE OSTEOLOGY AND RELATIONSHIPS OF THE MICROSTOMIDAE, A FAMILY OF OCEANIC FISHES

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This report describes the bony structures and the gross visceral anatomy of *Nansenia schmitti* (Fowler), defines the family Microstomidae, and presents reasons why that family should be placed in the suborder Opisthoproctoidei rather than the Salmonoidea. A discussion of the genera and species of the family is given. *Microstoma (Euproserpa) schmitti* is placed in *Nansenia*. *Bathymacrops macrolepis* is placed in the synonymy of *Nansenia ardesiaca*. The relationship of the family Microstomidae to the other Opisthoproctoidei is discussed.

The Microstomidae comprises a small group of pelagic, oceanic fishes distributed in the Mediterranean, North and South Atlantic, off southern Africa, and in the western Pacific. Although the group has been known since Risso's (1810) description of *Microstoma microstoma* from the Mediterranean, and specimens have not infrequently been taken since, to the writer's knowledge the internal anatomy of the group has not been explored previously and the position of the fish in the ichthyological system has been, in consequence, not precisely understood. The fish were long included with the argentines, smelts, etc., in the family Salmonidae (Günther, 1866), a practice followed by some ichthyologists in recent years (Gilchrist and von Bonde, 1924). Gill (1861) placed the genus *Microstoma* in a separate family, Microstomatoidae. The Bathylagidae have often, even in recent years (Barnard, 1925), been included in the Microstomidae, but the ichthyological position of that group has recently been defined (Chapman, 1943).

The following observations are based on a single specimen of *Nansenia schmitti* (Fowler), a paratype from 4°12′10″ N., 118°38′08″ E. near Mabul Island. It is a pleasure to acknowledge the kindness of Dr. Leonard P. Schultz, Curator of Fishes, United States National Museum, in permitting me to dissect this specimen.

OSTEOLOGY

Ethmoid cartilage (Figs. 1, 2, and 3) considerably restricted in extent. Main portion not pierced by median foramen as in *Plecoglossus* and some Osmerids (Chapman, 1941*a* and *b*). Foramen of olfactory nerve lies mostly in notch on inner side of prefrontal and scarcely notches side of ethmoid cartilage.

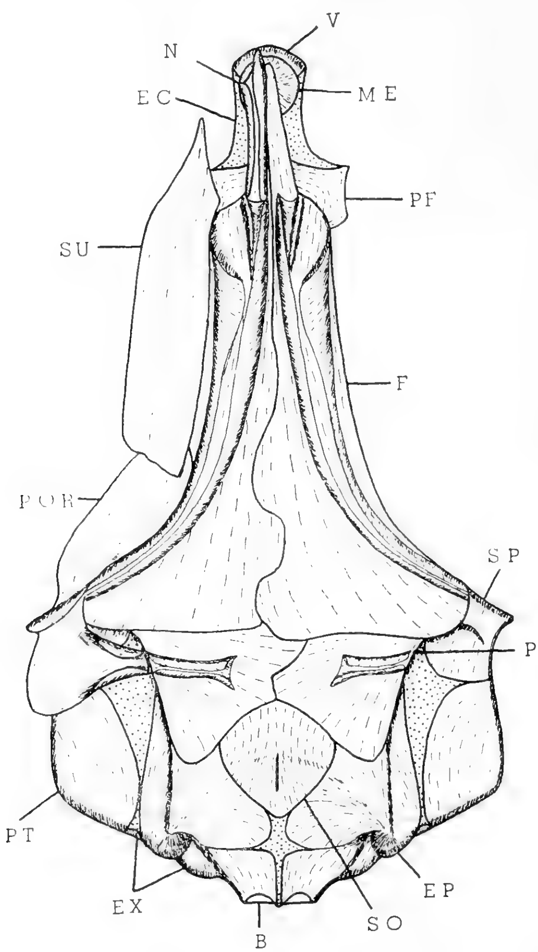

Fig. 1.—Dorsal view of the cranium of *Nansenia schmitti*, with circumorbital and nasal bones left on the left side, × 5.

Cartilage thinly separates frontals and prefrontals dorsally and extends back as thin band under frontals to lie between orbitosphenoid and alisphenoids below and frontals above to join chondrocranium of postorbital portion of cranium. Ethmoid cartilage a thin pad ventrally between mesethmoid above and vomer and parasphenoid below, rising upward to fill interior of irregularly conic mesethmoid, a rather thin ossification on surface of cartilage, and extending posteriorly along parasphenoid to end in point on that bone about halfway to pro-otics. Cartilage widest over parasphenoid and vomer, where it throws up a narrow column under each prefrontal for its support, and laterally projects outward to overlie median edges of mesopterygoids, binding those bones securely to parasphenoid.

Mesethmoid (Figs. 1 and 3) single, shaped like hollow cone which has been strongly flattened sideways. Considerably higher than in *Argentina* or *Bathylagus*. No ventral ethmoids (as in *Argentina* and most Osmerids) or lateral ethmoids (as in some Osmerids).

ABBREVIATIONS USED IN ALL FIGURES

AC	Actinost
AL	Alisphenoid
AN	Angular
AR	Articular
B	Basioccipital
BB	Basibranchial
BR	Branchiostegal ray
BS	Basisphenoid
C	Ceratohyal
CB	Ceratobranchial
CL	Cleithrum
CO	Coracoid
D	Dentary
E	Epihyal
EB	Epibranchial
EC	Ethmoid cartilage
EP	Epiotic
EX	Exoccipital
F	Frontal
G	Glossohyal
H	Hyomandibular
HB	Hypobranchial
I	Interhyal
IN	Interopercle
LLB	Lateral line bone
M	Maxillary
MC	Mesocoracoid
ME	Mesethmoid
MES	Mesopterygoid
MET	Metapterygoid
N	Nasal
O	Opercle
OR	Orbitosphenoid
OT	Opisthotic
P	Parietal
PA	Palatine
PAR	Parasphenoid
PC	Postcleithrum
PF	Prefrontal
PG	Pterygoid
PM	Premaxillary
POP	Preopercle
POR	Postorbital
POT	Pro-otic
PT	Pterotic
PTT	Posttemporal
Q	Quadrate
S	Symplectic
SB	Suprabasal
SC	Supracleithrum
SCA	Scapula
SO	Supraoccipital
SOP	Subopercle
SP	Sphenotic
ST	Supratemporal
SU	Supraorbital
SUB	Suprabranchial
V	Vomer
VH	Ventral hypohyal

Vomer (Figs. 1, 2, and 3) curves downward strongly at anterior edge, on which it bears about twelve tiny, slender teeth in a single series. It curves upward around end of cranium to reach and slightly overlie lower edge of mesethmoid, with long, thin, posterior shank extending along ventral side of parasphenoid to end in sharp point at vertical from about midway between upper end of prefrontals and orbitosphenoid. Vomer strongly concave on its under side.

Long, spatulate anterior end of *parasphenoid* (Figs. 2 and 3) strongly concave underneath. Concavity broadest and deepest anteriorly over vomer and tapers back to point under basisphenoid where bone becomes just as strongly convex. Short, broad wings sent up along anterior edge of pro-otics, to fall short of trigemino-facialis foramina of latter. Convexity of parasphenoid to-

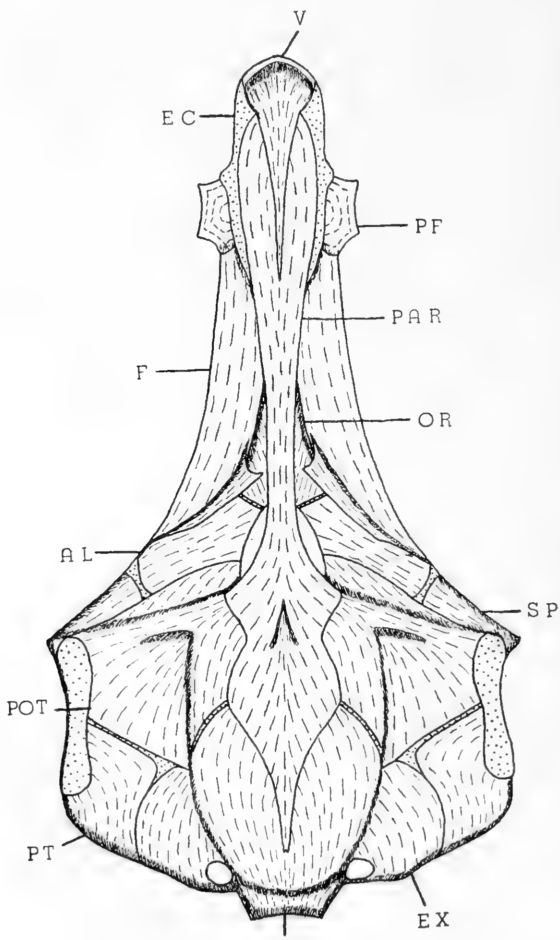

FIG. 2.—Ventral view of the cranium of *Nansenia schmitti*, × 5.

gether with narrow groove in cartilage between pro-otics and on basioccipital provides narrow and shallow myodome which opens by a tiny pore posteriorly. "Myodome" doubtfully functional, since no fibers of rectus muscles of eye were noticed upon lifting parasphenoid off other bones. There is evident again the peculiar correlation of the presence of a broad myodome with the presence of a mesocoracoid and the disappearance of the myodome with the disappearance of the mesocoracoid. In *Argentina* the myodome is commodious and opens broadly behind, and the mesocoracoid is well developed. In *Bathylagus,* the next closest known relative of the Microstomidae, the mesocoracoid is absent and so is the myodome. Even in the Osmeridae it was noted that in the *Thaleichthys* group of genera, where the mesocoracoid is well developed, the myodome opened broadly behind, and in the *Mallotus* group, where the mesocoracoid is more weakly developed, the posterior opening of the myodome is much restricted. It is hard to conceive of a functional relationship between these two organs.

Frontals (Figs. 1, 2, and 3) curiously interwoven on midline; first that of right side overlying that of left, then that of left overlying that of right, with result that none of underlying cartilage is exposed on midline. It is a relatively short step from this to the condition found in the Macropinnidae and Opisthoproctidae where the frontals are indistinguishably fused. Frontals not diverging anteriorly as in *Argentina* (Chapman, 1942*a*), but ending in single point on mesethmoid; overlying considerable portion of parietals and sphenotics posteriorly, but not quite reaching anterior edge of supraoccipital, which can be seen under parietals. Near lateral edge of each bone extends well-formed canal of sensory system. This deep canal not quite closed into tube dorsally at any place, and broadest anteriorly where it diverges over prefrontals to send one branch of nerve out over that bone and another through canal of basal bone to snout. Canal continued at posterior end down over postorbital and out onto circumorbital ring. On ventral side of frontal a wing extends down over upper

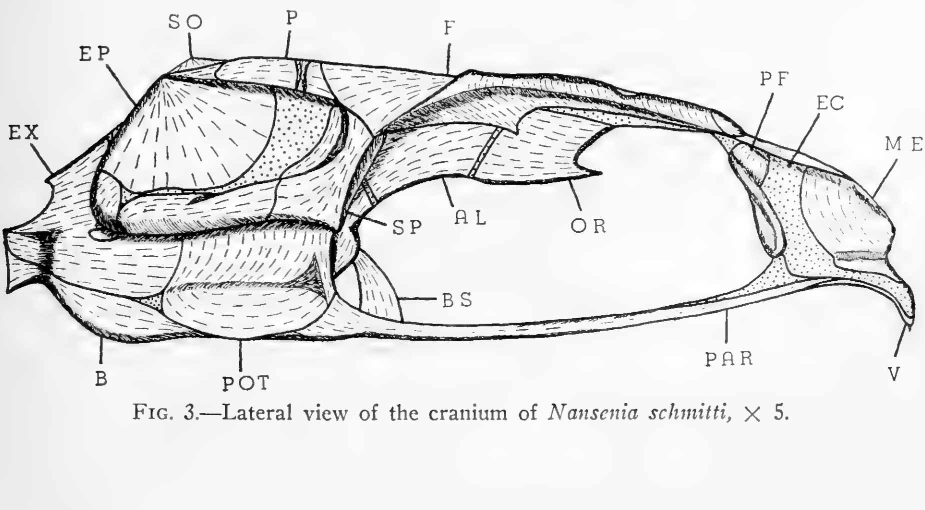

Fig. 3.—Lateral view of the cranium of *Nansenia schmitti*, × 5.

edge of alisphenoid and opisthotic, binding those bones and frontal together firmly.

Prefrontals (Figs. 1, 2, and 3) small, rather weakly ossified bones, mesial edge of each notched in middle for emergence of olfactory nerve into nasal capsule.

Large, flat *parietals* (Figs. 1 and 3) meeting broadly on midline, with that of left side overlying that of right for anterior three-fourths of their length. Nearly a third of their surface covered by frontals, and they in turn cover about half of supraoccipital as well as anterior tips of epiotics and small corner of sphenotics. Anteriorly they and frontals project slightly out over deep temporal fossae, but nothing like the deep caverns of *Argentina* is formed. Each parietal bears on its surface a flimsy trough for sensory canal.

Of half of *supraoccipital* (Figs. 1 and 3) exposed, about half forms dorsal surface and other half slopes downward on posterior surface of cranium. As in other fishes of this relationship, supraoccipital widely separated from foramen magnum, not only by exoccipitals but by protruding mesial wings of epiotics.

Epiotics (Figs. 1 and 3) high, broad, and narrowly rounded over semicircular canals of the ears.

Pterotics (Figs. 1, 2, and 3) merely flattened cones which surround horizontal semicircular canals of ears. Ventrally each bone bears posterior half of cartilage-lined surface of articulation for hyomandibular.

Ventral side of sphenotic (Figs. 1, 2, and 3) nearly entirely occupied by cartilaginous socket of hyomandibular, which extends to anterior edge of bone. Anterior face large and fills space between alisphenoid, pro-otic and frontal. About half of dorsal surface covered by frontal and rest covered by postorbital. Posterior surface largest and forms anterior end of enlarged temporal fossa.

Alisphenoids (Figs. 2 and 3) large, well-formed bones lying between orbitosphenoid and postorbital portion of cranium, not touching one another anywhere, but opening between them to brain cavity relatively narrow.

Orbitosphenoid (Figs. 2 and 3) a deep but narrow bone around olfactory lobes of brain and bases of olfactory nerves. Latter emerging from slit-like anterior opening of bone. Ventral edge of bone sharp with interorbital septum extending from it to parasphenoid.

Pro-otics (Figs. 2 and 3) the largest bones of postorbital part of cranium. A strongly ossified ridge which runs up from parasphenoid wing to sphenotic dividing bone into an anterior and posterior face. Anterior face large and somewhat concave, with four small nerve foramina, and two larger ones piercing it. Another nerve emerges right through dividing ridge, a second posterior to ridge, and a third through posterior face of bone. How many of these nerves are associated with the trigemino-facialis complex could not be determined. Posterior portion of bone forms a prominent part of enlarged bulges for otoliths. Mesial edges of pro-otics, and relatively slender band of cartilage between them, turn upward anteriorly and between this roof and wings of parasphenoid lies a shallow concavity in which rectus muscles of eyes are inserted.

Basisphenoid (Fig. 3*BS*) small and slender, curving downward from uplifted junction of pro-otics to parasphenoid, and capped with cartilage at its junction with parasphenoid, but not very strongly attached to that bone.

Basioccipital (Figs. 1, 2, and 3*B*) strongly constricted posteriorly to form entire occipital condyle, but thin and almost transparent forward where it bulges out to form posterior two-thirds of otolith expansions. Otoliths proportionately very large bones, plainly visible through basioccipital pro-otics, which extend from wings of parasphenoid back nearly to occipital condyle.

Exoccipitals (Figs. 1, 2, and 3) send broad wings up to form roof of foramen magnum. Each wing also extends over basioccipital on occipital condyle, but thin and forms none of junction with first vertebra. Exoccipital visible from dorsal aspect between pterotic and epiotic when opisthotic removed. Foramina of vagus nerves, which pierce bones near posterior edge of cranium, unusually large.

Opisthotics (Fig. 10) tiny, cup-shaped bones which cover junction of epiotic, exoccipital, and pterotic. Each little larger than ligament of posttemporal, which it attaches to cranium, and pulls off with it in position shown in figure.

Cartilage of postorbital portion of cranium considerably restricted. Largest expanse in bottom and mesial side of deep temporal fossa between sphenotic, pterotic, and epiotic; narrower expanse evident on posterior surface of cranium between epiotics, exoccipitals, and supraoccipital; and narrow band extends from this area down between exoccipitals. Long sockets of articulation of hyomandibulars lined with cartilage. Narrow band of cartilage evident between orbitosphenoid and alisphenoids, and between those bones and sphenotics and pro-otics.

SPECIAL OSSIFICATIONS OF SENSORY SYSTEM

Small bones associated with support of branches of lateral line system over head, while thin, broader and more extensive than in either *Argentina* or *Bathylagus*. This especially true of circumorbital bones, which cover entire cheek.

Seven bones present in *circumorbital series* (Fig. 5). Two thin bones over eye essentially same as in *Bathylagus* (shown in dorsal aspect on left side of Fig. 1). Both bones thin and projecting straight out over orbit to form dorsal protection for soft parts of eye. Neither of these bones supports sensory canal, which in this region courses through tube on lateral edge of frontal, except that suborbital branch of system crosses postorbital in open tube as it leaves frontal. Lachrymal small, with only about half area of succeeding bone. These two bones meet flush and form a sheath under which maxillary rests. Suborbital 4, largest bone of the series, completely covers space between orbit and preopercle, between suborbitals 3 and 5, and attaches securely by membranes to preopercle along entire ventral and posterior edges. Suborbital 5 and posterior plate of postorbital cover remaining area between orbit and preopercle. Suborbital branch of lateral line system runs around orbit from postorbital to its emergence from lachrymal along orbital edge of bones. Covered along its entire course by flange of thin bone that opens on side away from orbit to form a trough rather than tube. Suborbital bones all lined internally by brilliantly silvered membrane whose sheen is visible through thin, transparent bone.

Nasals (Fig. 1) small, thin, hollow tubes, incompletely closed dorsally, which lie over top of nasal capsules and support sensory canals from frontals to their anterior terminations.

Supratemporal (Fig. 4) thin and broad; attached loosely to sphenotic and pterotic on its dorsal edge, and extending ventrally over dorsal portion of opercle. Dorsal edge of bone curves over to form trough which does not completely close into tube. Supratemporal silvered on inner side like suborbital bones.

Extending posteriorly from sensory trough of supratemporal another semitubular bone attached to outer side of base of posttemporal (Fig. 10) serves to protect lateral line nerve from supratemporal to first enlarged scale of lateral line.

The Upper Jaw

Upper jaw (Fig. 4), except for small differences in shape of maxillaries, as in *Bathylagus*. Only *premaxillary* and *maxillary* present. Neither bears teeth; both thin. Premaxillary a simple curved bone loosely attached at anterior end between mesethmoid and vomer. Anterior end of maxillary prolonged and a little thickened where it lies against edge of mesethmoid. *In situ* broadened maxillary nearly completely hidden under first two suborbital bones. Upper jaw so weak and loosely attached to cranium as to have lost most, if not all, of function of aiding in ingestion of food.

Mandible

Mandible (Fig. 4) likewise essentially same as in *Bathylagus*. It consists of the *dentary, articular, angular, sesamoid articular, Meckel's cartilage,* and ossification of mandibular branch of sensory canal. Teeth larger and fewer than in *Bathylagus* but similar in shape, as closely pressed together, and borne in deep sockets along entire oral edge of dentary. Portion of tooth in socket as long as or longer than that protruding. Thirty-four teeth on each dentary in specimen examined. Angular larger than in *Bathylagus*.

Palatine Arch

Palatine arch (Fig. 4), as in *Macropinna* and *Bathylagus,* securely bound to ethmoid cartilage along its entire anterodorsal end, which includes palatine as well as cartilage behind it. Posterior to palatine cartilage of palatine arch rises in high and stout lump which is synchondrized with ethmoid cartilage at base of prefrontal. From this projection cartilage spreads posteriorly over anterior end of mesopterygoid to symplectic, but does not extend posteriorly to reach cartilage between hyomandibular and symplectic.

Palatine with a few teeth of same size as those on vomer, and extending in single line continuously back from latter. *Pterygoid* sends a wing dorsally along cartilage behind palatine which reaches to ethmoid cartilage, but is sep-

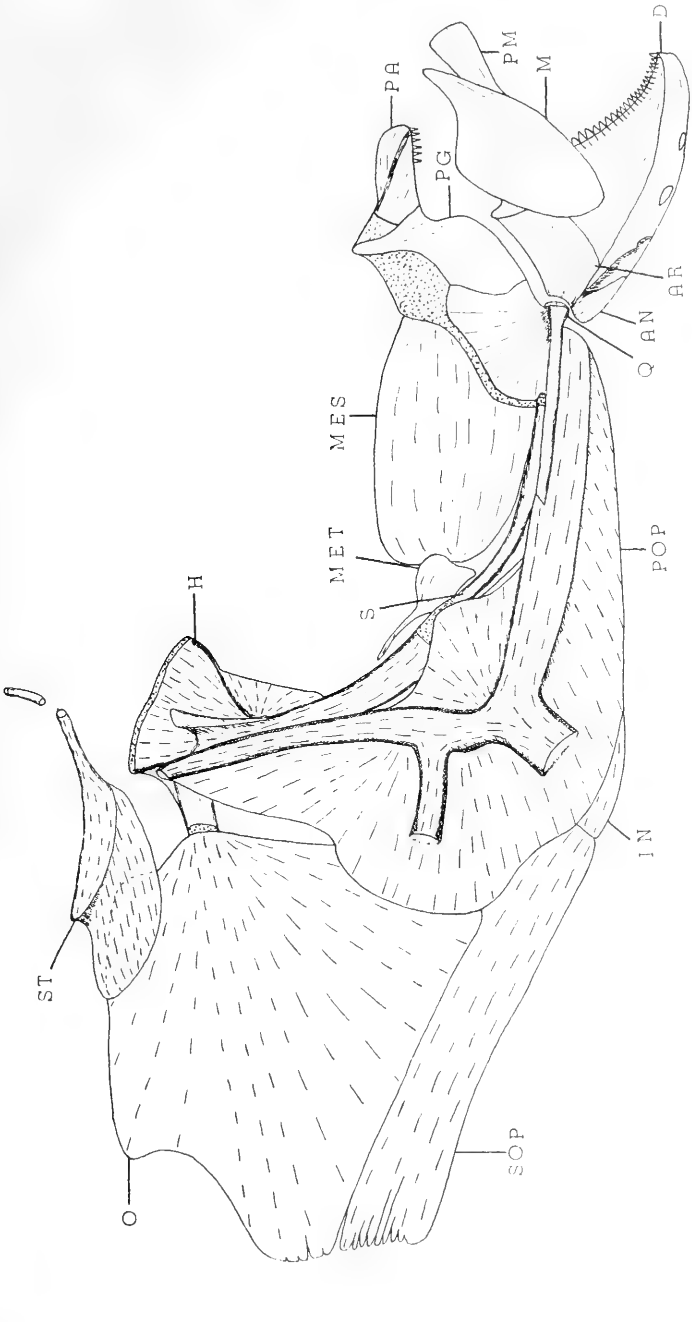

Fig. 4.—Lateral view of the suspensorium of *Nansenia schmitti*, with mouth parts pulled downward, × 5.

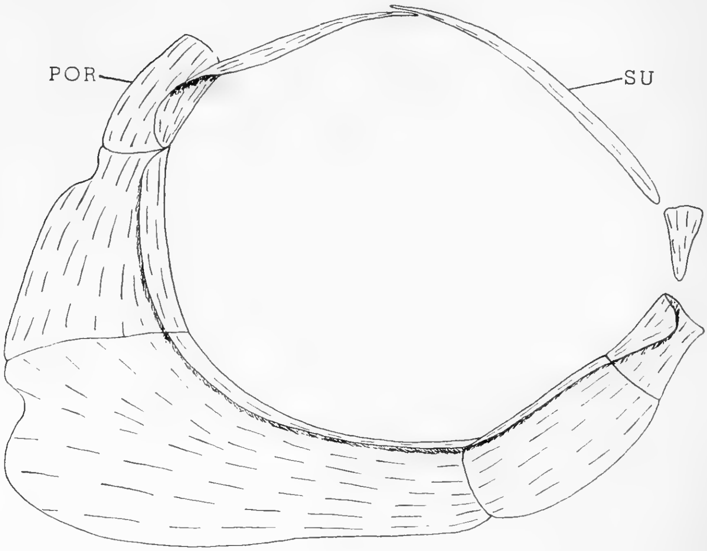

Fig. 5.—Lateral view of the circumorbital bones of *Nansenia schmitti*, × 5.

arated by considerable space from prefrontal. This wing merely a thin surface ossification on cartilage. Main portion of pterygoid broad and extends ventrally along quadrate more than halfway to condyle of that bone. *Quadrate* essentially as in *Bathylagus* except that posteriorly directed spur along preopercle is longer. *Mesopterygoid* large, broad, and thin; attached by membrane along its dorsal edge to parasphenoid; bears no teeth; and extends *under* cartilage of palatine arch. Two differences in this region from condition in *Bathylagus* notable. Levator arcus palatinus muscle extends only over posterior portion of mesopterygoid; and anteromesial edge of bone bound to cranium (parasphenoid) by overlapping wing of ethmoid cartilage (Fig. 2). *Metapterygoid* larger than in *Opisthoproctus, Macropinna,* or *Bathylagus,* but still a small and insignificant bone. It sends a slender process up along ventral shaft of hyomandibular but does not touch that bone. It overlaps edge of mesopterygoid ventrally. Degenerate condition of metapterygoid typical of Opisthoproctoidei and a character which sets off clearly from Osmeridae (with which Bathylagidae, Argentinidae, and Microstomidae have been associated in past) because of exceptionally strong development of the bone in Osmerids.

Hyoid Arch

Hyomandibular (Fig. 4) terminates dorsally in broad, cartilage-capped condyle which articulates in shallow socket that extends across nearly entire ventral face of pterotic and cartilage between sphenotic and pro-otic. Opercular condyle capped with cartilage, and longer than main articular head of bone, but narrow. Wing of thin bone present in angle between two condyles. Length of this process leaves space between opercle and preopercle filled, like space dorsal to opercular condyle between that structure and supratemporal, with dense and tough connective tissue. High flange of thin bone on lateral face of bone protecting truncus hyoido-mandibularis facialis nerve as it emerges on lateral face of bone. Foramen of that nerve enters bone a little below level of opercular condyle near anterior edge of bone and proceeds nearly straight ventrally to lateral face. Preopercle bound tightly to posterior edge of hyomandibular with only a narrow crack between them near ventral end of hyomandibular for re-entrance of ramus hyoidius facialis to inner side of skull. Wing of bone in anterior angle between articular head and ventral shaft of hyomandibular reduced in extent, but nearly as thick as rest of bone.

Rod of cartilage between hyomandibular and symplectic narrow, short, and straight so bones directly in line.

Symplectic (Fig. 4) narrow but thickened much longer than in *Bathylagus* and curve of bone much less. Membrane only between symplectic and metapterygoid and mesopterygoid. A small opening present between symplectic and angular flange of preopercle. Long anterior extension of bone bound tightly to posterior process of quadrate and extends a short way on main body of that bone.

Interhyal, epihyal, ceratohyal, and *hypohyals* (Fig. 6) essentially as in *Bathylagus,* interhyal a little smaller, ceratohyal more constricted in its middle, and ossification of dorsal hypohyal not extending broadly over dorsal side onto lateral surface of bone. Four *branchiostegal rays* broad, but thin and delicate. In Figure 6 they have been fanned out more than naturally. Most anterior of these attached to ceratohyal, others on cartilage around epihyal. First considerably shortest. All attached to epihyal-ceratohyal very loosely; held together and moved by broad and thin interhyoideus muscle which covers their

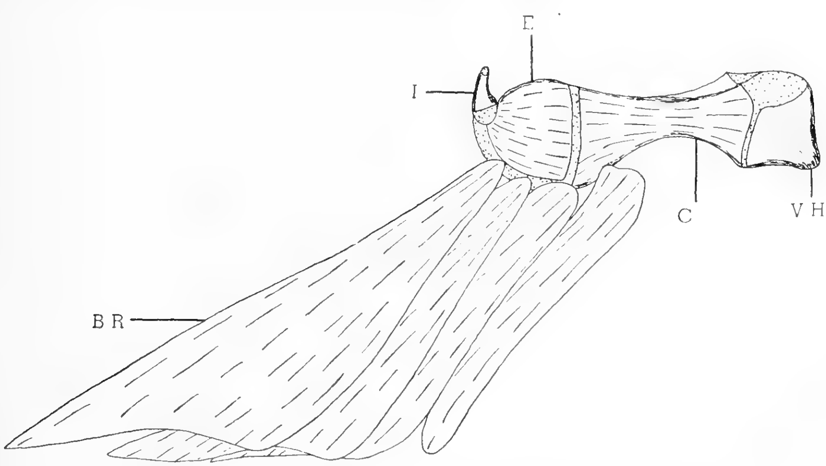

FIG. 6.—Lateral view of the hyoid apparatus of *Nansenia schmitti,* × 5.

surfaces. All covered on inner side by bright silvery pigment found under other bones of lateral surface of skull.

Opercular Apparatus

Opercle (Fig 4) a delicate, thin bone thickened only at small and shallow articular socket. Ventrally it overlaps dorsal edge of subopercle, to which it is tightly bound. Long, slender *subopercle* sends an arm dorsally around anteroventral corner of opercle which is covered by preopercle. From anterior edge of dorsal arm a short prong extends over dorsal edge of interopercle so all three opercular bones securely, but flexibly, joined together. Opercle and subopercle underlaid by same brilliantly silver pigment as circumorbital bones. Only small part of posterior end of long interopercle visible in lateral view, since it is hidden anteriorly clear to the angular by the preopercle.

Preopercle (Fig. 4) differs markedly from that of *Bathylagus* in broad posterior and ventral extensions, and in this character it resembles *Macropinna,* although the two preopercles do not overlap ventrally as in this latter genus. Good share of bone excluded from lateral view by broad, circumorbital bones. Bone tightly bound to hyomandibular, symplectic, and quadrate. Two prominent posterior projections from tube of sensory canal which courses it and, as in *Bathylagus,* tube closed on vertical arm of bone and open ventrally on large horizontal arm.

Gill Arches

Bones of *gill arches* (Figs. 7, 8, and 9) sturdy and resemble those of *Bathylagus* more than those of *Argentina.* Ossified portion of glossohyal larger than cartilaginous anterior part. Dental cement bone that it bears without teeth, flat, thin, and not curving downward around cartilage. Suprabasal bone likewise without teeth, simple, flat, and thin, much reduced from its prominent development in Osmerids. No first suprabranchial found. Fourth epibranchial entirely cartilaginous and curls peculiarly along edge of fourth suprabranchial. Fourth suprabranchial thin, but very broadly expanded, and high. It stands nearly at right angles to rest of superior gill bones and sticks up far above their level. On its posterior surface is inserted a broad muscle which extends directly downward to ceratobranchial below. This expanded fourth suprabranchial and broad muscle typical of Opisthoproctoid fishes and almost identical in *Argentina, Bathylagus, Microstoma,* and *Macropinna.* Trewevas (1933) shows bone similarly developed in *Opisthoproctus.* Small dental cement bone on cartilage ahead of fourth suprabranchial bears two teeth in *Microstoma* but no teeth oppose them on gill arch below.

Shoulder Girdle

Dorsal fork of *posttemporal* (Fig. 10) long, slender, and extending up along back side of epiotic, to which it is attached by a weak ligament. Ventral fork stout and stubby, sending a short, stout ligament to opisthotic. *Supra-*

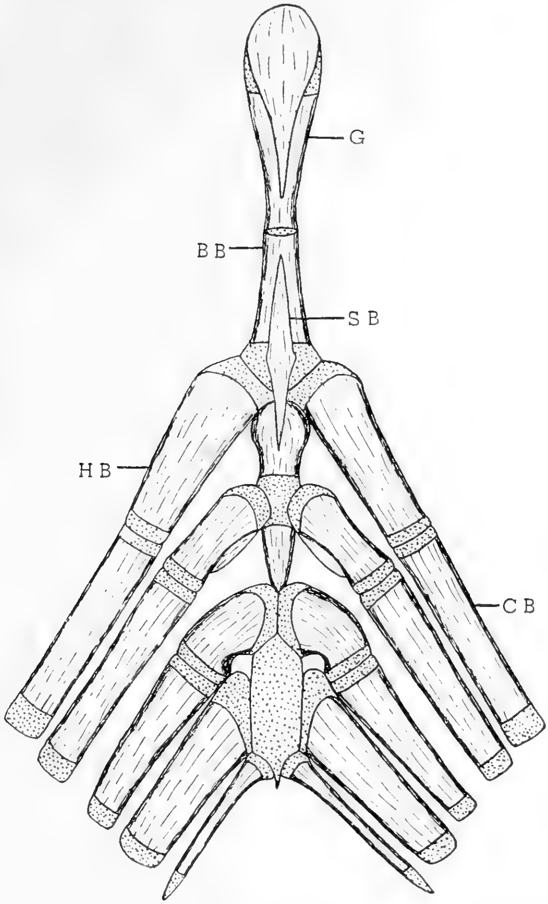

FIG. 7.—Dorsal view of the ventral half of the gill arches of *Nansenia schmitti*, × 5.

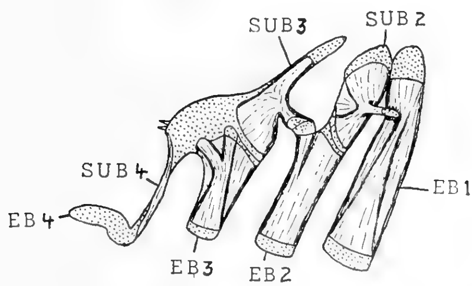

FIG. 8.—Dorsal view of the dorsal half of the gill arches of *Nansenia schmitti*, × 5.

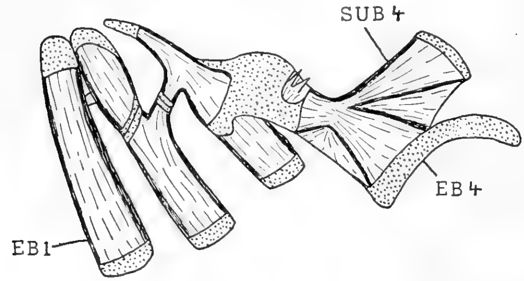

Fig. 9.—Ventral view of the dorsal half of the gill arches of *Nansenia schmitti,* with fourth suprabranchial somewhat depressed from its nearly vertical plane, × 5.

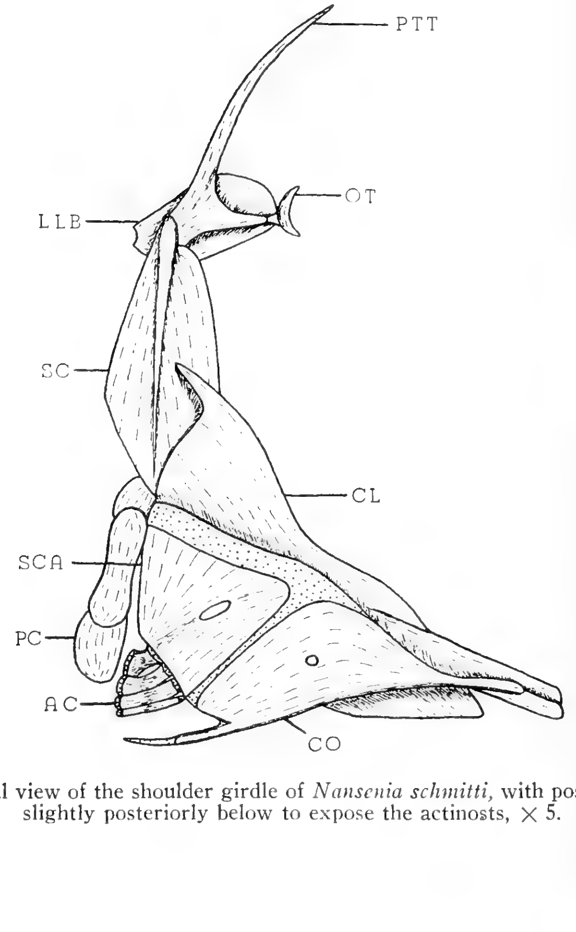

Fig. 10.—Mesial view of the shoulder girdle of *Nansenia schmitti,* with postcleithra pushed slightly posteriorly below to expose the actinosts, × 5.

cleithrum very thin, but on its mesial side a thin vane extends between the muscles and somewhat strengthens the bone. *Cleithrum* also thin and weakly ossified, except for a ray of denser ossification which extends dorsally to supracleithrum and the rod which extends anteriorly. On mesial side of bone a narrow ledge protrudes at an angle, to upper side of which attaches the primary shoulder girdle. A small, flat, special ossification of sensory canal bound to outer side of junction of posttemporal and supracleithrum. Three thin, flat *postcleithra* present just under skin, extending in a continuously overlapped row from supracleithrum to posterior process of coracoid. In Figure 10 these bones drawn backward slightly and primary shoulder girdle somewhat depressed to better show parts. In natural position lower postcleithrum lies against posterior process of coracoid.

Primary shoulder girdle bound to cleithrum by wide band of cartilage which continues downward between *scapula* and *coracoid*. Scapula nearly flat and has about same area as coracoid. Small scapular foramen entirely contained within bone. Four small *actinosts* borne entirely on scapula. Only dorsalmost actinost has normal hourglass shape. Coracoid bears both prominent posterior and anterior processes. Anterior process lightly bound to anterior extension of cleithrum, enclosing a considerable interosseous space between bones. Posterior process of coracoid is spike-like and bears rod of cartilage on posterior end, as in *Argentina*. No mesocoracoid.

Pelvic Girdle

Pelvic bones (Fig. 11) broad and relatively large, but rather lightly ossified. Similar in shape to those of *Argentina*.

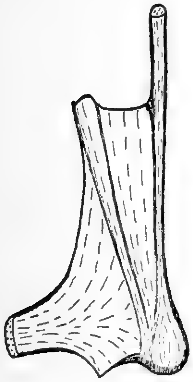

Fig. 11. — Ventral view of left pelvic bone of *Nansenia schmitti*, × 5.

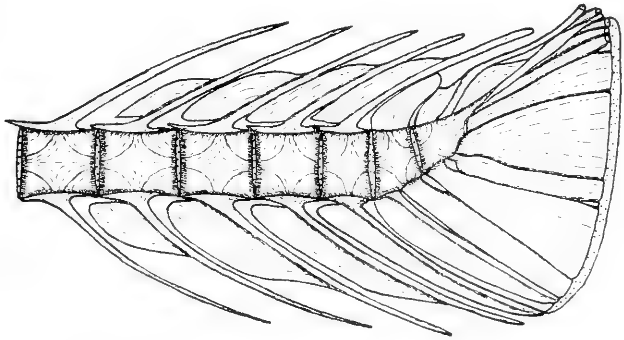

Fig. 12.—Caudal skeleton of *Nansenia schmitti*, × 5.

Axial Skeleton

Forty-three normal and a single upturned terminal vertebra present. It could not be determined with certainty if first vertebra bore ribs, but succeeding twenty-nine do, leaving 13 caudal vertebrae. Ribs long, slender, and flattened on proximal end, which is bound to a broad, heavy parapophysis. Neural spines lightly ossified and slender, not closing dorsally over neural canal until behind dorsal fin, where they become stouter and more spine-like. Thirteen broad and heavy interneurals present which form almost solid osseous line between cranium and dorsal fin. First particularly large, anastomosed to neural spine, and forms protective channel over spinal nerve as it emerges from foramen magnum. Interneurals project down to slender neural spines and efficiently protect spinal cord from above, besides giving broad areas for insertion of dorsal body muscles.

Besides terminal urostyle, five vertebrae and their neural and haemal spines modified for support of caudal fin (Fig. 12) and its muscles. Thin but broad wings of bone formed on anterior edges of these neural and haemal spines for insertion of caudal musculature so that interspaces between spines very restricted.

First basipterygium of dorsal fin inserted between twelfth and thirteenth neural spine and somewhat crowds last two interneurals. Nine of these bones present, all long and broad, like interneurals. First basipterygium of anal fin is inserted behind thirty-first vertebra's haemal spine. Supports of anal fin long and slender, unlike those of dorsal fin, and reach only to haemal spines, not between them.

Long, slender epineural inserted on broadened base of each neural spine of first seventeen vertebrae. Most posterior epineurals so slender and fine that they may have been accidentally removed from two or three other vertebrae. No epipleurals.

Body covered with rather large, thin cycloid scales, much like those illustrated by Beebe (1931) for *Bathylagus*.

VISCERAL ANATOMY

Viscera of single specimen available none too well-preserved, but some notes of value made. Most prominent feature of abdomen is large silvery air bladder which fills nearly whole dorsal half of abdominal cavity from cranium almost to anus. Completely closed and airtight at both ends, although vestigial ducts may have existed which were not discovered because of condition of specimen. Color a most brilliant silver, and organ has appearance of being made up of fine circular rings of bright, thin tinsel. Walls paper-thin; organ simple and blunt on both ends.

Kidney made up of same kind of granular matter filled with black specks as found in *Bathylagus* and *Macropinna;* restricted to posterior quarter of abdominal cavity, and gives appearance of being pushed into back corner by large air bladder.

Stomach long and slender, extending fully halfway back of abdominal cavity before turning forward again, with rugose external appearance and covered by dark-brown pigment. Pyloric end less than one-quarter length of cardiac end, but intestine runs forward under cardiac end nearly to its anterior end before flexing backward to run straight to anus. Three long, pyloric caeca present which all come off pyloris at same spot. Shortest extends back in crease between two arms of stomach to end of stomach; second little longer and bound tightly to wall of pyloric end of stomach; third slender and very long, extending along full length of stomach anteriorly and lying in crease between cardiac end of stomach and intestine, on left side.

End of intestine expanded somewhat, and bulbous. Anterior to this for about one-third length of intestine this organ filled internally by a series of lamellae which project inwardly so as to almost completely fill lumen of intestine. Although condition of specimen did not permit minute examination, it was assumed that this was a spiral valve similar to that found in *Argentina, Bathylagus, Leuroglossus,* and *Macropinna.*

Specimen examined was a female with eggs very minute and probably immature. As in *Bathylagus* and *Macropinna,* eggs arranged in thin, vertical lamellae which, lying closely one against the other, form the long, slender ovary.

THE GENERA AND SPECIES OF MICROSTOMIDAE

The family Microstomidae contains two genera: *Microstoma* Cuvier and *Nansenia* Jordan and Evermann. The following key will serve for their separation:

1 *a.* Dorsal fin placed well behind the middle of the body, the origin about midway between the posterior border of the eye and the first rays of the caudal; pelvic fins inserted a little anterior to the origin of the dorsal; no adipose fin; vertebrae 45 to 47. . . . . *Microstoma*

1 *b.* Dorsal fin originating approximately in the middle of the body; pelvic fins inserted under or a little behind the last dorsal ray; adipose fin present; vertebrae 43 to 45. . . . . *Nansenia*

A single species of *Microstoma, M. microstoma* (Risso), is known, from the Mediterranean and the Gulf of Guinea.

Six species referable to *Nansenia* have been described from the oceans of the world. *Nansenia groenlandica* was originally described by Reinhardt (1839) as *Microstomus groenlandicus* from a single specimen taken off the Greenland coast, and it was on his brief description that Jordan and Evermann (1896) based the genus *Nansenia.* More than 500 specimens of the species were subsequently taken by the Danish "Thor" expeditions (Schmidt, 1918) in the North Atlantic west of the British Isles, as far south as 48′ 43″ N. (west of Brittany), and as far west as Iceland. *Nansenia oblita* (Facciola) is known from the western half of the Mediterranean and off the west coast of Brittany (Schmidt, 1918). These two species have been capably differentiated by Schmidt (1918) as follows: *N. groenlandica;* predorsal length equals 43.4 to 50 percent of total length, preventral length equals 50 to 55 percent of total length, prepectoral length equals 21.4 to 22 percent of total length, greatest depth equals 9.5 to 12 percent of total length; whereas in *N. oblita:* predorsal length equals 52.7 to 58.7 percent of total length, preventral length equals 61.2 to 66.7 percent of total length, prepectoral length equals 28.2 to 30.5 percent of total length, greatest depth equals 16.0 to 18.6 percent of total length.

Three species have been described from the Western Pacific. Tanaka (1911) described a specimen from the Sagami Sea, Japan, as *Nansenia grönlandica.* On the basis of the reduced pelvic ray counts (9 to 10) given by Tanaka, the more posterior placement of the ventral fins, and the wide separation of locality from the North Atlantic species, Schmidt (1918) proposed that the Japanese form be recognised as a separate species to which he give the name *Nansenia tanakai.* Previously to this Jordan and Thompson (1914) described a new species *Nansenia ardesiaca* from a single specimen taken in Sagami Bay, Japan. This was known to Schmidt but the description was not available to him. Jordan and Thompson considered their species to be conspecific with Tanaka's, and if this were so their name would antedate Schmidt's. However, their description varies in some particulars from Tanaka's, the most important discrepancies being 12 plus 25 gill rakers on the first arch of their specimen as against 10 plus 11 on Tanaka's, and 50 scales in the lateral line to the base of the caudal as against 44 in Tanaka's. Unless the figure given by Tanaka for the raker count on the lower gill arch is a misprint for 21 it would be rather difficult to reconcile the descriptions. Until more Japanese specimens are available it will not be possible to determine whether two species are involved or if all the Japanese specimens are referable to *Nansenia ardesiaca.* At any rate the Japanese specimens agree with *N. groenlandica* in the depth of the body, but have fewer rays in the pectoral (Atlantic species 14 to 15, Japanese specimens 9 to 12), and agree with *N. oblita* in the number of pectoral rays but are more slender (greatest depth 5.4 to 6.2 in *oblita,* 7.5 to 8.0 in the Japanese specimens). Unfortunately no scale or gill raker counts are available in the literature for *oblita* or *groenlandica,* and a definite differentiation from the Japanese specimens cannot be made.

Fowler (1933) described *Microstoma schmitti* from the Philippines and Borneo, placing it in a new subgenus *Euproserpa.* The species has an evident adipose fin, 43 vertebrae, the dorsal fin is located in the middle of the body, and the ventrals are located slightly behind the dorsal. It is, therefore, a member of the genus *Nansenia,* rather than *Microstoma.* The species can be told from the Japanese specimens by the heavier body (greatest depth $6\frac{1}{8}$ in body length), fewer scales (38 along the lateral line to the caudal base), and fewer gill rakers (8 plus 18 on first gill arch). It cannot be differentiated from *Nansenia oblita* by means of the available descriptions, but it is probable that the comparison of Mediterranean and Philippine material would show the species to be distinct.

A sixth species was described by Gilchrist (1922) from material taken off South Africa as *Bathymacrops macrolepis*. In a later account (Gilchrist and von Bonde, 1924) he compared it with Tanaka's description and said: "The S. African and Japanese do not seem to differ generically and only in small details, specifically such as the number of rays and scales, though the number of gill-rakers in the former is much larger." The genus does not differ from *Nansenia* and must be considered a synonym of the latter; the species does not differ from *Nansenia ardesiaca* and must be considered a synonym of that species.

SYSTEMATIC POSITION OF THE MICROSTOMIDAE

The above description reveals that the Microstomidae bear no especially close relationship to the Salmonoid fishes. *Nansenia* agrees with the Opisthoproctoid fishes in the following characters: Dentition lacking on premaxillaries and maxillaries, and these bones reduced in size and function; no supramaxillaries; palatine arch strongly bound to cranium anteriorly; enlarged mesopterygoid bound to parasphenoid dorsally and extending under cartilage of palatine arch ventrally; metapterygoid minute; vomer with long posterior shaft and single row of teeth around head of bone forming entire dorsal dentition of mouth; spiral valve present; etc. It thus must be considered a member of the suborder Opisthoproctoidei of the order Isospondyli.

Although they diverge widely from the Argentinidae in many important characters (Chapman, 1942*a*) such as the dentition of the tongue, absence of mesocoracoid, minor development of myodome, reduced number of vertebrae and branchiostegal rays, absence of ventral ethmoid, no roof over temporal fossae, etc., the Microstomidae agree with that family in having deep temporal fossae, parietals large and meeting broadly on midline, a ventral flange on frontal binding the alisphenoid and orbitosphenoid to that bone, basisphenoid present, postcleithra present, pelvic bone roughly rectangular, and the presence of a well-developed air bladder. They must therefore be classed as the nearest known relative of the Argentinidae, and in some respects intermediate between those fishes and the Bathylagidae, although the relationship between these three families is definitely not in a straight evolutionary line. Such characters of the Microstomidae as the broadened circumorbital bones, broadened preopercle, lack of epipleurals, overlapping of frontals and parietals on the midline, broadened caudal supports of the last five vertebrae, absence of ventral ethmoid, etc., are not associated with either of the other families.

While they possess many differences the progression of the Microstomidae and the Bathylagidae from the *Argentina*-like stock has been in the same manner, a loss or reduction of bones and organs, such as the reduction in number of vertebrae and branchiostegal rays, loss of dentition on the glossohyal and fifth ceratobranchial, reduction or loss of myodome, loss of mesocoracoid, first suprabranchial, etc. The Microstomidae have simply not progressed as far in this direction as the Bathylagidae and it cannot be demonstrated that they are progressive points along a direct evolutionary line to the more bizarre Macropinnidae and Opisthoproctidae. Of particular interest is the strong development of the air bladder in the Microstomidae and its complete absence in the Bathylagidae. An identical contrast was found in the outwardly similar Macropinnidae and Opisthoproctidae (Chapman, 1942*b;* Trewevas, 1933) and this leads one to wonder if in this group of fishes there have not been two parallel lines of evolution to the shortened, vertical-eyed *Macropinna-Opisthoproctus* type, one line (with air bladder highly developed) by way of *Microstoma* to *Opisthoproctus,* the other (without air bladder) by way of *Bathylagus* to *Macropinna.*

The following diagnosis will serve to separate the Microstomidae from other fishes.

MICROSTOMIDAE

Opisthoproctoid fishes with laterally directed eyes, basisphenoid, postcleithra, orbitosphenoid, parietals meeting on midline, temporal fossae deep but not roofed over by bone, highly developed physoclistous air bladder, four branchiostegal rays, about 43 to 47 vertebrae, frontals separately distinguishable but overlapped along entire mesial edge; and lacking teeth on glossohyal and fifth ceratobranchial, mesocoracoids, first suprabranchials, and epipleurals.

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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 2, pp. 25-41, text figs. 1-18 June 28, 1948

THE OSTEOLOGY AND RELATIONSHIPS OF THE ROUND HERRING

Etrumeus micropus Temminck and Schlegel

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The round herrings are a small group of fishes found in tropical and temperate parts of the Atlantic, Pacific, and Indian oceans. They are sometimes included in the Clupeidae and sometimes segregated into a separate family, the Dussumieridae. The brief discussion of the skull of *Dussumieria acuta* by Ridewood (1904) is the chief source of information on the osteology of the group. To the writer's knowledge no study of the anatomy of the genus *Etrumeus,* or of the axial skeleton of any of the group, has been previously made. It is the purpose of the present report to describe the osteology of *Etrumeus micropus* Temminck and Schlegel and discuss the relationships of the round herrings to the other Clupeoid fishes.

Cranium

The cranium (Figs. 1, 2, and 3) bears a strong resemblance to that of the Clupeidae (Figs. 4, 5, and 6; and Phillips, 1942), but differs in the following respects: The ethmoid cartilage is considerably broader and bulkier between the prefrontals and the anterolateral wings of the mesethmoid. The ossification of the mesethmoid is correspondingly reduced in size. There is no foramen in the cartilage which is exposed dorsally between the anterior ends of the frontals. The anterior knob of the vomer is proportionately enlarged and bears teeth, while the posterior shank of the bone is broader than in the Clupeidae, and not so long.

The orbitosphenoid arches high under the frontals, without an opening between it and the cartilage, except the foramina for the emergence of the olfactory nerves. The anterior end is broad and curves downward behind the prefrontal to reach the cartilage over the parasphenoid, not as shown by Ridewood (1904, Fig. 131) for *Dussumieria acuta.* No median wing was found descending from the small basisphenoid to the parasphenoid.

The lateral projection of the sphenotic is much smaller than in the Clupeidae. The temporal foramen is a small slit. The epiotic fossa is deep and large, but scarcely visible in dorsal aspect. More of the supraoccipital is exposed between the parietals than in the Clupeidae. The sockets of articulation of the hyomandibular are separate, one on the pterotic, the other on the sphenotic. The auditory foramen is entirely borne by the exoccipital.

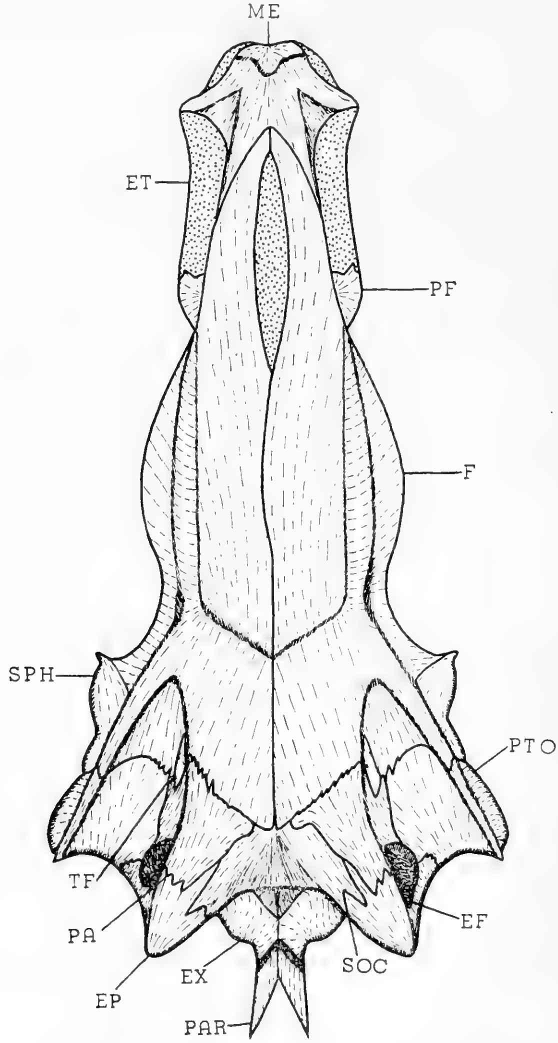

FIG. 1.—Dorsal view of the cranium of *Etrumeus micropus,* x4

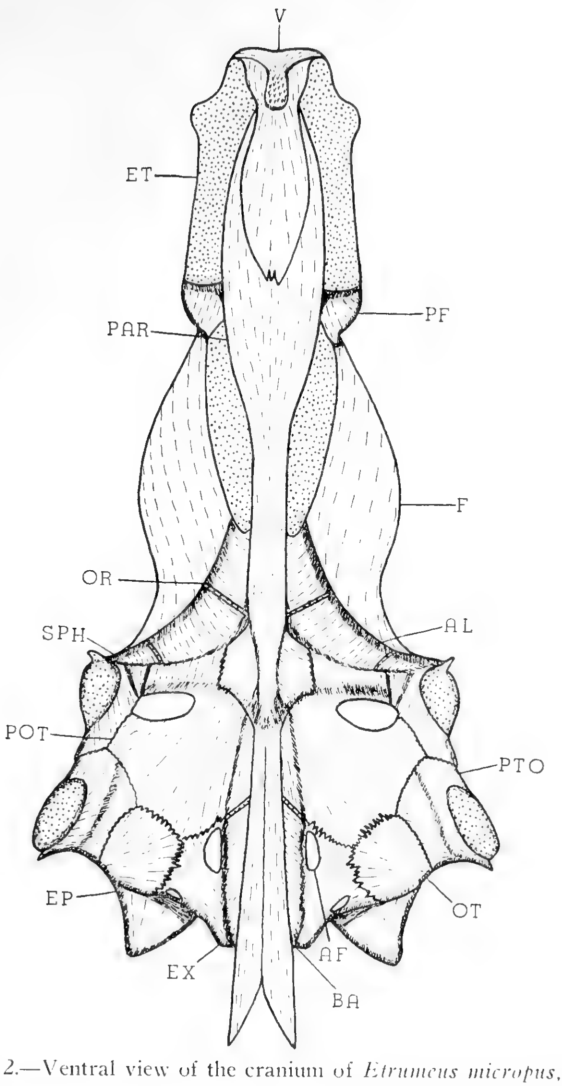

Fig. 2.—Ventral view of the cranium of *Etrumeus micropus*, x4

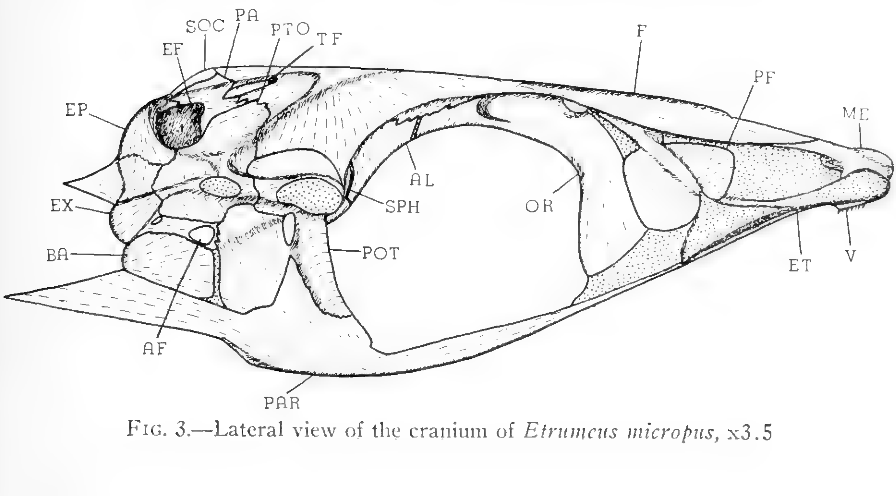

Fig. 3.—Lateral view of the cranium of *Etrumeus micropus*, x3.5

SPECIAL OSSIFICATIONS OF THE SENSORY SYSTEM

The nasal (Fig. 7) is a thin, flat bone with about the same surface area as the second circumorbital bone. It lies directly over the nasal capsule and, while it bears the anterior portion of the sensory nerve, it is not grooved nor tubular for the protection of the nerve, and is only slightly concave on top.

The seven bones of the circumorbital series of the Clupeidae are found here (Fig. 7), but in somewhat differing proportions. The anterior half of the first is broadened and flattened in a vertical plane. The second is likewise broadened, with its dorsal edge overlying the ventral edge of the first, and

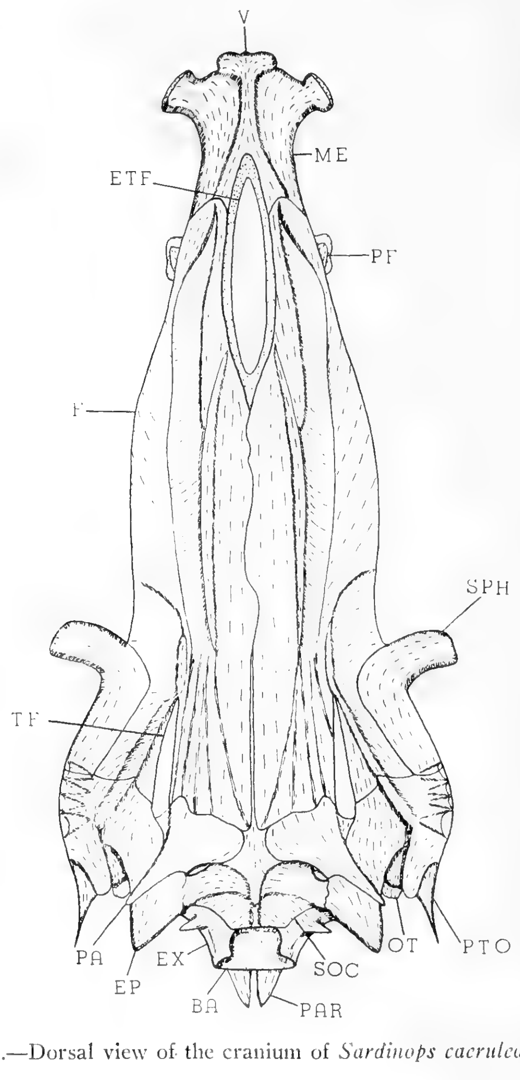

FIG. 4.—Dorsal view of the cranium of *Sardinops caerulea*, x2.5

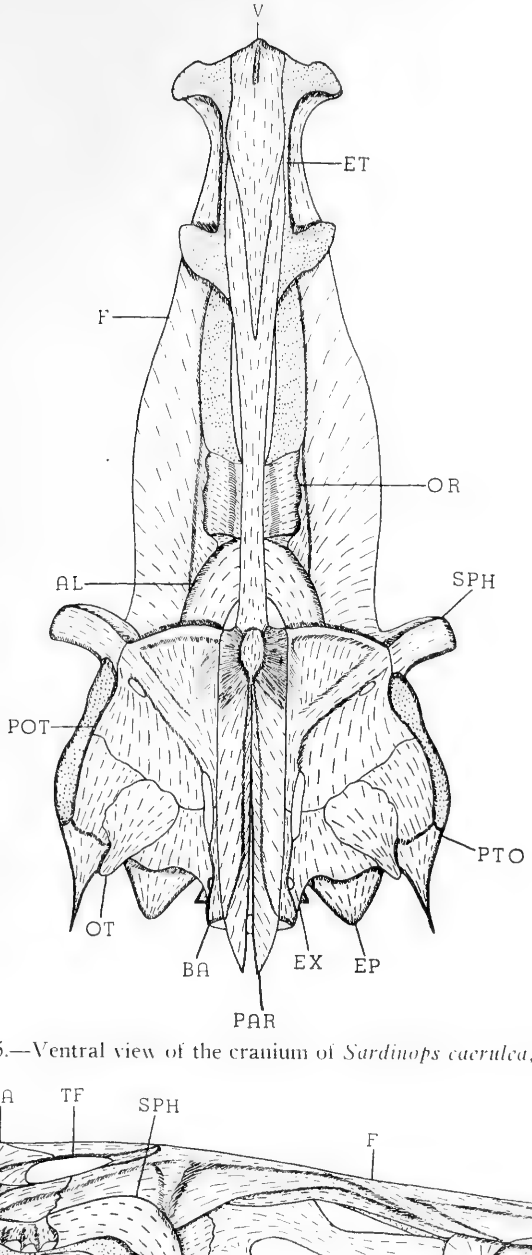

FIG. 5.—Ventral view of the cranium of *Sardinops caerulea*, x2.5

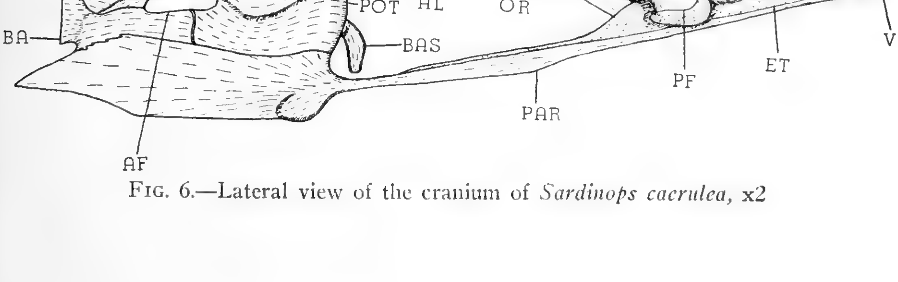

FIG. 6.—Lateral view of the cranium of *Sardinops caerulea*, x2

slightly underlying the dorsal edge of the third (lachrymal). The fifth is proportionately even larger than in the Clupeidae. Its posterior edge, together with the sixth and seventh bones, overlie the preopercle, leaving no interosseous space. A thin tubular bone, not illustrated, bridges the gap between the pterotic and posttemporal.

Upper Jaw

The premaxillary (Fig. 7) is smaller than in the Clupeidae and is without teeth. The lateral face of the maxillary bears a longitudinal ridge which in life meets the lower edge of the lachrymal, leaving the dorsal edge of the maxillary and the supramaxillary hidden under the circumorbital bones. The maxillary bears a single row of tiny teeth. There is a single, slender supramaxillary.

Lower Jaw

The mandible is deepest over its posterior third. The dentary (Fig. 8) bears a single row of teeth, which are larger than those on the maxillary. The small angular is almost covered laterally by the posterior prong of the articular. The sesamoid articular is a tiny, thin bone lying against the angular and over the posterior end of Meckel's cartilage. The latter is a slender straight rod of cartilage extending from the middle of the angular to the anterior third of the dentary. The angular is broadly overlapped by the dentary.

Palatine Arch

The palatine (Fig. 8) is long and slender and bears a plate of fine teeth (like those on the tongue) along its under and inner surface. The pterygoid is a thin bone, mostly in a vertical plane, which lies over the cartilage behind the palatine and that between the quadrate and mesopterygoid. It does not bear teeth, although the posterior projection of the palatine, which overlies the anterior end of the bone and does bear teeth, gives it the appearance of doing so. From the dorsal end of the bone, but borne mostly on the carti-

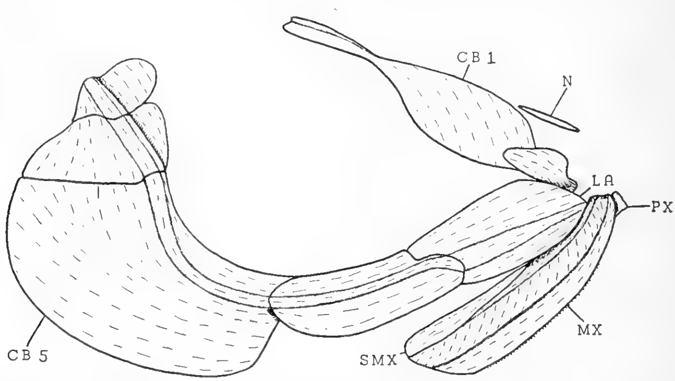

FIG. 7.—Circumorbital bones and upper jaw of *Etrumeus micropus*, x3

lage, a tough tendon runs to the cavity in the posterior side of the frontal above, and securely binds the palatine arch to the cranium. The mesopterygoid is long and thin and extends far forward along the inner side of the palatine nearly to the anterior end of that bone (as shown by Ridewood, 1904, Fig. 132, for *Dussumieria acuta*). Excepting the posterior quarter of its surface, the under side of the bone is entirely covered by fine, almost granular, teeth. The dorsal side of the bone is slightly concave and supports the eye. A small projection from the inner edge of the metapterygoid aids in supporting the posterior end of the mesopterygoid. Behind the mesopterygoid lies another bone of the same nature which is broader than the mesopterygoid and has almost as much surface area. It lies under the toothless posterior end of the mesopterygoid and extends posteriorly under the metapterygoid and hyomandibular. It lies loosely in the membranes of the roof of the mouth and is not associated with the other bones. A considerable thickness of membranes lies between it and the mesopterygoid. The under side of the bone is completely covered with fine teeth. This bone is not shown by Ridewood for *Dussumieria*. It has been found in the Engraulidae, but not the Clupeidae (Chapman, 1943, *a* and *b*).

The metapterygoid (Fig. 8) is proportionately smaller than in the Clupeidae, but it is a strongly ossified bone. There is a characteristic interosseous space between it and the ventral edge of the hyomandibular. The quadrate differs little from that of the Clupeidae.

Hyoid Arch

The hyomandibular (Fig. 8) has two distinct cranial condyles, of which the posterior one is a little the larger. The anterior condyle articulates entirely on the sphenotic; the posterior entirely on the pterotic. The opercular condyle

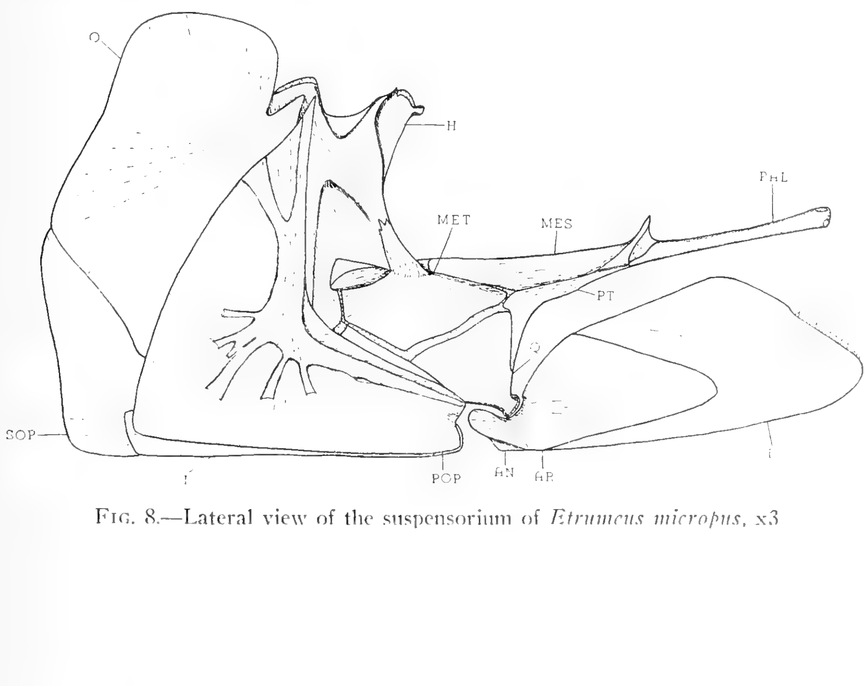

Fig. 8.—Lateral view of the suspensorium of *Etrumeus micropus*, x3

curves downward from the posterior condyle and is about the same size as the anterior condyle. The hyoido-mandibularis facialis nerve enters the bone on the inner side near the top of the anterior condyle and emerges through a broad opening near the center of the face of the bone. The anterior side of the ventral edge of the bone is suturally connected with a strong spur projecting up from the metapterygoid. The ventral edge of the bone is characteristically cut away, leaving a large opening between the hyomandibular and the metapterygoid. The long, slender sympletic extends anteroventrally at an angle of about 120° with the hyomandibular.

The tiny, conical interhyal (Fig. 9) is attached to the pad of cartilage

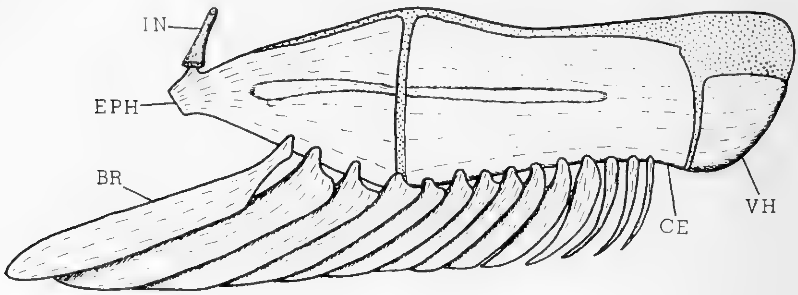

Fig. 9.—Hyoid apparatus of *Etrumeus micropus*, x4

between the hyomandibular and the symplectic and is attached ventrally to a slight protuberance from the epihyal. The ventral edge of the ceratohyal (Fig. 9) is not excavated as in the Clupeidae, but the groove in the middle of the epihyal and ceratohyal, characteristic of the Clupeidae, is found here. The dorsal hypohyal is not visible from the lateral aspect (Fig. 9), since it is covered with cartilage, but it is only a little smaller than the ventral hypohyal. There are a great many more branchiostegal rays (14) than in the Clupeidae, but they are considerably smaller. The loss of branchiostegal rays in the Clupeidae has been mainly from those articulating with the ceratohyal.

Opercular Apparatus

The opercle, subopercle, and interopercle (Fig. 8) differ only in relative proportions from the same bones in Clupeidae, except that the extensions of the sensory system over the opercle, which more or less mark the Clupeoid opercle, are not present here. The preopercle is broadly expanded posteriorly, quite unlike that of the Clupeidae; has numerous subsidiary tubules coming off the main nerve tube; nearly covers the interopercle, and leaves no open space between the preopercle and the other opercular bones. Rather than being of the customary boomerang shape, the preopercle is almost triangular in lateral view.

GILL ARCHES

The lower half of the gill arch (Fig. 10) is well supplied with small granular teeth, which work against those of the roof of the mouth. The

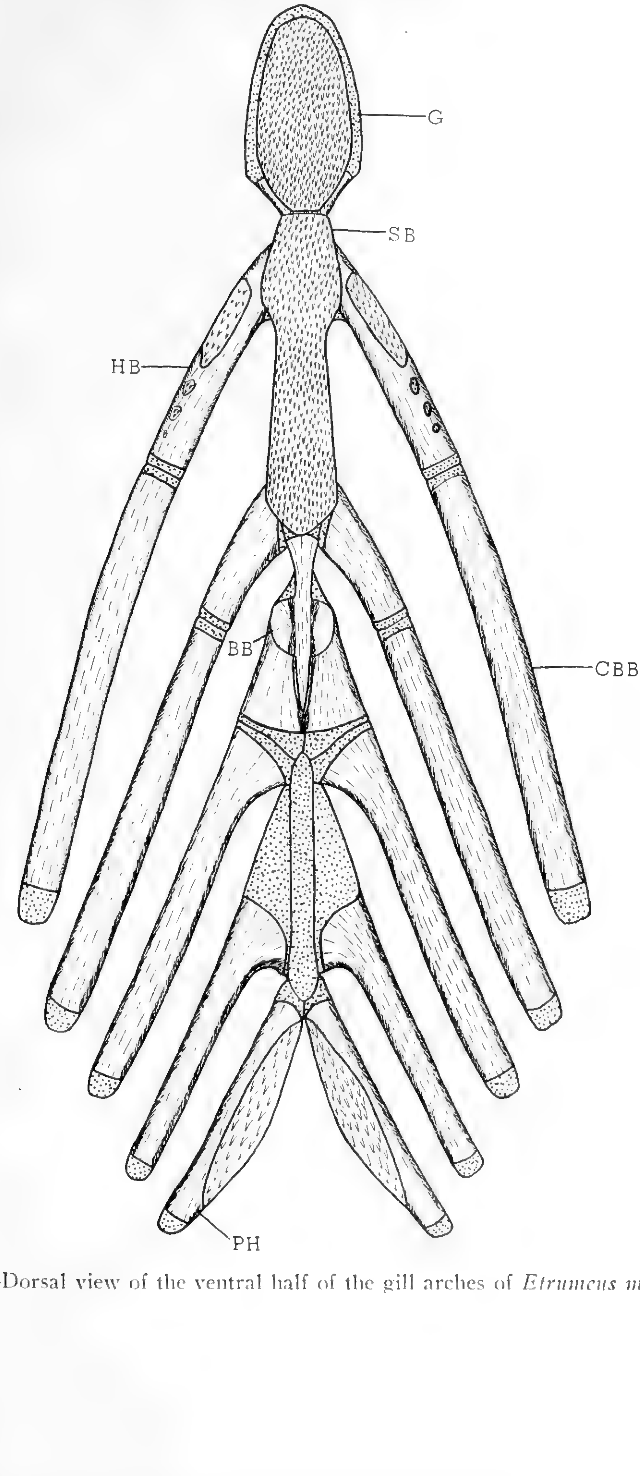

FIG. 10.—Dorsal view of the ventral half of the gill arches of *Etrumeus micropus*, x4

glossohyal is large, but mostly cartilaginous. It is nearly covered dorsally by a thin plate of teeth. The suprabasal bone, found so well developed in the Engraulidae, Osmeridae, and Plecoglossidae, but poorly developed and edentulous in the Clupeidae (Fig. 11), covers the first two basibranchials and is completely covered with teeth. There are small patches of teeth on separable bony plates on the hypobranchials of the first gill arch. The teeth of the anterior part of the gill arch work against those on the vomer, palatines, and

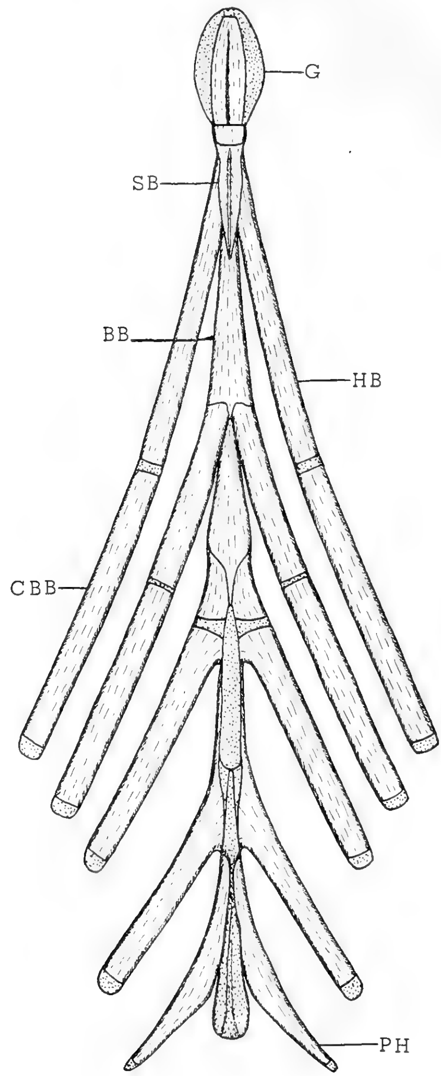

FIG. 11.—Dorsal view of the ventral half of the gill arches of *Sardinops caerulea*, x2

mesopterygoids above, although those on the palatines are more in apposition to those on the dentaries. The pharyngeals and fourth suprabranchials (Fig. 12) likewise bear plates of teeth which oppose each other. They are somewhat larger and not so thickly concentrated as those in the front of the mouth. There are no teeth dorsally on the first three gill arches (Fig. 12). The gill rakers (Fig. 13) are shorter, stubbier, and less numerous than is typical for the Clupeidae (Fig. 14).

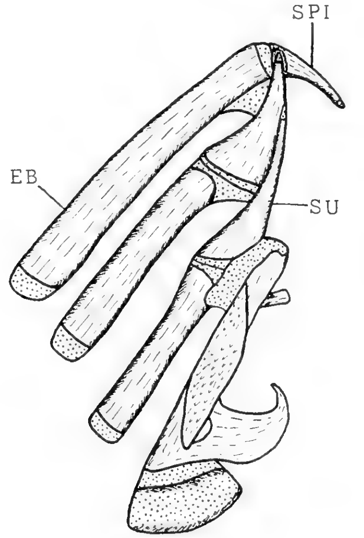

FIG. 12.—Ventral view of the dorsal half of the gill arches of *Etrumeus micropus*, x4

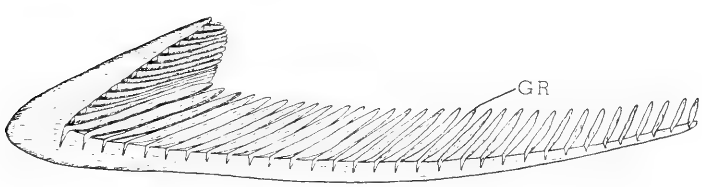

FIG. 13.—Lateral view of the gill rakers on the first arch of *Etrumeus micropus*, x4

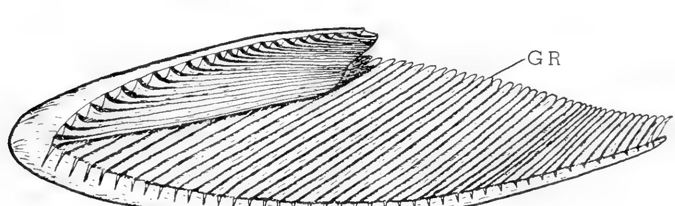

FIG. 14.—Lateral view of the gill rakers on the first arch of *Alosa sapidissima*, x4

Pectoral Girdle

The posttemporal (Fig. 15) is not as strong as in the Clupeidae (Fig. 16). The flattened body of the bone is smaller and both the epiotic and opisthotic arms are longer and more slender. The supracleithrum, on the other hand, is longer and considerably wider than in the Clupeidae. It bears a short tube for the lateral line nerve on its outer face. There are two postcleithra: the first a simple flat bone, shaped like a scale, which is fitted in between the supracleithrum and cleithrum, and the second, which has a long spine projecting posteroventrally like that of *Sardinops* (Fig. 16), although the spine is not so long or heavy as in the sardine.

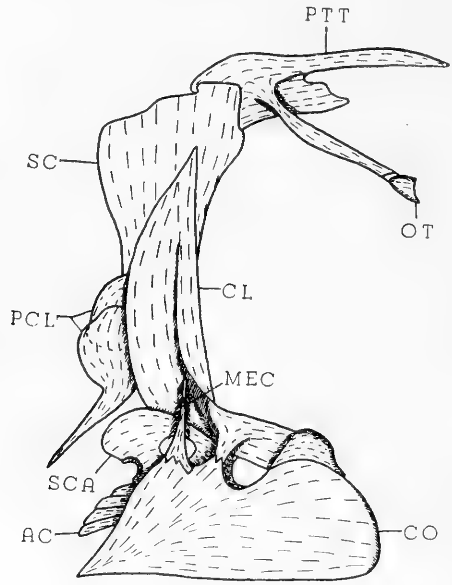

Fig. 15.—Mesial view of the shoulder girdle of *Etrumeus micropus*, x3

The mesocoracoid is slender and attached dorsally to the anterior edge of the inner side of the cleithrum. The coracoid is proportionately larger and more heavily ossified than in the Clupeidae. The anterior edge is particularly broadly expanded. The interosseous opening between the cleithrum and coracoid is about three times the size it is in *Sardinops*. Behind this opening the coracoid is suturally attached to a process from the inner side of the cleithrum. The shoulder girdle is otherwise much as in *Sardinops*.

Pelvic Girdle

The pelvic bones (Fig. 17) are triangular and considerably broader and larger than in the Clupeidae. The chief feature of the pelvic girdle is the two modified ventral scutes which are much broadened and probably serve to help distribute the stresses of the movement of the fin. These are the only ventral scutes present on the abdomen.

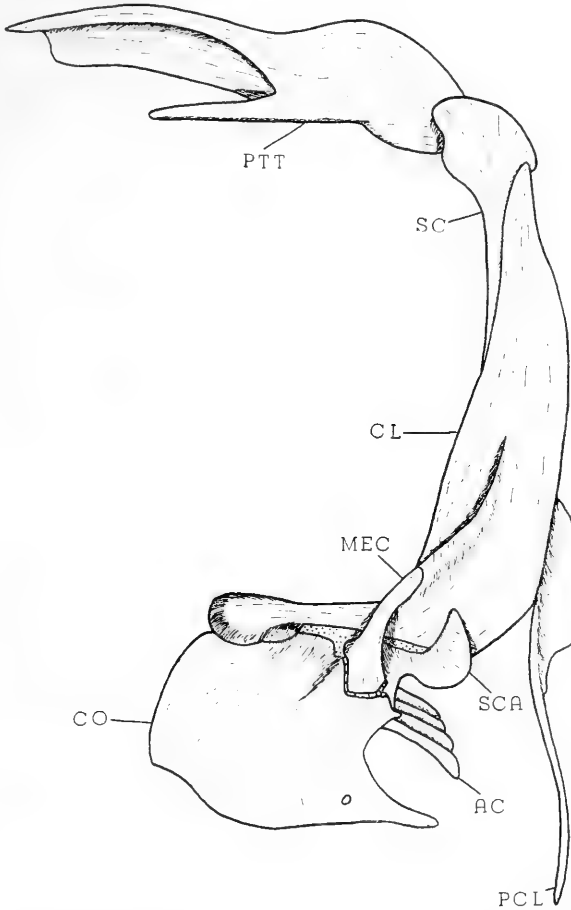

Fig. 16.—Mesial view of the shoulder girdle of *Sardinops caerulea*, x2.5

Axial Skeleton

In one specimen of *Etrumeus* there were 56 vertebrae, including the terminal centrum. The haemal arch is closed first on the 18th vertebra. On this vertebra the parapophyses, whose union on the posterior caudal vertebrae forms the haemal arch and spine, are short, and not as deep as the centrum. The parapophyses get only slightly larger back to the 29th vertebra, but posterior to that they become increasingly lengthened until the 41st vertebra is reached. All of the first 41 vertebrae bear pleural ribs, which are all attached ligamentously to the parapophyses. On the last ten of these vertebrae the ribs are very loosely attached. The parapophyses throughout the abdomen are

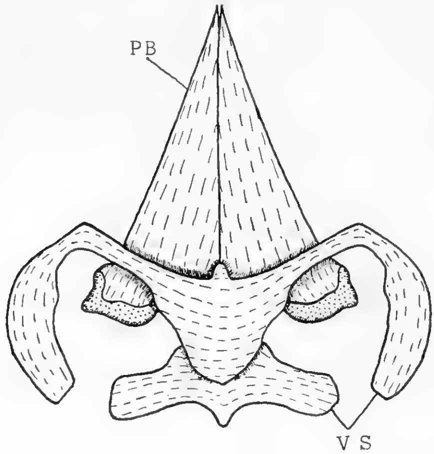

FIG. 17.—Ventral view of the pelvic girdle and supporting ventral scutes of *Etrumeus micropus*, x3

proportionately longer than those of the Clupeidae, and the ribs are broader. The anterior haemal zygapophyses appear first on the 31st vertebra; the anterior neural zygapophyses on the 25th. Anterior to this point the posterior neural zygapophysis is a blunt hump on the vertebra which does not overlap the following centrum, but by the time the 35th vertebra is reached this process has diminished in size until it is nearly lost. The posterior haemal zygapophysis retains its identity for another five vertebrae posteriorly, but then becomes only a point on the back of the vertebra. It does not project strongly ventrally as in the Engraulidae. The anterior zygapophyses of the caudal vertebrae (Fig. 18) are long, slender, and hug tightly the preceding vertebrae as in *Opisthonema* and *Sardinops*, though they are more slender and spikelike than in those genera. The anterior haemal zygapophysis of the penultimate vertebra is characteristically enlarged. Hypural number 4 is characteristically

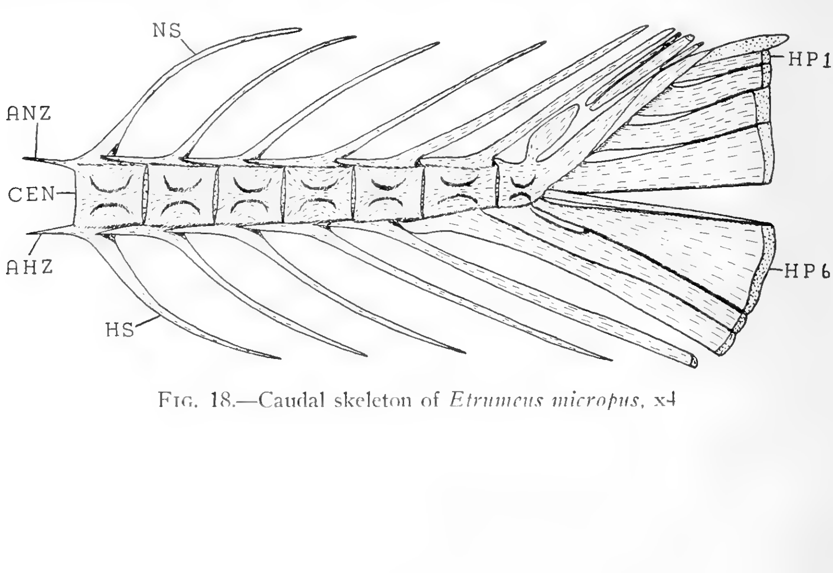

FIG. 18.—Caudal skeleton of *Etrumeus micropus*, x4

narrower than in the Clupeidae and hypural number 5 is slender and tapers posteriorly (unlike in the Clupeidae).

All of the neural spines anterior to, and under, the dorsal fin are very slender and are not united dorsally, the first one behind the dorsal fin being the first in which the two halves are united dorsally into a stiff spine. The first interneural is enlarged, lengthened and broadened, and extends down past the first neural spine to lie over the foramen magnum and protect the spinal nerve as it emerges from the cranium. The remaining interneurals are all much heavier than the adjacent neural spines. There are nineteen pterygiophores for the support of the dorsal fin. The first is very broadly expanded and the next five or six bear lateral vanes of bone which permit a broader attachment for the fin musculature. The series terminates in the long, slender dorsal stay typical of the Clupeoid fishes. The twelve pterygiophores of the anal fin are closely bunched together under the haemal spines of the 42d to 45th vertebrae. The first is somewhat broadened, but the rest are very long and slender, the twelfth little shorter than the second.

Epineurals and epipleurals are present on all vertebrae as in the Clupeidae, but those over the posterior part of the abdomen are branched several times instead of bearing a single fork as in the Clupeidae. On the caudal peduncle these bones are broadened and form an almost continuous bony sheath under the skin. Long, slender, simple epicentrals are present on all vertebrae in distinction to the condition in the Clupeidae and Engraulidae where they are absent on most of the caudal vertebrae. There are no myorhabdoi either dorsally or ventrally. The only ventral scutes present are the two associated with the support of the pelvic fins. In the anterior segments the backward radiating osseous brushes from the epiotic region of the cranium fill the place of the epineurals, which they resemble, except that they are even more slender, and more numerous. They are not grouped in bunches as in the Clupeidae.

Discussion

While the round herrings, of which *Etrumeus* is one, are often associated with the Clupeidae, and never with the Engraulidae, they nevertheless share several peculiar osteological characters with the latter (Chapman, 1943*b*) which are not found in the Clupeidae (Phillips, 1942; Chapman, 1943*a*). Among these are: (1) the possession of the toothed secondary mesopterygoid; (2) the well-developed, toothed suprabasal bone over the first two basibranchials; (3) the bifurcated, dorsal articular head of the hyomandibular; (4) the lack of a descending limb on the basisphenoid; (5) the numerous branchiostegal rays; and (6) the lack of ventral scutes, save for one or two remaining in the pelvic region. The first, second, and fifth of these characters must be considered primitive and are evidence that the round herrings are of ancient derivation and, rather than being a specialized offshoot of the Clupeidae, had already differentiated from the primitive Clupeoid stock before the development of recent Clupeidae. This is further borne out by the retention of epicentrals on all caudal vertebrae (lost on the posterior caudal vertebrae in the Clupeidae and Engraulidae), the presence of two postcleithra, and the primitive, simple condition of the various bony processes radiating back into the body musculature from the back of the cranium.

There is no indication, however, that the round herrings bear a close relation to recent Engraulids, for they share none of the striking specializations of that group, such as the enormous gape with its attendant osseous changes, the development of the cross-struts on the frontals, the exceptional development of the intermuscular bones of the body, and the large and prominent mesethmoid. The evidence is simply that both groups retain certain characters of the ancestral Clupeoid stock which recent Clupeids have lost.

The above-noticed characters, the rounded abdomen, the abbreviated anal fin, the posterior insertion of the pelvic fins, the complete fusion of the adipose eyelids over the eyes, and other characters cited in the text serve to show that these fishes are as deserving of familial status as the Engraulidae or Clupeidae. They comprise the family Dussumieridae.

Diagnosis of the Family Dussumieridae

Clupeoid fishes with a single supramaxillary; fifth bone of circumorbital series very large, not cut away anteriorly, and with its posterior edge overlying the preopercle; hyomandibular with two separate cranial heads, one for the sphenotic and the other for the pterotic articulation; ventral edge of the hyomandibular cut away so that there is an open space between it and the metapterygoid; preopercle broadly expanded posteroventrally so as to cover most of interopercle and its junction with the subopercle; gape small, not reaching behind eye; glossohyal large and covered with fine teeth; suprabasal long and broad, covering first two basibranchials and covered with fine teeth; two mesopterygoids, both covered with teeth; ceratobranchial of fifth gill arch with a long pad of small teeth; teeth found dorsally only on fourth gill arch; no ethmoid foramen; no median descending wing on basisphenoid; two postcleithra present; anterior zygapophyses very strongly developed in caudal region, and broadly overlapping the preceding vertebra; ventral scutes absent except for two in region of pelvic fin insertion; myorhabdoi absent both dorsally and ventrally; epicentrals present on all vertebrae; posterior haemal zygapophyses short throughout, and not projecting strongly on posterior abdominal vertebrae; pelvic fins behind dorsal; belly smoothly rounded; anal fin much shorter than dorsal; adipose layer over eye continuous, without vertical slit over pupil.

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ABBREVIATIONS USED IN ALL FIGURES

AC Actinost
AF Auditory foramen
AHZ Anterior haemal zygapophysis
AL Alisphenoid
AN Angular
ANZ Anterior neural zygapophysis
AR Articular
BA Basioccipital
BAS Basisphenoid
BB Basibranchial
BR Branchiostegal ray
CB Circumorbital
CBB Ceratobranchial
CE Ceratohyal
CEN Centrum
CL Cleithrum
CO Coracoid
D Dentary
EB Epibranchial
EF Epiotic fossa
EP Epiotic
EPH Epihyal
ET Ethmoid cartilage
ETF Ethmoid foramen
EX Exoccipital
F Frontal
G Glossohyal
GR Gill raker
H Hyomandibular
HB Hypobranchial
HS Haemal spine
I Interopercle
IN Interhyal
LA Lachrymal
ME Mesethmoid
MEC Mesocoracoid
MES Mesopterygoid
MET Metapterygoid
MX Maxillary
N Nasal
NS Neural spine
O Opercle
OR Orbitosphenoid
OT Opisthotic
PA Parietal
PAL Palatine
PAR Parasphenoid
PB Pelvic bone
PCL Postcleithrum
PF Prefrontal
PH Pharyngeal
POP Preopercle
POT Pro-otic
PT Pterygoid
PTO Pterotic
PTT Posttemporal
PX Premaxillary
Q Quadrate
SB Suprabasal
SC Supracleithrum
SCA Scapula
SMX Supramaxillary
SOC Supraoccipital
SOP Subopercle
SPH Sphenotic
SPI Spicular
SU Suprabranchial
TF Temporal foramen
V Vomer
VH Ventral hypohyal
VS Ventral scute

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 3, pp. 43-67, 11 text figs., 3 tables June 28, 1948

A POPULATION STUDY OF THE MEADOW MICE *(MICROTUS)* IN THREE SIERRA NEVADA MEADOWS*

BY

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Introduction

The importance of information concerning the exact numbers of organisms in a natural organic community, and the factors influencing changes in such populations, have become more and more evident as ecological studies have progressed.

The present study is an investigation into the numbers of meadow mice (*Microtus*)† inhabiting three neighboring meadows in the Canadian Zone of the central Sierra Nevada of California, at an elevation of about 7,500 feet, during 1937, 1938, and 1939. This area was selected because the natural meadow habitat of *Microtus* was small in proportion to, and quite distinct in character from, the surrounding terrain, and it was hoped that the factors influencing the existence of the meadow mice could therefore be more easily recognized. The three meadows totaled nineteen acres and were in the proportion of about one acre of meadow to fifty acres of rocky surroundings.

Live trapping was employed and the individual mice were given distinctive marks by means of a system of toe clipping, were then released, and those recaptured provided the detailed data that are presented and analyzed in the following pages.

* Printed from the John W. Hendrie Publication Endowment.

† The two forms that are found in this area are: *Microtus montanus yosemite* and *Microtus longicaudus sierrae*. Throughout this report, these forms are referred to by the specific names only.

Consideration is given to total and relative numbers per unit area, methods of estimating these, extent of territory occupied by individuals, length of life, competition between species, and such other factors as seem to cause changes in the population. An examination is made as to the adequacy of the number of traps to determine accurately the number of mice and it is shown that except for the first year of this study, the number of traps was sufficient to indicate the total population with a fair degree of accuracy.

For a critical reading of this manuscript I wish to thank Dr. Willis H. Rich and Dr. Frank W. Weymouth, both of Stanford University, and Dr. Robert T. Orr of the California Academy of Sciences.

Description of the Area

Geography

The area studied is located about ten miles south of Lake Tahoe in Eldorado County, California, and is locally known as the Echo Summit area, and the meadows as the Benwood meadows. This area is on a bench of a thousand feet above and immediately west of the extreme southern end of Lake (Tahoe) Valley. Also the bench is a thousand feet below and immediately east of the crest of the Sierra Nevada at this point. A portion of this bench, including the three meadows under study, drains into Lake Tahoe and thence into the Great Basin, while another portion of the bench drains into one of the uppermost tributaries of the American River, and thence into the Pacific. U.S. Highway 50 passes over the divide immediately north of the three meadows.

Geology

The predominant rock is granitic and forms part of the great batholith of the Sierra Nevada. Due to uplift and consequent erosion, the former superincumbent sedimentary rocks have been largely stripped off, although not far distant, in the Glen Alpine Canyon, a portion of the old roofing is still in evidence in the form of highly metamorphosed slates. On the ridge south of the Echo Summit area, as well as in other places more distant, can be found remnants of volcanic outpourings that were extruded at different times during the Tertiary uplift. These extrusions, largely tuffs and breccias and some lavas, have been extensively worn away and now exist mainly as cappings on the higher ridges. They have been but little disturbed in attitude, and form nearly horizontal layers, tilted slightly to the west.

During the Pleistocene, glaciers occupied the high Sierra several times and left their unmistakable marks. The two lower Benwood meadows (1 and 2) are former morainal lakes, now in the last stages of filling, while Benwood 3 is a rock basin, also sediment filled, that was formerly scooped out by the glacier which descended from the cirque-like canyon on the south. The rock walls that rise steeply from all sides of this meadow except at the outlet serve to isolate it with a greater degree of sharpness than is found in any other meadow in this vicinity.

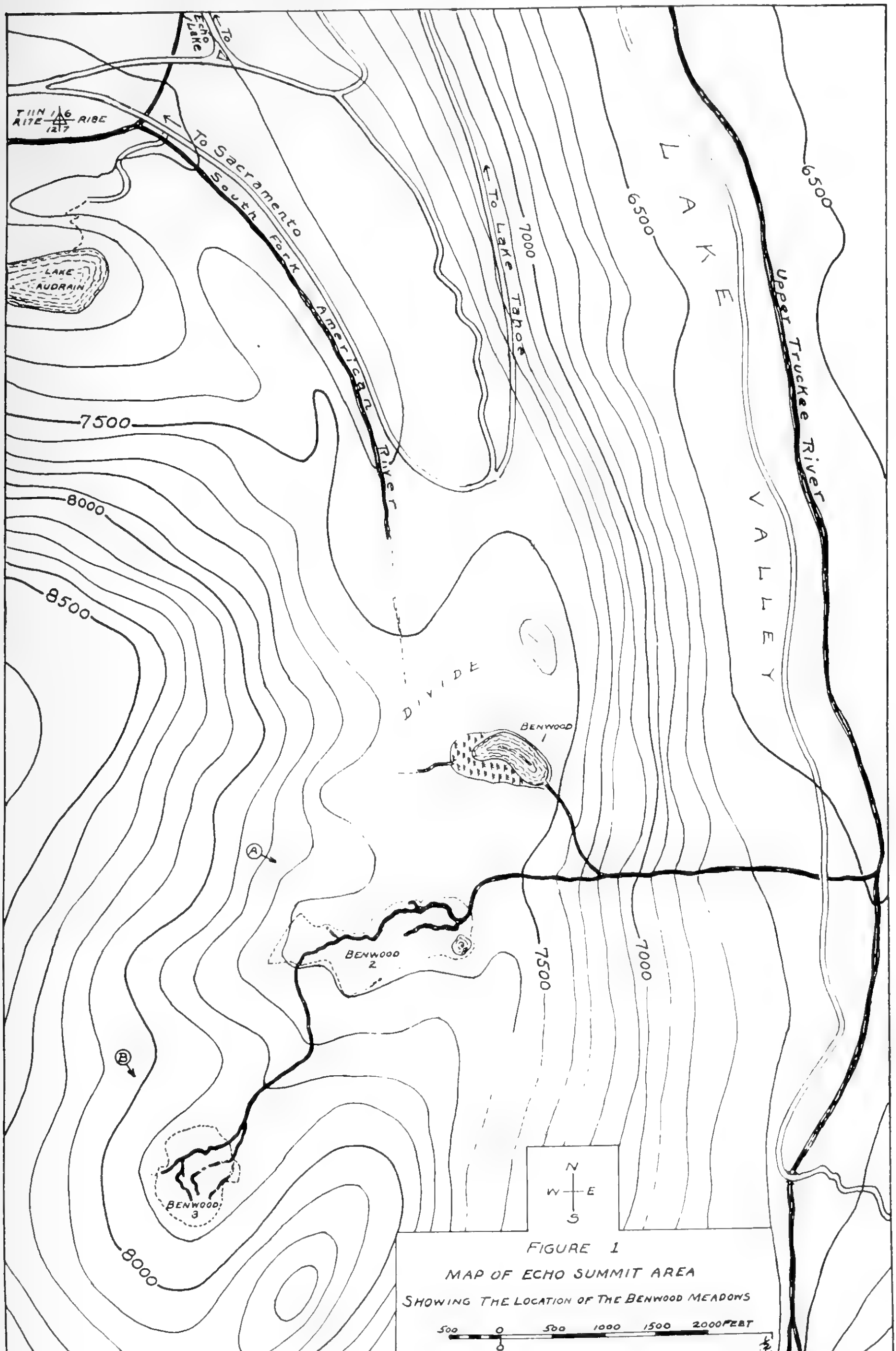

Fig. 1.—Map of Echo Summit area, showing the location of the Benwood meadows

Benwood 1.—This meadow is composed of about four acres of swampy ground, surrounding a shallow lake which is another four acres in extent. About the lake are numerous glacial boulders partially covered with muck, and here flourishes a growth of bilberry, willow, and kalmia. Carex rapidly follows the receding waters during the summer, and yellow water lilies bloom in the lake just before it dries up. A low morainal ridge separates the lake from the headwaters of the American River. The surrounding forest is similar to that described under Benwood 2.

Fig. 2.—Benwood 2. Camera at location *A* on the map. August 22, 1937

Benwood 2.—The open part of Benwood 2 measures about eight acres and is quite level although cut in places by meandering streams. The streams assume flood proportions when the snows are melting rapidly in the spring, but stop flowing shortly after the last vestige of snow has disappeared from the higher ridges. This occurred in the middle of August in 1937 and 1938, and somewhat earlier in 1939. A shallow lake of about half an acre forms behind a sand bar at the lower end of the meadow and dries up about a month after the stream stops flowing. Meadow grasses are constantly competing with stream cutting. Whenever the stream changes its course, a strong turf fastens itself upon the old stream bed. Then when the stream comes back across a turfed area, cutting may start in some new spot, and a depression resembling a pot hole boils out and begins to cut headward. Reduction of flow gives the grass another chance to come in and reclaim the spot to turf. All over the meadow are depressions more or less grown over with grass. Some are completely covered by long bladed Carex growing luxuriantly, thanks to the added moisture in the depressions, while other depressions are clean-cut and filled with fine white sand left by the active stream.

As portions of the meadow become slightly better drained, lodgepole pine, the forest tree most tolerant of wet feet, invades the meadow. Willows and alders abound along the more permanent stream courses and at the edges of the meadow where incoming water seepage is held near the surface of the ground owing to the shallowness of the soil. Surrounding the meadow the predominant trees are lodgepole pine where the ground-water table is higher, then red fir, Jeffrey pine, and Western white pine. Juniper occupies the higher, drier rocky slopes, and, on the ridge eight hundred to a thousand feet above the meadow, alpine hemlock predominates. White fir is scattering and apparently has reached the limit of its altitudinal endurance.

Benwood 3.—This meadow contains seven acres and is about 300 feet higher in elevation than the other two meadows. It is more restricted in the sense that the meadow floor terminates abruptly as it reaches the rocky walls that surround it. Thermometer records showed, for the months of July and August 1938, lower maxima and minima than on Benwood 2, while for September the maxima were higher and the minima lower. The season appeared to be about two weeks later in Benwood 3 than in Benwood 2, judging from both relative temperatures and amount of ground moisture. The meadow bordered closer on the Hudsonian Zone than Benwood 2, as shown by a greater invasion of alpine hemlock. Otherwise the vegetation was about the same.

Climate and Life Zones

The first snows in the autumn are sometimes followed by warm periods or rain, causing the snow to disappear quickly. Heavier storms may come in November, and the snow pack usually starts to form in December. From then on the pack increases, and a density equivalent to 30 or 40 percent

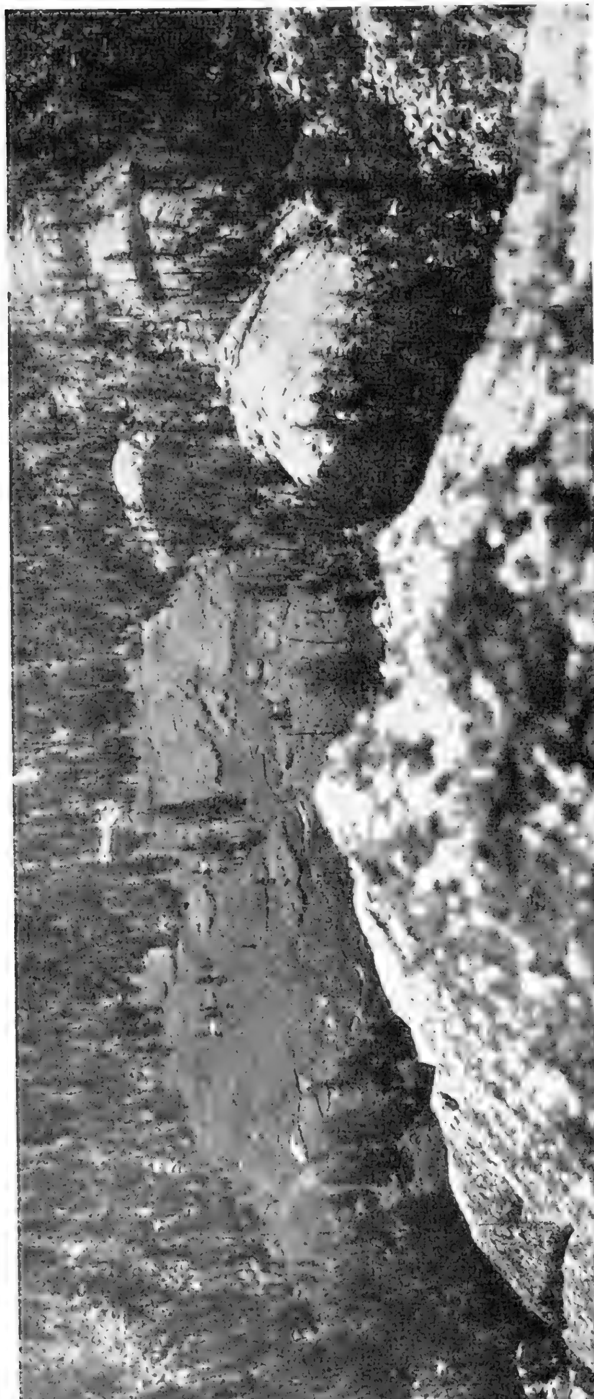

FIG. 3.—View of terrain, showing the restricted character of Benwood 3. Camera at location *B* on the map. August 5, 1938

of water may be reached. In April the snow may still be falling in considerable amounts, and by May or June it will start to melt and run off, owing to warmer weather and rainfall. By July usually the only snow remaining is that on the higher ridges, disappearing gradually through the summer. The following records from Twin Lakes, Alpine County, 7,970 feet, ten miles south of the Benwood area, are taken from the climatic summary of the United States Weather Bureau, 1930, Sec. 17, pp. 41 and 46.

Snowfall in Inches. 12-Year Average (1919–1931)

July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Seasonal
0	0	1.3	13.5	27.8	58.3	72.6	57.1	51.6	40.9	6.2	1.8	331.1

Total Precipitation in Inches. 11-Year Average (1919–1930)

July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Seasonal
.46	.24	.88	2.04	3.41	6.70	7.47	5.83	5.16	4.46	1.46	1.41	39.52

During the summer months (July, August, and September) the temperature is mild, ranging from about 70 and rarely 80 degrees F. in the middle of the day to 40 or 50 degrees at night. Occasionally the temperature drops at night to 32 degrees and a light frost may be seen on the meadows. At this time of year thunderstorms of short duration, and with little precipitation, may occur during the middle of the day but on the whole there is an abundance of sunshine.

The Benwood meadows are within the Canadian Zone as is indicated by the flora.

FAUNA

Only those vertebrates that seemed to have any ecological relation with *Microtus* are noted below and no attempt is made to present a complete list of all of the animals occupying the territory. Those which were observed are marked with an asterisk (*). The others listed are those which might be expected on these meadows.

Possible predators:

* *Accipiter gentilis.* Goshawk.
Accipiter striatus. Sharp-shinned hawk.
* *Buteo jamaicensis.* Red-tailed hawk.
Bubo virginianus. Horned owl.
Strix nebulosa. Great gray owl.
* *Cyanocitta stelleri.* Steller jay.
* *Canis latrans.* Coyote.
Vulpes fulva. Red fox.
* *Martes caurina.* Pine marten.
Mustela frenata. Long-tailed weasel.
* *Mustela erminea.* Short-tailed weasel. This diminutive predator no doubt takes a heavy toll on the mouse population of the meadows. In Benwood 2, three short-tailed weasels were collected, and another was captured, marked, and released. In Benwood 3 still another was collected.
Mustela vison. Mink.
Taxidea taxus. Badger.

Food competitors:

- * *Peromyscus maniculatus.* White-footed mouse.
- * *Thomomys monticola.* Pocket gopher.
- * *Zapus pacificus.* Jumping mouse.
- * *Citellus beecheyi.* Ground squirrel.
- * *Citellus lateralis.* Golden-mantled ground squirrel.
- * *Eutamias speciosus.* Tahoe chipmunk.
- * *Odocoileus hemionus.* Mule deer.
- * Domestic stock. Horses, cattle, and sheep.

METHODS OF WORK

General plan.—The field work for this study was carried on during the three summer seasons of 1937, 1938, and 1939. Occasional week-end visits were made to the area between the summers.

At first, forty-five live traps were made and tried out in Benwood 2. It was soon seen that these would be inadequate to give a true picture of the population of the meadow. One hundred additional traps were then constructed in camp and put into service as rapidly as possible.

During this same summer of 1937 a preliminary map was made of the area. This was followed up in the autumn of that year, and at times during the summer of 1938, with a more accurate survey. Transit and stadia rod were used to outline the meadows, locate the main features, and tie the meadows to one another and to the main highway. An observation was taken on Polaris to determine true North.

Within the meadows a plane table and telescopic alidade were used, setting up on stations previously determined by the transit and stadia rod. The trap locations in Benwood 1 and 3 were determined by this method, but in Benwood 2 hub stakes were set on corners of fifty-foot squares determined by stadia and engineer's tape. These hub stakes were further marked by lath which stood above the grass and made it easy to see location of traps as well as plant growth, stream cutting, gopher workings, etc.

Before starting field work in 1938, 300 live traps had been completed, which allowed the placing of 27 traps in Benwood 1, 176 in Benwood 2, and 80 in Benwood 3, and which also allowed a surplus to replace traps that got out of order.

Traps and trapping procedure.—The first traps used were patterned after that described by Moore (1936, p. 372, Fig. 1). A modification of this trap was adopted as shown in Figure 4. The advantages were: (1) longer can with more room, (2) square can to prevent rolling, (3) snap trap inside of can where ground moisture could not so readily affect the wooden base, (4) wire screen door for easier observation.

The traps were scattered over the meadows as evenly as possible. A greater number was placed in Benwood 2 than in Benwood 3 although the area of the two meadows was nearly the same. The results, however, seemed to indicate that the number in Benwood 2 was more than necessary, instead of the number in Benwood 3 being inadequate. If the trap was in a position liable to receive the full force of the sun at some time during the day, it was covered with brush or with V-shaped board covers. Cotton was placed in the back of each trap to afford nesting material as a protection against cold. Rolled oats were used exclusively for bait. In 1937 the traps were visited three or four times a day, but in 1938 and 1939 once a day, in order to give time to cover a greater trapping area.

Mice taken from the traps were handled as follows: A wide-mouthed, Mason glass jar was held against the open door of the trap and the mouse was shaken down into the jar. It was then easy to transfer the mouse to a small cloth sack. By turning down the folds of the sack an examination of the parts of the mouse could be made without danger of escape or damage to the mouse or to the fingers of the observer. No anaesthetic was used. The procedure was first to weigh the mouse, measure the tail, determine sex, and then to examine for a previous mark, or, if the mouse were a new capture, to mark accordingly.

Marks were made by clipping the end of one or two toes at the last joint to represent numbers as indicated in Figure 5. This permitted the use of numbers up to 89. After that the numbers that had been given to mice that died were used over again without causing confusion. When these numbers became exhausted, combinations of two toes cut on front feet and none on the hind, or two on the hind and none on the front, served for identification and this was sufficient to care for all needs. Records were kept of date, time, trap

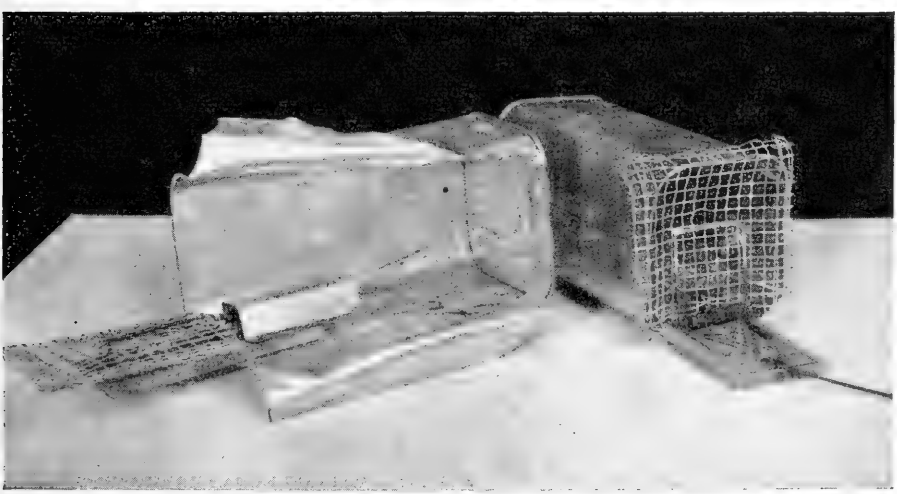

FIG. 4.—Live trap used in these operations, cut open to show: common snap trap fastened to inside of can; wire screen door soldered to loop on trap; extension treadle partially covered by guard to permit mouse to get well into can before springing. Can is 6¼ x 3½ x 3 inches and is known as an "asparagus can number 2½."

number, mouse number, sex, weight, and tail length. Separate pages were used for posting the records of each individual mouse. All records were carried in the field, and before a recaptured mouse was released the data were compared with past records as a check against the possibility of incorrect reading of the toe numbers.

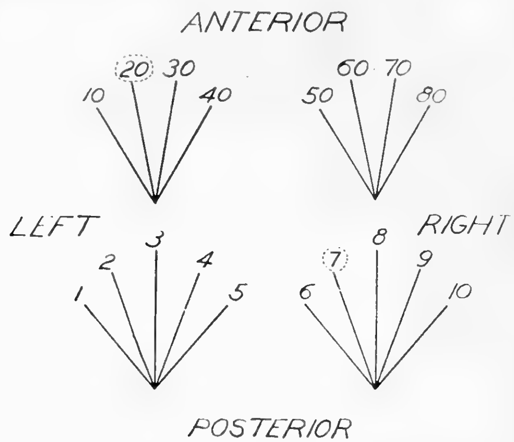

FIG. 5.—Diagram indicating the order of numbers assigned to toes. If those encircled by dotted lines were cut at the first joint that mouse would be recorded as No. 27.

Species identification.—Determination of weight and tail-length was necessary to differentiate *Microtus longicaudus* from *Microtus montanus*. Specific characteristics include a slight color difference, but this was difficult to be sure of when examining one mouse at a time, without a series for comparison, and especially out of doors under varying conditions of light and shade, and with a live, wriggling mouse. Tail length relative to body length is considered a good differentiating character by systematists. With a live specimen, tail length was easy to obtain by using the cloth sack as described, but body length could not be accurately determined without possible damage to the mouse. Therefore, weight was taken as a substitute for body length, and differentiation was easily made in every case. The relation between weight of mouse and length of tail for the two species is plotted graphically in Figure 6.

ANALYSIS OF DATA

Table I (p. 55) shows that 195 individual *Microtus* came under observation during this study. It will be seen that there were about twice as many *M. longicaudus* as *M. montanus* and one and one-third as many males as females. Within species limits, the *montanus* males outnumbered the *montanus* females by nearly two to one, while the *longicaudus* males were approximately one-fifth more numerous than the females. Other significant data are shown in this table, for later reference.

Population Density

In Figure 7 the total length of the bars indicates the cumulative first captures or, in other words, indicates the total number that had been marked, up to the date of record. After each first capture the mouse was marked and released and the methods of capturing, marking, and identification have already been described.

The length of the stippled portion of the bars denotes the cumulative number of mice that were found dead in the traps or that were purposely killed.

The difference between the cumulative first captures (total bar length) and cumulative known deaths (stippled portion of bar) would give the maximum possible number of marked individuals that could be at large on the meadow for any date indicated, and is represented on the chart by the distance

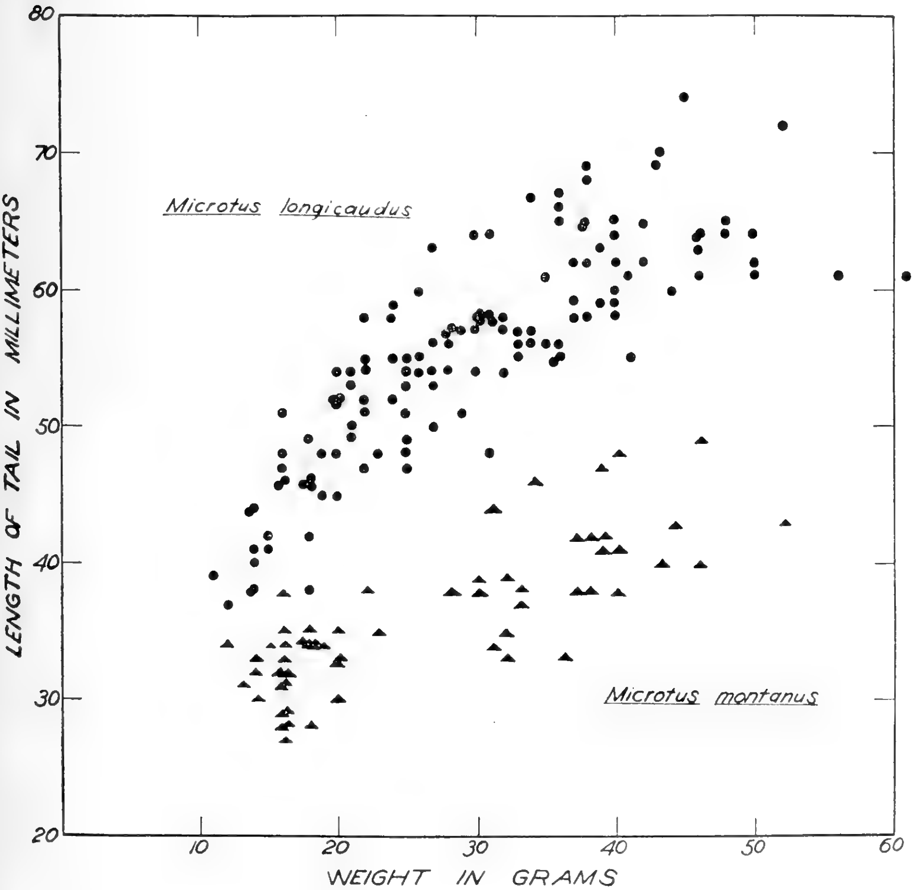

Fig. 6.—Graph showing relation between weight of mouse and length of tail for the two species.

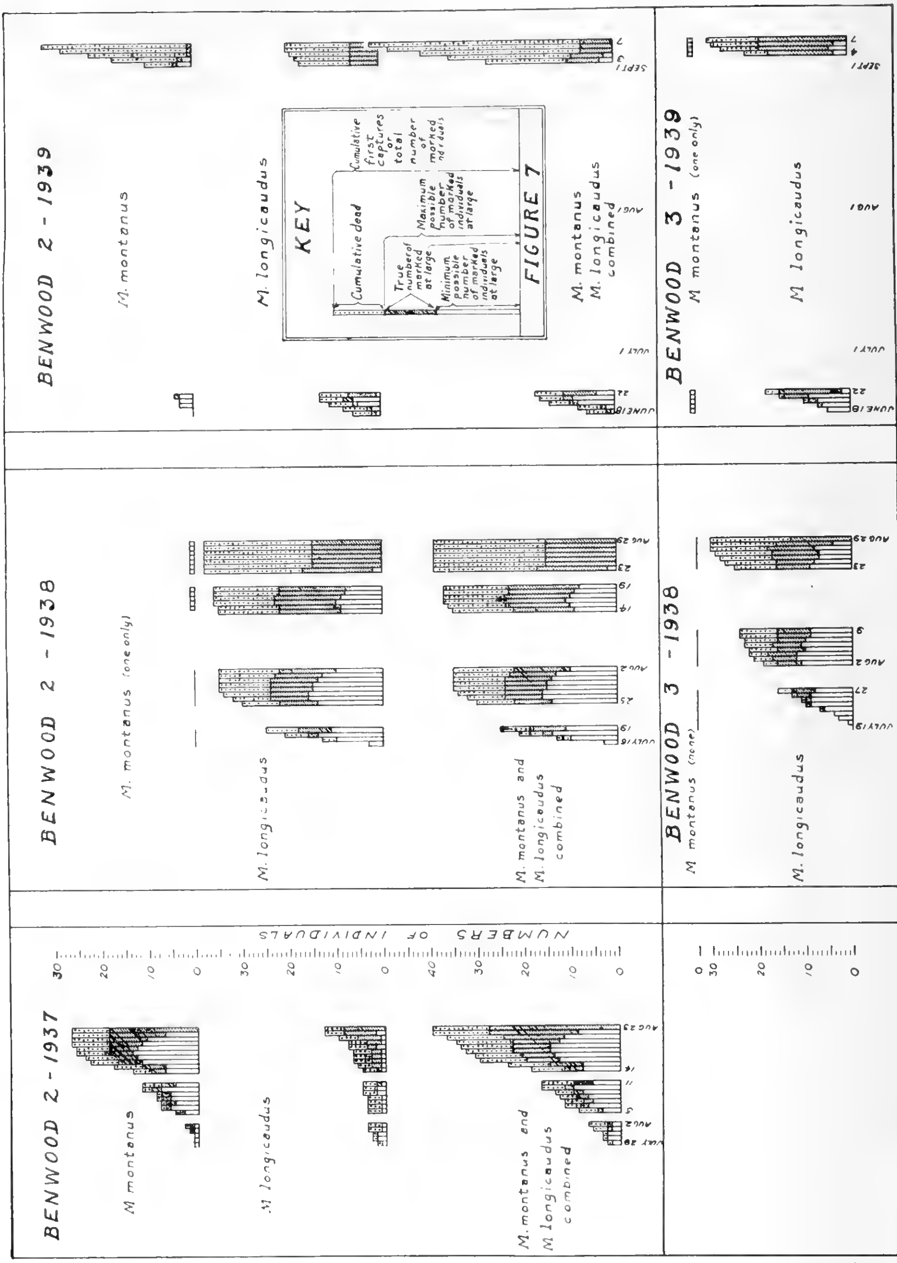

FIG. 7.—Graphs showing number of *montanus* and *longicaudus* trapped (i.e., population density) in Benwood 2 and 3 during 1937–1939

TABLE I

Number of *Microtus* captured:

	Males	Females	Total
M. montanus	41	21	62
M. longicaudus	73	60	133
Both species	114	81	195

Total number of acres trapped	19 acres
Maximum number of traps operated at any one time	283 traps
Average number of traps per acre	15 traps
Number of seasons (1937–1938–1939)	3 seasons
Total number of season-acres (1 x 4, 3 x 8, and 2 x 7)	42 season-acres
Total number of days of trapping	70 days
Maximum distance in a straight line between the outside edges of the three meadows	5,800 feet
Total number of trap-days (one trap-day equals one trap in operation 24 hours from noon to noon	10,839 trap-days
Total number of captures (including recaptures)	645 captures
Average number of trap-days per capture	16.8 trap-days
Total number of different individual mice captured	195 mice
Average number of trap-days per individual	55.6 trap-days
Average number of individual mice per acre per season in all meadows	4.55 mice
Maximum number of individuals per acre for any meadow (as found on Benwood 2)	6.5 mice
Minimum number of individuals per acre for any meadow (as found on Benwood 1)	2 mice
Number of times each individual was caught: minimum 1; maximum 15; average	3.3 times caught
Known dead (including those purposely killed)	113 mice
Same, expressed in percent of total individuals	58 percent
Known dead (found dead in traps and not including those purposely killed)	73 mice
Same, expressed in percent of total individuals	37 percent

from base line to top of shaded bar or the bottom of the stippled bar. The maximum point reached by the tops of shaded bars is at Benwood 2, for total *montanus* and *longicaudus* on August 22 and 23, 1937, and would represent a total of 28 mice for the meadow or 3.5 per acre. This is referred to hereafter as the "possible maximum."

It must be assumed that some of the marked individuals died after being released or that they might even have left the meadow. Therefore the length of the clear bar is used to indicate the number of individuals that up to the dates given had been marked and released, but which were certainly not dead or lost as was proved by capture at some later date. This number would then represent the minimum possible number of marked individuals that were at large on the meadow for the dates indicated. This number, of course, would be reduced to zero on the last day of trapping, for the obvious reason that no more subsequent recaptures were made, and therefore there could be no proof that the mice were still living.

The true number of marked mice at large on the meadow must then lie somewhere in the shaded bar between the top of the clear bar and the bottom of the stippled bar, for any date indicated, and lacking further evidence, one may make an arbitrary assumption that the true number of marked mice at large lies nearest to the mid-point within this shaded area. This mid-point reaches its peak of 20 mice on Benwood 2 on July 26 and 27, 1938, or 2.5 mice per acre. This figure may then be taken as the best estimate of the maximum number of marked mice that were at large at any one time on any meadow. This is referred to hereafter as the "probable maximum."

To recapitulate, we have the following figures for the three Benwood meadows for the summer seasons of 1937, 1938, and 1939:

Number of marked *Microtus* per acre at large at any one time on any meadow:

Possible maximum ....3.5 mice per acre per season
Probable maximum ....2.5 mice per acre per season

Number of *Microtus* per acre, cumulative for any entire season:

Average for all three meadows and three seasons...4.55 mice per acre per season
Maximum in Benwood 2, 1939....................6.5 mice per acre per season
Minimum in Benwood 1, 1938....................2.0 mice per acre per season

An examination will now be made of the adequacy of the number of the traps used, in giving a true picture of the total numbers in the Benwood area.

It will be noted upon referring to Figure 7 (total *montanus* and *longicaudus* combined, Benwood 2, 1937), that the curve representing cumulative total captures rose steadily during that season. This was the first year of trapping, and because some of the traps had to be manufactured in the field, they were only gradually placed in operation, starting with 45 or 5.6 per acre at the beginning of the season and increasing up to 140 or 17.5 per acre at the end of the season. Therefore the steady rise in captures was due in part to the increase in the number of traps.

The graph for Benwood 2, 1938, represents the effect of applying the full number of traps (176 total or 22 per acre) at the beginning of the 1938 season. Here will be noted a sharp rise in cumulative captures at first, and then a flattening off of the curve toward the end of the season. During the last week 103 additional traps were placed in the meadow, and all mice captured in any traps were purposely killed. This was done in order to test thoroughly for total population at this time, and in spite of the added trapping efforts, no new individuals were discovered. This seemed to indicate that the number marked very closely approached the total population. Another point of interest was that, during the first two days of this final week, only eight recaptures (of marked mice) were made. During the following five days of trapping with 279 traps operating on eight acres, there were no captures of *Microtus* at all. This would seem to indicate that only eight *Microtus* were at large on the meadow at the beginning of this final week. At the date August 23, 1938, the number eight will be seen to lie very close to the middle of the shaded bars, the upper and lower limits of which indicate the estimated maximum possible and minimum possible number of marked mice that could be at large. This then would seem to substantiate the assumption that the mid-point of the shaded bars gives the best estimate of the true number of marked mice at large.

In Benwood 3, 1938, the number of traps was increased from 60 to 80 in the first two weeks, and here the curve of cumulative captures rose steadily, seeming to indicate the effect of the increased trapping effort. The curve finally flattened off but not so early in the season as with Benwood 2, 1938, and also at a slightly lower level. It was further noted in Benwood 3, 1938, that the total captures (including recaptures) per acre per day were exactly the same as for Benwood 2, 1938, while the total marked (or first captures) for the season, for Benwood 3, 1938, were but 88 percent of the total marked for Benwood 2, 1938. This would seem to indicate that the 80 traps on Benwood 3 (11.4 traps per acre) were enough to ascertain the true population, while the 176 traps on Benwood 2 (22 per acre) were not only enough but included a surplus that insured a fair record of the whole population.

To conclude, then, we can assume that by the end of the 1937 season and for the 1938 and 1939 seasons the number of traps was sufficient to indicate the total populations with a fair degree of accuracy, and the number of *Microtus* at all times was not over 6.5 mice per acre per season, or to express this in round numbers, was not more than 10 per acre per season.

This figure seems surprisingly low. Published records of the density of population of *Microtus* in other localities are given in Table II, page 58.

It is interesting to note in the records quoted, that the excessively high numbers, of over 1,000 per acre, were termed "plagues" by the authors. Numbers of over 100 per acre occurred during periods which the authors thought to be the peaks of population cycles. I suggest, then, on the basis of my figures for the two species dealt with in this paper, that less than 10 per acre may be taken as an indication of borderline living conditions continually threatening local extinction.

The factors in these borderline living conditions that restrict population increase in the Benwood meadows to this low number of less than 10 per acre are probably as follows, listed in the order of importance:

1. *Predator control.*—This is very likely the chief limiting factor for mouse populations here, although the evidence was not complete. The total area of the three meadows is nineteen acres and they are surrounded by a much larger extent of wooded, brushy, and rocky country, which is not adapted to the life of the meadow mice but which does form a natural habitat for several predators. The areal proportion of meadow to nonmeadow in this general region is 1 to 50 or more. One can imagine that the weasels, badgers, coyotes, or other predators of this region might regularly make the rounds of the meadows in order to pick up some small morsel of mouse flesh, so easily caught. Evidence of this is in the presence of the three weasels (*Mustela*

erminea) that were caught in Benwood 2 in 1937 and the one in Benwood 3 in 1939. Quantitative data regarding weasel populations and feeding habits are quite meager, yet the high potential mouse predator value is very obvious. It concerns an animal which is small enough to enter a mouse runway, and which was found in my experiments during a short period of captivity to consume more than one mouse per day. Coyotes and pine martens were seen at no great distance, and what were thought to be badger diggings were noted in the meadows. Other predators are known to inhabit the Sierra Nevada at this elevation and may have invaded this territory. In the light of this evidence, I assume the predators to be the chief controlling factor of increase in population.

2. *Climatic control.*—Climate is probably favorable most of the time but may occasionally act suddenly to the great disadvantage of the mice. Accumulated snow merely followed by a gradual melting in the spring is probably not very detrimental to the mice. Tunnels were found under the snow where food had been stored in the form of grass roots and other preserved plant materials. Slight differences in the ground level could afford sufficient escape from water saturation, and thus moderate rainfall and gradual melting of snow might work no hardship. However, climatic extremes will undoubt-

TABLE II

PUBLISHED RECORDS OF *Microtus* NUMBERS

Authority	Species	Country	Authors' figures converted to number per acre
Pidoplichka as reported by Vinogradov (1934)	*M. pelliceus*	U.S.S.R.	2½
Wooster (1939)	*M. haydeni*	Kansas	0 to 4
Seton (1909, p. 522)	*M.* [*pennsylvanicus*] *drummondi* plus *M. minor*	Manitoba	16
Merriam (1884, p. 274)	*M. pennsylvanicus*	Adirondacks	23
Hamilton (1937*b*, p. 789)	*M. pennsylvanicus*	Northeast United States	15 to 40 (low) 50 to 250 (high)
Townsend (1935, p. 96)	*M. pennsylvanicus*	Central New York	2 to 67
Elton, Davis and Findlay (1935, p. 279)	*M. agrestis*	England	50 to 250
Selle (1928)	*M. californicus*	Kern County, California	4,000
Piper (1908)	*M. montanus*	Humboldt Valley, Nevada	8,000 to 12,000
Hall (1927, p. 192)	*M. californicus*	Kern County, California	12,342

edly reduce populations, as for example, a sudden downpour of rain and resulting flood conditions such as are described later. Another condition that could cause particular hardship to the underground forms, although we have no actual record of such an occurrence in this area, would be a hard freeze following quickly after the meadows became water-saturated.

3. *Food control.*—As long as predators, plus any adverse climatic conditions, hold the number of mice to a low level, the food factor would not be operative. Apparently the food was very abundant in proportion to the numbers of mice observed, and no evidence was noted of a depleted supply. Only if and when the numbers of mice became greatly increased could food be a limiting factor.

4. *Disease* was not observed. The mice seemed in good physical condition when they had not been in the traps too long. No doubt scarcity of population makes infection less likely, while abundance of food and elimination of the weaker by predators and climate would make for selection of the healthier individuals.

SPECIES DIFFERENCES

Figure 7 not only shows the differences in total population density of *Microtus,* but also indicates certain significant differences in the numbers of the two species. In brief, *M. montanus* shows greater yearly differences in numbers, and apparently is more sensitive to environmental changes than is *M. longicaudus.*

On Benwood 2, in 1937, the numbers of *montanus* exceeded those of *longicaudus* two to one, and in 1938 *montanus* had disappeared until the end of the season, when a single female appeared and was caught seven times in nine days. No other *montanus* were taken that season, although *longicaudus* had increased in numbers. In seeking for an explanation it is noted that in December 1937 a sudden downpour of rain occurred in this region. Records from the United States Weather Bureau showed for Twin Lakes, ten miles south of Benwood 2, on December 10, 3.82 inches of rain in 24 hours, and on December 11, 3.58 inches. Locally the forest rangers and others reported excessive flooding in the meadows and streams. Check dams and trails where present were washed out and meadows were heavily flooded. An animal that was largely restricted to the meadow would be fairly caught and drowned out. Grinnell (1939) noted a marked depletion in the terrestrial mammal population of northeastern California following this same storm.* In 1938 the golden-mantled ground squirrels had completely disappeared from the Benwood area, while the tree-dwelling Tahoe Chipmunk showed no diminution in numbers. *M. montanus* has been found inhabiting burrows and making use

* Dr. Grinnell refers to this storm as occurring on "December 10" preceding "June 1937," therefore indicating the date of the storm as December 10, 1936. Mrs. Hilda W. Grinnell writes me as follows: " 'June 1937 . . . .' should have read 1938. It was a misprint which we ourselves overlooked when reading proof, but noted in the printed article."

of runways, while *M. longicaudus* was never found using burrows or runways. Also, as is shown farther on in this article, the range of *montanus* proved to be restricted to smaller areas than *longicaudus*. *M. montanus* was not found to leave the meadow, while at least three individual *longicaudus* were noted to have left one meadow and entered another during the time of the field observations. Grinnell and Storer (1924, p. 130) noted that *longicaudus* "lives chiefly along the banks of swift-moving mountain streams and in marshes, but also on dry hillsides at some distance from water." Thus the indication is that *montanus* was caught and nearly eliminated from Benwood 2 in the winter of 1937–38, while *longicaudus* was able to come back probably from the surrounding higher ground. It is interesting to note that one *montanus* female did come into this meadow late in the summer of 1938, thus showing the difficulty of a complete extinction of this type of animal.

At the end of the 1938 summer, all *Microtus* of both species that were taken on Benwood 2 during the last seven days of trapping were purposely killed in order to see what the effect would be upon the next year's population. There was no storm of sudden flood proportions during the winter between 1938 and 1939, and apparently, in spite of the artificial reduction in numbers in the late summer of 1938, enough mice escaped to bring the population back in 1939 to 6.5 per acre.

Just why Benwood 3 showed no *montanus* in 1938 and but a single specimen in 1939 is not clear. It is quite probable that if there were any *montanus* in that meadow in 1937, the storm of December 1937 destroyed them, just as it did in Benwood 2. It is possible that the restricted physical nature of Benwood 3 made the storm more effective in drowning out the meadow-dependent *montanus* and also in making it more difficult for them to migrate from other localities, while the wider-ranging *longicaudus* could more easily come in and fill the niche left by those destroyed.

Breeding and Length of Life

Most collectors of mammals are at work during the summer only, therefore their many published records concerning specimens containing embryos only tell us that breeding goes on in the summer, as we might well guess. However, the painstaking work of some recent investigators sheds light on this important phase of the life history.

In England, John R. Baker and R. M. Ranson (1933) collected *M. agrestis* each month for two years, and from 2,500 specimens taken, determined that this species has a well-marked breeding season from mid-March to late September (rarely February and October), with no evidence of breeding in the winter (November, December, and January).

In central New York, W. J. Hamilton, Jr., (1937*b*, p. 785) found *M. pennsylvanicus* commonly breeding from mid-March until mid-November. He noted further that although the mice do not customarily breed during the winter months (December to February), yet in a year of greatest mouse abundance the animals continued to produce young throughout the winter. At the same time, however, there was a considerable decrease in litter size and frequency of breeding. These facts have considerable bearing on the problem of cycles of population and mouse plagues.

During the three seasons of investigation on the Benwood meadows and out of a total of 62 marked *M. montanus,* none was recaptured during a second season. Of 60 female and 73 male marked *M. longicaudus* only 3 male *longicaudus* were recaptured during a second season. This would seem to indicate that the *Microtus* seldom live more than a year, due very likely to their early attainment of sexual maturity, extreme prolificness, and high metabolic activity, as has been noted by several authors. I found pregnant females as late as September, and it is quite possible that breeding continued much later in the fall. The last litters which escaped marking were probably those that made up the breeding stock for the next year.

The Size and Character of Individual Ranges

Field observers have inferred that the home range of the meadow mouse was quite restricted. Seton (1909, p. 522) gave as his opinion that "the home range of the individual [*M. pennsylvanicus drummondi*] is probably less than 50 feet across. I have seen an isolated hollow of that size which was obviously the whole world of a dozen or more of these Mice."

Hamilton (1937*a*) arrived at very nearly this same figure after recapturing 100 of his 600 marked mice. He stated (p. 263) that "the home range of an individual vole seldom encompasses an area in excess of 1/15 of an acre [about 54 feet across] . . . . [Also on p. 261.] The results of this study point to a very limited home range, even in extensive areas of similar habitat. Males wander more widely than females, and are more likely to take up residence in new areas which have been previously unpopulated by the species. This is in keeping with the 'wandering tendency' theory proposed by Townsend (1935)."

My own records on the Benwood meadows showed that, with the exception of three individual mice, the average size range of all *Microtus* was an area with a diameter of 163 feet, increasing to a maximum diameter of 820 feet. The method of obtaining the field data has been described. Each catch was recorded by exact location and the position plotted on a large scale detailed map of the meadow. This gave for each individual mouse a series of points on the meadow where the mouse had at some time been found. Although it would never be possible to obtain a complete record of the area ranged over by any individual, it was desirable to obtain a measure of the range that would be reasonably comparable in indicating differences in size of ranges between sexes, species, etc.

To connect all of the points where an individual had been found would be to describe a geometrical figure with a measurable area. But since this area would become zero whenever all of the points happened to lie along a straight line, comparison by this method would obviously be of little use. To measure the length of the broken line connecting all points would also be a poor measure, since an individual if caught often enough in a small area might show a longer total line than one that was caught but twice, even though the two captures were far enough apart to suggest a much greater width of range.

It was finally decided to use as the factor that would probably come nearest to expressing the comparative extent of ranges, the distance between the two points of capture that were most widely spaced, or in other words, the maximum diameter of the observed range. These distances were then scaled off on the large scale maps and recorded for each individual. A summary of these records is given in Table III, but with omission of all cases where but one capture was made, since in such cases there could be no opportunity to determine the size of the range. In cases where an individual mouse was each time captured in the same trap, the record was retained but the range was recorded as zero.

TABLE III

SIZE OF RANGES OF *Microtus*

Grouping	Number of Individuals	Length of Record in Days		Diameter of Range in Feet	
		Average	Extremes	Average	Extremes
Total *Microtus*	113	12.6	2 to 50	163	0 to 820
Total females	53	14.3	2 to 47	144	0 to 730
Total males	60	11.0	2 to 50	179	0 to 820
Total *montanus*	27	12.2	2 to 47	115	0 to 410
Total *longicaudus*	86	12.7	2 to 50	177	0 to 820
M. montanus females	11	12.5	4 to 47	82	0 to 360
M. montanus males	16	12.0	2 to 47	138	0 to 410
M. longicaudus females	42	14.8	2 to 46	161	0 to 730
M. longicaudus males	44	10.7	2 to 50	194*	0 to 820*

* These figures are for ranges within the meadow. Three individuals, all male *longicaudus*, were found to have left one meadow and to have appeared in another meadow. In two of these cases the distance covered (measured in a straight line from one meadow to the other) was 3,000 feet and in one case the distance was one mile.

From Table III it is seen that males have a wider range than females in both species, and that *M. longicaudus* has a wider range than *M. montanus* in both sexes, and even the *longicaudus* females have wider ranges than the *montanus* males.

To determine whether the ranges as given in Table III express the full size of the natural range of the species and sex groups of *Microtus*, Figures 8, 9, 10, and 11 may be examined. Here the diameter of range in feet for each individual is plotted on the y axis as against the time or length of record in days on the x axis for each of the following groups:

M. montanus females
M. montanus males
M. longicaudus females
M. longicaudus males

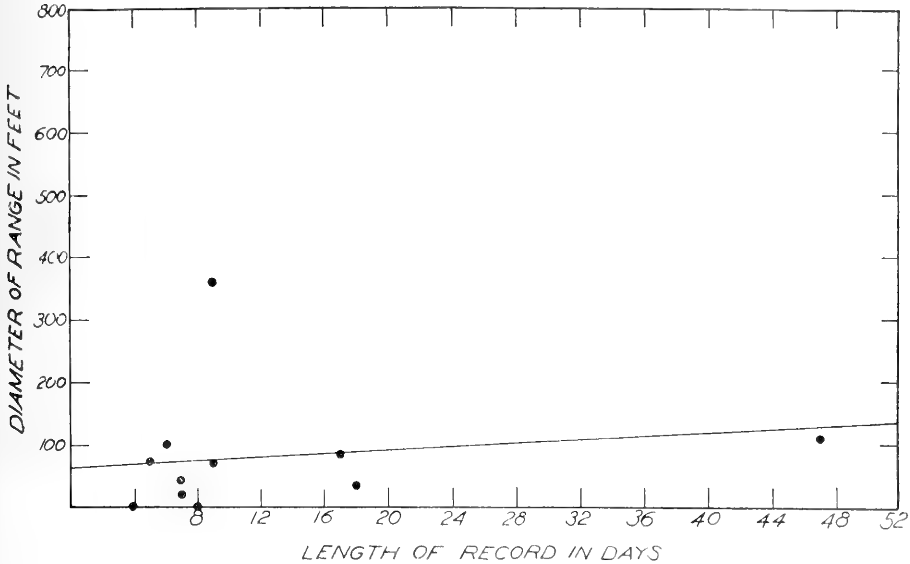

Fig. 8.—*Microtus montanus* (females)

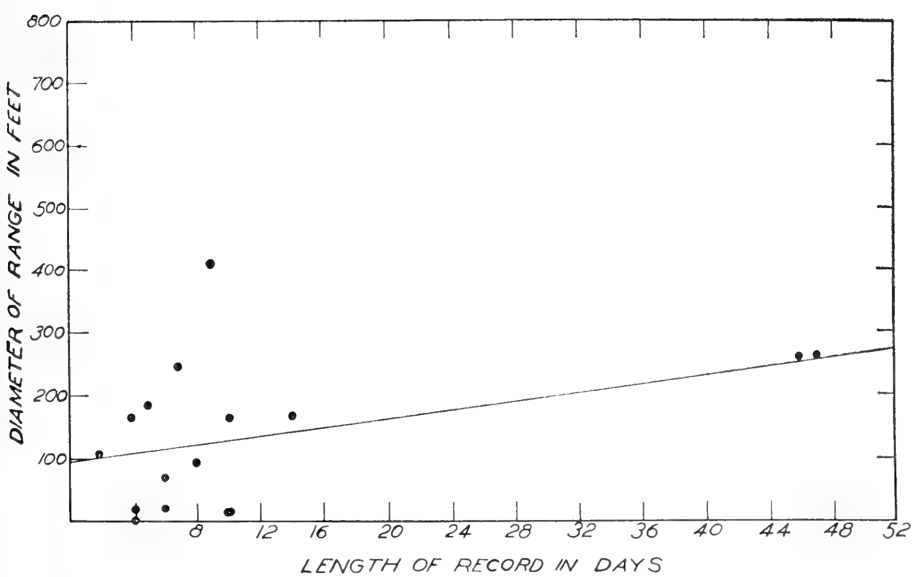

Fig. 9.—*Microtus montanus* (males)

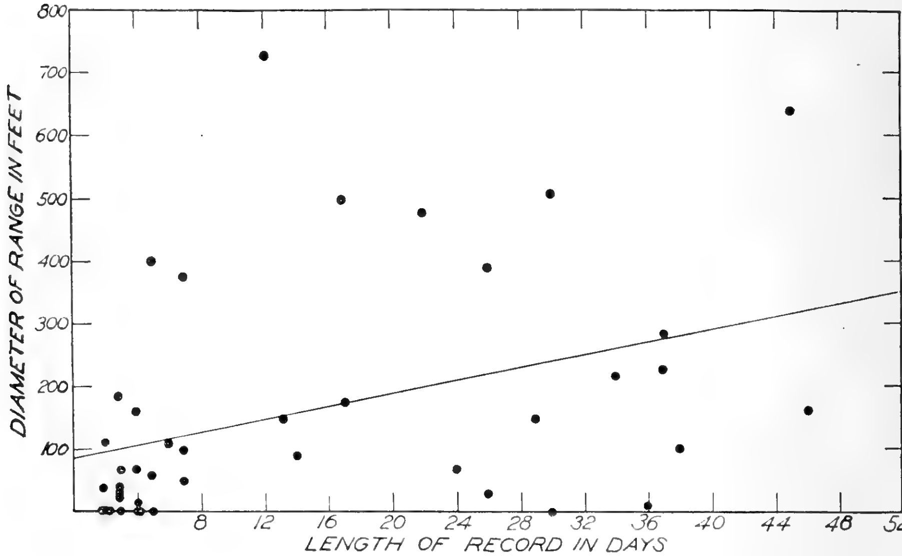

FIG. 10.—*Microtus longicaudus* (females)

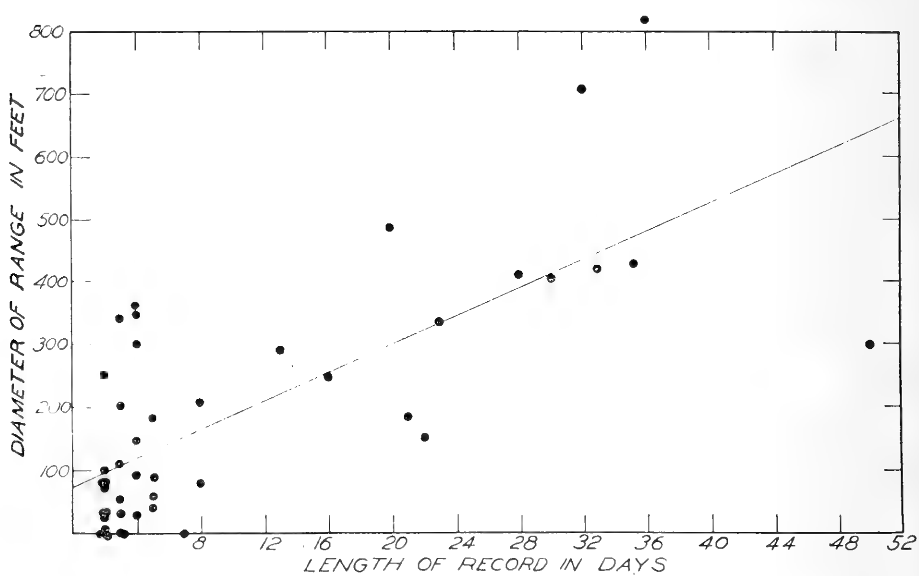

FIG. 11.—*Microtus longicaudus* (males)

From these graphs it appears that with one group only, namely the *longicaudus* males, there is a definite correlation between length of record and range, such that as the length of record increases, the diameter of range also increases. With the other groups an increase in the length of records does not show correspondingly significant increase in the size of ranges.* This may be interpreted as indicating that in these experiments the natural limit of the size of the ranges of all groups, except *longicaudus* males, has been determined. To elucidate by a simple example: If a man were confined to the four walls of a room, within which he were free to move, and his position were recorded every day, then an increase in the number of records or in the number of days when records were taken would not show an increase in the distance that he was able to put between himself and the center of the room. But if, on the other hand, the man were free to leave the room and, upon leaving, had no inclination to return, then an increase in the number of records or in the number of days when records were taken would continuously show some correlation with the distance he was able to put between himself and the original point of confinement.

Relating this example to the case in hand, we may arrive at the conclusion that as far as the data of these experiments show: (1) the *longicaudus* males are not limited in their ranges but continue to wander farther and farther from the initial point of capture, and that the previously noted "average diameter of range" of 194 feet and the "extreme" of 820 feet within the meadows and the "extreme" of one mile from one meadow to another, were merely the average and the extremes as obtained during these experiments, and did not express a true measure of the natural ranges of the *longicaudus* males; (2) with the *longicaudus* females, as shown on the graph, an increase in the time of taking records did not show a corresponding increase in the sizes of ranges, and it may be assumed that these experiments revealed the true size of their ranges, namely, an average distance of 161 feet or an extreme of 730 feet; (3) there were not as many *montanus* captured as *longicaudus* and therefore the results were not as conclusive. However, the graphs seem to indicate that the limit of ranges was reached in both sexes of *montanus* and that the true ranges of the *montanus* males averaged 138 feet in diameter with an extreme of 410 feet while the true ranges of the *montanus* females averaged 82 feet with an extreme of 360 feet.

Summary

1. By means of live-trapping on three Sierra Nevada meadows in the boreal zone of central California, data have been obtained concerning 195 individual *Microtus* of two species. (The two forms were *Microtus longicaudus sierrae* and *Microtus montanus yosemite*, and are referred to throughout this report by specific names only.)

* The regressions of range on length of record were calculated for each group, and the regression coefficient was found to differ significantly from zero only in the case of the *longicaudus* males.

2. The population density of *Microtus* as indicated by the method of trapping used, in the three meadows totaling 19 acres, during the summer seasons of 1937, 1938, and 1939, averaged 4.55 mice per acre per season, with a possible maximum of 6.5 mice per acre per season, and a probable maximum of 2.5 mice per acre at any one time. Therefore, by allowing a margin of safety in the estimate, it is reasonably certain that the population, if expressed in round numbers, was never more than 10 per acre for any season.

3. It is suggested that a population density of over 1,000 per acre may be taken to represent so-called "plague" conditions, over 100 per acre to represent normal peaks in population cycles, and less than 10 per acre to indicate the presence of borderline conditions of existence threatening local extinction. The factors producing such borderline conditions are thought to be as follows: (*a*) *predation,* first in importance and of continuous application; (*b*) *climate or weather,* second in importance and of only intermittently controlling influence; (*c*) *food* and (*d*) *disease,* both of which do not become controlling factors as long as *a* and *b* impose severe restrictions on populations. In other words, when populations are low, due to predation or adverse weather conditions, then food is entirely sufficient and disease is not readily transmitted.

4. Differences in the population behavior of *Microtus montanus* and *Microtus longicaudus* are noted as follows: *M. montanus* was seen to fluctuate more in numbers, even disappearing entirely for a time, while *M. longicaudus* maintained a more nearly uniform, though low, population density. The difference is thought to be due to the greater dependence of *M. montanus* upon meadow conditions, while *M. longicaudus* could survive outside of the meadow and was therefore able more readily to reinvade the meadow.

5. The length of life of *Microtus* seemed to be, with but few exceptions, less than a year. Very likely the breeding stock of each season was recruited principally from litters last born in the preceding season.

6. Individual ranges were measured for purposes of comparison by taking the greatest distance between any two points of capture for each individual *Microtus* and the following conclusions are reached: (*a*) Males of both species have wider ranges than females. (*b*) Individuals of *M. longicaudus* have wider ranges than those of *M. montanus* in both sexes. (*c*) The determined ranges are shown to be as follows:

	Number of Individuals	Average Diameter of Range	Extreme Diameter of Range
Total *Microtus*	195	163 feet	820 feet
M. montanus females	21	82	360
M. montanus males	41	138	410
M. longicaudus females	60	161	730
M. longicaudus males	73	194	820 feet within meadow up to 1 mile out of meadow

The natural limits of the ranges of the first three groups above were apparently reached in these experiments, whereas with the last group, namely the *M. longicaudus* males, the limit of the range was still increasing at the close of the experiments, thus indicating that the *M. longicaudus* males were not restricted as to range but continued to wander during the season.

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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 4, pp. 69-99, pl. 1, figs. 1-10; 1 text fig. June 28, 1948

NOTES ON LAND AND FRESH-WATER MOLLUSKS OF CHEKIANG PROVINCE, CHINA*

BY

TENG-CHIEN YEN

INTRODUCTION

THE PRESENT paper† is based on a collection of land and fresh-water mollusks made by Mr. John T. Wright during 1925 to 1928, in several localities along the Chien-tang-kiang Valley of Chekiang Province, and includes a few lots from Shanghai and Haimen in Kiangsu Province. The material was obtained by the California Academy of Sciences through purchase, and it was partially and preliminarily identified by the late Dr. Bryant Walker. The collector's primary interest was ornithology, but mollusks were taken when seen. However, it is remarkable that numerous species of comparatively minute forms of land snails are present in the collection and some of these are here described as new to science. Mr. Wright deserves credit for the discovery of these small forms. Formal headings and descriptive notes are given for one hundred species. Of these, five are described as new.

The mollusks of Chekiang were first collected from Chowshan Island, ten miles east of the coast of Chekiang, by Theodore Cantor. In early literature, the island was romanized as "Chusan." Cantor's material was studied by W. H. Benson in 1842, who thus contributed the first paper since 1758 on Chinese mollusks with a precise and exact locality. The types of Benson's species are now preserved in the Indian Museum in Calcutta, and most of the land and fresh-water species described by him from Chowshan are included in the present collection. Isaac Lea's paper on new species of exotic Melaniana in 1856 (Proc. Acad. Natural Sci. Philadelphia, **8**: 144–145) also includes one species, namely *Melania ningpoensis,* from Chekiang. Lea's specimens were

* Printed from the John W. Hendrie Publication Endowment.

† This work was carried on with a grant-in-aid from the Johnson Fund of the American Philosophical Society in Philadelphia.

collected by S. R. House. From 1882 to 1890, Père Heude recorded a few species of *Clausilia* from Chowshan, and many of his species described from the neighborhood of Chekiang Province are contained in the present collection. B. Schmacker obtained a collection of mollusks from Ningpo and vicinity, and his material was partly recorded by himself jointly with Oscar Boettger in 1890 to 1891.

Early in the present century, Pilsbry and Hirase (1908) published a paper on Chinese mollusks in which a few species of land snails were described from Hangchow, the capital of Chekiang. During his residence in Chekiang, Mr. A. W. L. Oliver collected mollusks in Hangchow, Mokanshan, Yen-chow, Tsao-ngo River, etc. His collection was afterward presented to the Indian Museum in Calcutta. The gastropods were studied and reported by T. N. Annandale and the pelecypods by B. Prashad (Annandale and Prashad, 1924).

The molluscan species of medical importance from Chekiang have received more attention only in recent years. Early records show that a few species of *Oncomelania* Gredler were reported from this province. Dr. F. C. Li in 1934 made a very detailed study of the anatomy, development, and ecology of *Oncomelania*. Li's material was collected from Kashing and its neighboring regions in Chekiang. Paul Bartsch in 1936 also contributed a very comprehensive paper on molluscan hosts of parasites, in which species of *Oncomelania* were recorded from Shaohing, Wuhing, and Kashing; species of *Blanfordia* and *Katayama* from Shaohing and Ling-an. Bartsch's series of specimens were collected at different times by E. C. Faust, Mary Andrew, Y. T. Yao, and F. C. Li.

The present collection represents, as the subsequent pages will show, an important part of the molluscan fauna of this province; however, such common forms as *Cathaica fasciola* (Draparnaud), *Oncomelania schmackeri* Moellendorff, *Oncomelania moellendorffi* (Schmacker and Boettger), *Parafossarulus eximius* (Frauenfeld), *Assiminea scalaris* Heude, etc., are conspicuously absent. The large series of young and adult examples available for some species, such as *Cyclophorus martensianus* Moellendorff, *Cyclotus fortunei* (Pfeiffer), *Mirus cantorii* (Philippi), etc., makes it possible to trace a wider range of shell variation in adult characters as well as in developmental stages.

Among the minute forms, species of *Cyathopoma, Carychium,* and *Hawaiia* are again recorded in this country. *Cyathopoma* and *Hawaiia* came to my notice for the first time in the molluscan fauna of China when I studied a collection of gastropods from western Szechwan Province. It may be considered as one of the few parallel cases of *Heudiella* Annandale (1924) whose known geographical range up to the present is Yunnan and eastern Chekiang. Further records of these forms to fill the gap of such a long distance depend on future exploration along the Yangtze Valley.

My acknowledgment cannot be completed without mentioning my appreciation to Dr. Robert C. Miller, Director of the California Academy of Sciences, who was for a time Visiting Professor of Zoology at Lingnan University—a missionary institution in Canton—for his kindness and courtesy extended to me during my stay in the Museum of the California Academy of Sciences. I am equally grateful to Dr. G. D. Hanna and Dr. L. G. Hertlein of the Department of Paleontology of the same Academy, for their kindness and for giving me the privilege of studying this collection of Chinese mollusks. The illustrations shown on the plate accompanying this paper were drawn by Miss Helen Winchester. The line drawing of the new species of *Psidium* was made by Dr. G. D. Hanna.

SYSTEMATIC DESCRIPTIONS

Family HYDROCENIDAE

Georissa sinensis (Heude), 1882

Realia sinensis HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 8, pl. 12, fig. 7; pl. 19, fig. 2.

Collecting stations: Hangchow, Fengshiu, Lanchi, and Chiang-shan.

This species was originally described from Anhwei Province, and has been recorded from various places in the lower Yangtze Valley. Heude described it as "imperforate," but the umbilical space seems to be well traceable on these specimens, and in adult ones it is covered more or less completely by a columellar callosity.

Georissa nivea (Heude), 1882

Realia nivea HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 9, pl. 19, fig. 4, 1882.

Collecting stations: Fengshiu, Lanchi, Wong-kiang, Yenchow, Chekiang.

This species differs essentially from the preceding one by its much smaller size, less elongate outline, and in possessing four and one-third rapidly increasing whorls. The spiral lines are very distant and prominent, except on the basal region where the sculpture is rather faint.

According to Moellendorff this is only a form of *G. bachmanni* (Gredler).

Family CYCLOPHORIDAE

Lagochilus sexfilaris (Heude), 1882

Cyclophorus sexfilaris HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 3, pl. 12, fig. 4.

Collecting stations: Mokanshan, Tunglu, Fengshiu, and Yenchow.

This species was originally described from Ningkuofu and Chechowfu, Anhwei Province.

Cyclophorus martensianus Moellendorff, 1874

Cyclophorus martensianus MOELLENDORFF, Jahrb. Deutsch. Malakol. Ges., 2: 120, Taf. 3, fig. 3, 1874.

Collecting stations: Mokanshan, Tunglu, Lutzepu, Fengshiu, Lanchi, and Cha-yuan-chen.

This is a common species occurring in the lower and middle Yangtze Valley. It was originally described from Kiukiang of Kiangsi Province. The shell is variable in size as well as in color pattern, and such names as *nankingensis, pallens,* and *ngankingensis,* all proposed by Heude, which were based on differences in size and color patterns, can be retained perhaps only for local races. In the present collection there are several large series of specimens from the above localities, including many forms of the young.

The adult specimens from Feng-shiu represent the typical form, measuring 24 × 25 mm., with 5¼ whorls, and bearing lighter color markings. Those from Tung-lu are smaller in size, the largest of which measures 21 × 23 mm., with 5 whorls, and lighter color pattern. They approach nearly the form *pallens*. The specimens from Lan-chi bear rather dark color patterns which appear almost unicolor in dark brown except the lightly colored peripheral band. The largest of that lot measures 21 × 23 mm. with 5 whorls.

Cyclotus fortunei (Pfeiffer), 1853

Cyclostoma (Cyclotus) fortunei PFEIFFER, Proc. Zool. Soc. Lond., 1852, p. 146.

Collecting stations: Hangchow, Fuyang, Mokanshan, Tunglu, Lutzepu, and Fengshiu.

This species is rather variable in size, elevation of the spire, and color patterns. The color band, whenever present, is often infraperipheral. A few examples in the collection are unicolored olive-brown. The peristome is simple in the young and double margined in the fully matured and aged shells. A number of forms were described from various parts of China on the basis of differences in size and color markings such as *C. chinensis* Pfeiffer, 1854, from Hong Kong; *C. approximus* Heude, 1882, from Ningkuofu of Anhwei; *C. stenomphalus* Heude, 1882, from Hunan; *C. tubaeformis* Moellendorff, 1882, from Canton; and *C. diffillimus* Schmacker and Boettger, 1890, from Wuchang of Hupei Province and Ningpo of Chekiang. It seems that these forms are very closely related to each other, if not identical. They are compared in the following table. The young forms usually consist of about 3 whorls and are small. They appear to be different from the adult forms because the rapid increase in size of the following two whorls changes considerably the general outline of the shell. The measurements are given in millimeters.

	Altitude of Shell	Width of Shell	Number of Whorls
C. chinensis	6.5– 7.5	13–14	4
C. fortunei	7.0	10–12.5	4½
C. approximus	11.0	13–16	4½
C. stenomphalus	11.0	13–15	5
C. tubaeformis	10.5–11.5	17–19	5
C. diffillimus	10.0–12.5	14–16	5

Platyrhaphe fodiens (Heude), 1882

Cyclotus fodiens HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 5, pl. 12, fig. 9.

Collecting stations: Mokanshan, Tunglu, Fengshiu, Lanchi, and Wongkiang.

This species was originally described from Ningkuofu and Chechowfu, Anhwei. A few of the specimens in the present collection are larger than the typical form, one of which measures 5.1 mm. in altitude, 7.2 mm. in width, with 4⅕ whorls. Some examples from Lanchi are decidedly higher in altitude, one of which measured 5.8 mm. in altitude, 6.2 mm. in width, with 4½ whorls.

Platyrhaphe hunana (Gredler), 1881

Cyclotus hunanus GREDLER, Jahrb. Deutsch. Malakol. Gesell., **8**: 113, 1881.

Collecting station: Cha-yuan-chen, Chekiang Province.

This species differs from the preceding one by its more planorboid outline, much larger size, wider umbilicus, and finer sculpture. It was originally described from Hunan, and these examples of Chekiang agree with the typical form except for the slightly greater altitude. A larger specimen in the collection measures 6.2 mm. in altitude, 10.0 mm. in width, with 4⅕ whorls.

Cyathopoma micronicum Yen, new species

Plate 1, figures 3, 4

Shell minute, subdiscoidal, widely umbilicated. The umbilicus contains one-third of the diameter of the shell. The shell substance is rather thin and subtranslucent. The whorls increase very rapidly in width, are well rounded, and are separated by a deep suture. The first whorl is oblique and high, but the following whorls of the spire are only slightly elevated. The sculpture consists of growth lines decussated by faint spiral lines; the latter are more distinctly traceable on the body whorl rather than on the early whorls. The body whorl is somewhat tubular and has the last one-third to one-fourth free from the penultimate whorl. The aperture descends in front, with continuous circular form. The peristome is simple and thin. The operculum is rounded, consisting of numerous closely coiled lamellose whorls, concave externally, and dark in the center. Measurements: altitude 1.1 mm.; width 1.8 mm.; diam. umb. 0.48 mm.; 3⅓ whorls.

Holotype, No. 8237, and *paratypes* Nos. 8238, 8239, 8240, Mus. Calif. Acad. Sci. Paleo. Type Coll., from **Yenchow, Chekiang Province, China.** Also found at Mokanshan, Fuyang, Tunglu, Lutzepu, Fengshiu, Chayuanchen, Shunan, and Puchiang.

This species approaches the size and general outline of *Cyathopoma taiwanicum* Pilsbry (Proc. Acad. Nat. Sci. Philadelphia, **57**: 724, 1905), and is somewhat larger than *C. micron* (Pilsbry), (Nautilus, **14**: 12, 1900), also from Formosa. However, it differs from both of them by having its last one-third of the body whorl conspicuously free from the penultimate whorl.

This genus has been known hitherto from India, Polynesian islands, and Formosa. The present series of specimens was obtained from the lower Yangtze Valley, and gives a second record of this genus from this country, indicating that it probably has a wide range of distribution south of the Yangtze River.

Cyathopoma planorboides Yen, new species

Plate 1, figures 8, 9

Shell minute in size, planorboid in form, umbilicated, the umbilicus more than one-third of the shell diameter. The spire is very low, having only the prominent smooth apical whorl obliquely elevated. The whorls increase very rapidly in size, bearing fine but distinct spiral lines which are intersected by fine growth striae and occasionally by coarser lines of growth. The aperture is circular in form, not descending in front, and the peristome is simple and thin. Measurements: altitude 1.2 mm.; width 2.5 mm.; diam. umb. 1.0 mm.; 3⅓ whorls.

Holotype, No. 8241, and *paratypes* Nos. 8242, 8243, Mus. Calif. Acad. Sci. Paleo. Type Coll., from **Yenchow, Chekiang Province, China.** Also found at Chihlilung near Puchiang, Chekiang Province.

This species is essentially different from the preceding one by its larger size, planorboid outline, and bearing distinct spiral lines of sculpture. It seems to be closely related to *C. taiwanicum* Pilsbry, differing by its larger size, lower altitude, and in the more planorboid outline.

Chamalycaeus rathouisianus (Heude), 1882

Alycaeus rathouisianus Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 7, pl. 12, figs. 12, 12*a*.

Collecting stations: Tunglu, Yenchow, Chihlilung near Puchiang, and Lanchi.

The present collection contains a series of specimens which are identical with this species except that they are larger in size. The typical form is 2.5 mm. in altitude, 4.0 mm. in width, with 4 whorls, while most of the specimens in this collection measure 3.2 mm. in altitude, 5.0 mm. in width, with 4 whorls. It was originally described from Sungkiang, Kiangsu Province, in the near neighborhood of Chekiang.

Chamalycaeus sinensis (Heude), 1882

Alycaeus sinensis Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 7, pl. 12, figs. 13, 13*a*.

Collecting stations: Mokanshan, Tunglu, and Fengshiu.

This species differs from the preceding one by its smaller size, lower spire, and absence of spiral lines of sculpture. It was originally described from Tung-liu, Anhwei Province. Measurement: altitude 2.0 mm.; width 3.5 mm.; 4 whorls.

Diplommatina paxillus (Gredler), 1881

Moussonia paxillus Gredler, Jahrb. Deutsch. Malakol. Ges., **8**: 29, Taf. 1, fig. 7, 1881.

Collecting stations: Hangchow, Wongkiang, Fengshiu, Chihlilung near Puchiang, Lanchi, and Chiangshan.

This species was originally described from Hunan Province, but has been further recorded in lower Yangtze Valley.

Diplommatina paxillus mucronata Schmacker and Boettger, 1890

Diplommatina (Sinica) paxillus var. *mucronata* Schmacker and Boettger, Nachrichtsbl. Deutsch. Malakol. Ges., Jahrg. 22, 1890, p. 122, Taf. 2, fig. 4.

Collecting stations: Mokanshan, Tunglu, Lutzepu, and Yenchow.

This subspecies differs from the *forma typica* by its smaller size and more contracted outline. It was originally described from Dalanshan near Ningpo, Chekiang Province.

Diplommatina confusa Heude, 1885

Diplommatina confusa Heude, Mem. Hist. Nat. Emp. Chinois, 1885, p. 97, pl. 24, figs. 12, 12*a*.

Collecting station: Mokanshan, Chekiang Province.

A few specimens from the above locality agree well with this species but are slightly smaller in size. One of the better preserved specimens measures 3.5 mm. in altitude, 2.0 mm. in width, with 7 whorls. It was originally described from Szechwan.

Pseudopalania dautzenbergiana Yen, new species

Plate 1, figure 1

Shell sinistral, perforate, minute in size, and ovately oblong in outline. The whorls are roundly convex, increasing moderately rapidly in size. The sculpture consists of fine but distinct and close ribs, but the apical whorls appear to be smooth. The suture is well impressed. The aperture is circular in outline, having its peristome continuous, somewhat thickened and double-margined. The columellar lamella is deeply inserted and hardly visible from a frontal view. Measurements: altitude 2.1 mm.; width 1.1 mm.; 5⅓ whorls.

Holotype, No. 8244, Mus. Calif. Acad. Sci. Paleo. Type Coll., from **Tunglu, Chekiang Province, China.**

Judging by its weakly developed columellar lamella and the sinistral coiling of the shell, this species evidently belongs to *Pseudopalania* Moellendorff, a genus not hitherto recorded from China. Its general outline approaches that of some species of *Palania* O. Semper, but differs by having a distinct but deeply inserted columellar lamella.

Family VIVIPARIDAE

Viviparus chinensis lecythoides (Benson), 1842

Paludina lecythoides Benson, Ann. Mag. Nat .Hist., (1) **9**: 488, 1842.

Collecting stations: Yuyao, Tunglu, Fengshiu, and Lanchi.

This subspecies differs essentially from other forms of *chinensis* Gray, such as *fluminalis* Heude, *ventricosa* Heude, *longispira* Heude, etc., by its smaller size. It was originally described from Chowshan Island, and Annandale in 1924 has designated a lectotype from Benson's original lot of specimens and figured it in reduced size.

This is a very common form in the lower Yangtze Valley, but the present collection contains only a few adult specimens with a large series of young forms, which evidently belong to this subspecies.

Viviparus quadratus (Benson), 1842

Paludina quadrata Benson, Ann. Mag. Nat. Hist., (1) **9**: 487, 1842.

Collecting station: Tunglu, Chekiang Province.

This is another species of the genus commonly occurring throughout the country. It is easily recognized by its elongate outline, scarcely convex whorls, and obtusely angulated periphery.

Viviparus quadratus lapillorum (Heude), 1890

Paludina lapillorum Heude, Mem. Hist. Nat. Emp. Chinois, 1890, p. 177, pl. 40, figs. 11, 11*a*.

Collecting stations: Chien-tang-kiang and Lanchi.

This subspecies differs from the *forma typica* by its more ovate outline and smaller size. It was described from Ningkuofu of Anhwei Province, but it has been subsequently recorded from Huchow and other places around Tai-hu (Great Lake).

Viviparus lithophaga (Heude), 1889

Paludina lithophaga Heude, Journ. Conchyl., **37**: 49, 1889; Mem. Hist. Nat. Emp. Chinois, 1890, p. 177, pl. 40, figs. 13, 13*a*.

Collecting station: Tunglu, Chekiang Province.

This species is small, subglobose in outline, and almost rounded at the periphery. The apical whorl is rather obtuse. It was originally described from Ningkuofu, and the typical form seems to be considerably larger than the examples in the present collection; however, they agree well in other features. The typical form is 33.0 mm. in altitude, 20.0 mm. in width, with 5 whorls, while the largest specimen here is only 20.0 mm. in altitude, 15.0 mm. in width, with 4 whorls.

Its general outline, thick shell, and obtuse, apical whorls seem to suggest resemblance to *Viviparus praerosus* (Gerstfeldt) and *Viviparus chui* Yen, which were described from Amur and Kirin, respectively.

Family HYDROBIIDAE

Parafossarulus striatulus (Benson), 1842

Paludina (Bithynia) striatula BENSON, Ann. Mag. Nat. Hist., (1) **9**: 488, 1842.

Collecting stations: Siwoo near Yuyao, Bamowoo, Lanchi, and Chiangshan.

This is a very common species occurring throughout the country. The sculpture varies and may be obscure or prominent; however, no smooth form has been recorded. The shell is unicolored but in some cases with a thin, yellowish-brown periostracum. The young form is more conical in outline.

Parafossarulus longicornis (Benson), 1842

Paludina (Bithynia) longicornis BENSON, Ann. Mag. Nat. Hist., (1) **9**: 488, 1842.

Collecting stations: San-chiang and Lanchi.

This species is often collected together with the preceding one; however, it is less common. It differs from *P. striatulus* by having a much shorter spire, finer sculpture, and ovately globose outline. It is more commonly recorded from the Yangtze Valley and along the canal zone.

Bithynia misella Gredler, 1884

Bythinia misella GREDLER, Arch. Naturgesch., **50**: 276, Taf. 19, fig. 8, 1884.

Collecting stations: Yuyao, Tunglu, Lanchi, and Chiangshan.

The shell is conically ovate in outline, rather thin and translucent. The sculpture consists of fine spiral and growth striae, and the shell is rather variable in size. The whorls of the spire are occasionally marked by lip-margin lines which indicate various periods of resting. A few specimens are larger than the typical form, described from south Hunan Province; one measures 7.0 mm. in altitude and 4.0 mm. in width.

Katayama fausti Bartsch, 1925

Katayama fausti BARTSCH, Jour. Washington Acad. Sci., **15**: 72, 1925.

Collecting station: Lanchi, Chekiang Province.

The single specimen measures 7.0 mm. in altitude, 3.0 mm. in width, and has 5⅓ whorls. It was described from Shaohing, Chekiang Province.

Blandfordia species undetermined

Collecting station: Lanchi, Chekiang Province.

The single specimen has its apical whorl injured. It measures 6.4 mm. in altitude, 3.0 mm. in width, with 6⅓ whorls. It resembles *B. formosana* Pilsbry and Hirase (Proc. Acad. Sci. Philadelphia, **57**: 750, 1906), but it appears to be more slender in outline.

Stenothyra divalis (Gould), 1859

Bithynia divalis GOULD, Proc. Boston Soc. Nat. Hist., **7**: 41, 1859.

Collecting stations: Sanchiang, Chekiang Province; Haimen, Kiangsu Province.

This species was originally described from Canton, but it has been subsequently recorded from the Yangtze Valley.

Stenothyra toucheana Heude, 1890

Stenothyra toucheana HEUDE, Mem. Hist. Nat. Emp. Chinois, 1890, p. 173, pl. 33, figs. 13, 13*a*, 13*b*.

Collecting station: Haimen, Kiangsu Province.

This species differs from the preceding essentially by its smaller size, and in that the spiral lines of punctations are more closely arranged.

Stenothyra decapitata Annandale, 1918

Stenothyra decapitata ANNANDALE, Mem. Asiatic Soc. Bengal, (5) **6**: 308, pl. 10, fig. 1, 1918.

Collecting station: Bamowoo, Chekiang Province.

This species is larger in size than either of the above two species, and its apical whorls are almost always eroded.

Family ASSIMINEIDAE

Assiminea latericea H. and A. Adams, 1863

Assiminea latericea H. and A. ADAMS, Proc. Zool. Soc. Lond., 1863, p. 434.

Collecting station: Haimen, Kiangsu Province.

This is one of the common species occurring on the coast of China. *Assiminea flummea* and *A. haematina,* described by Heude from farther interior from the coast, are generally recognized as only forms of this species. The specimens contained in this collection agree well with *A. flummea* except that they are somewhat smaller in size.

Assiminea violacea Heude, 1882

Assiminea violacea HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 82, pl. 21, figs. 4, 4*a*, 4*b*, 4*c*.

Collecting stations: San-chiang, Chekiang Province; Haimen, Kiangsu Province.

This species was described from the mouth of the Yangtze River. The shell is imperforate, rather solid, elongately conical in outline, usually bearing a sutural band of lighter coloration, and obtusely angulated at the periphery.

The present specimens here are slightly smaller than the typical form, the largest of which measures 6.6 mm. in altitude, 3.7 mm. in width, with 7 whorls.

Assiminea schmackeri Boettger, 1887

Plate 1, figure 2

Assiminea schmackeri BOETTGER, Jahrb. Deutsch. Malakol. Ges., **14**: 201, Taf. 6, fig. 9, 1887.

Collecting station: Haimen, Kiangsu Province.

This species was originally described from Lantao near Hong Kong, but the specimens here are identical with this interesting species, which seems to have a different outline from other Chinese forms of *Assiminea* so far recorded.

The shell is subglobose in outline, rather solid, perforate, but partly covered by the columellar margin. It seems that Boettger's description was based on an immature specimen measuring 1⅞ mm. in altitude, 2⅛ mm. in width, with 3½ whorls, while a large specimen in the present collection is 3.0 mm. in altitude, 2.9 mm. in width, with 6 whorls; another 2.0 mm. in altitude, 2.1 mm. in width, with 4 whorls.

Family THIARIDAE

Melanoides gredleri (Boettger), 1887

Melania tumida GREDLER, Arch. Naturgesch., **50**: 277, Taf. 19, fig. 9, 1884. (Not *Melania tumida* PHILLIPS, 1836).

Melania (Melanoides) gredleri BOETTGER, Jahrb. Deutsch. Malakol. Ges., **14**: 108, 1887.

Collecting station: Shunan, Chekiang Province.

This species seems to be closely related to *M. ningpoensis Lea* (= *M. cancellata* Benson, 1842), but it differs by having stronger and fewer riblets which are not cancellated by any spiral lines. The species was originally described from South Hunan.

Melanoides ningpoensis (Lea), 1856

Melania cancellata BENSON, Ann. Mag. Nat. Hist., London, **9**: 488, 1842. Not *Melania cancellata* SAY, 1829.

Melania ningpoensis LEA, Proc. Acad. Nat. Sci. Philadelphia, **8**: 144, 1856.

Collecting station: Bamowoo, Chekiang Province.

This is a common species recorded from different parts of the country. It is characterized by its narrowly oblong outline, convex whorls bearing close riblets, and fine but distinct spiral lines. The base is sulcated with a few rather strong spirals.

Semisulcospira libertina jacquetiana (Heude), 1890

Melania jacquetiana HEUDE, Mem. Hist. Nat. Emp. Chinois, 1890, p. 163, pl. 41, figs. 7–9; pl. 43, fig. 5.

Collecting station: Shunan, Chekiang Province.

These specimens have the early whorls decollated, its sculpture more obscure and of smaller size than the typical form, which was described from

Ningkuofu, Anhwei Province. However, these features, as already pointed out by Annandale, are considered to be rather variable. He has examined a large series of specimens collected from Hangchow.

Semisulcospira libertina davidi (Brot), 1874

Melania davidi BROT, Martini-Chemnitz Conchyl.-Cab., **1** (Abt. 24. *Melania* and *Melanopsis*): 62, Taf. 7, fig. 3, 1874.

Collecting station: Shunan, Chekiang Province.

This form occurs in mountain-stream habitats and was originally described from Lushan, Kiangsi Province. After examining the type specimens of *S. libertina* (Gould) and this series of specimens which agree well with *S. davidi* (Brot), I am convinced that *davidi* may be only a subspecies of *libertina*. It is smaller and bears three distinct color bands on the body whorl which are sometimes traceable in the aperture, while *libertina,* also recorded from the Lower Yangtze Valley, is much larger and is usually unicolored.

Semisulcospira theaepotes (Heude), 1888

Melania theaepotes HEUDE, Journ. Conchyl., **36**: 307, 1888; Mem. Hist. Nat. Emp. Chinois, 1890, p. 163, pl. 41, fig. 10.

Collecting station: Chihlilung near Puchiang, Chekiang Province.

This species was originally described from the tea district in Hweichow, Anhwei Province. It is conically turreted in outline, with an acute spire and ventricose body whorl. It differs from *S. libertina* by its obscure sculpture and conical outline.

The specimens in the present collection are somewhat smaller than the typical form; the largest one measures 23.5 mm. in altitude and 10.5 mm. in width.

Semisulcospira joretiana (Heude), 1890

Melania joretiana HEUDE, Mem. Hist. Nat. Emp. Chinois, 1890, p. 166, pl. 41, fig. 20.

Collecting station: Lanchi.

This species was originally described from Hoshan of Anhwei, and seems to be related to the preceding species.

Semisulcospira praenotata (Gredler), 1884

Melania praenotata GREDLER, Arch. Naturgesch., **50**: 278, Taf. 19, fig. 10, 1884.

Collecting station: Tunglu, Chekiang Province.

The single specimen in this collection agrees well with this species, which was described from South Hunan Province, except that it is somewhat smaller in size. It measures 17.0 mm. in altitude, 6.5 mm. in width, with 10 whorls. It is narrowly turreted in outline, bearing fine sculpture on the scarcely convex whorls representing what Gredler described as "suturam inferiorem convexiusculi, supra plane."

Semisulcospira dolium (Heude), 1890

Melania dolium Heude, Mem. Hist. Nat. Emp. Chinois, 1890, p. 166, pl. 41, figs. 24, 24*a* 25; pl. 43, fig. 6.

Collecting station: Fengshiu, Chekiang Province.

These specimens agree with Heude's Figure 25, except for being of much smaller size. The largest one measures 14.0 mm. in altitude and 12.0 mm. in width. Among the 30 examples, there is only one bearing strong, spiral sculpture and unicolored, while the others bear only faint and fine spiral and growth lines, and most of them are marked with three color bands.

It seems that the sculpture is rather variable in this species, as Heude has figured both the strongly and obscurely sculptured forms. However, he mentioned nothing of the color bands.

Semisulcospira pacificans (Heude), 1888

Melania pacificans Heude, Journ. Conchyl., **36**: 305, 1888; Mem. Hist. Nat. Emp. Chinois, 1890, p. 164, pl. 41, figs. 22, 22*a*.

Collecting station: Fengshiu, Chekiang Province.

This species was originally described from Anhwei Province, and was recorded by Schmacker and Boettger from Dalanshan of Snowy Valley near Ningpo. It is ovately conical in outline, thick, having a small and low spire and inflated body whorl. The sculpture is rather obscure, with spiral lines faintly traceable. In this collection the specimens bear three color bands which are in some cases only traceable in the aperture. These color bands were mentioned in the record noted by Schmacker and Boettger, but not mentioned in the original description for the species by Heude. The largest one measures 18.4 mm. in altitude and 12.0 mm. in width.

Family ELLOBIIDAE

Carychium minusculum Gredler, 1887

Carychium minusculum Gredler, Jahrb. Deutsch. Malakol. Ges., **14**: 362, 1887.

Collecting stations: Mokanshan, Fuyang, Tunglu, and Fengshiu.

This species was described from Hupei Province and recently recorded from Pungshan of Western Szechwan. It has not been reported hitherto from the Lower Yangtze Valley.

Family LYMNAEIDAE

Radix plicatulus (Benson), 1842

Lymnaea plicatula Benson, Ann. Mag. Nat. Hist., (1) **9**: 487, 1842.

Collecting stations: Hsiaoshan, Yuyao, Sanchiang, Bamowoo, Shunan, Lanchi, and Chiangshan.

This is a very common species occurring throughout the country. It varies considerably in outline as well as in size. The typical form is elongately ovate but it is not uncommon that some specimens have quite inflated body whorls.

Galba ollula (Gould), 1859

Limnaea ollula GOULD, Proc. Boston Soc. Nat. Hist., **7**: 40, 1859.
Galba ollula GOULD, Yen, Proc. Calif. Acad. Sci., (4) **23** (38): 580, pl. 51, figs. 42, 50, 1944.

Collecting station: Lanchi, Chekiang Province.

After examining the type specimen of this species, I became convinced that it agrees well with those specimens hitherto identified as *L. parvia* von Martens and *L. andersoniana* Nevill, which are to be replaced with the earlier name *Galba ollula* (Gould).

This is another common species which occurs in fresh-water bodies throughout the country.

Family PLANORBIDAE

Gyraulus saigonensis (Crosse and Fischer), 1863

Planorbis saigonensis CROSSE and FISCHER, Journ. Conchyl., **11**: 362, pl. 13, fig. 7, 1863.
Planorbis compressus HUTTON, 1834. Not *Planorbis compressus* MICHAUD, 1831.

Collecting stations: Hangchow, Yuyao, Sanchiang, Tunglu, Feng-shiu, Shunan, Lanchi, and Chiangshan, Chekiang Province; Haimen, Kiangsu Province.

This species is characterized by its very rapidly increasing whorls, having its apical whorls sunken and the body whorl much dilated. It resembles *G. albus* (Mueller) but it differs by its larger size and by having more whorls.

Gyraulus zilchianus Yen, 1939

Gyraulus zilchianus YEN, Abhandl. Senck. Naturforsch. Ges., No. 444, p. 68, Taf. 6, fig. 2, 1939.

Collecting stations: Yuyao and Chiangshan, Chekiang Province.

This species is readily recognized by the high altitude of the shell, strong peripheral keel, and dilated body whorl. It is not uncommonly found around the Tai-hu region, and more frequently found near the bank of the Great Canal. The specimens from Yuyao are mostly young and not well preserved.

Gyraulus membranaceus (Gredler), 1884

Planorbis membranaceus GREDLER, Jahrb. Deutsch. Malakol. Ges., **11**: 153, 1884.

Collecting station: Haimen, Kiangsu Province.

This species is much smaller than *G. saigonensis*. Its periphery is very obtusely angulated, the last whorl is not so rapidly dilated, and the peristome is calloused within, which makes the lip-margin appear to be reflected.

This species was described from Hunan, and the type was given as 4.5–

4.75 mm. in width, 1.0 mm. in altitude, with 2–3½ whorls, while the largest specimen in the present lot measures only 4.0 mm. in width, 1.0 mm. in altitude, with 4 whorls.

Hippeutis distinctus (Gredler), 1887

Planorbis (Hippeutis) distinctus Gredler, Malakol. Blätt., N.F., **9**: 15, 1887.

Collecting stations: Yuyao, Lanchi, Foulanchi, and Chiangshan.

It differs from the closely related species *H. umbilicalis* (Benson), also commonly found in China, by its smaller size, more lens-shaped outline, and in having a less shallow umbilicus.

Polypylis hemisphaerula (Benson), 1842

Planorbis hemisphaerula Benson, Ann. Mag. Nat. Hist., (1) **9**: 487, 1842.

Collecting stations: Yuyao, Tunglu, Fengshiu, Lanchi, and Foulanchi.

This species was described from Chowshan Island, and the type was given as 0.25 poll. in diameter. Most of the specimens in the present collection are somewhat smaller than the type; one of them measures 6.0 mm. in width, 2.7 mm. in altitude, with 5½ whorls.

Its relationship to the following species as well as to *P. succineus* (Gredler), described from Hunan Province, is not yet clear. They resemble each other in general outline, but differ considerably in size.

Polypylis largillierti (Dunker), 1867

Planorbis largillierti Dunker, in von Martens, Malakozool. Blätt., **14**: 217, 1867.

Collecting station: Sanchiang, Chekiang Province.

This species was originally described from Hong Kong and at the same time recorded from Amoy. The type was given as 3.5 mm. in altitude, 8.5 mm. in width (diameter), with 5 to 6 whorls. The single specimen in the present collection measures 4.0 mm. in altitude, 8.0 mm. in width, with 5½ very rapidly increasing whorls.

It differs essentially from the preceding species by its larger size with almost similar number of whorls, and having a more concave base.

Family SUCCINEIDAE

Succinea erythrophana Ancey, 1883

Succinea erythrophana Ancey, Il Naturalista Siciliano, 1883, p. 270.

Succinea rubella Heude, Mem. Hist. Nat. Emp. Chinois, 1890, p. 80, pl. 18, fig. 29 (non Pease).

Collecting stations: Sanchiang, Chekiang Province; Haimen, Kiangsu Province.

This species was described from Shanghai, but has been since recorded from different parts of the Yangtze Valley. The type was given as 9.5 mm.

in altitude, 5.0 mm. in width, with 3 whorls. One of the specimens from Sanchiang measures 7.0 mm. in altitude, 4.0 mm. in width, with 3 whorls.

Family PUPILLIDAE

Gastrocopta armigerellum (Reinhardt), 1877

Pupa (Leucochila) armigerella REINHARDT, Sitzungsber. Ges. Naturforsch. Freunde, Berlin, 1877, p. 96.

Collecting stations: Sanchiang and Fengshiu, Chekiang Province; Shanghai, Kiangsu Province.

This species is common along the Yangtze Valley, with its infraparietal tooth being, in some cases, much reduced or even totally absent. One of the examples from Shanghai measures 2.3 mm. in altitude, 1.3 mm. in width, with 5⅓ whorls.

Boysidia hunana (Gredler), 1881

Pupa hunana GREDLER, Jahrb. Deutsch. Malakol. Ges., **8**: 23, Taf. 1, fig. 5, 1881.

Collecting stations: Wongkiang, Fengshiu, Lanchi, and Chiangshan.

These specimens agree well with this species which was originally described from Hunan Province and subsequently recorded from various parts of the Yangtze Valley. A few shells from Chiangshan show the tendency of the aperture to be almost free from the penultimate whorl and some of them show that it barely touches the preceding whorl.

Boysidia hangchowensis (Pilsbry and Hirase), 1908

Hypselostoma (Boysidia) hangchowensis PILSBRY and HIRASE, Proc. Acad. Nat. Sci. Philadelphia, **60**: 42, fig. 6, 1908.

Collecting station: Hangchow, Chekiang Province.

This differs from the preceding species by its much smaller size and bearing only two palatal plicae.

Family VALLONIIDAE

Vallonia pulchellula (Heude), 1882

Helix pulchellula HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 20, pl. 13, fig. 17.

Collecting stations. Fengshu and Lanchi, Chekiang Province; Shanghai and Haimen, Kiangsu Province.

This is one of the common species occuring along the Yangtze Valley and also in the northwestern part of China. It was originally described from Shanghai, and at the same time recorded from Ningkuofu of Anhwei Province. Heude's figure was not well done. The sparse and delicate rib lines on the specimens are much more distinctly shown in contrast with the growth striae.

Family ENIDAE

Mirus cantorii (Philippi), 1844

Bulimus cantorii Philippi, Zeitschr. Malakol., **1**: 165, 1844.

Collecting stations: Hangchow, Fengshiu, Chayuanchen, and Wongkiang.

This species was originally described from "Goldinsel bei Nanking" with specimens collected by Largilliert. The locality apparently means Chin-shan of Chenkiang, about 60 miles eastward from Nanking. Chin-shan was formerly an island situated in the Yangtze River and is now almost connected with the mainland at the south side of the river.

This is a common form occurring in the Lower Yangtze Valley. In the present collection, the specimens agree well with the typical form except that some of them from Chayuanchen are of much smaller size and yet not so cylindric as to agree with *pallens* Heude, a varietal form of this species.

Mirus cantorii obesus (Heude), 1882

Buliminus obesus Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 51, pl. 17, fig. 7.

Collecting stations: Tunglu, Fengshiu, Yenchow, Lanchi, and Chiangshan.

It differs from the *forma typica* by its much lower altitude and greater diameter. It was originally described from Nanking, and has been recorded around the Tai-hu region. The present series contains specimens approaching the typical form, one of them measuring 17.0 mm. in altitude and 6.0 mm. in width, but a few of them measured 20.0 mm. in altitude and 7.0 mm. in width.

Mirus minutus (Heude), 1882

Buliminus minutus Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 49, pl. 17, fig. 15.

Collecting stations: Tunglu and Chiangshan, Chekiang Province.

This species was originally described from Shanghai, and also "in insulis Magni Laci" which apparently means west Tung-ting-shan of Tai-hu, about 45 miles away from Shanghai. It is characterized by its small size and convex whorls. The typical form is 10.0 mm. in altitude, 4.0 mm. in width with 6–7 whorls, while the examples in this collection range from 10.5 mm. to 13.0 mm. in altitude and 4.2 mm. to 4.8 mm. in width, with 8 whorls.

Family CLAUSILLIDAE

Hemiphaedusa cecillii (Philippi), 1847

Clausilia cecillii Philippi, Zeitsch. f. Malakol., **4**: 68, 1847.

Collecting stations: Mokanshan, Tunglu, Lutzepu, Fengshiu, and Lanchi.

The original locality was given by Philippi as China, based on specimens collected by Largilliert. Judging by the subsequently repeated records, the type was probably collected from somewhere in Chekiang Province, where numerous specimens of this species have been found.

Hemiphaedusa frankei (Boettger and Schmacker), 1894

Clausilia (Hemiphaedusa) frankei BOETTGER and SCHMACKER, Proc. Malacol. Soc. London, **1**: 115, pl. 9, fig. 3, 1894.

Collecting station: Wongkiang, Chekiang Province.

The single specimen in the present collection seems to agree well with this species which was originally described from Kiangsi Province. Boettger and Schmacker have already pointed out that it is closely related to the preceding species, differing only by its slender form and smaller aperture.

Hemiphaedusa möllendorffiana (Heude), 1882

Clausilia möllendorffiana HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 60, pl. 17, figs. 31, 31*a*, 31*b*.

Collecting stations: Tunglu and Chayuanchen, Chekiang Province.

This species was originally described from Ningkuofu and Kwangtehchow, Anhwei Province. The specimens here are typical, but a few specimens more ventricose in outline and shorter in altitude may belong to the varietal form, *edentula* Boettger and Schmacker 1894.

Euphaedusa heudeana (Moellendorff), 1882

Clausilia heudeana MOELLENDORFF, Jahrb. Deutsch. Malakol. Ges., **9**: 202, 1882.
Clausilia pachystoma HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 61, pl. 18, fig. 1. Not *Clausilia pachystoma* KUESTER, 1848.

Collecting stations: Tunglu, Lutzepu, Fengshiu, Lanchi, Chekiang Province; Haimen, Kiangsu Province.

This small species is easily recognized by its obtuse apical whorls and small aperture. It was described from the Tai-hu region and commonly found in the Lower Yangtze Valley. *Clausilia obliterata* Hsu, which was described in a subfossil state from Hsia-shu, Kiangsu Province, belongs to this common species. The species described by Hsu was founded upon juvenile specimens of *Euphaedusa heudeana.*

Euphaedusa aculus (Benson), 1842

Clausilia aculus BENSON, Ann. Mag. Nat. Hist., (1) **9**: 487, 1842.

Collecting stations: Wongkiang, Tunglu, Fengshiu, Chayuanchen, Chihlilung near Puchiang, and Chiangshan.

This species was described from Chowshan Island and it is very commonly found along the Yangtze Valley. The shell is rather variable in size, and varietal names such as *shanghaiensis* Pfeiffer, *moellendorffi* Martens, *insularis* Heude, *vinacea* Heude, *fulvella* Heude, *labio* Gredler, etc., have been adopted for different local forms of this species.

Family SUBULINIDAE

Opeas gracile (Hutton), 1834

Bulimus gracilis HUTTON, Jour. Asiatic Soc. Bengal, **3**: 93, 1834.

Collecting stations: Hangchow, Mokanshan, Fuyang, Sanchiang, Tunglu, and Fengshiu, Chekiang Province; Shanghai and Haimen, Kiangsu Province.

This species was originally described from India and has a wide range in the Indo-Pacific Province. The Chinese specimens approach very nearly the typical form which has a narrowly elongated outline with an obtuse apex, distinct sculpture, crenulations near the suture, and a reflexed columellar margin.

Opeas filare (Heude), 1882

Stenogyra filaris HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 56, pl. 17, fig. 27.

Collecting stations: Sanchiang, Chayuanchen, Lanchi, Wongkiang, Chekiang Province; Haimen, Kiangsu Province.

This species was described from Ningkuofu. It is characterized by its narrow, slender outline and strong sculpture. It differs from the preceding species only by its more slender outline.

Opeas turgidulum (Heude), 1882

Stenogyra turgidula HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 59, pl. 17, fig. 19.

Collecting stations: Hangchow, Mokanshan, Yuyao, Tunglu, Lutzepu, Fengshiu, and Chayuanchen.

This species was described from Sung-kiang, Kiangsu Province. The shell has a swollen outline and bears fine sculpture. This is one of the forms which may belong to *Opeas clavulinum* (Potiez and Michaud).

Tortaxis erectus (Benson), 1842

Achatina erecta BENSON, Ann. Mag. Nat. Hist., (1) **9**: 487, 1842.

Collecting station: Tunglu, Chekiang Province.

This species was described from Chowshan Island. There are 2 specimens in the collection from Tunglu. It is cylindrically turreted with an obtuse apex and convex whorls. The adult specimen measures 2.6 mm. in altitude, 6.2 mm. in width, with 7⅓ whorls.

Family ENDODONTIDAE

Punctum orphana (Heude), 1882

Helix orphana HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 21, pl. 13, fig. 18.

Collecting stations: Tunghu, Chihlilung near Puchiang, Chekiang Province; Haimen, Kiangsu Province.

This species was described from Shanghai and occurs commonly in the Lower Yangtze Valley. Its generic position was rather uncertain. For a time it was considered to be a species of *Pyramidula*, but Pilsbry in 1935 pointed out that it appears to be a species of *Punctum* because of the presence of microscopic spiral striae on the apical whorl.

The young forms contained in this collection consist of 3¾ whorls, while the adult ones have 4 to 4½ whorls. The last whorl of an adult shell coils somewhat below the periphery of the penultimate whorl, so that its general outline appears to be more trochoid and the spire more elevated.

Family CORILLIDAE

Plectopylis emoriens (Gredler), 1881

Helix emoriens GREDLER, Jahrb. Deutsch. Malakol. Ges., **8**: 15, 1881.

Collecting station: Lutzepu, Chekiang Province.

This species was described from Yung-chow, southern Hunan Province, and subsequently recorded from the Lower Yangtze Valley. It seems to be closely related to the following species, but it differs by its larger size, more angulated periphery, and in having a much weaker parietal margin.

Plectopylis diptychia (Moellendorff), 1885

Helix diptychia MOELLENDORFF, Jahrb. Deutsch. Malakol. Ges., **9**: 390, Taf. 10, fig. 17, 1885.

Collecting stations: Fengshiu, Tunglu, and Wongkiang.

This species was described from Kweichow Province. It is characterized by its thin and subpellucid shell, bearing distant, membranous ribs in addition to the granulose sculpture. There are 5 to 6 short plicae on the outer wall and 2 approximate vertical lamellae on the inner wall of which the one on the right side is more weakly developed.

Family ZONITIDAE

Hawaiia minuscula (Binney), 1840

Plate 1, figures 5, 6

Helix minuscula BINNEY, Jour. Boston Soc. Nat. Hist., **3**: 435, pl. 22, fig. 4, 1840.

Collecting stations: Fengshiu, Shunan, Lanchi, and Chiangshan.

This species was originally described from North America, and subsequently recorded from Hawaii. In the present collection there are several lots of specimens which are hardly differentiated from *H. minuscula* so far as the shell features are available for reference.

Family ARIOPHANTIDAE

Kaliella franciscana (Gredler), 1881

Hyalina (Conulus) franciscana GREDLER, Jahrb. Deutsch. Malakol. Ges., **8**: 13, 1881.

Collecting stations: Hangchow, Tunglu, Fengshiu, Shunan, Chihlilung near Puchiang, Lanchi, and Chiangshan.

This species was originally described from Hunan Province. The shell is narrowly and shallowly umbilicated, obtusely angulated in the young, but in the adult stage rounded at the periphery, having roundly convex and closely coiled whorls and bearing sculpture of very fine growth striae. The base is quite convex.

Kaliella franciscana gredleriana (Heude), 1882

Hyalina gredleriana Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 19, pl. 19, figs. 11, 11*a*.

Collecting station: Tunglu, Chekiang Province.

This subspecies differs from the typical form by its smaller size and greater height. This form was also described from Hunan Province, and Moellendorff in 1887 included it as a synonym of *Kaliella franciscana*.

Kaliella imbellis (Heude), 1882

Hyalina imbellis Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 19, pl. 13, fig. 16.

Collecting stations: Hangchow, Mokanshan, Tunglu, Lutzepu, Fengshiu, Yenchow, Lanchi, and Chiangshan.

This species was described from Ningkuofu, Anhwei Province. The general outline of the shell resembles that of the preceding species, but it is somewhat larger in size and bears both distinct growth and spiral lines and is obtusely angulated at the periphery. The young forms are less conical in shape and the peripheral angulation is stronger.

Kaliella depressa Moellendorff, 1883

Kaliella depressa Moellendorff, Jahrb. Deutsch. Malakol. Ges., **10**: 368, Taf. 12, fig. 7, 1883.

Collecting station: Chiangshan, Chekiang Province.

This species was described from Canton. The shell has a low, conical outline and is umbilicated and obtusely angulated at the periphery. A medium-sized specimen measures 3.2 mm. in width, 2.5 mm. in altitude, with 5½ whorls.

Kaliella euconus Moellendorff, 1899

Kaliella euconus Moellendorff, Ann. Mus. Zool. Acad. Imp. Sci., St. Petersburg, **4**: 54, Taf. 2, fig. 4, 1899.

Collecting stations: Chihlilung near Puchiang, Fuyang, Hangchow, Mokanshan, Chekiang.

This species was described from Ta-chien-lu, west of Szechwan Province. The shell is umbilicated, conical, elevated, with scarcely convex whorls and strongly keeled periphery. This peripheral keel of the whorls of the spire is visible along the suture. The sculpture consists of distinct growth lines above the periphery of the body whorl and fine spiral striae on the base.

Kaliella cuneus (Heude), 1885

Conulus cuneus HEUDE, Mem. Hist. Nat. Emp. Chinois, 1885, p. 105, pl. 27, fig. 6.

Collecting station: Mokanshan, Chekiang Province.

The single specimen in the collection seems to be identical with this species, which was described from Szechwan Province. It measures 4.6 mm. in altitude, 3.8 mm. in width, with 7 whorls, and is apparently a young shell; however, it is well characterized by its conical outline, bearing strong ribs on the surface of the whorls and with fine growth striae on the base.

Kaliella chekiangensis Yen, new species

Plate 1, figure 10

Shell broadly conical in outline, highly elevated, umbilicated and thin. Apex prominent and obtuse, the whorls roundly convex and closely coiled. The sculpture consists of fine but distinct lines of growth and occasionally of obscure ribs on the later whorls. The body whorl is very rapidly dilated, roundly convex at the base and distinctly keeled at the periphery. The peripheral keel is visible along the suture of the whorls of the spire. The aperture is semicircular with its outer lip margin simple and thin, and parietal margin lightly calloused and well defined, but it is very thin in the young. The columellar margin is short and slightly reflected, and bears a white, but weak, plica on the axis and is somewhat obliquely twisted. This plica is traceable also in the shell of the young. Measurements: holotype, altitude 5.3 mm., width 4.0 mm., with 7½ whorls.

Holotype, No. 8247, and *paratypes* Nos. 8248, 8249, Mus. Calif. Acad. Sci. Paleo. Type Coll., from **Fengshiu, Chekiang Province, China.**

This species resembles in form *Conulus pyramis* Heude 1885 (Mem. Hist. Nat. Emp. Chinois, 1885, p. 105, pl. 27, fig. 9), which was described from Chenkou of Szechwan Province, and according to Moellendorff, 1887, is a species of *Kaliella* Blanford. But it differs from that species by its higher altitude, narrower width, and the presence of an axial plica. The generic position is considered to be uncertain. On account of the presence of the columellar fold, the species does not seem to belong to the typical *Kaliella,* and the general outline of the shell suggests its similarity with some species of *Buliminopsis* Heude. It may belong to an undescribed group, but any definite generic assignment might best be deferred until more morphological information is at hand.

Microcystina zikaveiensis (Heude), 1882

Hyalina zikaveiensis HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 16, pl. 13, fig. 9.

Collecting stations: Fuyang, Fengshiu, Tunglu, Lutzepu, and Yenchow.

The shell is minute in size, having a depressed spire, and bearing sculpture of fine striae. It was described from a suburban district of Shanghai. The specimens from Tunglu are typical, while the two specimens from Lutzepu are somewhat larger in diameter with one-fourth of a whorl more.

Macrochlamys microgyra (Heude), 1882

Nanina microgyra Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 13, pl. 13, fig. 10.

Collecting stations: Fengshiu, Wongkiang, and Lanchi.

This species is characterized by its low conical outline, closely coiled whorls, and keeled periphery. The specimens in the present collection are typical, except that they are somewhat larger in size. Measurments: altitude 3.8 mm., width 5.2 mm., with 7 whorls; altitude 4.0 mm., width 6.0 mm., with 7½ whorls.

Euplecta rathouisii (Heude), 1882

Hyalina rathouisii Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 14, pl. 20, figs. 31, 31*a*.

Collecting station: Hangchow, Chekiang Province.

This is a common species existing in the Lower Yangtze Valley, although the present collection contains only a single lot of four specimens. These are slightly larger in size than the typical form, one of them measuring 4.0 mm. in altitude, 7.0 mm. in width, with 7¼ whorls.

Sitala turrita Moellendorff, 1883

Plate 1, figure 7

Sitala turrita Moellendorff, Jahrb. Deutsch. Malakol. Ges., **10:** 371, Taf. 12, fig. 3, 1883.

Collecting stations: Mokanshan, Tunglu, and Shunan, Chekiang Province.

The figured specimen is from Tunglu. This species was described from Kwangtung Province, with which a few specimens here agree well. It is of minute size, conically turreted and bearing characteristic spiral sculpture. The largest specimen measures 2.8 mm. in altitude, 2.0 mm. in width, with 6½ whorls, which approaches nearly to that of the type.

Helicarion sinense Heude, 1882

Helicarion sinense Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 11, pl. 13, fig. 4.

Collecting stations: Mokanshan, Tunglu, Yenchow, and Lanchi, Chekiang Province.

This is a common species occurring along the Yangtze Valley. In the present collection, there is only a series of young specimens, the largest of which measures 11.8 mm. in width, 7.0 mm. in altitude, with 5 whorls, while the smaller one measures only 5.0 mm. in width, 3.0 mm. in altitude, with 3 whorls. The measurements of the type were given as 16.5 mm. in width, 10.0 mm. in altitude, with 5½ whorls. The last whorl increases very rapidly in size, so that a difference of one-half of a whorl causes considerable change in the size and outline of the shell.

Family PLEURIDONTIDAE

Ganesella brevibarbis (Pfeiffer), 1859

Helix brevibarbis PFEIFFER, Proc. Zool. Soc. London, 1859, p. 25, pl. 43, fig. 4.

Collecting stations: Fengshiu and Wongkiang, Chekiang Province.

This species is characterized by its trochoid outline with scarcely convex whorls, bearing a color band and spiral rows of hairs along the periphery of the body whorl. The umbilicus is narrowly open and slightly covered by the columellar margin. One of the adult examples measures 11.0 mm. in altitude, 13.2 mm. in width, with 7¼ whorls.

Family BRADYBAENIDAE

Bradybaena similaris (Férussac), 1821

Helix similaris FÉRUSSAC, Tableaux systématiques des Animaux Mollusques . . . . , 1821, p. 47.

Collecting stations: Tunglu, Yenchow, Lanchi, and Chiangshan.

This is one of the common species existing throughout the country. It includes unicolored and banded forms. The color band, whenever present, is normally along the periphery of the body whorl. The whorls are angulated at the periphery in the young and almost rounded in the adult.

Bradybaena ravida (Benson), 1842

Helix ravida BENSON, Ann. Mag. Nat. Hist., (1)**9**: 486, 1842.

Collecting stations: Fuyang, Hsiaoshan, Mokanshan, Tunglu, Lutzepu, Yenchow, and Chiangshan.

The specimens from Tunglu are typical and identical with this species; others are of younger stages, so that they appear to be much smaller in size and different in outline. However, it has been noticed that the size of the shell of this species varies considerably, and its last whorl is rapidly dilated, so that the differences of size of one-half of a whorl causes much change in the general outline of the shell.

Bradybaena fortunei (Pfeiffer), 1850

Helix fortunei PFEIFFER, Zeitsch. f. Malakol., **7**: 73, 1850.

Collecting stations: Mokanshan, Tunglutze, Lutzepu, and Fengshiu.

This species was described from "Shang Hi, Chinae" [Shanghai], based on the material collected by Fortune Magazine. It is a common species of the Yangtze Valley. Its present known range is from Chekiang and Kiangsu provinces in the east to Hunan Province in the southwest. It is usually sinistral, may be either unicolored or single banded, and is sculptured by distinct, fine growth and spiral lines.

Bradybaena uncopila (Heude), 1882

Helix uncopila Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 41, pl. 16, fig. 6.

Collecting station: Mokanshan, Chekiang Province.

This species differs essentially from the preceding one by its more globose outline and its granulose sculpture and hairy surface.

Bradybaena laeva (Pilsbry and Hirase), 1908

Eulota laeva Pilsbry and Hirase, Proc. Acad. Nat. Sci. Philadelphia, **60**: 39, fig. 3, 1908.

Collecting stations: Tunglu and Lutzepu, Chekiang Province.

This species was described from Hangchow and seems to be closely related to the preceding species, differing only by its smaller size, higher altitude, and narrower umbilicus. One of the specimens in this collection measures 13.5 mm. in altitude, 17.0 mm. in width, and has 5¼ whorls, being slightly larger than the typical form.

Aegista chinensis (Philippi), 1845

Helix chinensis Philippi, Abbild. Beschr. Conchyl., (1) **1**: 1, *Helix*, Tab. 6, fig. 1.

Collecting stations: Mokanshan, Fengshiu, and Tunglutze.

One of the two larger specimens from Mokanshan agrees well with Philippi's original figure, while the other specimen is larger and with thin lip margin.

Plectrotropis sedentaria (Heude), 1885

Helix sedentaria Heude, Mem. Hist. Nat. Emp. Chinois, 1885, p. 109, pl. 28, figs. 9, *9a*.

Collecting station: Chiangshan, Chekiang Province.

This species was described from Kweichowfu of Upper Yangtze Valley. It differs essentially from *P. trichotropis* (Pfeiffer) by its smaller size.

Plectotropis barbosella (Heude), 1882

Helix barbosella Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 38, pl. 16, figs. 3, *3a*.

Collecting stations: Mokanshan, Fuyang, Wongkiang, Tunglu, Tunglutze, Yenchow, Chihlilung near Puchiang, and Langchi.

This species was described from the Shanghai and Tai-hu region. The specimens in the present collection appear to be typical, but most of them are slightly smaller than the type. A large specimen measures 8.0 mm. in altitude, 11.0 mm. in width, with 6 whorls.

Euhadra orientalis moreletiana (Heude), 1882

Helix moreletiana Heude, Mem. Hist. Nat. Emp. Chinois, 1882, p. 38, pl. 16, fig. 1.

Collecting station: Mokanshan, Chekiang Province.

This subspecies was described from Kwangtehchow, Anhwei Province, in the near neighborhood of Mokanshan. It is not uncommonly found in the Lower Yangtze as well as in the southern part of the country.

It agrees well with its *forma typica,* described from Borneo, differing only by its wider umbilicus.

Family STREPTAXIDAE

Ennea strophiodes (Gredler), 1881

Pupa strophiodes GREDLER, Jahrb. Deutsch. Malakol. Ges., **8**: 118, Taf. 6, fig. 4, 1881.

Collecting stations: Tunglu, Yenchow, Chayuanchen, Shunan, Chihlilung near Puchiang, and Chiangshan.

These specimens are slightly larger than the typical form, which was described from Hunan Province, but they agree well in other features with the species. Measurements: altitude 4.5 mm., width 2.5 mm., with 7⅓ whorls; altitude 5.0 mm., width 2.6 mm., with 7½ whorls.

Ennea dolium Heude, 1885

Ennea doliolium HEUDE, Mem. Hist. Nat. Emp. Chinois, 1885, p. 116, pl. 30, fig. 15. (non Morelet).

Ennea dolium HEUDE, Journ. Conchyl., **33**: 43, 1885.

Collecting station: Lanchi, Chekiang Province.

This species differs from the preceding one by its smaller size, finer sculpture, and more cylindric outline. It was described from Chen-kou of Szechwan Province. Measurements: altitude 3.2 mm., width 2.0 mm., with 6¼ whorls; altitude 3.0 mm., width 2.0 mm., with 6 whorls.

Ennea larvula (Heude), 1882

Pupa larvula HEUDE, Mem. Hist. Nat. Emp. Chinois, 1882, p. 75, pl. 18, fig. 23.

Collecting station: Chiangshan, Chekiang Province.

This species differs from the preceding one by its smaller size and in possessing almost one more whorl. It measures 3.1 mm. in altitude, 1.8 mm. in width, with 7 whorls.

Ennea microstoma (Moellendorff), 1881

Pupa microstoma MOELLENDORFF, Jahrb. Deutsch. Malakol. Ges., **8**: 311; **10**: 278, Taf. 10, fig. 10.

Collecting station: Lutzepu, Chekiang Province.

This species was described from Kwangtung Province. It is openly umbilicated, bearing rather distant ribs and with the body whorl compressed. The aperture is small, descending in front, having its peristome continuous and bearing one well-developed parietal and one columellar lamella, and one bilobed palatal plica. The columellar lamella is deeply inserted. It measures 2.9 mm. in altitude, 1.6 mm. in width, with 6 whorls.

Family MYTILIDAE

Modiolus lacustris von Martens, 1875

Modiola lacustris VON MARTENS, Sitzungsber. Gesell. Naturforsch. Freunde, Berlin, 1875, p. 3; Malakol. Blätt., **22**: 186, 1875.

Modiolus (Limnoperna) lacustris VON MARTENS, Lamy, Journ. Conchyl., (4) **80**: 361, 1937.

Collecting station: Fuyang, Chekiang Province.

This species was described from Tung-ting-hu, Hunan Province, and was based on specimens collected by Baron von Richthofen. It has been recorded subsequently from various parts of the Yangtze Valley. The specimens contained in the present collection are much smaller in size than the typical form.

Family UNIONIDAE

Anodonta arcaeformis (Heude), 1877

Anodon arcaeformis Heude, Conchyl. Fluv. Prov. Nanking, Fasc. 3, 1877, pl. 19, fig. 40.

Collecting station: Bamowoo, Chekiang Province.

A single pair of very young valves is present in the collection. This is a common species, occurring in various parts of the Lower Yangtze Valley. It was described from Sung-kiang of Kiangsu, in the near neighborhood of Chekiang.

Family CORBICULIDAE

Corbicula fluminea (Mueller), 1774

Tellina fluminea Mueller, Verm. Hist., **2**: 206, 1774.

Corbicula fluminea Müller, Prashad, Mem. Indian Mus., (Calcutta), (2) **9**: 51, pl. 7, figs. 1–10, 1929.

Collecting stations: Zahkou, Shunan, Fengshiu, and Chuchow, Chekiang Province.

The specimens from the above localities bear strong and rather distant ribs, and are interiorly tinged with purple. They seem to agree well with this species, except that they are of much smaller size. The species has been recorded previously from this province as well as from other parts of the Yangtze Valley.

Corbicula largillierti (Philippi), 1846

Cyrena largillierti Philippi, Abbild. Beschr. Conchyl., (3) **2**: 75, Tab. I, fig. 1, 1846.

Collecting station: Hangchow, Chekiang Province.

This species was described from Yangtzekiang. The specimens here agree well with the typical form, except in being much smaller. It differs from the preceding species by bearing much finer and closer ribs.

Family SPHAERIIDAE

Sphaerium parvium Yen, new species

Text figure 1

Shell ovate and inflated in outline, subequilateral, small, thin, and yellowish-brown in color. The sculpture consists of concentric and close lines of growth. Umbones small, slightly projecting, and slightly inclined anteriorly. The anterior end is semi-ovately curved, while the posterior side is subcircular in outline. The hinge is slightly curved and the ventral margin is almost rounded. The interior of the shell is pale brown and smooth. A single, small cardinal tooth in the right valve, rather compressed and slightly curved, but in the left divided, rather straight, and parallel to each other. The lateral teeth are strong, divergent, somewhat projecting, lamelliform, double in the right and single in the left. Measurements: length 6.5 mm., height 5.5 mm., convexity 3.2 mm.

Holotype, No. 8251, Mus. Calif. Acad. Sci. Paleo. Type Coll., from **Foulanchi, Chekiang Province, China.**

A

B

Text Fig. 1.—*Sphaerium parvium* Yen, new species. Holotype, No. 8251, Calif. Acad. Sci. Paleo. Type Coll., from Foulanchi, Chekiang Province, China. *A*, right valve, *B*, left valve. Length, 6.5 mm.; height, 5.5 mm.

This genus has been recorded previously by Moellendorff in 1902 from Kansu Province and Ordos district, by Annandale in 1918 from Tai-hu, and by Prashad in 1924 from Shang-kuan, on the northwestern shore of Tali Lake in Yunnan Province, but none of the specimens was specifically identified. The two examples that Annandale obtained from the island of West Tung-ting in Tai-hu may probably also belong to this species, but his brief statement mentions nothing of the shell features.

The present lot contains a single pair of valves with three pairs of embryonic valves inside.

This species seems to resemble *Sphaerium inutilis* Pilsbry 1901 (Proc. Acad. Nat. Sci. Philadelphia, **53**: 406, 1901) but it differs by its smaller size, less curved hinge-line, lower beak, and stronger sculpture.

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EXPLANATION OF PLATE 1

FIG. 1.—*Pseudopalania dautzenbergiana* Yen, new species. Holotype, No. 8244, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Tunglu, Chekiang Province, China. Altitude, 2.1 mm.; width, 1.1 mm. P. 75.

FIG. 2.—*Assiminea schmackeri* Boettger. Hyptotype, No. 8245, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Haimen, Kiangsu Province, China. Altitude, 3.0 mm.; width, 2.9 mm. P. 79.

FIG. 3.—*Cyathopoma micronicum* Yen, new species. Holotype, No. 8237, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Yenchow, Chekiang Province, China. Altitude, 1.1 mm.; width, 1.8 mm. View of base. P. 73.

FIG. 4.—*Cyathopoma micronicum* Yen, new species. Same specimen as shown in Figure 3. Apertural view.

FIG. 5.—*Hawaiia minuscula* (Binney). Hypotype, No. 8246, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Chiangshan, Chekiang Province, China. Altitude, approximately 1.37 mm.; width, 2.5 mm. View of base. P. 88.

FIG. 6.—*Hawaiia minuscula* (Binney). Same specimen as shown in Figure 5. Apertural view.

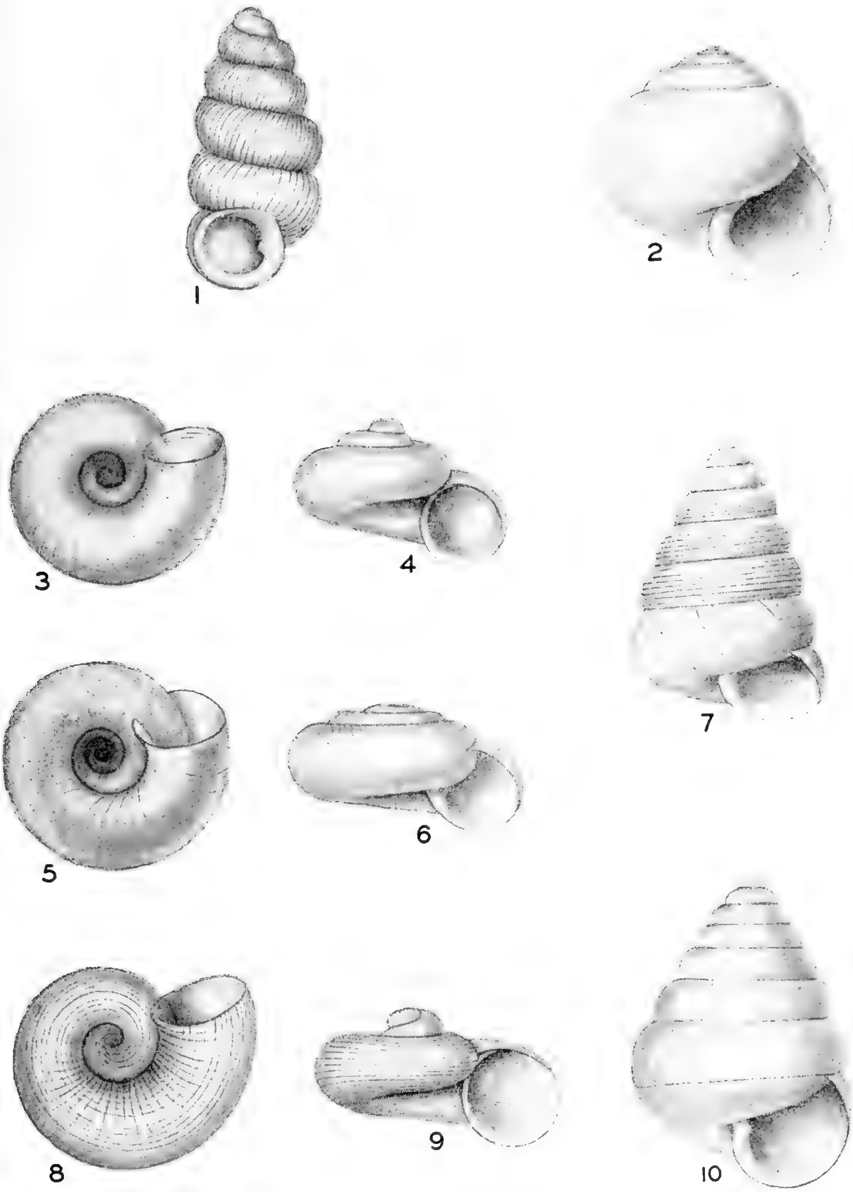
FIG. 7.—*Sitala turrita* Moellendorff. Hypotype, No. 8250, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Tunglu, Chekiang Province, China. Altitude, 2.8 mm.; width, 2.0 mm. P. 91.

FIG. 8.—*Cyathopoma planorboides* Yen, new species. Holotype, No. 8241, Mus. Calif. Acad. Sci. Paleo. Type Coll., from Yenchow, Chekiang Province, China. Altitude, 1.2 mm.; width, 2.5 mm. View of base. P. 74.

FIG. 9.—*Cyathopoma planorboides* Yen, new species. Same specimen as shown in Figure 8. Apertural view.

FIG. 10.—*Kaliella chekiangensis* Yen, new species. Paratype, from Fengshiu, Chekiang Province, China. Altitude, 5.2 mm.; width, 4.0 mm. P. 90.

Scales of drawings are indicated by adjacent lines which equal 1 mm. magnified the same as the specimens. All drawings on this plate are by Miss Helen Winchester.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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 5, pp. 101-124, 2 text figs. June 28, 1948

A SYSTEMATIC STUDY OF THE FAMILY POLYORCHIDAE (HYDROMEDUSAE)*

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Acknowledgment

I wish to express my appreciation to Professor S. F. Light and Dr. R. Stohler of the University of California, Berkeley, for their courtesy in procuring and sending me material of *Polyorchis penicillatus* from San Francisco Bay, California, one of the localities from which A. Agassiz obtained his specimens and possibly one of the sources of Eschscholtz' type material; and to Professors J. E. Lynch and T. Kincaid for sending me material of this genus from the Puget Sound region, Washington.

General Classification

The classification of the Hydromedusae offers very serious difficulties, a fact recognized even by some of the early investigators, e.g., Gegenbaur (1856, p. 217). Indeed, even the segregation of two of the main subdivisions of this group, viz., the Anthomedusae and the Leptomedusae, is both difficult and confusing. For this reason it was a most gratifying development when, mainly through the efforts of R. Weill, the study of the nematocysts opened up a new and very promising approach to this problem. In his large, monographic summary, Weill (1934) demonstrated clearly that, if one takes into account all the different types of nematocysts occurring in a species, i.e., the cnidome, one usually obtains a clear-cut indication as to the true position of this form in the natural system. The new method, unfortunately, has some quite serious

* Printed from the John W. Hendrie Publication Endowment.

limitations: fresh material is often indispensable; the nematocysts frequently are extremely small and, in addition, are refractory to stains.

To the medusae of uncertain systematic position, between the Anthomedusae and the Leptomedusae, belongs one of the most commonly seen forms of the coastal waters of western North America—*Polyorchis penicillatus* (Eschscholtz). A brief account of the systematics of this species and of those which have been taxonomically more or less closely associated with it will give a convincing illustration of the confusion which has pervaded the field and at the same time will demonstrate what difficulties may be resolved through the application of facts brought out by a careful analysis of the cnidome.

Polyorchis penicillatus was established by Eschscholtz in 1829 under the name of *Melicertum penicillatum*. The genus *Melicertum* was very ill-defined and was placed, with six other genera, under the family Oceanidae, a unit which, as conceived by Eschscholtz, was extremely heterogeneous indeed. In brief, the first systematic allocation of this form was uncertain and may be said to have resulted from a guess, quite in accordance with the primitive state of the scientific knowledge of the Coelenterata in those early days of zoological investigation.

The same may be said about the decision made by de Blainville (1834) to remove this form to the Trachymedusan genus *Aglaura* Péron and Lesueur. This unfortunate choice evidently was caused by the fact that *Aglaura hemistoma* Péron and Lesueur has a deep bell-like shape and pendent, sausage-shaped gonads.

The first to submit *P. penicillatus* to careful examination was A. Agassiz whose results appeared in a preliminary form in L. Agassiz (1862, pp. 349, 352). In this work it was made the type of a new genus, *Polyorchis,* which in its turn was made the sole representative and hence the type of a new family, Polyorchidae, placed in the suborder Sertulariae. This suborder corresponded largely to what we now term the Leptomedusae. (L. Agassiz, 1862, p. 348, although doubtfully, also placed in this suborder forms which we now refer to the Trachymedusae.) In his attempt to establish families within the Leptomedusae, Agassiz met with considerable difficulties because of the incompleteness of the available data. Hence he decided to proceed in accordance with the principle of progressive elimination (p. 352): he distinguished "as belonging to distinct families all those free Medusae and Hydroids which have distinct patterns." Thus *Polyorchis* was made to represent a special family because its members are "quite remarkable for their branching, chymiferous tubes, and their pendent, reproductive organs."

In A. Agassiz (1865), too, Polyorchidae contained but a single genus. This, however, was due to the limitation of the material on which his report was based, as will be seen from the fact (p. 118) that Agassiz actually suggested that the genus *Olindias* F. Müller, 1861 (now belonging to the Trachymedusae) would form a "very natural family" with *Polyorchis,* a suggestion evidently based on the identification of the lobe-like gonads on the radial canals in *Olindias* with the sterile side branches of these canals in *Polyorchis*.

In his monumental monograph, "Das System der Medusen," Haeckel (1879, p. 140) described and analyzed the large family Cannotidae, previously (1877) established by him in a preliminary manner. Haeckel, of course, fully recognized that the 15 genera referred by him to this family are very heterogeneous; indeed, some of the previously described ones had been classified as Anthomedusae while others had been arranged with the Leptomedusae—and some of the latter showed quite divergent features. Haeckel maintained, however, that a careful analysis had convinced him that all of these genera were "echte Leptomedusen" and that they should be placed next to the Thaumantiadae, i.e., near the bottom of the Leptomedusan system. Two of the most outstanding characters of the Cannotidae are the branching of the radial canals and the multiple gonads originating from these canals. The Cannotidae was divided by Haeckel into three subfamilies, one of which was Polyorchidae. This subfamily, however, did not correspond to Agassiz's family of this name, but was a greatly broadened concept. It included, besides *Polyorchis,* the highly diversified genera, *Staurodiscus, Staurophora, Ptychogena,* and *Gonyonema.*

Quite naturally, a systematic unit as diversified as the Cannotidae aroused criticism among later investigators. Among the most important of these critics should be noted Browne (1896) and especially Maas (1904). The former demonstrated that the genus *Willsia* (*Proboscidactyla*), strikingly characterized by its branching radial canals, is not a Leptomedusa but an Anthomedusa since its sex products do not originate on the radial canals but on the manubrium. Maas submitted the whole family Cannotidae to a searching analysis, the result of which was the complete dissolution of this family and the scattering of its component genera to various places in the system. Some of the component members, e.g., the *Willsiidae sens. rect.,* Browne (1896), were allocated to the Anthomedusae, while others, such as the greatly restricted Polyorchidae, were classified with the Leptomedusae. This reevaluation by Maas (1904) was in a large measure accepted by Mayer in his "Medusae of the World" (1910), a work which forms the main foundation of our modern knowledge of these organisms. Mayer presents the Polyorchinae as a subfamily of the comprehensive family Thaumantiidae, the first of the three large families forming the Leptomedusae.

Throughout these classificatory studies we find emphasis on the branching of the radial canals. However, the fundamental value attributed to this character by Haeckel (1879) was decidedly weakened when Browne (1896) was forced to place some forms with branched canals among the Anthomedusae while others were allowed to retain the position among the Leptomedusae assigned to them by Haeckel. This type of arrangement, of course, implied the tacit admission that branching had occurred more than once in the course of the evolution of the Hydromedusae. In this connection it is of interest to note that quite a long time before Haeckel's large monograph was published, Gegenbaur (1856, p. 219), with his keen sense for systematics, clearly realized that the branching of the radial canals is not such an important character as it may at first appear to be (see below, p. 122).

The first investigator to question the correctness of the allocation of the Polyorchidae to the Leptomedusae was Fewkes (1889*b*, p. 106). In a footnote he wrote as follows: "It is probable that when the *Polyorchis* buds from its hydroid it has four radial tubes, four tentacles and possibly the stumps of four similar interradial appendages. As the radial tubes at that time lack lateral branches, we have in this stage a medusa closely resembling the young *Sarsia.* If my suppositions are correct, there seems no doubt that *Polyorchis* belongs to the true Anthomedusae, and that it is allied to *Sarsia.*" This was a bold suggestion, completely at variance with the prevailing ideas of the time. Fewkes's assumption about the number of tenacles was borne out by Foerster (1923, p. 34) who established that the young medusae of *Polyorchis* found in British Columbia have four tentacles until they reach a bell height of approximately 5 mm.

The only one who, up to the present time, has accepted Fewkes's view that the Polyorchidae are true Anthomedusae is Uchida (1927, p. 170) who based this conclusion to a large extent on his examination of the development of *Spirocodon saltatrix* (Tilesius). He found that the youngest recorded specimen of this species "is very similar to *Sarsia* which is the most primitive of the Anthomedusae." In his reconstruction of the evolutionary differentiation of the Anthomedusae, Uchida (1927, p. 168, Fig. 22) placed the Polyorchidae and the Spirocodonidae near the top of the system, next to the Willsiidae; and he judged them to have evolved from the primitive Codoniidae, of which *Sarsia* is a member, and to have passed through an intermediate Tiaridae stage.

It may be worthy of notice in this connection that A. Agassiz stated on p. 132 of his in some respects quite remarkable "North American Acalephae," 1865, that the medusae of *Melicertum* "hold an intermediate position between the Campanularians and the Tubularians, being more closely allied to the latter in their embryonic condition, and assuming as adult Medusae somewhat the aspect of Campanularian Medusae." Since the genus *Melicertum* belongs to the subfamily Melicertinae of the Thaumantiidae, next to the Polyorchinae in Mayer's (1910) large monograph, it is evident that Agassiz to some degree anticipated Fewkes's and Uchida's solution of the problem of the systematic position of the Polyorchidae. Agassiz's figure 203 of the youngest stage of *Melicertum* certainly does show a remarkable similarity to the young medusae of *Polyorchis.*

To summarize: there are at present two fundamentally opposed interpretations in regard to the systematic position of the Polyorchids: (1) the great majority of the investigators consider these forms to be Leptomedusae, located near the base of this group; (2) according to Fewkes and Uchida, they are true Anthomedusae to be placed, with the Willsiidae, at the top of this group, and derived from Codoniidae-like ancestors. Uchida, in addition, believes that they have passed through a Tiaridae-like stage.

Which of these two interpretations is the more correct, according to evidence derivable from the cnidome? The answer to this is quite clear: the Polyorchids are unquestionably Anthomedusae. They are equipped with two types of nettle cells (bicnidome): desmonemes and stenoteles. According to Weill (1934, p. 478), neither of these categories ever occurs among the Calyptoblasts (Leptomedusae) while they are common, though by no means always present, among the Gymnoblasts (Anthomedusae); see Weill (1934, p. 444). Among the Anthomedusae, according to the same source, there is only one genus known to have a bicnidome consisting of desmonemes and stenoteles, and that is the genus *Sarsia*. Hence the close relationship between the Polyorchids and this genus may be considered to be settled with nearly complete certainty. The similarity even extends to quite detailed features of structure, and the peculiarity emphasized by Russell (1938, p. 150), that *Sarsia eximia* is characterized by the fact that its stenoteles occur in two different size classes, is repeated among the Polyorchids. Concerning Uchida's final assumption that the Polyorchids passed through a Tiarida-like stage, the evidence from the cnidome is equally decisive, even though it is derived from only a single member of the family Tiaridae—*Leuckartiara octona* (Fleming). In this form, there are neither desmonemes nor stenoteles, thus conclusively eliminating it and its closest relations from the pedigree of the Polyorchids. In regard to the placing of the Polyorchidae next to the Willsiidae (either among the Leptomedusae or among the Anthomedusae), it may be noted that in *Willsia stellata* Forbes we find (Russell, 1938, p. 154) a cnidome which does not indicate any close relationship. (Note: Uchida, 1927, p. 169, specifically states that he does not know the relationships of the family Willsiidae.)

A further tracing of the ancestry and systematic position of the Polyorchidae is impossible at present because of our fragmentary knowledge of the cnidomes of the various Hydromedusan genera. Suffice it to state that no forms are known, besides *Sarsia* and the Polyorchidae, in which there is a bicnidome consisting of stenoteles and desmonemes.

The preceding discussion may give the impression that the cnidome yields taxonomic clues both simple to establish and incontrovertible in their application. Unfortunately, this a far from being true, although indeed, the *Sarsia-Polyorchis* relationship evidently is one of the simplest examples in this field. Concerning the difficulties inherent in the establishment of the nature of the cnidome, reference is made to Weill (1934) and Russell (1938). These difficulties can be overcome only by very careful work. The really serious obstacles are encountered when we attempt to apply the evidence derived from the cnidome to taxonomic problems. This is due to the fact that the nematocysts, despite their structural complexities, evidently present amazing examples of the mysterious phenomenon which we call convergent evolution. A thorough morphological study of the cnidomes of a large number of genera distributed throughout the entire Coelenterate phylum and analyzed statistically should result in very valuable evidence bearing on the fundamental, although altogether too little understood, problem of convergence.

In his remarkable monograph, the "Medusae of the World," Mayer (1910) classified the orders of the Hydromedusae into families which often in their turn were divided into subfamilies which, in some cases, had their genera arranged into tribes. This classification may have been somewhat too elaborate and graduated considering the immense difficulties inherent in the appraisal of comparative degrees of relationship. Hence it was natural that the criticism of this classificatory system became quite strong and that pronounced changes were proposed. In regard to these changes, Foerster (1923, p. 224) states that the chief difference between the system of Mayer and those of later investigators "lies in the complete abandonment of all sub-families [and tribes]. These have been either elevated to separate families or incorporated in the family without further division." This policy, even though it was to a certain extent justifiable, probably was carried too far. After all, a classificatory system should mirror degrees of relationships to the greatest possible extent. In the present report I have proposed a couple of changes in the most recent classification along this line: the families Polyorchidae and Spirocodonidae have been joined as subfamilies of Polyorchidae *s.l.;* and, in addition, two genera were united and placed as subgenera, *Polyorchis* and *Scrippsia,* under the genus *Polyorchis s.l.* The material in these cases was such that it practically forced me to adopt this solution. It should be noted that the first to suggest the establishment of the Polyorchids and the Spirocodonids as subfamilies was Goette (1886, p. 832).

Family **Polyorchidae** A. Agassiz, 1862

Agassiz, A., in Agassiz, L. (1862), pp. 349, 352;—Agassiz, A. (1865), p. 118;— Haeckel (1879), *part.*, pp. 140, 142, 145, 149;—Goette (1886), p. 832;—Murbach and Shearer (1903), *part.*, pp. 174, 187;—Maas (1904), pp. 421, 423, 441;—Torrey (1909), p. 14;—Foerster (1923), p. 250;—Uchida (1927), pp. 169, 170, 171, 173, 226.

Diagnosis: Anthomedusae of medium to large sizes (height of bell, from about 20 to somewhat more than 100 mm.). Umbrellar outline deeply bell-shaped in lateral view; at least as high as wide. Mesoglea moderately thick to rather thin, except aborally where it forms a more or less pronounced peduncle, the gastric peduncle, from which the manubrium depends. Manubrium quadrate in section. Oral lips 4, simple in young specimens, becoming flaring, recurved, and moderately frilled with age; their edges somewhat thickened with densely set nematocysts forming distinct marginal band, but without oral tentacles. Marginal tentacles increase in number with age, at first probably always 4; in adults numerous, more than 20; simple and hollow, their canals connected with ring canal; armed with numerous, button-like aggregations of nematocysts scattered irregularly over the entire tentacle; when tentacle is contracted, buttons are closely set, except near tentacular base where they become increasingly scarce. Tentacles of different sizes, according to position in sequence of tentacular development; when relaxed, the longest are longer than bell is high. Stomach tubular, without marked enlargement at place where radial canals join it. Radial canals 4; their distal two-thirds sometimes simple, but show pronounced tendency to develop blind side branches on either side of each canal. Gonads located on parts of the 4 radial canals which are on gastric peduncle. Cnidome: bicnidome, consisting of stenoteles and desmonemes. Ocelli present at bases of tentacles. Statocysts and cordyli absent. Appears to be restricted to the Pacific Ocean.*

Remarks: As mentioned on page 106, Goette (1886, p. 832) segregated the Polyorchids and the Spirocodonids as subfamilies. On the other hand, in his excellent study on the Anthomedusae of Japan, Uchida (1927) decided that these forms should be regarded as representing two distinct families. His Spirocodonidae included only *Spirocodon,* while, in the Polyorchidae, Uchida placed two genera, *Polyorchis* and *Scrippsia.* Should the latter arrangement be accepted? A careful inspection of these forms will bring forth three basic facts: (1) Morphologically, these genera are very closely related. (2) This relationship is much closer than the relationship between any one of the three genera and any other genus of the Anthomedusae, a conclusion borne out by the fact that for a long time *Polyorchis* was considered a member of the Leptomedusae rather than of the Anthomedusae. (3) Of the three genera, *Polyorchis* and *Scrippsia* are mutually much more similar than either of them is to *Spirocodon.* These basic facts indicated first, that *Spirocodon, Polyorchis,* and *Scrippsia* should be kept together and, at the same time, be removed from the remaining members of the Anthomedusae; second, that *Spirocodon* should be removed from *Polyorchis* and *Scrippsia.* To accomplish this, it seems most advisable to revert to the classification proposed by Goette, i.e., to maintain Polyorchidae *s.l.* to include all these genera and to divide it in two subfamilies: Polyorchinae, for *Polyorchis* and *Scrippsia;* and Spirocodoninae, for *Spirocodon.* The most fundamental difference between these subfamilies is found in the structure of the gonads.

Subfamily **Polyorchinae**

Gonads in the form of narrow, sausage-like, multiple sacs, freely suspended in subumbrellar cavity.

Remarks: As will be seen from the remarks above, this subfamily includes two previously accepted genera, *Polyorchis* and *Scrippsia.* Since a close examination shows that these units are rather similar, the question presents itself: should these units maintain their present status?

At the time when the genus *Scrippsia* was established by Torrey (1909) to receive a single species, *S. pacifica,* there could hardly have been any rea-

* The statement by Murbach and Shearer (1903, p. 177) that the genus *Polyorchis* has been found in the Adriatic Sea is erroneous.

sonable doubt as to the justification of its establishment. Besides a number of quantitative differences from the related genus *Polyorchis,* the new form exhibited a qualitative differentiating feature: its canal system was simple, that is, it lacked every trace of branching, and branching was considered a characteristic of fundamental importance in *Polyorchis.* The discovery of *Polyorchis haplus* has completely changed the situation. *P. haplus* is a typical *Polyorchis* except in the fact that, until the very latest stages, thus long after the attainment of sex maturity, its canals remain simple. Only in the very largest specimens do the radial canals exhibit a knobby appearance, thus showing that in this species too there is, although nearly concealed, a branching tendency. By this discovery the only qualitative difference between the two genera has been removed. Among the quantitative differences, perhaps the most striking is the decided displacement of the outer tenacles in *Scrippsia* from the bell margin, along the exumbrellar side. However, this difference, too, loses much of its significance when we consider the fact that in the little-known *Polyorchis campanulata* (Chamisso and Eysenhardt), which evidently is furnished with branched radial canals, the oldest tentacles appear to be about as far removed from the bell margin as in *Scrippsia.* The elimination of generic value from these two characters makes, I think, the generic status of *Scrippsia* untenable. However, considering the rather striking difference in general appearance between *Scrippsia* and the typical *Polyorchis,* it may be advisable, at least for the time being, to maintain *Scrippsia* as a systematic unit, assigning to it a subgeneric status. Further knowledge of *Polyorchis campanulata* may make even this status untenable.

Polyorchis A. Agassiz, 1862

Polyorchis: Agassiz, A., *in* Agassiz, L. (1862), pp. 348, 349;—Agassiz, A. (1865), p. 119;—Haeckel (1879), pp. 140, 141, 142, 144, 149;—Murbach and Shearer (1903), p. 174;—Maas (1904), pp. 425, 426, 442;—Loeb (1906*a*), pp. 87, 88, 89, 90, 91, 141;—Hargitt (1908), p. 317;—Mayer (1908), p. 126; (1910), pp. 197, 218;—Torrey (1909), pp. 14, 16;—Little (1914), p. 307;—Foerster (1923), p. 250;—Uchida (1927), pp. 170–173, 227.

Medusa: Chamisso and Eysenhardt (1821), *part.,* p. 359.

Melicertum: Eschscholtz (1829), *part.,* p. 105.

Melicerta: Blainville (1834), *part.,* p. 284.

Aglaura: Blainville (1834), *part.,* p. 283.

Campanella: Lesson (1843), p. 281.

Polyorchidium: Haeckel (1877), no. 148; (1879), p. 150.

Diagnosis: Bell margin straight, i.e., not divided into lobes. Gastric peduncle subconical or rounded. Tentacles throughout life fairly uniformly distributed along entire bell margin. Following appearance of first 8 tentacles (first 4 perradial and then 4 interradial), tenacles increase by multiples of 2, i.e., 2 tentacles appear about simultaneously in each quadrant, resulting in a tentacular series of: (4–8)—16—24—32, etc.* First 24 tentacles originate in a nearly completely fixed sequence (Fig. 1), viz., first, 4 perradial; second, 4 interradial; third, 8 adradial; fourth, 8 between second and third.† Tentacles connected with ring canal by canals of different lengths, due to continued growth of these canals throughout life, canals of earliest tentacles being of moderate length, those of the later tentacles being progressively shorter, the youngest being for all practical purpose absent. Thus tentacles are arranged in concentric, slightly irregular rings, the outermost ones tending to become removed from the bell margin.

Remarks: Since the nomenclatorial correctness of *Polyorchis* has been criticized, and since this question has not yet been properly settled, it may be advisable to submit it to a brief review.

Fig. 1.—*Polyorchis montereyensis.* Diagram showing sequence of formation of tentacles, within one quadrant.

* There is nearly always a slight difference in the time of appearance between members of each pair; and thus it would perhaps be more correct to state that 4 tentacles are added at a time, 1 in each quadrant. However, even though this is true, the difference in size between the members of the pairs soon disappears, and hence it may be permissible and preferable always to deal with these structures as paired.

† Following the fourth group of tenacles, deviations from the "normal" sequence, as expressed in Figure 1, may be found, as shown by the following exceptions found in *Polyorchis montereyensis:* (1) Rate of development not always identical in all four quadrants; e.g., a pair of tentacles found in one quadrant or in two or three quadrants may be absent from the remaining; such an absence of even three tentacles has been observed by me. (2) Sequence of origin may be quite irregular in one to three quadrants and perfectly normal in the rest. (3) Sometimes the bud of a tentacle originates in its normal position but, for some unknown cause, its further development is inhibited.

In his discussion of the genus *Melicertum,* Haeckel (1879, p. 136) states that, if he followed the usual procedure of nomenclature, he would be justified in changing the names of *Melicertum* and *Polyorchis* as used by L. and A. Agassiz (1862): "so wäre ich vollkommen im Rechte, wenn ich ihre Genera *Melicertum* und *Polyorchis* einfach striche, ihre *Polyorchis* als *Melicertum* und ihr *Melicertum* mit einem neuen Namen bezeichnete; ebenso auch ihre Familie Polyorchidae als Melicertidae und ihre Melicertidae unter neuem Namen aufführte." The only reason why Haeckel did not carry through this radical nomenclatorial change was that Agassiz was the first to give a good description of the genus *Melicertum!* Disregarding this invalid reason, would it be correct to change the name of *Polyorchis* to *Melicertum?* What are the facts in the case?

The first to use *Melicertum* as a generic name was Eschscholtz (1829, p. 105) who introduced it as an emended form of Oken's (1815) *Melicerta.* According to Article 36 of the "International Rules of Zoological Nomenclature," even though generic names differ only in trivial details, e.g., in termination, they should not be regarded as identical: hence the two mentioned names must be dealt with separately. *Melicerta,* as used by Oken, must be discarded as a homonym, yielding to *Melicerta* Schrank (1803), referring to Rotifers. *Melicertum* Oken, now commonly in use because of the fact that Oken (1835) accepted the emended form suggested by Eschscholtz, must be rejected, while *Melicertum* Eschscholtz becomes a legitimate name.

Melicerta was used by Oken (1815) to designate generically a species previously named *Medusa campanula* by Fabricius in his "Fauna Groenlandica" (1780). Eschscholtz (1829) included in his *Melicertum,* besides this species, *M. campanulatum* (Chamisso and Eysenhardt), *M. penicillatum* Eschsch., and *M. pusillum* (Swartz). Which of these four species should be selected as the type of the genus? *M. pusillum* is so poorly described that it should be assigned to *"Species incertae sedis." M. penicillatum* can be reasonably well identified, but it has been made the type of another genus, *Polyorchis. M. campanulatum* may also be a member of *Polyorchis,* although this identification is rather questionable, and hence its choice is not recommendable. Thus our choice must fall on the sole remaining species, *M. campanula,* i.e., on Oken's type for *Melicerta,* and evidently intended as a type by Eschscholtz.

The answer to our question thus is that the name *Polyorchis* as used by A. and L. Agassiz is justified.

(This decision, however, does not imply that these investigators were right in their usage of the name *Melicertum.* Indeed, the chances are that they were wrong in this respect. Whether Mayer's [1910, p. 207] solution to this problem is acceptable may well be questionable. It may, perhaps, be advisable to have this nomenclatorial tangle settled by the International Commission on Zoological Nomenclature since, if a review is carried out in strict accordance with rules, it will imply a number of rather unfortunate changes.)

Subgenus **Polyorchis**

Diagnosis: Gastric peduncle of moderate size, as shown by the fact that point of origin of manubrium is never more than 0.40 the height of bell from exumbrellar apex. Manubrium long or of moderate length, always longer than gastric peduncle. An ocellus on base of every tentacle.

Type Species: *Polyorchis penicillatus* (Eschscholtz).

Remarks: To decide how many of the recorded forms should be referred, as species, to this subgenus is fraught with difficulties because of two conditions: first, the subgeneric delimination must still be regarded as tentative; second, the fact that very similar species may occur within a very narrow distributional range, as exemplified by *P. penicillatus* and *P. montereyensis* (within 80 English miles of each other), and the fact that many of the previous investigators have submitted their material to comparatively superficial inspection, force us to proceed with the greatest caution when the question arises whether forms previously recorded and identified really are specifically identical.

Here follows an enumeration of the forms of this group which have been named up till the present time: *Polyorchis penicillatus* (also named *Melicertum penicillatum* Eschscholtz; *Aglaura penicillata* Blainville; *Polyorchis eschscholtzii* Haeckel); *P. campanulata* (also named *Medusa campanulata* de Chamisso and Eysenhardt; *Melicertum campanulatum* Eschscholtz; *Melicerta campanulata* Blainville; *Polyorchidium campanulatum* Haeckel; *Campanella chamissonis* Lesson); *Polyorchis pinnatus* Haeckel; *P. minuta* Murbach and Shearer; and *P. karafutoensis* Kishinouye. What is the systematic status of these several forms? In regard to *P. penicillatus,* see the following discussion under the treatment of this form.

Mayer (1910, p. 218) suggested that *Medusa campanulata* Chamisso and Eysenhardt, 1821, may be a synonym of *Polyorchis penicillatus,* indicating his doubt, however, by adding a question mark. If we are to accept at all the data in the original description, this identification must be unhesitatingly rejected, even though we take into account the evident incompetence with which the description was made. The most revealing difference is to be found in the arrangement of the tentacles. In *Medusa campanulata,* as in *Polyorchis (Scrippsia) pacifica,* the oldest tentacles are quite far removed from the umbrellar margin; while in *Polyorchis penicillatus,* their removal from the margin is very slight. Considering the emphasis placed on this feature in Plate 30, Figure 1*a,* of Chamisso and Eysenhardt (1821) and its systematic significance in this group of medusae (of which these authors knew nothing!), it can hardly be considered as justifiable to neglect it or to discard it as due to erroneous observation and recording. Most other authors have accepted this form as a distinct species. It may even be subgenerically different (see above, p. 108).

Polyorchis pinnatus Haeckel (1879, p. 149) was identified with *P. peni-*

cillatus by Mayer (1910, p. 218). Had Haeckel's single specimen of this form been taken in San Francisco Bay, this decision would undoubtedly have been fully justified. However, its locality was Honolulu in the Hawaiian Islands; i.e., it came from a region that shows little faunistic relationship to the California waters. This, of course, makes it necessary to proceed with caution.

Haeckel's specimen of *P. pinnatus* measured about 30 mm. in height, according to the magnification given for his Plate 8, fig. 13. The following specific features were particularly noted: (1) Radial canals, proximally to peduncular bend, without branches; distally to this bend, with 12–15 pairs of branches. (2) Tentacles, of uniform length, 40 in number. (3) Each radial canal with 8 gonads. From this it is evident that *P. pinnatus* agrees with the San Francisco Bay form of this genus in regard to the number of gonads while at the same time it differs very decidedly in respect to the number of tentacles: a specimen of *P. penicillatus* only 19 mm. high has not less than about 100 of them as compared with 40 in a specimen of *P. pinnatus* of 30 mm. height. The number of side branches on the radial canals also exhibits distinct differences. Other differences also may be adduced, e.g., the lengths of the tentacles and the arrangement of the branches on the radial canals. Unfortunately, however, it is probably fair to assume that these are in part due to Haeckel's somewhat superficial treatment of his material. Even so, the differences are too large to allow us to establish identity, at least until further observation on Hawaiian material justifies such procedure, especially if we also take the difference in geographical locations into consideration, as well as the systematic differentiations this genus exhibits along the California coast.

It may finally be noted in this connection that *P. pinnatus* does not agree sufficiently with any of the other forms of this genus occurring on the west coast of North America to justify full systematic identification; and that therefore, for the time being at least, it must be regarded as a distinct species.

There can be no doubt that *Polyorchis karafutoensis* is a distinct species; see Uchida (1925, p. 88, Fig. 13).

While the systematic positions of these forms may be regarded as reasonably certain, the nature of those forms of *Polyorchis* on the west coast of North America which are furnished with branched radial canals is very difficult, if not impossible, to decide at present with anything approaching scientific certainty, due to the absence of sufficient data. We can state with certainty that we have forms which show quite characteristic differences, while at the same time they present so striking similarities that unity of species at first sight appears probable. It may be that the observed differences are caused by direct environmental modifications and that they are not inherited, but until this has been proved experimentally, there seems to be no choice except to assume tentatively that we are concerned with systematically distinct forms which, in the absence of clear-cut transitions, probably should be best regarded as species.

The only form of this kind, besides *Polyorchis penicillatus*—the type species of the genus—named up till the present time, is *P. minutus,* a species established by Murbach and Shearer (1903, p. 174) on a single, small specimen taken in Puget Sound, Washington. The authors stressed that what they called Fewkes's "revised version" of *P. penicillatus* approached their new species "very closely. In fact we have only ventured to give it separate specific rank on account of size, a feature of no very great importance." They had found that their specimen, measuring only 15 mm. in height, was sexually mature, judged by the long gonads, and this size appeared to them too small to be compatible with previously published data.

There can be no doubt that *P. minutus* is very closely related to *P. penicillatus;* indeed, it would be rash to separate these two specifically if we had available only the descriptive and pictorial material given by Murbach and Shearer (1903). Fortunately, this is not the case. Foerster (1923, pp. 222, 226, 228, 232, and 250) presented under the name of *P. penicillata* observational data on a large material from Puget Sound. Judging by these data as well as by observations made by me on specimens from this locality, collected by Dr. T. Kincaid, I have concluded that we are concerned with a special form, different from the California species, and hence that the name of *P. minutus* should be maintained as a specific denotation. A very striking difference is found, for example, in the coloration. Foerster (*loc. cit.,* p. 251) states that *P. minutus* has the gonads, manubrium, and tentacle bulbs of a purple color, a condition found neither in *P. penicillatus* nor in *P. montereyensis.* Because the specimens which I obtained from Puget Sound were all large (more than 30 mm. high) and hence could not yield sufficient data for a detailed description, I have decided to desist from attempting to write a supplementary description and simply refer to Murbach and Shearer (1903) and to Foerster (1923, p. 250). It may finally be noted that Mayer, in his large "Medusae of the World," 1910, p. 219, states that the ocelli in *P. minutus* (which he accepts as a valid species) are yellow. This is misleading, yellow being the color only in preserved specimens. (Besides, by Murbach and Shearer, 1903, p. 174, *P. minutus* was noted by these authors in 1902, pp. 71, 72; Maas, 1904, pp. 425, 442; Mayer, 1910, p. 219; and Foerster, 1923, pp. 250, 251, who also noted this form under the name of *P. penicillata* on pp. 222, 226, 228, 232).

In regard to *P. penicillata* recorded by Fewkes (1889*a, b*) as well as the specimen recorded under this name by Bigelow (1940), see pages 120, 121, under "Remarks" to *P. penicillatus.*

Murbach and Shearer (1903, pp. 175–76) were right when they criticized Haeckel's (1879, p. 149) inclusion of the paired arrangement of some pinnate branches of the radial canals in the generic diagnosis of *Polyorchis.* This arrangement of the branches in the earliest published figures (Eschscholtz, etc.) is undoubtedly, as they suggested, simply due to the crudeness of the representation. Likewise, they were probably right when they criticized

Fewkes (1889*a, b*) for his representation of all these branches as paired in what he terms *Polyorchis penicillata* from southern California.

In addition to the forms of *Polyorchis* accepted in the foregoing as distinct species, I introduce in this report two new species, both from Monterey Bay, California, viz., *P. montereyensis,* with branched radial canals, and *P. haplus,* with simple radial canals. Since this study was begun on *P. montereyensis,* and since I have had available a much larger and more varied material of this form than of *P. penicillatus,* I have chosen to present it first and to give to it an elaborate description to be used for the purpose of comparison.

Polyorchis (Polyorchis) montereyensis Skogsberg, new species

Description: The largest among the hundreds of specimens seen by me were about 40 mm. high. Umbrellar outline somewhat variable; presents no distinct progressive change with age. Ratio between height and greatest width of body, 1.2 (1.0–1.6) : 1. Greatest width either about the middle of bell or near level of attachment of gonads. Aboral end of exumbrella usually almost semicircular in lateral outline and varies from this type gradually to the extremes of broadly conical shapes represented by Agassiz (1865, Fig. 179) and by Fewkes (1889*a,* Pl. 23); all of these shapes were found mingled with each other in Monterey Bay. Lateral sides of umbrella either broadly convex, with bell opening constricted (ratio between greatest width of bell and width of bell opening, about 1.3–1.4 : 1); or sides are more or less flattened, especially orally, the noted ratio sometimes being as low as 1.1 : 1. Velar opening about 0.6–0.7 the umbrellar opening (about as in Pl. 23 of Fewkes, 1889*a*); I never found it as small as indicated by Little (1914, p. 310, Pl. 13). Mesoglea quite firm, enough so to maintain shape of medusa out of water except for closing of umbrellar opening. Point of origin of manubrium about 0.25–0.40 the height of bell from exumbrellar apex (which shows size of the rounded gastric peduncle); it should be noted that my smallest specimen was about 6.0 mm. high; in still smaller specimens, this peduncle probably is smaller, as indicated by Fewkes (1889*b,* p. 106) and Foerster (1923, p. 252).

Tentacles increase in number throughout life; arranged in 1–4 fairly distinct, concentric circles, the number of circles depending on age of specimen; in specimens of the usual sizes (15–25 mm. high), number of circles is 3. Number of tentacles varies as follows in relation to height of bell: (height of bell, 1–4 mm., tenacles, first 4 and then 8; these values are assumptions since I have not as yet seen any specimens of these sizes); height of bell 5 mm., tentacles 16; bell 6–10 mm., tentacles 24; bell 8–10 mm., tentacles 32; bell 10–15 mm., tentacles 40; bell 12–17 mm., tentacles 44; bell 17–20 mm., tentacles 48; bell 25–30 mm., tentacles about 72; bell about 35 mm., tentacles around 80. From this it will be seen that there is a considerable variation in regard to the ratio between the size of the bell and the number of tentacles.

Even more striking deviations from the typical ratios were observed. Thus, in a couple of specimens about 18 mm. high, the number of tentacles was not less than 64; and in one of 26 mm., I counted as many as 88. All of these variations were found in one and the same population, taken within the harbor of Monterey. What the maximum number is is not known. In old specimens, size differences among earlier tenacles become negligible, if not obliterated. Oldest tenacles are hardly at all removed from the bell margin. When relaxed, medium-sized specimens may have tentacles as much as five times longer than bell is high. Tentacular bulbs, if present, are not marked off clearly from rest of tentacles.

In specimens about 6.0 mm. high, manubrium extends, when relaxed, to a point about ⅔ the height of bell from apex of exumbrella; in specimens about 7.0 mm. high, it may extend to velum; and in older specimens it may extend slightly beyond this structure. In specimens as large as 10 mm., oral lips may be nearly even, but usually marginal folding begins somewhat earlier than in this stage.

In specimens about 6.0 mm. high, each radial canal may have as few as 10–12 knob-like side branches on either side, beyond peduncular bend; but this number may be as high as 20–25 at this early stage, i.e., within the range characteristic of older specimens which is from 19 to 33. Thus the full number of these branches seems to develop nearly simultaneously at a very early stage. Sometimes almost the entire range of variation has been found in the 4 canals of a single specimen; the prevailing numbers are 25–30. Most of the branches of the two sides of each canal alternate irregularly; see "Remarks" to subgeneric diagnosis, page 112; proportion of paired branches varies even among the 4 canals of each specimen. From their knob-like beginning, most of the branches increase in length, some, although seldom, reaching a maximum length of about 0.20 the distance between radial canals. Longest branches occur near the middle of bell; in oral portion of radial canals, branches usually more or less small and rather few in number. Scattered among the longer branches there are often a few smaller ones (some of which may possibly be of later development); among these there may be some which are so small that it is difficult to decide whether they should be counted, a fact that makes the establishment of the number of branches uncertain. At first, side branches are simple, fairly straight, and nearly at right angles to radial canals. Later a variable number of them begin to become irregularly bent, slightly enlarged distally; or they send out, in distal half, 1–4 short, irregular secondary branches. In exceptional cases, a few of these secondary branches may even anastomose with neighboring branches of the same radial canal, thus forming local reticulation. In regard to these irregularities, it should be especially noticed that the 4 radial canals may be quite independent in their variations. In this connection it should be added that, although very rarely, even the main radial canals may be more or less irregular; thus I have seen specimens in which 1 or 2 of these canals had a more or less zigzag course. At place where radial canal bends over on gastric peduncle ("peduncular bend"), there are, on either side of canal, about 7–10 closely-set, fine, somewhat irregular but not much branched branches, the longest of them usually somewhat shorter than longest branches beyond this bend. On radial canals of gastric peduncle, thus among gonads, branching is very variable. Often 1–2 of these canals are unbranched or furnished with only a few short branches; at other times, there are 5–8 medium-sized branches on either side of each canal; and in one specimen, 25 mm. high, I even found these branches of the 4 radial canals quite well anastomosed. In each quadrant, ring canal usually has about 8–15 irregularly spaced, blind branches, most of them very short, knob-like; sometimes their length may be as much as five times width of ring canal (Agassiz, 1865, Fig. 183); they may even show signs of branching. As many as 16–20 were counted in the quadrants of one specimen, and in all probability larger numbers will be found; exceptionally, specimens were found with no branches of this kind. There was no regular spacing between these branches and canals leading to tentacles.

When comparatively few, gonads usually are located near middle of radial canals on gastric peduncle; when many, they occupy nearly entire length of these peduncular canals. Number of gonads difficult to establish for two reasons: first, some gonads may be so small that it is nearly arbitrary whether they should be counted; second, some gonads are branched in many specimens. Branching may take place at any level of gonad; when it occurs very close to radial canal, it may become almost impossible to decide with certainty whether there is a common part or whether "branches" originate directly from radial canal. Gonads begin to appear in specimens 5–6 mm. high and increase in number with age. Mature gonads may be found in specimens about 13 mm. high. Number of gonads on each radial canal varies even among the 4 canals of each specimen; thus, for example, in a specimen 30 mm. high, these canals carried 25–29–30–34 of them. Maximum number not known; as many as 45 have been counted. Under adverse conditions, gonads are reduced; in specimens about 25 mm. high which had been submitted to prolonged starvation, as few as 6–10 were found on each canal. When fully developed, longest gonads may extend nearly to velum, while others at the same time are still very short; relative position of gonads of different lengths variable. When branched, each gonad usually has only one branch, but 2–4 branches have been recorded. Usually only a rather small number of the gonads are branched.

Basal part of each tentacle has dark red to purple coloration, often with brownish admixture. Since this tentacular part is furnished with a rounded mammilliform extension (Fig. 2) covering exumbrellar side of bell margin, and since sizes of tentacles differ in a more or less regular sequence, this coloration assumes quite a striking and distinctive pattern. Colored zone extends often around base and covers a distance from tip of base that is slightly less to somewhat more than basal width of tentacle. Within the mammilliform projection of tentacle base the eye forms a round, red-black spot. Rest of body fairly transparent, of greyish tone, sometimes with a faint somewhat pinkish tinge. However, canals of digestive tract and of gonads tend to absorb color of food. (Thus, for instance, these structures became brown in my cultures after a richly red-brown copepod, *Tigriopus fulvus,* had been used as food. This coloration of the endodermal cells remained during quite a long period of starvation, a fact that made the study of the canal system very easy.)

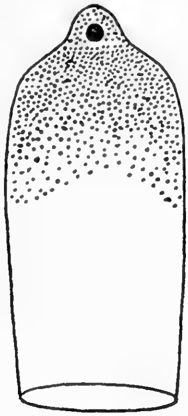

FIG. 2.—*Polyorchis montereyensis.* Diagram of base of tentacle, in which general distribution of pigmentation is indicated by stippling. In proximal portion of pigmented area, chromatophores are so close that pigment appears continuous; toward distal portion, chromatophores are more or less spaced.

Occurrence: By far the most commonly observed Hydromedusa in Monterey Bay, California, where it has been recorded throughout several years (1937–1942), from February to December, inclusive, in Monterey Harbor (type locality). In this locality the species was characterized by as yet unexplained prolonged periods of absence, followed by periods when it occurred in moderate to large numbers. Spawning specimens and specimens of very different sizes were present throughout the noted months. Hydroid stage not yet found.

Surface temperatures throughout the years 1919 to 1928, inclusive, ranged from 14.9° to 9.2° C.; the usual range is 11°–13° C. Salinity for the same period ranged from 32.5 percent to 34.1 percent, according to records taken at Hopkins Marine Station of Stanford University, located less than one English mile from the type locality (Bigelow and Leslie, 1930, Bull. Mus. Comp. Zool. Harvard Coll., **70**: 5; 1930).

The species does not appear to have been recorded in literature before.

Remarks: This species differs from *Polyorchis penicillatus* of San Francisco Bay mainly in having a larger number of gonads and branches on the radial canals and a smaller number of tentacles; the pigmentation at the base of the tentacles also shows a striking and readily recognizable difference.

Polyorchis penicillatus (Eschscholtz)

Non Medusa campanulata, Chamisso and Eysenhardt, (1821), p. 359, pl. 30: 1*a*, *b*, *c*. (This, of course, also eliminates the several synonyms of this species.)

Melicertum penicillatum, Eschscholtz (1829), p. 106, pl. 8:4; Blainville, (1834), pl. 38;—Dujardin (1840), p. 160;—Agassiz, L. (1862), pp. 348, 349;—Agassiz, A. (1865), p. 119;—Haeckel (1879), pp. 136, 149, 150;—Murbach and Shearer (1903), p. 176;—Maas (1904), pp. 425, 442;—Bedot (1905), p. 144;—Foerster (1923), p. 250.

Melicertum penicillata, Lesson (1843), p. 293;—Agassiz, A. (1865), p. 119.

Aglaura pencillata, Blainville (1834), p. 283, pl. 33: 4;—Agassiz, L., (1862), pp. 348, 349;—Agassiz, A. (1865), p. 119;—Haeckel (1879), p. 150.

Polyorchis penicillata, Agassiz, A., *in* Agassiz, L. (1862), *part.*, p. 349;—Agassiz, A. (1865), *part.*, p. 119, figs. 179–183;—Haeckel (1879), *part.*, p. 150;—Murbach and Shearer (1903), *part.*, p. 175;—Bancroft (1904), pp. 43–46, 4 text figs.;—Maas (1904), pp. 425, 442;—Bedot (1905), *part.*, p. 144;—Torrey (1909), p. 16;—Mayer (1910), *part.*, p. 218, fig. 111;—Little (1914), pp. 307–328, pls. 13–15;—Johnson and Snook (1935), *part.*, p. 66, fig. 55.

Non Polyorchis penicillata, Foerster (1923), pp. 222, 226, 228, 232, 250; refers to *P. minutus*.

Polyorchis penicillatus, Haeckel (1879), *part.*, p. 149;—Maas (1904), *part.*, pp. 425, 442; —Foerster (1923), *part.*, p. 250.

Polyorchis eschscholtzii, Haeckel (1877), *part.*, no. 147; (1879), *part.*, p. 150.

Non Polyorchis pinnatus, Haeckel (1879), p. 149, pl. 8:13;—Maas, (1904), pp. 425, 442;—Mayer (1910), p. 218;—Foerster (1923), p. 250.

Polyorchis, Loeb (1906*a*), pp. 87, 88, 89, 90, 91, 141; (1906*b*), p. 427;—Maccallum (1907), p. 385.

Description: Largest specimens recorded so far, about 25 mm. high. Ratio between height and greatest width of bell, about 1.0–1.3 : 1. Greatest width either at about the middle or somewhat closer to apex of bell. Aboral end of exumbrella usually almost semicircular in lateral outline; only very few specimens have a tendency toward the formation of a small, broadly rounded apical cone. Sides of bell usually subvertical; more or less flattened, especially orally; and oral constriction frequently very slight or not developed at all. Velar opening about 0.4–0.5 the umbrellar opening (whether it ever is so small as figured by Little, 1914, Pl. 13, Fig. 1, seems uncertain). In large specimens gastric peduncle of about the same size as in *P. montereyensis*.

Tentacles increase in number throughout life; arranged in 1–4 concentric circles. Number of tentacles increases very rapidly with age, as shown by the following values: height of bell about 2 mm., number of tentacles 12–16; height of bell about 3.5 mm., number of tentacles about 24; height of bell about 10 mm., number of tentacles about 50; height of bell about 19 mm., number of tentacles about 100; height of bell about 21 mm., number of tentacles about 120. Maximum number of tentacles so far recorded, 160. In older specimens, size differences among most tentacles, except the latest ones, are nearly negligible. Oldest tentacles are but slightly removed from bell margin. In Little (1914, Pl. 14, Fig. 3), tentacles drawn in a manner suggestive of presence of large, well-marked tentacular bulbs; tentacular bulbs, if at all present, usually are not clearly marked off from the rest of tentacles. Manubrium as in *P. montereyensis*. (It may be noted that Little's [1914, p. 310] statement that there is an "enlarged sac-like stomach" at place where radial canals meet is incorrect. In accordance with family diagnosis given above, no such differentiation occurs.)

Number of branches on either side of each radial canal, beyond peduncular bend, about 16–25 of sizes about as in Little's (1914) Plate 13, Figure 1, except that among the well-developed branches shown in this figure, there are a number of scattered, very short, more or less knob-like ones. Sometimes most of the well-developed ones are about equal in size, as in the noted figure; but at other times those near the middle of bell are slightly longer than the others. Branches near margin of bell are both few and short. A varying number of the branches have 1–4 secondary branches, mostly knob-like, a few of which may in their turn be branched. In a few instances, anastomosis has been observed between neighboring branches. Proximally to peduncular bend, there are about 5–7 branches on either side of canal, of lengths about as those beyond this bend. Among gonads, there are on either side of radial canals 0–5 usually knob-like, irregularly placed branches. The 4 radial canals of each specimen vary independently of each other in respect to branching. In each quadrant, ring canal has about 0–6 irregularly spaced, blind branches, mostly knob-like, at most a few times longer than canal is wide.

Gonads located near middle of radial canals of gastric peduncle; their number small, each group containing only 4–11, averaging about 8; branching occurs, but rarely. Relative position of gonads of different lengths varies.

Pigmentation restricted to the bases of the tentacles where it is much less developed than in *P. penicillatus*. In regard to the distribution of the pigment, I refer to Little (1914, Pl. 15, Fig. 8). As will be seen from this picture, the pigment is very scarce, sometimes nearly absent outside the ocellus, occupying somewhat different patterns in different individuals. These patterns agree closely with what I have observed in freshly killed material sent me from San Francisco Bay by Dr. R. Stohler, of the University of California, Berkeley. In regard to the nature of the pigment, Little (*loc. cit.*, p. 312) gives red and brown, while Dr. Stohler informed me by letter that he had found it maroon with a purplish hue or purplish with a brownish hue—in other words, about the same colors that I found in the case of *P. montereyensis*.

Occurrence: This species is common in San Francisco Bay, California, where Little (1914, p. 308) found it from December to the middle of April. For a period of one year, beginning in the middle of December 1942, daily records of this species were made from a pier in this bay (at Berkeley) through the arrangement of Dr. R. Stohler. General estimates of frequency and size were recorded, and data pertaining to tidal phase and general weather conditions at the hour of the day when the observations were made were also entered in the records. An analysis of these data shows that *Polyorchis penicillatus* was observed near the surface all the year around, with the exception of a period from August 9 to October 8, 1943, when the records were consistently negative. During the rest of the time, no distinct regularity was evident in the occurrence. Usually at least a few specimens were seen, but there were irregular periods of absence, in some cases as long as 14 days. The causes for these periods of absence could not be deduced from the available data. The occurrence at the surface appears to be remarkably independent of the tidal phases, of rain and sunshine, and of calm and rough water; also, observations were made at various hours of the day and from these observations there appeared no indications of a daily rhythm. Finally, it may be noted that large and small specimens were seen throughout the year, although on this point the records are too incomplete for certainty of statement. No other locality for this species is as yet known.

Remarks: This species was possibly first described by Eschscholtz (1829, p. 106, Pl. 8, Fig. 4) under the name of *Melicertum penicillatum.* The original description is very incomplete and is in addition, at least in some respects, incorrect. As for the type locality, Eschscholtz simply records: "Coast of California."

Considering the fact that we evidently have more than one form of the genus *Polyorchis* along this coast, the uncertainty both in regard to description and type locality is extremely unfortunate. Indeed, perhaps it would even justify the relegation of this species of Eschscholtz to *"Species incertae sedis."* I know of no account of the localities visited by Eschscholtz during the six years of voyages when he made his observations and collections. However, considering the fact that in the earliest part of the nineteenth century shipping in California was quite undeveloped except in the region about San Francisco, it is not unreasonable to assume that Eschscholtz secured his type material of this species while at anchor in San Francisco Bay, especially since there is a form of this general appearance which is rather common in this neighborhood. For this reason and because A. Agassiz acquired most of his material of *Polyorchis penicillata* (Eschscholtz) from San Francisco Bay. I have decided that it is reasonable to maintain this species of Eschscholtz as identifiable. A factor that contributes to the advisability of this decision is that its acceptance will imply a minimum of nomenclatural changes. Other factors worthy of notice in this connection are that Agassiz's redescription is quite acceptable, and that the form treated by him should be regarded as the type of the genus *Polyorchis.* Because of the fact that some of Agassiz' material was taken in the waters of the Strait of Georgia, British Columbia, hence in the region of *P. minutus, P. penicillata* Agassiz is stated as only partly identical with *Melicertum penicillatum* Eschscholtz in the list of synonyms given in the foregoing discussion.

In regard to *Polyorchis penicillata* Fewkes (1889*a,* p. 593, Pl. 23, Text Fig. 4; 1889*b,* p. 103, Pl. 4, Figs. 6, 7), it has not been included in the above list of synonyms because of its uncertain status. It was taken south of Point

Conception in southern California, and at this place there is a very decided faunistic change associated with oceanic circulatory phenomena.

Polyorchis penicillata, Johnson and Snook (1935), is furnished with a *part.* because of the color notation: "stomach, gonads, tentacle-bulbs, and radial canals are reddish brown to purple." This indicates that at least part of their material had a northern origin.

Polyorchis penicillata, Bigelow (1940, p. 296), refers to a single specimen. This is entirely too scantily described for full certainty of specific identification and, in addition, it was taken very far to the south of the type locality of this species, viz., in the Gulf of California, a region characterized by tropical waters. Considering the difficulties inherent in the classification of the species of *Polyorchis,* it was judged advisable under these circumstances not to include this record in the above list of synonyms.

In regard to the remaining names in this list, it should be noted that all of them refer either to Eschscholtz's original material or to the species described by A. Agassiz. The names referring to the latter are furnished with a *part.* to indicate the restriction attached to Agassiz' form.

The description given above is based in part on data taken from Little (1914), partly on specimens from San Francisco Bay where they had been collected by Dr. R. Stohler and kindly sent to me.

Polyorchis (Polyorchis) haplus Skogsberg, new species

Description: Largest specimens recorded were about 20 mm. high; most specimens seen were about 15 mm. high or less. Ratio between height and greatest width of body, 1.1–1.3 : 1. Greatest width either at about middle of body or somewhat above. Aboral end of exumbrella almost semicircular in lateral outline; broadly conical shapes, such as figured for *P. penicillatus* by Agassiz (1865, Fig. 179) and Fewkes (1889*a,* Pl. 23), were never seen. Lateral sides of umbrella broadly convex, usually somewhat flattened toward oral end; ratio between greatest width of body and width of bell opening, about 1.3–1.4 : 1. Velar opening, mesogloea, and point of origin of manubrium about as in *P. penicillatus.*

Tentacles arranged in fairly distinct concentric circles. Number of tentacles comparatively small. Whether there is an increase throughout life is uncertain; it should be noted that in the oldest specimen observed there were not even the slightest indications of tentacular buds despite the fact that the latest tentacles were large and well developed. Number of tentacles varies about as follows in relation to height of bell: height of bell ?–7 mm., tentacles 16; bell 8–11 mm., tentacles 18–20; bell 12–20 mm., tentacles 24 (possibly the maximum number). There undoubtedly is a greater variation in regard to ratio between size of bell and number of tentacles. Oldest tentacles hardly at all removed from bell margin. Length of manubrium about as in *P. penicillatus* but in large specimens lips appear to be slightly less folded than in that species.

In specimens up to about 17 mm. high., all canals appear to be simple, i.e., without any side branches. In the oldest specimens (about 20 mm. high), the radial canals are either simple or are furnished with closely set, knob-like branches, less than or about as long as width of canals; ring canal may also be furnished with a few branches of this kind, and, occasionally, both types of canals may be furnished with a few somewhat longer, simple branches at about right angles to main canals. Thus in most specimens of this species as yet recorded, all canals were simple, and it is to this peculiarity that the species owes its name. Bend of radial canal at base of gastric peduncle forms, on the average, a more pronounced and acute angle than in *P. penicillatus;* and this feature emphasizes the fact that the peduncle is more conical than in the noted species.

When comparatively few, as in young specimens, gonads are located on inner half of radial canals of gastric peduncle; when many, they occupy entire length of peduncular canals. Number of gonads is difficult to establish for same reasons as in *P. penicillatus;* number appears to vary between 20 and 25 on each canal in fully developed specimens. When fully developed, longest gonads reach nearly to velum. Those close to manubrium usually are the longest, and this causes gonads to appear to be more crowded to manubrium than in *P. penicillatus.* Only a small number of gonads are branched; I have not seen more than one branch to any gonad. Mature gonads may be found in specimens about 12–13 mm. high.

There is a small area of deep red pigment around each eye, not much larger than the mammiliform projection on which the eye is placed. Tentacles and gonads of a yellowish tinge, sometimes quite canary yellow; this color, which is quite characteristic of the species in contrast with *P. penicillatus,* remains even after a prolonged period of starvation in aquarium. In some specimens, however, the yellow is very faint, yielding to a greyish-brown tinge. Rest of body fairly transparent and of a greyish tone.

Occurrence: So far recorded only at Monterey (type locality), where it was found in the harbor as well as in shallow water off a sandy beach; in latter place it was taken while dredging for sand dollars (*Dendraster*). Rare or moderately common from August to November.

Remarks: The presence of a species with unbranched radial canals within the genus *Polyorchis* is very interesting indeed, since it clearly indicates that the branching phenomenon does not have the fundamental significance attributed to it by many of the leading taxonomists of the Hydromedusae. As a matter of fact, the branching of the radial canals offers many excellent examples of the important role played by convergence in the evolutionary history of this group. It may be of interest to recall in this connection that Murbach and Shearer (1903, p. 177) state that the comparatively late appearance of the branches on the radial canals, in the postembryonic development, "points to their being a recent acquisition in the evolution of the race, probably within the limits of this particular group" (*Polyorchis*).

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PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series
Vol. XXVI, No. 6, pp. 125-133, pl. 2, figs. 1-12 June 28, 1948

+ # 7

NEW FOSSIL CYPRAEIDAE FROM THE MIOCENE OF FLORIDA AND COLOMBIA*

BY

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Three extinct species of Cypraeidae from the Miocene of Alum Bluff, Calhoun County, Florida, and two extinct species from Miocene strata in the vicinity of Tuberá, Colombia, are herein described.

These new Cypraeidae from Florida bring the total of recognized species and subspecies of extinct fossil Cypraeidae described from North America to forty-two (Ingram, 1942). The Colombian species described here were referred to by Anderson (1929) in his work on the marine Miocene of northern Colombia. He considered them both to be *Cypraea henekeni* Sowerby (Sowerby, 1850).

The writer wishes to express his thanks to Dr. G. Dallas Hanna and to Dr. Leo George Hertlein of the Department of Paleontology of the California Academy of Sciences, who allowed the writer to examine the collections of Cypraeidae in that institution, and who for a number of years have extended every courtesy to the writer in his conchological work. The writer also wishes to express his appreciation to Dr. Herbert W. Graham, Professor of Biology at Mills College, for making the illustrations of the holotype specimens.

Florida Species

Cypraea hertleini Ingram, new species

Plate 2, figures 1, 2

Shell bulbous, sloping steeply in lateral profile from the dorsum toward the anterior and posterior canals; spire obscured; sides of shell calloused; callosity of sides extends over lateral margins of dorsum, leaving an undu-

* Manuscript received October 19, 1944.

lating pattern on top of the dorsum; pattern superficially recalls the dorsal pattern of *Cypraea spadicea* Swainson; a 4 mm. wide shelf is present dorsally over anterior canal, shelf lacking over posterior canal; base convex, upturned at lateral margins, leaving a barely visible ridge at dorsal margin of upturned basal sides, and recalling a similar condition in *Cypraea arenosa* Gray; anterior canal extremity straight ventrally, strongly curved to the left dorsally; posterior canal turned toward the left; anterior canal lips of equal length; anterior canal 3 mm. broad by 4 mm. wide; terminal ridge of anterior canal sunken; anterior region of outer lip declivous; outer lip teeth approximately 4 mm. long; outer lip teeth along anterior one-half of lip have interstices of approximately 1 mm.; along posterior one-half interstices are approximately 1.50 mm. wide; anterior columellar teeth over anterior two-fifths of lip exist as nodules, the longest two extending 2 mm. into the aperture on the columella of the shell; three poorly developed non-noduled teeth are present on the central fifth of the columella; posterior two-fifths of the columella without teeth; barely noticeable depression on columella just posterior to the terminal ridges; columella from terminal ridge to approximately mid-point of its length slightly concave; columella from mid-point to posterior extremity convex; columellar surface just behind terminal ridge approximately 10 mm. deep; aperture 5 mm. wide anteriorly just behind terminal ridge, and narrowing posteriorly to 3 mm. just in front of posterior canal. The type measures: length, 40 mm.; breadth, 29.50 mm.; height, 22.50 mm.

Holotype, No. 8044, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about twenty feet above the water level, on the left bank of the Apalachicola River, about three and one-half miles above Bristow, at **Alum Bluff on Apalachicola River, Calhoun County, Florida**; E. L. Packard, collector. Lower Miocene.

Discussion: Preservation in the holotype is excellent. The outer layer of the shell is nearly intact except where sand grains have made small, narrow, longitudinal furrows over the central region of the dorsum. The shell color is faded, but evidence is present to indicate that while living this species possessed four color zones: a broad basal zone, a broad lateral zone, a line color zone that bounded the dorsal designs, and the dorsal design. The line color zone exists in the holotype as an orange-brown line; the color from the other zones has faded.

This species is named for Dr. Leo George Hertlein, Assistant Curator, Department of Paleontology, California Academy of Sciences, who has untiringly given his time to aid the writer.

Cypraea apalachicolae Ingram, new species

Plate 2, figures 6, 8

Shell bulbous, sloping steeply in lateral profile toward the anterior canal; posteriorly the slope is marked by a broadly open concavity above the outer lip side of the shell; calloused base; callosity of the base extends up to the lateral margins, recalling a similar condition in *Cypraea arenosa* Gray; dorsum unornamented; dorsal shelf over anterior canal 5 mm. wide; shelf absent over posterior canal; base convex; upturned lateral margins of base leave a series of small, smooth, barely discernible nodules on the outer lip side of base; nodules lacking on outer surface of columella side of base; anterior canal straight ventrally and dorsally; posterior canal turned toward the left; terminal ridge of anterior canal sunken; anterior region of outer lip declivous; outer lip teeth approximately 5 mm. long; teeth along anterior one-half of outer lip have interstices of approximately 1 mm., along posterior one-half of approximately 1.50 mm.; anterior columellar teeth over anterior two-fourths of columella well developed, nodule-like; those of third fourth extremely small, barely visible; those over posterior one-fourth well developed, nodule-like; columella teeth longest over anterior one-fourth, extending 3 mm. into the aperture; strong depression visible on interior columellar surface posterior to terminal ridge; columella from terminal ridge caudad one-third, strongly concave; columella strongly convex over posterior two-thirds; concave surface of columella is produced enough to be considered a toothless fossula; aperture 3 mm. wide just behind posterior canal, 5 mm. wide anteriorly over fossula. The type measures: length, 48 mm.; breadth, 37 mm.; height, 28 mm.

Holotype, No. 8045, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about twenty feet above the water level, on the left bank of the Apalachicola River, about three and one-half miles above Bristow, at **Alum Bluff on Apalachicola River, Calhoun County, Florida;** E. L. Packard, collector. Lower Miocene.

Discussion: The outer layer of the shell is missing from the posterior and lateral two-thirds of the shell. A piece is broken from behind the terminal ridge on the anterior columellar base of the shell. No dorsal pattern is present on the part of the dorsum remaining intact.

This species is related to *C. hertleini* Ingram, but it differs from that species in possessing a defined, toothless fossula, in having a straight anterior canal ventrally and dorsally, in possessing teeth along the entire columella, in lacking an ornamented dorsum, and in that the posterior canal is produced.

Cypraea alumensis Ingram, new species

Plate 2, figures 3, 4

Shell ovate, sloping gently in lateral profile toward the anterior and posterior canals; shelves over both canals, anterior one 2 mm. broad, posterior one 4 mm. broad; lateral margins calloused; base calloused, convex, angled upward at its union with shell sides; terminal ridge extends directly back from columellar side of aperture and bends dorsad into shell; fossula absent; anterior canal straight ventrally, curved to left dorsally, 1.50 mm. wide and 3.50 mm. long; posterior canal slightly curved to the left, 2 mm. wide and 4 mm. long; outer lip teeth declivous at anterior extremity; outer lip teeth with interstices of approximately .50 mm., confined to the aperture, and extending dorsad around lip into shell; teeth very minute caudad on outer lip, and extending on to posterior canal; first anterior columella tooth very elongate, narrow, next two nodule-like, remainder of teeth elongate, fine with broader interstices than those of anterior three teeth. The type measures: length, 28.50 mm.; breadth, 20.50 mm.; height, 14.50 mm.

Holotype, No. 8043, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about twenty feet above the water level, on the left bank of the Apalachicola River, about three and one-half miles above Bristow, at **Alum Bluff on Apalachicola River, Calhoun County, Florida;** E. L. Packard, collector. Lower Miocene.

Discussion: The shell is moderately eroded; no indication of its original color remains. The aperture area and the lips are intact.

Discussion of Fossil Relationships of Florida Species

Aside from the relationship of *Cypraea hertleini* Ingram and *Cypraea apalachicolae* Ingram, pointed out in the foregoing, these two species are quite distinct from other Cypraeidae of the Western Hemisphere. Superficially they recall the extinct lower Miocene species, *Cypraea chilona* Dall, from the Chipola Beds, Alum Bluff, Florida (Dall, 1900; Ingram, 1939, 1942). However, the columellar teeth are not so well developed in *C. chilona;* the shell is flattened dorsoventrally; there is a flange on the columellar side of the anterior canal; and the shelf over the anterior canal is absent.

Cypraea alumensis Ingram bears relationship to *Cypraea heilprini* Dall from Ten Mile Creek, Calhoun County, Florida (Dall, 1890). This extinct lower Miocene species differs from *C. alumensis,* however, by possessing unequal posterior canal lips, by having the outer lip teeth extend over the lip and not confined to the aperture, and by lacking well-defined differentiation of the columellar teeth. Dall (1890) in describing *C. heilprini* likened this species to *Cypraea pinguis* Conrad.

Cypraea alumensis also shows affinity to *Cypraea ballista* Dall, from the Miocene of the Tampa Silex beds at Ballast Point, Tampa Bay, Florida; it differs, however, in having the outer lip teeth more nearly confined to the aperture; in lacking the widened aperture area just posterior to the terminal ridge; in having well-defined columellar teeth along the anterior one-fourth of the columella; and in having the posterior canal strongly curved to the left rather than being straight.

Cypraea alumensis Ingram is, in several characteristics, likewise similar to the living West Coast species, *Cypraea robertsi* Hidalgo, except in lacking a toothed fossula; in having the columellar teeth more nearly confined to the aperture, of a different shape, and more numerous; and in having a more produced posterior canal. Distributional records of the living species indicate that it is found at: Colombia; Taboga Island, Panama; Pacific side of the Canal Zone; Gulf of Fonseca between Costa Rica and Nicaragua; Concepción Bay and La Paz, Lower California; and Guaymas, Sonora, Mexico.

Other extinct Florida species, described from the Miocene, are quite distinct from those discussed above. Such species are *Cypraea carolinensis floridanus* Mansfield described from the Tamiami Trail, forty-two miles west of Miami, Florida, by Mansfield (1931), and *Cypraea tumulus* Heilprin from Ballast Point, Hillsboro Bay, Florida, a species that Dall (1890) considered to be a synonym of *C. pinguis,* but referred to as a valid species when he described *C. ballista,* discussed above (Dall, 1915).

Colombian Species 3

Cypraea andersoni Ingram

Plate 2, figures 5, 7

Shell heavy with a high dorsum, in lateral profile sloping gradually toward the anterior and steeply toward the posterior canal; posterior canal produced 5 mm., sides flaring out at free extremity; two nearly obscured protuberances on dorsum just anterior to the central transverse axis of dorsum; base convex and upturned on its lateral margins; anterior canal not produced, and minute for size of mollusk, 3 mm. long by 3 mm. broad, curved to the left; terminal ridge sunken, sloping immediately into shell aperture; fossula absent; anterior region of outer lip notably constricted; outer lip teeth run from anterior end of constricture to beginning of posterior canal; teeth with interstices of from 1 to 1.50 mm. broad, teeth curved around lip into shell; columellar teeth elongate, running into aperture on columella, interstices from 1 to 2 mm. broad; longest columellar teeth from 3 to 5 mm., in central columellar region; posterior columellar teeth poorly developed, as slightly raised lines; teeth on both lips confined to the aperture; aperture curves to the left anteriorly and posteriorly; aperture 8 mm. broad just behind terminal ridge, and 5 mm. broad just in front of posterior canal. The type measures: length, 60 mm.; breadth, 44 mm.; height, 32 mm.

Holotype, No. 8042, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 267B (C.A.S.), Tuberá Hill at west base of Tuberá Mountain, in the lower part of the Tuberá group, **1 mile west of Tuberá, Colombia**; Frank M. Anderson, collector. Middle Miocene.

Discussion: The holotype is moderately eroded dorsally; the shell is not fragmented. By scraping the sand matrix from its interior the characteristics of the teeth, canals, and aperture were revealed.

This species is named for the late Dr. Frank M. Anderson, Honorary Curator, Department of Paleontology, California Academy of Sciences.

Cypraea tuberae Ingram

Plate 2, figures 9, 12

Shell heavy with a high dorsum, in profile sloping steeply immediately into the posterior canal notch, and sloping gradually toward the anterior canal; sides are streaked in brown, recalling the condition in *Cypraea mus* Linnaeus;

one tubercle present on right of dorsum just above and to the right of the posterior canal notch; base flat, upturned at lateral margins but slightly; line of base demarcation well developed at lateral margins; posterior canal notch 8 mm. deep; distally free extremities of notch constricted (i.e., notch 8 mm. wide at base, and 5 mm. wide at free extremities); anterior canal bounded by two fractured flanges, remnants of right flange 8 mm. wide, of left flange 12 mm. wide; aperture curved to the left anteriorly and posteriorly; aperture has maximum width, 7 mm., just posterior to terminal tooth, and is narrowest, 5 mm., just behind posterior canal; teeth on anterior margin of outer lip declivous; outer lip teeth interstices from 1.50 to 2 mm.; teeth on anterior one-half of outer lip elongate, on posterior one-half nodule-like; columellar teeth longest at anterior and posterior regions of columella, approximately 5 mm. long, shortened in the columellar center to 2 to 3 mm. The type measures: length, 64 mm.; breadth, 47.50 mm.; height, 35 mm.

Holotype, No. 8041, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 267B (C.A.S.), Tuberá Hill at west base of Tuberá Mountain, in the lower part of the Tuberá group, **1 mile west of Tuberá, Colombia;** Frank M. Anderson, collector. Middle Miocene.

Discussion: Color markings are partially preserved, indicating that the base and lateral surfaces were probably brown. The outer shell layer on the left posterior region of the dorsum has been broken away, possibly carrying away one tubercle, since one remains, and such protuberances in the Cypraeidae are typically bilateral. The shell would have a greater length if a part of the flanges on either side of the anterior canal had not been broken away.

Discussion of Relationships of the Colombian Species

Cypraea andersoni and *Cypraea tuberae* described in the foregoing belong to the "*Cypraea henekeni* Sowerby group" of Cypraeidae. Evidence indicates that the "*C. henekeni* group" may generally denote the presence of approximately Miocene strata. Of the nine species and subspecies of the related Cypraeidae belonging to this group in the Western Hemisphere, all but one are of Miocene occurrence, and the authors of this one exception, *Cypraea cayapa* Pilsbry and Olsson (1941), state in describing their species from the Pliocene of Ecuador that it possibly belongs to "an older fossiliferous series." The extinct species of the Western Hemisphere related to the two new Colombian species appear to be: *Cypraea almirantensis* Olsson (1922) from Water Cay, Panama, Gatun Stage, middle Miocene; *Cypraea angustirima* Spieker (1922) from the lower Zorritos, Quebrada Zapotal, Peru, middle Miocene; *Cypraea henekeni* Sowerby (1850) from Santo Domingo, middle Miocene; *Cypraea henekeni potreronis* Ingram (1939) from Rio Amina near Potrero, Provincia de Santiago, Santo Domingo, Gurabo formation, middle Miocene; *Cypraea noueli* Maury (1917) from Cercado de Mao, Santo Domingo, middle Miocene; and *Cypraea henekeni amandusi* Hertlein and Jordan (1927) from San Ignacio Arroyo, southwest of San Ignacio, Lower California, Isidro formation, middle Miocene. Of these species, *C. almirantensis* Olsson is unusually elongate as the holotype figure indicates, and does not have the typical shape of the other species in the *C. henckeni* group.

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PLATE 2

Figs. 1–2.—*Cypraea hertleini* Ingram, new species. Length, 40 mm., breadth, 29.50 mm., height, 22.50 mm. Holotype, No. 8044, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about 20 feet above the water level, on the left bank of the Apalachicola River, about 3½ miles above Bristow, at Alum Bluff on Apalachicola River, Calhoun County, Florida; lower Miocene. P. 125.

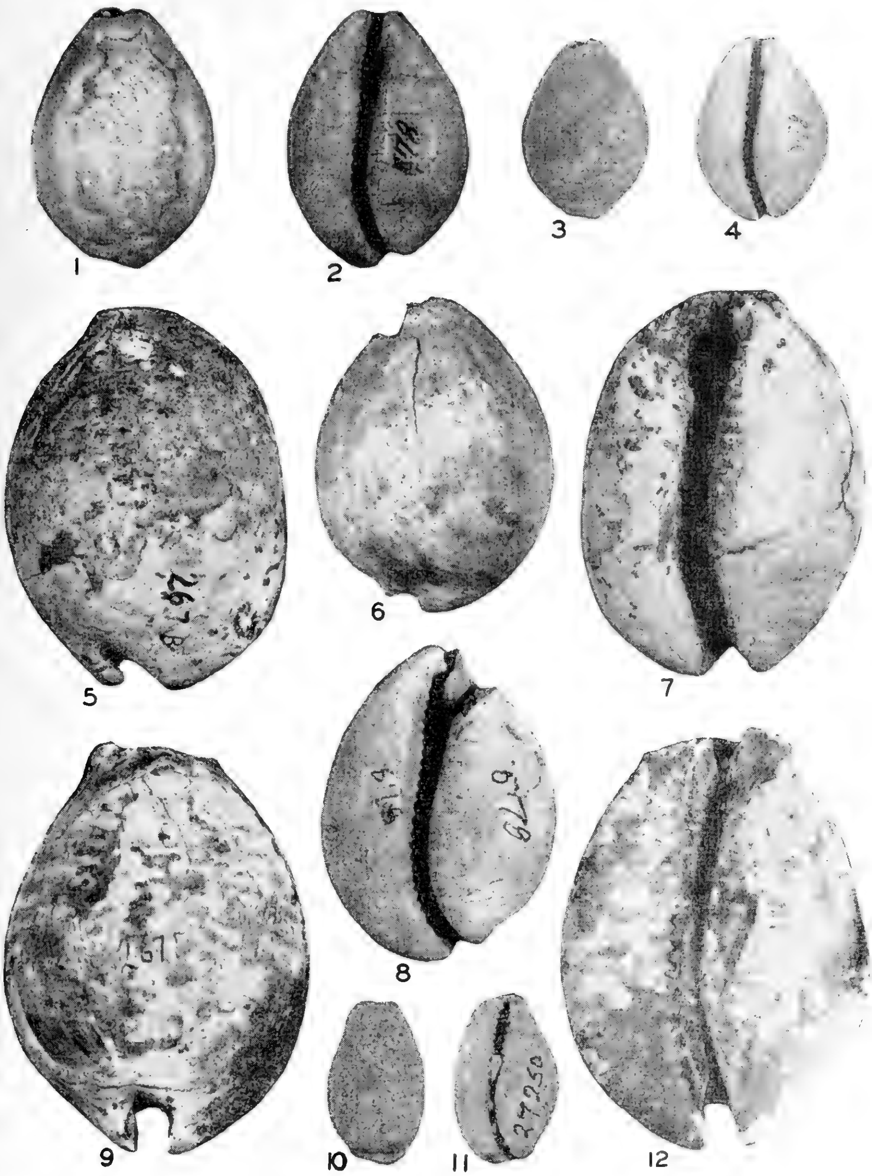
Figs. 3–4.—*Cypraea alumensis* Ingram, new species. Length, 28.50 mm., breadth, 20.50 mm., height, 14.50 mm. Holotype, No. 8043, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about 20 feet above the water level, on the left bank of Apalachicola River, about 3½ miles above Bristow, at Alum Bluff on Apalachicola River, Calhoun County, Florida; lower Miocene. P. 127.

Figs. 5, 7.—*Cypraea andersoni* Ingram. Length, 60 mm., breadth, 44 mm., height, 32 mm. Holotype, No. 8042, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 267B (C.A.S.), Tuberá Hill at west base of Tuberá Mountain, in the lower part of the Tuberá group, 1 mile west of Tuberá, Colombia; middle Miocene. P. 129.

Figs. 6, 8.—*Cypraea apalachicolae* Ingram, new species. Length, 48 mm., breadth, 37 mm., height, 28 mm. Holotype, No. 8045, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 578 (C.A.S.), marl bed about 20 feet above the water level, on the left bank of Apalachicola River, about 3½ miles above Bristow, at Alum Bluff on Apalachicola River, Calhoun County, Florida; lower Mioicene. P. 126.

Figs. 9, 12.—*Cypraea tuberae* Ingram. Length, 64 mm., breadth, 47.50 mm., height, 35 mm. Holotype, No. 8041, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 267B (C.A.S.), Tuberá Hill at west base of Tuberá Mountain, in the lower part of the Tuberá group, 1 mile west of Tuberá, Colombia; middle Miocene. P. 129.

Figs. 10, 11.—*Cypraea darwini* Ingram, new species. Length, 26 mm., breadth, 16 mm., height, 13.50 mm. Holotype, No. 8046, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 27250 (C.A.S.), old beach deposit along beach, probably 5 feet thick, bay on northwest part of island on west side, South Seymour Island, Galapagos Islands, Subfossil. P. 144.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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 7, pp. 135-145 June 28, 1948

THE CYPRAEID FAUNA OF THE GALAPAGOS ISLANDS*

BY

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An attempt is here made to list the entire Cypraeid fauna of the Galapagos Islands. No writer who has worked with the Mollusca of these islands has yet included all the Cypraeidae. Stearns (1893) listed *Cypraea exanthema* Linnaeus var. (= *Cypraea cervinetta* Kiener) from James and Indefatigable Islands; *Cypraea nigropunctata* Gray from James, Hood, and Indefatigable Islands; and *Cypraea albuginosa* Gray from James Island. Tomlin (1927) listed *Cypraea nigropunctata* Gray from Charles and Narborough Islands. Wimmer (1880) lists *Cypraea exanthema* Linnaeus [*Cypraea cervinetta* Kiener] from the Galapagos Islands;† *Cypraea albuginosa* Gray from Charles Island; and *Cypraea nigropunctata* Gray from Hood and Bindloe Islands. Hertlein (1937) lists *Cypraea moneta* Linnaeus from the Galapagos Islands.[1] Pilsbry and Vanatta (1902) listed *Cypraea exanthema cervinetta* Kiener [*Cypraea cervinetta* Kiener] from Tagus Cove, Albemarle Island, and from Narborough Island; and *Cypraea nigropunctata* Gray from Point Christopher, Albemarle, and from Narborough Islands. Fossil records have been reported by Hertlein and Strong (1939) who list *Cypraea nigropunctata* Gray from late Pleistocene of James Bay, James (San Salvador) Island, from the late Pleistocene of South Seymour Island, and from the late Pleistocene or as a subfossil from Tagus Cove, Albemarle (Isabella) Island; and by Dall and Ochsner (1928) who reported a *Cypraea* (young) aff. *cervinetta* Kiener from the Pliocene of Seymour Island, and *Cypraea albuginosa* Gray from the Pleistocene of Albemarle Island. The writer has examined this latter specimen,

* Manuscript received October 19, 1944.

† No specific locality within the Galapagos Islands was indicated.

identified by Dall and Ochsner (1928) as *C. albuginosa* Gray, and has found it to be unmistakably a mature individual of *Cypraea nigropunctata* Gray.

Seven living and one new fossil species represent the complete Cypraeid fauna of the Galapagos Islands as reported today. The living species are: *Cypraea moneta* Linnaeus, *Cypraea isabella mexicana* Stearns, *Cypraea arabicula* Lamarck, *Cypraea cervinetta* Kiener, *Cypraea nigropunctata* Gray, *Cypraea albuginosa* Gray, and *Pustularia pustulata* (Lamarck). A new fossil species is herein described as *Cypraea darwini*. Collections indicate that only one species, *Cypraea nigropunctata* Gray, is really common in the waters about the Galapagos Islands. The material examined shows that the other species are relatively rare. In the course of compiling data for this paper, 465 specimens were examined.

The Cypraeid fauna of the Galapagos Islands is typically allied to that of the coastal waters of the West Coast of the Americas. Hertlein and Strong (1939) pointed out that the Galapagos Islands lie about 600 miles west of Ecuador, and that the cool Humboldt current sweeping up the coast of Peru serves to make the shore climate of the Islands unusually cool even though they lie on the equator. The number of western American Cypraeidae found in the Galapagos Islands indicates that these temperate zone species can adapt themselves to the shore water conditions about these islands, for of the nine typical West Coast species all but three, *Cypraea spadicea* Swainson, *Cypraea annettae* Dall, and *Cypraea robertsi* Hidalgo, are found in the Galapagos Islands. Available data indicate that the migration from West Coast waters of at least one species, *Cypraea cervinetta* Kiener, began in the Pliocene, and that of *C. nigropunctata* Gray began in the Pleistocene.

The single example of migration from the Indo-Pacific to this island group is *Cypraea moneta* Linnaeus. Clipperton Island, about 670 miles southwest of Acapulco, Mexico, is approximately 10 degrees north of the equator, and possesses a greater number of Indo-Pacific and Polynesian species of Cypraeidae than the Galapagos, although both are approximately the same distance from the coasts of the Americas. In contrast with the one Indo-Pacific species in the Galapagos, it is interesting to note that Hertlein (1937) has reported five tropical Pacific Cypraeidae from Clipperton Island: *Cypraea gillei* Jousseaume (*C. intermedia* Gray), *Cypraea isabella* Linnaeus, *Cypraea moneta* Linnaeus, *Cypraea scurra* Chemnitz, and *Cypraea teres* Gmelin. It is possible that any great number of Indo-Pacific or tropical Pacific Cypraeidae is prevented from becoming established in the Galapagos Islands by the relative coolness of the sea and lack of coral reef formation.

Because of the importance of the Galapagos Islands as one of the frontiers of western American and tropical Pacific Cypraeidae, measurements are given of the specimens on which this study is based, to permit ready comparison by others working on these species. Also included as a comparative aid are the mainland records of localities of the species listed from the Galapagos.

The writer wishes to thank Dr. G. Dallas Hanna and Dr. Leo George

Hertlein of the California Academy of Sciences for allowing him to study the collection of Galapagos Island Cypraeidae upon which this paper is based. Appreciation is expressed to the following individuals who permitted the writer to examine Cypraeid records from the West Coast of the Americas: Dr. Paul Bartsch and Dr. Harald Rehder, United States National Museum; Dr. Henry A. Pilsbry, The Academy of Natural Sciences, Philadelphia; Mr. William J. Clench, Harvard University; and the late Dr. Bruce L. Clark, University of California.

Species List

Cypraea albuginosa Gray

Galapagos Islands records:

James Island (4 specimens: 3 beach, 1 living).

Length 27 mm.; breadth 15 mm.; height 12 mm.
Length 23 mm.; breadth 14 mm.; height 10 mm.
Length 22 mm.; breadth 12 mm.; height 10 mm.
Length 20 mm.; breadth 11 mm.; height 9 mm.

Hood Island (2 specimens: 1 beach, 1 living).

Length 28 mm.; breadth 18 mm.; height 13 mm.
Length 32 mm.; breadth 20 mm.; height 15 mm.

Albemarle Island, Banks Bay (1 specimen, beach).

Length 27 mm.; breadth 16.50 mm.; height 13 mm.

The 32 mm.-long Hood Island individual is larger than any of the numerous specimens that the writer has examined from the coastal waters of the Americas.

Mainland records*

United States National Museum: La Paz, Cape San Lucas, Lower California; southwest side of Ceralbo Island ("Ceralleo" Island), and San José Island, Gulf of California; Tres Marias Islands; Mazatlán, Mexico; Panama.

California Academy of Sciences: Maria Madre Island, Tres Marías, Mexico; Bay of Panama, Panama.

Harvard University: Cape San Lucas, Lower California.

University of California: Mazatlán, San Pedro, northwest of Guaymas, Sonora, Mexico; Marquer Bay, Carmen Island, Gulf of California.

* The distribution records listed here were selected by the writer as being authentic; not all records were taken when a question of authenticity arose. Only specific localities were used. Additional records have no doubt been added to the collections since the writer's visits from 1937 to 1942. Too, it is likely that some records were inadvertently overlooked under the pressure of time; an indication of the true range is indicated nevertheless.

Cypraea arabicula Lamarck

Galapagos Islands records:

Hood Island (2 specimens: 1 beach, 1 living)

Length 29 mm.; breadth 20 mm.; height 15 mm.
Length 27 mm.; breadth 18 mm.; height 13 mm.

Indefatigable Islands (1 specimen, beach)

Length 23 mm.; breadth 13 mm.; height 10 mm.

The Indefatigable Island record is that of an individual far below the mean size of the species. It is notably elongate in shape.

Mainland records:

United States National Museum: Mazatlán, Acapulco, and Manzanillo, Mexico; Cape San Lucas, Lower California; southwest side of Ceralbo ("Ceralvo") Island, San José Island, Concepción Bay, Lower California; Corinto, Nicaragua; Punta Dominical, Costa Rica; Panama.

California Academy of Sciences: Mazatlán, Tenacatita Bay, Tangola-Tangola Bay, Tres Marias Islands, Mexico; Corinto, Nicaragua; Bat Island, Costa Rica; Bahía Honda, Taboga Island, Changame Island, Venado Island, Panama.

University of California: Mazatlán, Mexico; (recent; fossil) San Pedro Bay, northwest of Guaymas, Mexico.

Cypraea cervinetta Kiener

Galapagos Islands records:

Albemarle Island (2 specimens, beach)

Length 71 mm.; breadth 33 mm.; height 25 mm.
Length 73 mm.; breadth 38 mm.; height 29 mm.

Albemarle Island, Tagus Cove (3 specimens, beach)

Length 89 mm.; breadth 42 mm.; height 33 mm.
Length 82 mm.; breadth 39 mm.; height 29 mm.
Length 81 mm.; breadth 41 mm.; height 31 mm.

Hood Island (1 specimen, living)

Length 83 mm.; breadth 39 mm.; height 28 mm.

James Island (1 specimen, living; in tide pool)

Length 83 mm.; breadth 41 mm.; height 28 mm.

Indefatigable Island, Academy Bay (2 specimens, living)

Length 78 mm.; breadth 39 mm.; height 29 mm.
Length 78 mm.; breadth 38 mm.; height 29 mm.

Indefatigable Island (2 specimens, living)

Length 65 mm.; breadth 31 mm.; height 23 mm.
Length 72 mm.; breadth 34 mm.; height 26 mm.

Charles Island (1 specimen, beach)

Length 84 mm.; breadth 41 mm.; height 32 mm.

The tide pool record from James Island indicates one of several likely habitats for this species. All individuals are typical *C. cervinetta* Kiener. The reports of *C. exanthema* Linnaeus [= *C. zebra* Linnaeus] from the Galapagos Islands have been based on faulty identification, for this species is confined in its distribution to the Atlantic side of Central America. A closely related species, *Cypraea cervus* Linnaeus, is also found on the Atlantic side of Central America. A likely ancestral type from which these closely related species descended is the extinct Miocene species, *Cypraea trinitatensis* Mansfield, from Trinidad. Probably *C. cervinetta* Kiener, or an ancestral type, migrated through Central America to the Pacific, and then was isolated from its parental stock with the closure of the migrational pathway sometime in the Miocene. The two living East Coast species, *Cypraea zebra* Linnaeus and *Cypraea cervus* Linnaeus, appear to have remained closer to their center of origin.

Mainland records:

United States National Museum: Margarita Bay, La Paz, and Cape San Lucas, Lower California; Guaymas, Mazatlán, and Mendia (Sinaloa), Mexico; Panama; Manta, Ecuador; Payta (Paita), Peru.

California Academy of Sciences: Isabel Island, Mexico; Corinto, Nicaragua; Taboga Island, near Panama City, Vique Point, Panama.

University of California: Mazatlán, Mexico; Panama; Cardalitos, Peru.

Harvard University: Mazatlán, Mexico; Panama City, Pearl Island, and Palo Seco, Panama.

Cypraea isabella mexicana Stearns

Galapagos Islands records:

Hood Island (4 specimens, beach)

Length 44.50 mm.; breadth 23 mm.; height 19 mm.
Length 32 mm.; breadth 16 mm.; height 13 mm.
Length 29 mm.; breadth 14.50 mm.; height 12 mm.
Height 29 mm.; breadth 14 mm.; height 12 mm.

Abemarle Island, north of Tagus Cove on beach (2 specimens, beach)

Length 47 mm.; breadth 27 mm.; height 22 mm.
Length 46 mm.; breadth 28 mm.; height 24 mm.

The two Albemarle Island individuals are more inflated than is the typical *Cypraea isabella mexicana* Stearns; too, both specimens lack a well-defined fossula. The teeth characteristic of the fossula in *C. isabella* Linnaeus and in the subspecies *mexicana* Stearns are entirely absent in one individual, and have been reduced in the other to extremely obscure nodules. If these two individuals had been examined and measured independently of a lot of 33 specimens from Clipperton Island, they might have been considered as representing a new species or subspecies. However, certain intergradations exhibited by the series from Clipperton Island seem to indicate that they are only aberrant individuals.

Mainland records:

United States National Museum: Cape San Lucas, Lower California; Clarion Island, Tres Marias, Mexico.

California Academy of Sciences: Socorro Island, Revillagigedo Islands, Tres Marias Islands, Mexico.

Cypraea moneta Linnaeus

Galapagos Islands records:

Hood Island (6 specimens, beach)

Length 30 mm.; breadth 23 mm.; height 14 mm.
Length 28 mm.; breadth 22 mm.; height 13 mm.
Length 28 mm.; breadth 20 mm.; height 13 mm.
Length 28 mm.; breadth 19 mm.; height 12 mm.
Length 27 mm.; breadth 19 mm.; height 12 mm.
Length 25 mm.; breadth 19 mm.; height 11 mm.

In all specimens the outer layer of shell is eroded from the dorsum, making it impossible to distinguish its original color. The lateral margins, sides, and bases are white. Two specimens have been shellacked, giving a color distortion of yellow-orange over the sides, when in reality the shell sides are white. The writer has seen individuals similar to these from the Marquesas and Tuamotu Islands; no specimens resemble the type of *C. moneta* Linnaeus found in the Hawaiian Islands.

No authentic records are available from the mainland of the Americas. Hertlein (1937) has reported this Indo-Pacific species from Cocos Island off the coast of South America, and closer to the mainland than this Galapagos Island record, a record also included by him.

Cypraea nigropunctata Gray

Galapagos Islands records:

Indefatigable Island (11 specimens: 5 living, 6 beach)

Length 34 mm.; breadth 19.50 mm.; height 15 mm.
Length 30 mm.; breadth 16.50 mm.; height 13 mm.
Length 30 mm.; breadth 16 mm.; height 13 mm.
Length 28 mm.; breadth 15 mm.; height 13 mm.
Length 27 mm.; breadth 15 mm.; height 12 mm.
Length 27 mm.; breadth 15 mm.; height 11.50 mm.
Length 26.50 mm.; breadth 14 mm.; height 10.50 mm.
Length 26.50 mm.; breadth 14.50 mm.; height 12 mm.
Length 25 mm.; breadth 13 mm.; height 11 mm.
Length 25 mm.; breadth 15 mm.; height 11 mm.
Length 24 mm.; breadth 13 mm.; height 10 mm.

Charles Island, Post Office Bay (1 specimen, beach)

Length 18 mm.; breadth 9 mm.; height 7 mm.

South Seymour Island (4 specimens, beach)

Length 30 mm.; breadth 17 mm.; height 13.50 mm.
Length 27 mm.; breadth 16 mm.; height 13 mm.
Length 24 mm.; breadth 13 mm.; height 10 mm.
Length 24 mm.; breadth 12.50 mm.; height 10 mm.

Albemarle Island (10 specimens: 9 beach, 1 living)

Length 30 mm.; breadth 16 mm.; height 12 mm.
Length 26 mm.; breadth 14 mm.; height 11 mm.
Length 26 mm.; breadth 15 mm.; height 12 mm.
Length 25.50 mm.; breadth 15 mm.; height 11 mm.
Length 25 mm.; breadth 13 mm.; height 10 mm.
Length 25 mm.; breadth 14 mm.; height 11 mm.
Length 24 mm.; breadth 14 mm.; height 10 mm.
Length 22 mm.; breadth 12 mm.; height 9 mm.
Length 20 mm.; breadth 10 mm.; height 8 mm.
Length 19 mm.; breadth 11 mm.; height 8 mm.

Albemarle Island, Tagus Cove (4 specimens, beach)

Length 27 mm.; breadth 15.50 mm.; height 12.50 mm.
Length 25 mm.; breadth 14 mm.; height 11 mm.
Length 25 mm.; breadth 14.50 mm.; height 11 mm.
Length 18 mm.; breadth 10 mm.; height 8 mm.

Albemarle Island, Banks Bay (25 specimens, beach)*

Length 37 mm.; breadth 20 mm.; height 17 mm.
Length 36 mm.; breadth 21 mm.; height 17 mm.
Length 33 mm.; breadth 19 mm.; height 15 mm.
Length 33 mm.; breadth 18 mm.; height 15 mm.
Length 33 mm.; breadth 19 mm.; height 15 mm.
Length 32 mm.; breadth 18 mm.; height 15 mm.
Length 30 mm.; breadth 17 mm.; height 14 mm.
Length 30 mm.; breadth 17 mm.; height 14 mm.
Length 30 mm.; breadth 17 mm.; height 14 mm.
Length 30 mm.; breadth 17 mm.; height 13 mm.
Length 30 mm.; breadth 17 mm.; height 13 mm.
Length 30 mm.; breadth 17 mm.; height 13 mm.
Length 30 mm.; breadth 15 mm.; height 12 mm.
Length 28 mm.; breadth 16 mm.; height 12 mm.
Length 28 mm.; breadth 15 mm.; height 12 mm.
Length 27 mm.; breadth 15 mm.; height 12 mm.
Length 27 mm.; breadth 14 mm.; height 12 mm.
Length 26 mm.; breadth 14 mm.; height 11 mm.
Length 25 mm.; breadth 13 mm.; height 11 mm.
Length 24 mm.; breadth 13 mm.; height 10 mm.
Length 23 mm.; breadth 13 mm.; height 10 mm.

* Not all of the available specimens from the following localities were measured: Hood Island, 271 specimens; James Island, 56 specimens; Banks Bay, Albemarle Island, 71 specimens. Series were selected to illustrate the gradual reduction in size from the largest to the smallest. If intermediate lengths were not available to a collector, and only extreme sizes were studied, one might be led to believe that the smallest and largest were separate subspecies.

Length 21 mm.; breadth 12 mm.; height 10 mm.
Length 21 mm.; breadth 12 mm.; height 9 mm.
Length 20 mm.; breadth 11 m.m.; height 8 mm.
Length 17 mm.; breadth 9 mm.; height 7 mm.

Hood Island (21 specimens, beach)

Length 39 mm.; breadth 22 mm.; height 17 mm.
Length 35 mm.; breadth 21 mm.; height 16 mm.
Length 34 mm.; breadth 20 mm.; height 17 mm.
Length 33 mm.; breadth 19 mm.; height 15 mm.
Length 32 mm.; breadth 18 mm.; height 15 mm.
Length 31 mm.; breadth 17 mm.; height 14 mm.
Length 30 mm.; breadth 18 mm.; height 15 mm.
Length 30 mm.; breadth 17 mm.; height 14 mm.
Length 29 mm.; breadth 17 mm.; height 14 mm.
Length 28 mm.; breadth 15 mm.; height 13 mm.
Length 27 mm.; breadth 15 mm.; height 12.50 mm.
Length 26 mm.; breadth 15 mm.; height 13 mm.
Length 25 mm.; breadth 14 mm.; height 11 mm.
Length 24 mm.; breadth 13 mm.; height 10 mm.
Length 23 mm.; breadth 13 mm.; height 11 mm.
Length 22 mm.; breadth 12 mm.; height 10 mm.
Length 21 mm.; breadth 12 mm.; height 10 mm.
Length 20 mm.; breadth 11 mm.; height 9 mm.
Length 19 mm.; breadth 10 mm.; height 8 mm.
Length 18 mm.; breadth 10 mm.; height 9 mm.
Length 17 mm.; breadth 10 mm.; height 8 mm.

James Island (11 specimens, beach)

Length 33 mm.; breadth 19 mm.; height 16 mm.
Length 28 mm.; breadth 17 mm.; height 14 mm.
Length 27 mm.; breadth 15 mm.; height 12 mm.
Length 26 mm.; breadth 15 mm.; height 12 mm.
Length 25 mm.; breadth 14 mm.; height 12 mm.
Length 24 mm.; breadth 13 mm.; height 10 mm.
Length 23 mm.; breadth 13 mm.; height 11 mm.
Length 22 mm.; breadth 12 mm.; height 11 mm.
Length 21 mm.; breadth 13 mm.; height 10 mm.
Length 19 mm.; breadth 10 mm.; height 8 mm.
Length 18 mm.; breadth 10 mm.; height 8 mm.

This species shows an extremely wide variation in size of its adult individuals, ranging from 17 mm. to 39 mm. in length. Throughout its range the greatest abundance in individuals seems to be reached in the Galapagos Islands. This species may be considered one of the less common of the Cypraeidae of the world, and one with quite a restricted distribution.

The series of bullae of this rare species warrants description, since they are undescribed, and show a remarkable early development of the anterior columellar teeth, uncommon in comparable stages in other Cypraeidae. Five early bulla stages are present in the collections; none is mature enough to have the outer lip in-turned. These five stages will be numbered here from youngest to oldest, bullae 1 to 5.

Bulla 1: This growth stage is represented by 3 specimens of from 6 mm. long by 3 mm. wide; 6.50 mm. long by 3.50 mm. wide, and 5 mm. long by 3 mm. wide. The color is not preserved in two of these; bleaching turns the bulla ivory-white. The dorsum is brown. Seven color bands are faintly visible dorsally on the outer lip; these are colored in an anterior-posterior direction; brown, white, brown, white, brown, white, brown. The brown spire sutures are colored by a narrow white line. The anterior one-half of the columella is white; the posterior one-half brown.

Bulla 2: Two beach specimens, one fresh and one faded, represent this stage. They are 7 mm. long by 4 mm. wide; 7.50 mm. long by 4 mm. wide. Eight color zones are present; from anterior to posterior they are the same as those of bulla 1, with an addition of a posterior white zone mottled with brown. The spire is brown with the suture white. The columella coloring is as in bulla 1.

Bulla 3: Two specimens, 11.50 by 4 mm. wide and 10 mm. long by 5 mm. wide, represent this stage. The eight color zones of bulla 2 persist, but with an addition of a yellowish-tinged white area over the anterior canal. The body whorl begins to become inflated, making the spire less conspicuous. The anterior one-half of the columella is white and the posterior one-half brown.

Bulla 4: One specimen, 17 mm. long by 8 mm. wide, represents this stage. Eleven color zones are present on the dorsum; in an anterior-posterior direction they are: brown, white, brown, white, brown, white, brown, white, brown, brown, white mottled with brown. The anterior half of the columella is white, while the posterior one-half is banded with brown. The spire continues to be obscured by the inflating body whorl.

Bulla 5: This stage is represented by one specimen, 19.25 mm. long by 9 mm. wide. The eleven color zones as present in bulla 4 persist, and the columella is colored the same. A terminal ridge of the anterior columellar region has formed, and 3 anterior columellar teeth have developed on the anterior one-third of the columella. The spire is as in bulla 4.

Mainland records:

United States National Museum: Manta, Ecuador; Parinas (Punta Parinas), Peru.

Pustularia pustulata (Lamarck)

Galapagos Islands records:

James Island (3 specimens, beach)

Length 24 mm.; breadth 15 mm.; height 11 mm.
Length 16 mm.; breadth 12 mm.; height 6 mm.
Length 15 mm.; breadth 10 mm.; height 6 mm.

The 16 mm. specimen is remarkably oval in proportion to its length. The

24 mm. individual is larger than most specimens that the writer has examined from mainland localities.

Mainland records:

Harvard University: Mazatlán, Mexico.

University of California: Mazatlán, Mexico; west coast of Panama.

California Academy of Sciences: San Marcos Island, Gulf of California, Mexico; Bay of Panama, Panama. Also various localities from the Gulf of California to the Bay of Panama.

United States National Museum: La Paz, southwest side of Ceralbo Island, Cape Pulmo, Cape San Lucas, Lower California; near Modesto, Mazatlán, Tres Marías Islands, Acapulco, Mexico; Taboga Island, Panama.

Cypraea darwini Ingram, new species

Plate 2, figures 10, 11 (see p. 132)

Shell elongate-ovate; deep umbilicus present over posterior canal; spire completely obscured; well-defined lateral margin over posterior canal, and over posterior one-fourth of shell; well-defined lateral margin over both sides of anterior one-third of shell; dorsally, shelf absent over anterior canal; outer-lip teeth deeply incised anteriorly, with incisures shallow posteriorly; anterior one-third of outer-lip teeth, after first two which are short, are approximately 2 mm. in length, extending free from the lip and directed into the interior of the shell; outer-lip teeth confined to the aperture edge, not extending over the base; fossula absent; anterior four columellar teeth approximately 3 mm. in length and prominent; remainder of these teeth from 1 mm. to 1.50 mm. in length; anterior four columellar teeth slant diagonally toward the outer lip in shell interior; terminal ridge heavy, directed obliquely into aperture; columella lip of anterior canal narrow, very slightly produced; outer lip of anterior canal not produced, broadly rounded; anterior canal bends gradually to the left; posterior canal bends strongly to the left; posterior canal lips approximately equal; posterior maximum width of aperture is 2.50 mm.; anterior maximum width of aperture is 3 mm. The type measures: length, 26 mm.; breadth, 16 mm.; height, 13.50 mm.

Holotype, No. 8046, Calif. Acad. Sci. Paleo. Type Coll., from Loc. 27250 (C.A.S.), old beach deposit probably 5 feet thick, along beach of bay on northwest part of island on west side, **South Seymour Island, Galapagos Islands**; L. G. Hertlein, collector. Subfossil.

Discussion: From the dorsal side, anteriorly the shell recalls *C. albuginosa* Gray, while posteriorly the shell recalls *C. nigropunctata* Gray. The columellar teeth and the anterior outer-lip teeth are extremely different from any of the Cypraeidae occurring in the Galapagos Islands. The shell is intact and is crusted with a hard deposit, possibly limestone.

Only one specimen was collected by Dr. Hertlein; it is not aberrant, for the specific characteristics are well formed. It seems quite likely that others will be found with further exploration, and it may well be that living individuals of this species will be found when an attempt is made to collect only living, and not beach, shells from these islands. The Cypraeidae collection discussed here indicates either that the greater part of collecting was confined to the beaches, or that the habitat in which the Cypraeidae live in the Galapagos Islands is extremely secluded.

This new species is named for Charles Darwin.

Key to the Living Cypraeidae of the Galapagos Islands

A. Dorsum not noduled
- *a*) Fossula absent
  - *b*) Shell ocellated on dorsum .... *albuginosa*
  - *bb*) Shell not ocellated on dorsum
    - *c*) Shell with transverse bands under outer layer .... *nigropunctata*
    - *cc*) Shell without transverse bands .... *moneta*
- *aa*) Fossula present
  - *d*) Teeth extending over base, marked with brown .... *cervinetta*
  - *dd*) Teeth not extending over base, not marked with brown
    - *e*) Canals covered with orange blotches superimposed with black *isabella mexicana*
    - *ee*) Canals not covered with orange blotches and not superimposed with black *arabicula*

B. Dorsum noduled .... *pustulata*

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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 8, pp. 147-245, pls. 3, 4, 4 text figures Dec. 15, 1948

THE MARINE MOLLUSKS AND BRACHIOPODS OF MONTEREY BAY, CALIFORNIA, AND VICINITY

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COLLECTING ACTIVITIES

The first historical record of shell collecting in the Monterey region so far discovered is contained in Father Peña's account of the Perez expedition in the *Santiago* in 1774. Apparently shells from Monterey were in demand by the Indians of the northwest coast for inlay work and other purposes and explorers of that day, knowing this, supplied themselves with abalones and other Monterey shells for trade with them. The journal of Manuel Quimper of 1790 mentions shells traded to the Indians and Pantoja's account of the Eliza expedition in 1791 mentioned "Monterey shells" as being traded at various places along the coast. Caamaño's journal (1792) gives the clue that the shells most desired were black abalones. Concerning the villages on Graham Island, he writes:

> The Indians wanted to exchange them (furs) for clothing, or shells, but the latter they desired to have of as green a color as those that some wore in great numbers hanging at their ears. We were surprised to see that several had those of a sort that is found only at Monterey, and even more surprised when they told us that we ought to arrange that in Spain the meat be not

> extracted by heating the shells, as this process damaged the enamel, but that it should be done with a knife. I enquired who had taught them this, or had given them the Monterey shells, but either they did not catch my meaning, or I misunderstood their reply.

These facts and others from an interesting account by R. F. Heizer (1940) indicate that shell collecting at Monterey goes back at least one hundred and seventy years, perhaps even further.

For conchologists, the region of Monterey Bay has been a favorite collecting ground for more than a hundred years. Some of the characteristic shells of Monterey appear to have reached European collections soon after the beginning of the nineteenth century, probably through the trade then being carried on with Pacific Coast ports, especially in hides. By this means the following shells, well known for their beauty and for their abundance at Monterey, could easily have been and perhaps were actually obtained there:

Black Abalone, *Haliotis cracherodii* (Leach)—Zoological Miscellany, 1817.
Red Abalone, *Haliotis rufescens* (Swainson)—Bligh Catalogue, 1822.
Giant Key-Hole Limpet, *Megathura crenulata* (Sowerby)—Tankerville Catalogue, 1825.
California Olive-Shell, *Olivella biplicata* (Sowerby)—Tankerville Catalogue, 1825.
California Coffee-Bean Shell, *Trivia californiana* (Gray)—Zoological Journal, 1828.

It is not unlikely, also, that La Pérouse and Vancouver, both of whom visited Monterey in the course of their explorations, the former about 1787 and the latter in 1795, may have obtained some of the species described by early conchologists. Both of these expeditions were accompanied by naturalists.

Humboldt and Bonpland, though coming no nearer than Acapulco, obtained there in 1804 one species that seems exclusively Californian, the red abalone, probably brought down by some coastal ship.

It does not seem that Captain Beechey's exploration, from 1825 to 1828, obtained any shells at Monterey although many species common there were collected elsewhere.

The first authentic collections there were those of Professor Nuttall, in 1835, who discovered 70 of the more common land and sea-beach shells of California, of which 9 species were from Monterey, although some had already been described.

About 1838 the *Venus,* with Captain Abel du Petit Thouars, visited Monterey and obtained two or three new species besides several of Nuttall's. These were described by Deshayes and Valenciennes.

The surveying ship *Sulphur,* Captain Belcher, with the eminent conchologist Hinds, explored the west coast of North America from 1838 to 1842 but collected nothing new at Monterey although 21 species were discovered elsewhere in California. Reeve, in his monumental *Conchologica Iconica,* quoted *"Fissurella Lincolni,* Gray," now known as *Diodora aspera* (Eschscholtz), from "Monterey, Belcher."

Another British surveying ship, the *Pandora,* Captain Kellett, followed much the same route in 1849 without taking anything new at Monterey. The same year Colonel Edward Jewett collected 45 new species in California, spending a week at Monterey, where he found two of them. Lieutenant Green, U.S.N., and Major Rich, U.S.A., also visited the Bay, where the latter found two out of his three new Californian species along with seven species that probably came from other localities.

The botanist Hartweg was in Monterey in 1855 and found a new species of chiton. Some time prior to 1860, A. S. Taylor sent four new species from Monterey to the Smithsonian Institution.

The records cited above are based on the reports to the British Association for the Advancement of Science by Dr. P. P. Carpenter in 1856 and 1863 on the mollusks of the West Coast, as reviewed by Dr. J. G. Cooper, who concludes that in 1860 there were 277 species of shells known from California, of which 66 were reported from Monterey, 22 being discovered there for the first time by six collectors.

In 1861, Dr. Cooper spent several weeks collecting on shore at Santa Cruz, Carmel, and Monterey, doing considerable dredging in Monterey Bay down to a depth of 40 fathoms and in Carmel Bay to 35 fathoms. He published a list of the shells collected, consisting of 272 species and subspecies of marine mollusks, and gave an interesting account of his work (Cooper, 1870a, 1870b). From Monterey only, Cooper found 197 species "excluding manifest varieties," which, with 50 others he collected at Santa Cruz only, brought the total collected in the Bay to 247.

During the next decade Cooper stated that collections made by Dall, Stearns, Newcomb, Canfield, and Harford brought the list of mollusks found to 316. In this period Cooper lived for a year at Santa Cruz and reported that he collected 107 species there during that time.

While the results of the work of four of the collectors mentioned by Cooper remain only in the shells they collected, some of which are still preserved in the United States National Museum and occasionally in other collections, William H. Dall, one of the country's foremost conchologists, has left us an account of his work at Monterey in 1866. While acting as Chief of the Scientific Corps of the Western Union Telegraph Expedition to Alaska in 1865-66, he obtained a three-week leave in January of the latter year, which he spent at Monterey. He was unable to do any dredging and, with the help of Dr. C. A. Canfield of Monterey, spent the entire time shore collecting. The results of his work were covered briefly in a note in the Proceedings of the California Academy of Sciences in which he stated that he himself had collected in two weeks no less than 219 species, including 23 that were new or not previously reported from the region. He remarked that this number, added to the 44 already found at Monterey, but not collected by him, gave 263 as the number of species then known to have been found there (Dall, 1866). Later, he wrote: "I prepared at that time a faunal catalogue of the shells of Monterey, with notes and habitats, and on such species as appeared to be undescribed" (Dall, 1871), but his manuscript was never published. The new species Dall discovered, 17 in number, were finally described in the American Journal of Conchology along with others collected mostly in Alaska while he was with the Telegraph Expedition (Dall: 1871).

In the early 1890's Dr. Dall collected again at Monterey. While he published no special account of the results of his work then, he made the following interesting comment in a letter to Dr. H. A. Pilsbry, editor of *The Nautilus*: "Monterey as a collecting ground is already greatly injured, and will probably be nearly ruined before long, on account of the Hotel Del Monte, the new town of Pacific Grove, and the increased population of old Monterey, all the sewage of which is turned into the bay in front of the town. Beaches which formerly would afford several hundred species are now nearly bare, or offensive with stinking black mud. Old collectors will learn this with regret" (Dall, 1892).

The next published record of shell collecting in Monterey Bay is in 1893, when Williard M. Wood (1893) spent two weeks there and reported taking 91 species and subspecies. His list is interesting as it gives the numbers of each species collected and contains some unusual records in the light of present day collecting there. Like Dall, he bemoaned the fact that "Monterey is no longer the famous collecting ground it used to be. The increasing population at and around Pacific Grove is driving away all the land shells. The deadly sewerage flowing from the various towns into Monterey Bay is killing the marine shells."

In the summer of 1897, Dr. Harold Heath of the Stanford Marine Station (now the Hopkins Marine Biological Laboratory) collected a series of invertebrates and fishes for the Academy of Natural Sciences of Philadelphia, among which were a number of chitons. A list of 25 species and subspecies, including two new species, was published subsequently by Dr. Henry A. Pilsbry (1898) of the Academy, representing the most complete account of the group at the time.

In 1904, as part of a comprehensive plan for the study of marine biology by the United States Bureau of Fisheries, the steamer *Albatross* conducted dredging operations in Monterey Bay from May 10 to June 15. Hauls were made at a total of 128 collecting stations at depths varying from a few fathoms to nearly 1100 fathoms, data on which are listed in the report of the Bureau of Fisheries for the year 1905.

> In addition to investigations of purely scientific interest, the work of the vessel included the development of a number of fishing banks hitherto only locally known. . . . A number of banks and ledges in Monterey Bay, all good rockfish (rock cod) grounds, were developed and charted. Off Point Santa Cruz is a small area called Rock Oyster Bank; an extensive rocky ledge, called Black Point Reef, extends entirely across the harbor of Santa Cruz; off Sauquel Point is a ledge called Sauquel Reef. About midway between Sauquel Cove and the mouth of the Pajaro River, parallel to the shore and about a mile distant, is a long narrow reef called Rock Cod Ledge; and off the mouth of the Estero Grande is a small spot similarly named. In the vicinity of Point Pinos are four fishing grounds much frequented by the boats from Monterey. Seventy Fathom Bank, or Coopers Rock, lies about 3.5 miles west of the Point; Italian Ledge, a smaller bank, is about the same distance north of the Point; Portuguese Ledge, still smaller, lies about 3 miles north-northeast of Point Pinos; and Humpback Rock, a tiny spot, is about 2 miles east of it.

The above quotation from the Report is of interest because the vicinity of localities good for fishing are, in our experience, usually also inhabited by a larger fauna than is to be found elsewhere, and are generally good places to dredge for shells and other marine life.

The work of the *Albatross* contributed vastly to our knowledge of the mollusks of the Bay, especially the deep-water species living in 100 to 1000 fathoms, which are impossible to obtain without special gear and equipment of considerable power. At least fifty species, about twenty-five of them new, were added to the list from the Bay based on a study of *Albatross* dredgings by Dall and Bartsch, who published their results from time to time in the Proceedings of the United States National Museum.

Dr. S. S. Berry of Redlands, California, did considerable collecting in the vicinity of Monterey and Pacific Grove and made a series of dredge hauls, mostly in shallow water, over a six weeks' period in 1906. His list, published later in *The Nautilus* (Berry: 1907 and 1908), is a valuable addition to the mollusk-fauna of the Bay as it contains many records of species not previously reported. In addition, he added 14 new species and 2 new subspecies. Berry stated that he collected 318 species and varieties (including land and fresh-water as well as marine). In his account he quite properly calls particular attention to the extraordinary development of the chitons (26 species and 4 subspecies); of *Epitonium* (9 species); of the Pyramidellidae (18 species); and of the prominence of the limpets in the shore fauna, both in number of species (15) and of individuals.

The senior author began collecting in Monterey Bay and its environs in the summer of 1910 under the expert tutelage of Professor Josiah Keep, of Mills College, who for a number of years had come to Pacific Grove to deliver a series of talks on conchology in connection with the Chautauqua assemblies held there. His audiences consisted largely of local collectors, a scattering of scientists in other fields, and a number of young people who were attracted perhaps not so much because of the subject and the enjoyable field trips, but more because of the man himself and his unusual ability to infect all who came in contact with him with his seemingly inexhaustible store of knowledge and boundless enthusiasm for the broad field of natural history, particularly in conchology. His shock of white hair, his ruddy complexion, and his booming laugh are well remembered by all who were fortunate enough to attend his classes during the period. In all probability he accomplished more in developing a knowledge and appreciation of the remarkable marine-shell fauna of Monterey Bay than any other individual. His books on West Coast shells are full of references to the shells of the region. Less well known, however, is the list he printed privately for his later Chautauqua classes containing 97 of the commoner species of the Bay (Keep, 1910).

One of the molluscan groups for which Monterey Bay is a center consists of the sea-slugs, or nudibranchs, of which there are many species. Cooper listed only 4 genera and 4 species in 1871, but in 1906 Dr. F. M. MacFarland of Stanford University increased this to 16 genera and 20 species in a paper devoted to an account of these beautiful animals (MacFarland, 1906).

The next scientific paper of any extensiveness on the mollusk-fauna of the Monterey region is a study by G. E. McGinitie (1935) on the ecological aspects of Elkhorn Slough in which a careful analysis was made, among other biological groups, of the marine shells of this locality. This completes the principal written records to the present date.

The junior author began collecting in the Bay in 1920, and has continued his work there ever since. More concentrated effort was made in 1932 while stationed at the Hopkins Marine Biological Laboratory.

Many others have collected extensively in the Bay and although the results of their work is unpublished they have added many new records of species as a result of careful work over many years. While it is impracticable to name them all, the efforts of the late Mrs. Charles S. Fackenthall, Mrs. David Muir, M. J. Becker, Miss Isabel Thayer, and Mrs. Bernard Freeman, all of Pacific Grove, among the older collectors are especially worthy of mention. The contemporary collectors who have done considerable work in Monterey Bay include Mr. Andrew Sorensen and the Rev. Elwood B. Hunter of Pacific Grove, Mr. and Mrs. Emery P. Chace of Lomita, Mr. and Mrs. Harry Turver, and Tom and John Q. Burch of Los Angeles.

While shore collecting is undoubtedly far from what it must have been in the days of Dall, Canfield, and Cooper, it is still a good collecting area if one knows where to go. Gone, however, are the windrows of shells from many of the favorite beaches, which have long since been cleaned of the better and rarer specimens by collectors and the frequent summer visitors who come for a day or a vacation at the seashore. No longer is it possible to collect two hundred species in two weeks, as Dall did in 1866. Even at extremely low tide the rocky shores are less productive, as many of the movable rocks have been overturned in the ever-increasing search for specimens of marine life. In recent years the more spectacular species, such as the red abalone, the owl limpet *Lottia gigantea* (Sowerby), the giant key-hole limpet *Megathura crenulata* (Sowerby), the red top-shell *Astraea inaequalis* (Martyn), and the horn-mouth *Purpura foliata* (Martyn), to mention a few, have become increasingly scarcer.

Shore areas where one is free to collect without restriction are much fewer. Prohibited spots now cover some of the best former collecting ground along the rocky coast. Among these is a two-mile stretch of coastline from Pacific Grove to Point Pinos, which has been wisely set aside by the city authorities as a marine-life refuge where collecting is prohibited. Another extends along the ocean front of the Monterey Peninsula, where access to the rocky shores is restricted by the private estates along the famous 17-Mile Drive. The Point Lobos area, now a State park, is another wild-life area closed to collecting. While there are still long stretches of rocky coast from Carmel to Point Sur and below that afford good collecting in favorable spots, there are a few good places in the more sheltered areas of Monterey and Carmel Bays that are unrestricted and where the conchologist can operate without special permission.

Dredging is probably still about as good as formerly, although in shallow water near the end of Monterey Bay one is liable to find a foul bottom where cannery and other refuse have killed all the marine life that was once there in abundance.

Off-shore kelp beds, a splendid harbor for top-shells *(Calliostoma* and *Tegula),* have disappeared from many areas off Pacific Grove and Del Monte Beach, where they were once thick. Carmel Bay, however, still has a heavy growth of kelp off shore.

While restrictions and changed conditions place definite limitations on shell collecting in the Monterey region it is to be hoped that a closing of certain areas will result in a return of the finest species to the size and numbers of former years. Apparently, this is already proving to be true of the black abalone on the rock ledges of Point Lobos.

PHYSIOGRAPHIC FEATURES AND MOLLUSK FAUNAS

The area considered in this paper extends from Pigeon Point south to Point Sur, a distance of approximately fifty-five miles, airline. The shoreline distance, which would follow all the irregularities and indentations of the coast, is more than a hundred miles. Monterey Bay itself covers an area of about 130 square miles. In the comparatively small area under consideration, almost all of the better-known types of shore and submarine ecologic conditions common to the temperate West Coast are encountered.

The rocky open seacoast condition of the littoral zone is typified by conglomerate and other resistant sedimentary rocks exposed in the vicinity of Point Lobos, a few miles south of Carmel, and by the porphyritic granite of the Monterey Peninsula between Pescadero Point and Point Pinos. Here, in tidepools, nestling in rock crevices, or clinging to various species of algae are found about one hundred species of marine mollusks, chiefly gastropods and chitons. The porphyritic granite that crops out at Carmelo Point and between Point Pinos and Monterey is partly sheltered from the open sea, which permits a coarse-grained granitic sand to collect in pockets among the kelp-covered rocks and boulders. The fauna in this habitat totals almost one hundred and eighty species of mollusks, including most of those found along the rocky coast together with a number of small gastropod species that nestle under boulders set in the sand and a few pelecypod species that live in the sand itself.

Strata of soft Miocene shale crop out in the vicinity of Santa Cruz Point and other strata of Pliocene sandstone are exposed near Capitola. These rocks harbor a number of rock-boring pelecypods as well as other mollusks—a total of not quite eighty species.

The open beach condition is represented by Carmel Beach, with its famed white sand, and by small sandy beaches between Cypress Point and Point Joe on the Monterey Peninsula. Only five species, all of them pelecypods, manage to thrive in these wave-swept stretches, though numerous mollusks inhabit the rocky points between them. From Monterey to Watsonville extends a long unbroken sandy beach, somewhat protected from the direct buffeting of the open sea. The sand of this beach varies in coarseness and patches of gravel are exposed locally, at low tide. About fifteen species of mollusks, most of them pelecypods, comprise the normal littoral fauna.

The last of the various ecologic types of the littoral zone, the typical estuarine condition, is encountered in Elkhorn Slough. Approximately thirty-five species of mollusks, the majority of them pelecypods, inhabit the fine sand and mud. Some live in interesting commensal relationships with prawns, worms, and other mud-flat denizens. The Slough is noted for the abundance of individuals of the species living in it.

Intimately associated with the littoral fauna of the rocky coast, but constituting a separate sub-littoral faunal group is the giant kelp assemblage, which includes about one hundred and forty-five mollusks and one brachiopod. The habitat of these species centers around the giant kelp plants growing at depths of from one to five fathoms. Some of the mollusks cling to the kelp stems, others nestle in the protecting mazes of the holdfasts, and still others live in the coarse sand and on the boulders to which the holdfasts are attached.

The bottom of the shallower part of the neritic zone of Monterey Bay, from five to forty fathoms in depth, consists of fine dark sand with locally scattered fragments of shale or other rocks. From this type of bottom four species of brachiopods and about two hundred and twenty of mollusks, many of them gastropods, have been collected.

Strata of Miocene shale form submarine reefs in eight to twelve fathoms off Del Monte, and at Humpback Rock in about forty fathoms off Pacific Grove. Other reefs in ten to fifteen fathoms off Watsonville, Soquel Point, and Santa Cruz are of Pliocene sandstone, some of it fossiliferous. Clinging to, boring into, and nestling among these rocks are about ninety-five species of mollusks, in addition to most of the sand-dwelling forms encountered around the fringes of the reefs. These are the most prolific collecting stations in the Bay, with almost three hundred species recorded from them.

At depths of from thirty to one hundred and fifty fathoms the fine sand that is common in the shallower parts of the Bay grades into mud, and harbors a small but interesting fauna of about sixty molluscan species. In parts of this deeper neritic zone, between forty and one hundred fathoms, are large areas of gravel and clay. The presence of rock and gravel generally adds four brachiopods and twenty mollusks to the above-mentioned muddy bottom fauna. The gravel beds in the southern part of the Bay are favorite fishing grounds, especially in the neighborhood of Italian Ledge and Portuguese Ledge, which are sedimentary reefs lying in fifty to sixty fathoms about three or four miles in a general northerly direction from Point Pinos.

The Monterey Submarine Canyon is a distinctive and remarkable physiographic feature of the Bay. Its head lies in seventy fathoms about three-quarters of a mile west of Moss Landing and it extends in a general westerly direction. It is narrow-walled at first but opens out to a width of three and a half miles in a distance of about eight miles, where the bottom depth is four hundred fathoms. Beyond this point the Canyon takes a southerly direction and opens out rapidly into the Monterey Sea Valley with the maximum depth dropping to a thousand fathoms or more. The edges of the Canyon are at a depth of about seventy fathoms, and of the Sea Valley west of Point Pinos and Cypress Point, about a hundred fathoms. The hundred-fathom line west of Cypress Point is only a mile off shore and the depth increases to nearly seven hundred fathoms four miles or so off the Point.

A similar but less extensive submarine canyon is Carmel Canyon, whose head lies two-fifths of a mile off the mouth of the Carmel River, and which expands irregularly with the depth dropping to three hundred and fifty fathoms three miles or so off shore. Carmel Canyon has not been as well explored as Monterey Canyon and consequently little is known of its mollusk fauna below twenty-five fathoms. The side-walls of both canyons have been reported to have many jagged pinnacles of hard rock.

The occurrence of these two submarine canyons in the Monterey region adds a bathyal zone to the marine ecologic conditions already described.

The fauna of this zone in Monterey Bay includes about fifty-five reported species of mollusks on a fine sand or mud bottom, and seven mollusks and four brachiopods where the bottom is rock or gravel.

In addition to the bottom dwellers at least eight pelagic species of mollusks and fifteen free-swimming cephalopod species are to be found in the Monterey region.

For additional information on the shore conditions around Monterey Bay the reader will find much of interest in Ricketts and Calvin's "Between Pacific Tides," published in 1939. An account of the bottom conditions in the Bay is given by Galliher (1932). Another study, by Bigelow and Leslie (1928), covers the temperature, salinity, and chemical content of the ocean water of the Bay, and also the availability of microscopic fauna and flora for food. For the hydrography of the Bay, reference may be made to the work of Skogsberg (1936). A list of the marine algae has been published recently by Smith (1944).

COMMERCIAL USE OF MOLLUSKS FROM MONTEREY BAY AND VICINITY

The Red Abalone

One striking feature of the mollusk-fauna of the Monterey region is the fact that it contains six of the eight major species of abalone described from the West Coast. Of these, the red abalone *Haliotis rufescens* Swainson is of great commercial importance because of its excellence when well prepared and served as steaks, in chowder, or as the basic ingredient for other delectable fish dishes. In fact, it is not at all unusual in California restaurants to find that one has been served abalone cut to the right shape instead of the "eastern scallops" that were ordered. Nor is this such a flagrant substitution, as the flavor of the two is close and defies detection by all except the expert. Species other than the red abalone are of no commercial value. The meat of the black abalone is of inferior quality, while the others are small in size, rare, and found usually in relatively deep water.

The red abalone fishery in California is an old one and the vicinity of Monterey has been one of its principal centers for many years. The Chinese carried on the industry, beginning as early as 1864 to dry the meats for shipment to China. In this, they were joined by the Japanese, but of late, with operations shifting to deeper and deeper water, the Japanese until the second World War dominated the industry by use of the most modern diving equipment.

The first legal restrictions on the taking of abalones for commercial purposes was reported by Stearns (1899), when he stated that the supervisors of Monterey and of other seaboard counties had taken the necessary steps to regulate the "fishery." The Monterey County ordinance restricted "fishing" for abalones, except in deep water and set a license fee of $60 to be paid by commercial operators.

The drying of abalones was stopped by State law in 1915 and the good-sized drying camp located within the city limits of Monterey was closed. However, the canning of abalones, which had started about 1905 at Cayucos, in San Luis Obispo County, was carried on for many years near Point Lobos on the south side of Carmel Bay. This cannery shut down operations in 1928 and there has since been no canning of abalones in California.

For a more detailed discussion of abalone diving operations and the economic status of the red species the reader should refer to two interesting papers by Paul Bonnot (1930, 1940), of the California Division of Fish and Game. He has stated that the present fishery extends along the coast line between Point Pinos and Point Buchon, south of Morro Bay in San Luis Obispo County, approximately one hundred and twenty-five miles in length.

After making a series of thirty-four dives in 1939 at depths varying from twenty to one hundred feet, Bonnot said:

> Abalones are found on rocky bottoms from the low tide line to an undetermined depth. There are vast numbers of them out to the 60-foot level. From 60 to 80 feet there is a gradual decrease in numbers and at 100 feet only a few are found in unusually favorable places, a condition which is said to continue to greater depths. The divers ordinarily work out to 80 feet. Only occasionally do they endeavor to work at greater depths. From the shore line to the 80-foot level in the territory surveyed, there are great numbers of abalones with shells that measure 6 to 8 inches in diameter. Comparatively few are 8 inches or larger (8 inches is the legal minimum size limit). This is a logical sequence in territory systematically worked by the divers.
>
> There are a few 5-inch and still fewer 4-inch abalones, and below 4 inches none at all, except in one or two areas where special conditions prevail. The absence of the small sizes constitutes a serious condition. As the 6- and 7-inch abalones reach 8 inches and are taken by the divers, there will be no younger age classes to replace them.

In 1918, the commercial catch for the entire State was only about three thousand dozen, but with the rise in popularity of the abalone as a sea-food, the catch increased to 56,350 dozen in 1927 and over 41,300 dozen in 1928. This latter figure represents more than 2,066,000 pounds, or over one thousand tons of abalones. The commercial catch of California boats landing abalones at Monterey during the ten-year period 1931-1940 is shown in the accompanying table, indicating a steady decline in the catch reported for each year since 1934. In addition, of course, there is the non-commercial catch, which must run to considerable proportions each year judging from the number of people who flock to good hunting grounds during the exceptionally low or "abalone" tides.

LANDINGS OF FRESH MOLLUSKS FROM CALIFORNIA BOATS
Region 50, Monterey
Pigeon Point, south to Point Piedras Blancas

Year	Abalone	Pismo Clam	Gaper Clam	Cockle	Clam (Misc.)	Calif. Mussel	Oyster Native	Oyster Eastern	Oyster Jap.	Squid	Octopus
1931	3,210,825	16,510	60	—	—	150	—	—	—	1,706,671	58,412
1932	2,135,375	25,157	—	54	16	—	9,142	—	—	4,087,621	17,554
1933	2,221,500	26,097	—	—	—	—	—	—	78,088	769,695	22,535
1934	2,786,775	19,198	—	—	—	—	—	—	50,240	1,486,446	18,958
1935	2,656,200	23,425	—	—	—	—	2,250	67,630	—	783,102	53,362
1936	1,575,675	20,289	—	—	—	750	—	—	9,226	933,231	48,721
1937	1,433,200	14,087	—	—	—	1,490	—	—	—	464,739	19,160
1938	1,203,950	20,110	—	7	800	150	—	—	—	1,472,003	24,423
1939	789,450	16,330	36	—	—	—	—	—	—	1,097,815	23,225
1940	813,400	13,524	—	—	—	100	—	—	—	1,644,122	17,591

Data from reports and papers published by the California Division of Fish and Game. All figures in pounds.

While the decline in the catch of the red abalone may not be a particularly serious matter in view of the existing supply of shells just under the legal limit, the rarity of young to medium-sized shells might spell tragedy for the fishery in the long run. The situation is particularly unfortunate because of the lack of adequate knowledge of the life history of the red abalone — especially with respect to breeding habits. No natural resource can be "managed" successfully unless the laws that regulate it are based on sound scientific information. It is to be hoped, therefore, that the fact-finding survey of the State Division of Fish and Game will be continued and also that a comprehensive study of the red abalone will be undertaken by individuals or institutions properly equipped for the task.

Squid

The commercial fishery in Monterey Bay is an interesting one and ranks as one of the most important in the Bay. This is due, in recent years, to an increased demand for dried squid for export to China as food, the establishment of canning operations for squid, and the creation of a small demand for fresh squid in the fish markets. To most people the idea of eating squid may be abhorrent, yet when well prepared and fried in pure olive oil it is said to be on a par with abalone steak or fried scallops. The species taken in the Bay is *Loligo opalescens* Berry.

There are two brief but informative accounts of the Monterey squid fishery by W. L. Scofield (1924) and Classic (1929). According to the former writer:

> The squid industry along our coast is one of the most interesting, one of the oldest, and probably the least known of our California fisheries. The Chinese at Monterey fished for squid years before sardine canning was thought of, even before salmon were caught in large commercial quantities and the old Chinatown on China Point near Monterey was a busy community that polluted the atmosphere for miles around with the odor of drying squid, an odor that yields the palm for potency only to a whaling station. In the days before the power boat and before the Mediter-

ranean lateen sail was a common sight on Monterey Bay, most of the fishing was carried on by Chinese in small junks rigged with the ribbed sails of China or sculled by a single long sweep. Before 1870 the Chinese had established a town on China Point and were catching and drying squid. Later on the lights from their floating bonfires on dark nights were a common sight off the south shores of Monterey Bay.

Squid are now caught with lampara nets mostly at night in the same manner as sardines. A few may be taken throughout the year but the spring months of April, May, and June are considered to be the squid season. The commercial catch is variable, as the figures in the table show. Not shown, however, is the high year of 1930, when a total of nearly 11,000,000 pounds was landed at the Monterey Wharf.

Eighty per cent of the squid used to be dried in open fields, baled, and shipped for export. However, no squid have been dried at Monterey or elsewhere in California since 1932, and those who still hold memories of the spot known as "Heliotrope Point" in the Monterey of former years are quite willing to allow their experiences with drying squid to remain buried in the dim past.

Phillips (1941) has pointed out that drying was stopped because of the unstable condition of Chinese foreign exchange, coupled with the competition caused by a low-priced product from Japan. He stated that:

Although fresh squid are sold in the domestic markets, the quantity absorbed through this channel is not great because these sales are mainly to people of a few nationalities who cultivated a taste for this cosmopolitan mollusk in the land of their birth. A great deal of the fresh squid is frozen for shipment to retail markets throughout California. During the spring of 1941, large quantities of fresh squid were also frozen in five-gallon liver cans and shipped as bait to shark fishermen working out of Santa Barbara and Port Hueneme, California.

Canning of squid in California is of minor importance. The average amount taken annually for canning during the period 1918-1940, inclusive, was approximately 50,000 pounds, and this includes two years when no squid were canned. During the last three years there has been a great increase in the amounts canned, reaching a peak of 935,000 pounds in 1940. Most of the recent pack has been produced by one Monterey cannery.

At present, squid is canned "natural style," that is, squid in its own ink. It is also canned in sesame oil with the ink absent. The cooked squid "has a mild, shrimp-like flavor," says Phillips. The bulk of the canned product has been exported.

Since August, 1935, another species of squid, the Jumbo Squid *Dosidicus gigas* (d'Orbigny), has been taken in and off Monterey Bay in great numbers although it was a rarity in the Bay prior to that date. In November, 1935, a thousand pounds were landed at Santa Cruz by a "dragboat" working in one hundred and ten fathoms. Set-line fishermen also reported taking them in depths as great as three hundred fathoms on hooks baited for sable-fish. Since then many have been seen occasionally swimming on the surface, sometimes close to shore.

The Jumbo Squid ranges from two to four feet in length and may weigh from five to thirty pounds. Richard S. Croker (1937) of the State Fisheries Laboratory remarked that no one has yet devised a way to make it palatable, when prepared for the table, and hence a commercial fishery for this species has not been developed. (See also Clark & Phillips, 1936). According to Croker:

> In 1936 they seemed to be even more abundant all the way from Monterey Bay to San Diego. It was in this year that they were first recognized as a nuisance by the fishermen. Albacore trollers were first bothered with them striking at the jigs. Usually the squid pulled loose, but they invariably left some of their tender anatomy on the hooks to foul them. Those that were caught squirted slippery, insoluble ink on the decks much to the disgust of the fishermen. Rockfish set-liners complained bitterly that the squid not only stole all the bait from their lines, but also damaged the fish that had been caught on the hooks.
>
> The plague of Jumbo Squid has been worse in 1937. Setline, net and troll commercial fishermen are still bothered with them, and in addition sport fishermen have been harassed all spring. No sooner does a pleasure boat start to fish than a horde of squid appears on the scene to crowd the game fish away and seize all the baits. When one is hooked, it proceeds to shower boat and fisherman with ink and water, and then delights in biting its captor with its parrot-like beak. Several fishermen have been seriously bitten this year. Although squid fishing is hilarious sport for a few minutes, it becomes too much of a good thing day after day.

Latest reports indicate that the Jumbo Squid is still a nuisance in the Bay.

Octopus

It may be news to some that California has a thriving "devilfish" or octopus fishery of commercial proportions although of minor importance. Since 1920 the annual catch for the State has varied from 10,000 pounds to 165,000 pounds, with an average of about 75,000 pounds, of which eighty-five per cent is landed at Monterey and Santa Cruz.

At Monterey and at other points along the California coast, octopi are captured in baited traps consisting either of a wire-screened box or a peculiar dome-shaped basket of wicker or rattan, reinforced with wires. There are two and sometimes four octopus fishermen at Monterey, all Italians, each using from ten to thirty of these traps. The men anchor their traps one-half to one mile off the open rocky shore between Point Pinos and Carmel, in from ten to thirty fathoms of water. The normal season for fishing is the spring, summer, and fall months, a set of ten traps producing an average of fifteen octopi a week. Monterey specimens generally run from twenty-five to thirty pounds in weight but there is a record of an individual that weighed ninety pounds. The form caught is *Octopus* sp., cf. *O. apollyon* Berry, although sometimes listed as *O. hongkongensis* Hoyle.

Japanese abalone divers, working as deep as one hundred feet along the coast where octopi are trapped for market, do not complain of attacks by this eight-armed cephalopod. On the contrary, an occasional one is cornered by a diver, who ties a line around its body so that it can be lifted to the surface, later to provide the main course of a meal.

Octopi are eaten in all of the fishing ports along the California coast, mostly by Italians. They do not ship well, so are not transported to any great distances.

For an excellent account of this small but unusual fishery on which information in the above paragraphs are based the authors are indebted to J. B. Phillips (1924).

OYSTERS — Native and Introduced

While there is no active oyster industry in Monterey Bay at present, attempts have been made to establish one in the past. The possibilities for development are limited to Elkhorn Slough, as this locality is about the only one in the Bay that is suitable for oyster propagation. The Slough consists of two long narrow channels that unite about half a mile from the ocean water of the Bay. The main arm is about six miles long and varies in width from fifty to one hundred yards. The Slough is open to the Bay at all times and is therefore subject to tidal flow.

Speaking of the oyster industry, Bonnot (1935) had the following to say:

> Because of its accessibility and freedom from pollution, the slough has been used for oyster experimentation for some years. Native oysters are indigenous. In 1923 small eastern oysters from Texas were planted but they gradually died out or disappeared. In 1929 Mexican oysters were tried but they also failed to survive. Japanese oysters were introduced in 1929 and as they showed up well, 243 boxes of Japanese seed, set on tarred rope, were put out the following year. The rope was handled after a method developed in Japan, by cutting it into short lengths and hanging it from rafts. From this plant of 243 boxes some 9000 gallons of oyster meat was harvested and sold. The growth of these oysters was remarkable, requiring only eight months from the time of planting to reach market size. By the next spring the few oysters that remained were too large for the market, which calls for an oyster of 200 count (200 to the gallon).
>
> Twenty-five barrels of Eastern oysters were planted in January, 1932. Some were laid out on the bottom and some were strung on copper wire and hung from floats. They have shown a good growth but have not equaled the Japanese in size. Experiments have been carried on for the past two summers at Elkhorn in an endeavor to obtain a local race of the Japanese oyster, but so far without success. Other experiments, however, have resulted in a heavy set of native oysters, and with a little attention the slough should be able to produce a good grade of native oysters in fair quantity.

From 1933 to 1936 good quantities of Japanese oysters were harvested but for several years none have been marketed. Small numbers of both the native and Eastern oysters were harvested in 1935 only. The oyster industry in Elkhorn Slough is not active at present.

The planting of oysters that are not indigenous to Monterey Bay should be watched carefully to prevent, if possible, the introduction of other species of mollusks that are harmful to them. The oyster drill *Urosalpinx cinereus* (Say) is already found in the Slough but so far the Japanese drill *Ocenebra japonica* (Dunker) has not been reported. Several other species have been introduced with oysters elsewhere in the State and in the bays and harbors of the Pacific Northwest. Shell collectors should therefore be on the lookout for new species liable to have been introduced into the Bay and report them, when found, to the proper authorities, particularly the Bureau of Marine Fisheries of the State Division of Fish and Game. For an excellent account of introduced species of mollusks the reader is referred to a paper by Dr. G. Dallas Hanna (1939) of the California Academy of Sciences, published by the State Department of Agriculture.

Eastern oysters planted in Elkhorn Slough were *Ostrea virginica* Gmelin, those from Texas probably being a variety of this same species. The species introduced from Mexico is likely to have been *O. chilensis* Philippi. The Japanese species is *O. laperouseii* Schrenck but is referred to by some as *O. gigas* Lamarck. The species native to the Bay is the well-known Olympia oyster *Ostrea lurida* Carpenter.

Clams and Mussels

Although many species of clams found in Monterey Bay are edible, with only two or three exceptions they are not taken in commercial quantities. One is the Pismo clam *Tivela stultorum* (Mawe), which is found in small numbers at Moss Landing and at Watsonville Beach. Although J. G. Cooper reported the Pismo clam as common at Santa Cruz in 1861, it does not appear to be taken there in any numbers at the present time. During the legal season Pismo clams may be bought in the markets at Monterey, Watsonville, and Santa Cruz, and along the highway between these cities, for ten or fifteen cents apiece. The preceding table shows the reported annual commercial catches for a ten-year period.

Unlike the red abalone, the Pismo clam has been carefully studied and its life-history is now well known (Weymouth, 1923). Steps were taken to protect the species after the great beds of them at Pismo Beach were virtually exhausted. Under present laws for a closed season during the breeding months and bag limits that control the number and size that may be taken, the species might have been expected to begin to rehabilitate itself where once it was common. Unfortunately this has not been sufficient even to maintain the species and the outlook for the industry, at least at Pismo, is not bright.

At Pismo a census is taken every year by the State Bureau of Marine Fisheries that gives information on the size of the previous year's "set," and the numbers of clams of spawning age and legal size. There have been only three good sets in the last fifteen years, one of which, in 1937, suffered an unusually high mortality. The clams reach legal size in about five years and then begin to be removed quickly. As a result of poor sets and other reasons it seems likely that the Pismo clam will have to be placed on the protected list for a number of years in order to give the species an opportunity to multiply to the point where there will be an ample supply in Monterey Bay and at beaches farther to the south. There is probably no hope that even under the most careful management there will ever be numbers comparable to those encountered in "the good old days" at Pismo, of which it has been said that the farmers could go down to the beach during a low tide with a horse and plow and turn clams out by the thousands.

The Pismo clam is one of the West Coast's finest species, which, for its combined qualities of size, tenderness and flavor, has few equals.

Other species of clams occasionally taken in Monterey Bay are the "gaper" or "rubberneck" clam *Schizothaerus nuttallii* (Conrad) and the cockle or little-neck *Protothaca staminea* (Conrad). Although the "geoduck" of Puget Sound and northern bays has been collected in limited numbers in Morro and San Pedro Bays, it appears to be quite rare in Monterey Bay, occasional specimens having been reported as taken in Elkhorn Slough.

The common California or sea mussel *Mytilus californianus* Conrad is also taken occasionally for the market, as the table shows.

All of the above species, and those in the following list, may often find their way to the tables of individual epicures, although the total catch is probably small:

Cardium nuttallii Conrad	Giant cockle
Macoma nasuta (Conrad)	Bent-nosed clam
Macoma secta (Conrad)	Butter clam
Mya arenaria Linnaeus	Eastern soft-shelled clam
Platyodon cancellatus (Conrad) . . .	Rock clam
Saxidomus nuttalli Conrad	Giant clam; Washington clam
Solen sicarius Gould	Jack-knife clam
Zirfaea pilsbryi Lowe	Mud-borer clam

SHELLFISH POISONING

Although the species of clams and mussels from the Monterey region listed above are edible under normal circumstances, a word of caution should be interjected, for there are times when clams, and mussels especially, make dangerous eating because of poison they absorb at certain times along the California coast. For a brief account of this situation we are indebted to Dr. G. Dallas Hanna, who was instrumental in assembling the following information:

> Since 1927 periodic cases of poisoning from eating the mussel, *Mytilus californianus,* have been reported along the west coast from southeast Alaska southward as far as La Jolla, California. Results are serious, as very severe illness and often death follow. Thus in June, 1939, the newspapers reported thirty-two cases and three deaths from eating these mollusks collected at Monterey, in spite of the fact that

the gathering of them at that time was strictly prohibited and all likely places had been posted with conspicuous signs.

A great deal of study has been given to this problem by members of the staff of the Hooper Medical Foundation of the University of California. Many papers have been published, references to which, together with a late summary of the results obtained, will be found in the two referred to below. (Sommer, Whedon, Kofoid, and Stohler: 1937; Sommer and Meyer, *et al.*; 1937.)

A few of the noteworthy points determined are:

1. The specific poisons are derived by the mussels from dinoflagellates belonging to the genus *Gonyaulax* and probably to the species *catenella*.

2. While *Mytilus californianus* has been responsible for most of the ill effects to human beings the toxic poison has been found in many other bivalve mollusks and even the common sand crab, *Emerita analoga*.

3. The following species have been selected from the papers referred to because dangerous amounts of poison were found in them.

Mytilus californianus Conrad—General distribution.
Saxidomus nuttalli Conrad—Washington.
Schizothaerus nuttallii (Conrad)—Bodega and Tomales Bays.
Siliqua patula (Dixon)—Half Moon Bay.
Protothaca staminea (Conrad)—Bodega and Tomales Bays.
Pholadidea penita (Conrad)—Half Moon Bay.
Tivela stultorum (Mawe)—Monterey Bay.
Macoma (species?)—Bodega Bay.
Volsella demissa (Dillwyn)—San Rafael, San Francisco Bay.
Probably this list will be extended with further study.

4. Except in the case of the single *Volsella demissa,* the mollusks of inner bays such as San Francisco have thus far been free from dangerous amounts of poison. Apparently the inhabitants of open surf-swept shores are the most susceptible.

5. Several poisons appear to be involved, the exact chemical structure having been determined for none of them as yet.

To this account we can add but one item, which relates the possible connection between the presence of phosphorescent "red water" off the coast and epidemics of shellfish poisoning (Bonnot and Phillips: 1938).

Fortunately, the California Division of Fish and Game is on the watch for any signs of this trouble and notices are posted and appear in the press whenever there is danger. At these times the epicure should, for his own protection, withhold his natural and perfectly understandable desires for a dish of his favorite shellfish, and wait for a more favorable time.

A list of references on shellfish poisoning, which is as complete as we have been able to obtain, is given on pages 242 and 243.

CHECKLIST OF SPECIES

In assembling the accompanying checklist of the mollusks and brachiopods of Monterey and its vicinity the attempt has been made to gather every authentic record, especially from the Bay itself. Besides searching all available literature, shells from many of the museums and private collections on the West Coast have been examined. The junior author has made an intensive search through the United States National Museum Collection at Washington, D. C., and determined the status of many questionable records for species listed by Dall in his "Summary of the Marine Shellbearing Mollusks of the Northwest Coast of America, from San Diego to the Polar Sea . . ," published by the National Museum in 1921.

The large collection at the California Academy has provided the source of many hitherto unpublished records. This includes the Hemphill Collection and a number of others acquired subsequently, including that of the junior author. In addition, the fine collection at Stanford University, which includes the Oldroyd Collection, the collection at the University of California at Berkeley, and a number of private collections have been carefully reviewed.

Because it has been necessary to exercise a degree of judgment in accepting some of the older published records and eliminating others, the present list is far from being the last word. Much careful collection needs to be done in order to confirm or reject the right of many species to remain in it, and perhaps to add new ones yet unreported. Also, inevitable taxonomic changes will result in adding, combining, or eliminating species.

The checklist follows, in general, the classification used by Dall in his "Summary," except that his emphasis on subgeneric names has not been applied. In certain other instances we have deviated from Dall's work for reasons that are believed to be sound. No attempt has been made to supply the latest view on taxonymy but where changes have been made the authorities on which they are based will be found listed under the heading "Synonymic Notes," beginning on a subsequent page.

In citing species names we have tried to adhere strictly to Article 23 of the International Rules of Zoological Nomenclature by placing parentheses around authors' names when the species are classified under different genera from those originally used. Because of the many taxonomic changes that have been made, there is a question whether this procedure still serves any useful purpose.

Records that are patently erroneous or that appear to be doubtful are shown in brackets ([]) in the list. Many of these belong to a fauna farther to the south in California or Lower California and we have not been able to confirm the fact that they really belong to the fauna of the Monterey region.

Species described from specimens originally collected in the area are preceded with an asterisk (*). To these, we are adding 18 new species and subspecies, which are described and figured on subsequent pages. It is notable that about 27 per cent of the valid species in the list have Monterey Bay or its vicinity as the type locality, the total being 197.

As the relative abundance of individuals of a species, the range in depth within which a species normally may be found, and the conditions or nature of its habitat are important essentials in a checklist, we have given careful attention to these three items. While this information for each species represents our knowledge at the present time, we would be the first to point out that it is still far from accurate or complete for a great many of them, especially those living in the deeper parts of the Bay and the surrounding ocean.

In order to show relative occurrence of a species in point of numbers we have used a five-step scale, based on the occurrence of individuals *within the known habitat,* as follows:

Occurrence	*Definition*
1. Abundant	A species of which individuals may be found everywhere in large numbers. The collector can take an almost unlimited number of specimens, if he so desires, at any time when the tide is right or when dredging at the proper depths on the proper type of bottom.
2. Common	Individuals occur in considerable numbers and can be collected usually in fair quantity under the right conditions. A collector could expect to find specimens of a common species easily without making a special search.
3. Fairly Common	Species of which individuals may normally be taken in small numbers. A collector could expect to find a few specimens of a fairly common species each time he sought for it.
4. Scarce	Individuals occur occasionally, and then singly or only a few at a time. The collector could not expect to find specimens of a scarce species every time he collected, nor would it come up in every dredge haul.
5. Rare	Species of which only a few specimens are known to have been collected. A number of species listed as rare are based on a single shell.

Species shown as rare may, in some instances, prove to be scarce or even common when more is learned of their habitats, or, if they live in deep water, when more opportunity and better facilities for dredging for them is afforded. The exact number of specimens existing for a rare species is given in the checklist, if known.

The checklist contains 732 species and subspecies considered valid, which are classified under 139 families and 305 genera. Also listed are 80 more considered doubtful or erroneous. This is truly a remarkable assemblage of mollusks and brachiopods from a north latitude of 36°. The following table gives a breakdown of the total, by groups:

Group	Numbers of Species and Subspecies *Valid*	*Doubtful*	*Total*
Pelecypods	189	22	211
Scaphopods	10	0	10
Gastropods			
Pteropods	5	0	5
Opisthobranchs	21	2	23
Nudibranchs	36	0	36
Pulmonates	5	0	5
Ctenobranchs	393	44	437
Chitons	51	9	60
Cephalopods	15	1	16
Brachiopods	7	2	9
TOTAL	732	80	812

We know of no other locality outside of tropical or semitropical areas where the molluscan fauna has such a large number of species. The fact that the ranges of nearly a hundred additional species not yet authentically reported from the Monterey region extend both to the north and to the south of it indicates the possibility of adding these to the list, bringing the total to over 800 species and subspecies.

Genera having the largest representation of species and subspecies are shown in the following table, which lists those having six or more:

Genus	Number	Genus	Number
Turbonilla	30	*Margarites*	8
Odostomia	27	*Balcis*	8
Acmaea	16	*Nuculana*	7
Epitonium	14	*Pecten*	7
Ischnochiton	14	*Colus*	7
Cerithiopsis	11	*Propebela*	7
Bittium	11	*Pholadidea*	6
Macoma	10	*Dentalium*	6
Ocenebra	10	*Mangelia*	6
Alvania	10	*Nassarius*	6
Mitrella	9	*Amphissa*	6
Mopalia	9	*Boreotrophon*	6
Calliostoma	8	*Haliotis*	6

The authors will be grateful for any additions or for further information that will serve to make the checklist more complete and accurate.

In acknowledging our debt to those who have assisted us in the prepara-

tion of this paper, it should be mentioned that experts on various molluscan groups have been of very material help. Dr. F. M. MacFarland of Stanford University furnished the list of nudibranchs and supplied much information on the habitats and occurrence of many species in this group to which he has given special study for many years. Dr. S. Stillman Berry reviewed the lists of his specialties, the chitons and cephalopods. Mrs. Avery R. (Grant) Test of the University of Michigan furnished collecting records and notes on the taxonymy of the limpets. Dr. Paul Bartsch reviewed the turrids and has kindly published the descriptions of several new species from the Monterey region so they could be listed here, in advance of the appearance of his monograph on this group. Both Dr. Bartsch and Dr. Harald Rehder of the National Museum were particularly helpful on problems connected with the survey of the shells from Monterey in the vast collection at Washington.

Appreciation goes also to Mr. and Mrs. Emery P. Chace of Lomita, California, Tom and John Q. Burch of Los Angeles, Dr. A. Myra Keen of Stanford University, the late George Willett of the Los Angeles Museum, Professor William J. Raymond of Berkeley, the Rev. Elwood B. Hunter and Mr. Andrew Sorensen of Pacific Grove, and Mr. John Strohbeen of Santa Cruz, all of whom have been generous with the loan of specimens for study and for invaluable information. We are especially indebted to Drs. G. Dallas Hanna and Leo G. Hertlein of the Academy's staff for much assistance, encouragement, and advice throughout the period this study has been under way.

PELECYPODA

Prionodesmacea

SOLEMYACIDAE

Solemya panamensis Dall—9 fathoms off Pacific Grove, in coarse granitic sand; one specimen (Gordon).

Solemya valvulus Carpenter—10-25 fathoms off Monterey, in sand; rare.

NUCULIDAE

Nucula cardara Dall—43-108 fathoms off Point Pinos and Santa Cruz, in soft green or dark mud (USFC Stas. 4475, 4482, 4483, 4523); fairly common.

Nucula carlottensis Dall—581 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3670); rare.

Nucula linki Dall—51 fathoms off Point Pinos, in soft dark gray mud (USFC Sta. 4464); rare.

Nucula tenuis (Montagu)—15-149 fathoms, in mud, sand and clay; fairly common.

Acila castrensis (Hinds)—15-149 fathoms, in mud, sand and clay; common.

NUCULANIDAE

Nuculana acuta (Conrad)—28-35 fathoms off Point Pinos, in blue mud, sand and shells USFC Sta. 4441); rare. While the shells to which we refer here are close to the East Coast's *N. acuta,* there are differences that may result eventually in classifying them as a separate species. Until recently, collectors have incorrectly applied the name *acuta* to the fairly common subglobose shell with a short rostrum, which is properly identified as *N. penderi* (Dall).

**Nuculana amblia* (Dall)—465-1041 fathoms off Point Pinos, in green, blue and soft gray mud, and hard sand (USFC Stas. 3128, 4516, 4517, 4530, 4536-9, inclusive); abundant.

Nuculana conceptionis (Dall)—298 fathoms off Point Sur, in yellow sand and mud (USFC Sta. 3187); one specimen.

[*Nuculana cuneata* (Sowerby)—Monterey (Cooper). This is not *N. cuneata* (Sowerby), which is a synonym of *N. elenensis* (Sowerby). Early collectors applied the name to the species that Dall called *N. acuta* (Conrad).]

Nuculana hamata (Carpenter)—35-158 fathoms, in mud and sand; fairly common.

Nuculana leonina (Dall)—152-766 fathoms off Point Pinos and mouth of Salinas River, in green mud, sand and rocks (USFC Stas. 3202, 4509, 4514, 4517, 4541); fairly common.

Nuculana penderi (Dall and Bartsch)—8-35 fathoms, in sand; common.

Nuculana taphria (Dall)—8-51 fathoms, in coarse and fine sand; abundant. Common in fish stomachs (Sorensen).

Yoldia beringiana Dall—152-1041 fathoms off Point Pinos, in hard sand and blue and soft gray mud (USFC Stas. 3128, 4509, 4536); scarce.

**Yoldia cooperi* Gabb—5-15 fathoms off Soquel, in sand; scarce.

**Yoldia montereyensis* Dall—25 fathoms (Mrs. Oldroyd); 60 fathoms (Lowe); 152-871 fathoms off Point Pinos and mouth of Salinas River, in mud and sand (USFC Stas. 3128, 3202, 3670, 4509, 4514, 4517, 4538, 4540, 4541, 4542); common.

Yoldia scissurata Dall—35-139 fathoms, in mud. Common in fish stomachs (Sorensen). Syn. *Y. ensifera* Dall.

Yoldia seminuda Dall—21 fathoms off Monterey, in sand; one living specimen (Gordon).

Malletia faba Dall—581-627 fathoms off Point Pinos and mouth of Salinas River, in mud (USFC Stas. 3128, 3670).

Malletia pacifica Dall—152-329 fathoms off Point Pinos, in soft gray mud (USFC Sta. 4509); rare.

Tindaria gibbsii Dall—755-958 fathoms off Point Pinos, in soft gray mud (USFC Sta. 4530); rare.

ARCIDAE

Glycymeris subobsoleta (Carpenter)—5-15 fathoms off Pacific Grove, in coarse granitic sand, valves only; scarce.

[*Arca bailyi* Bartsch—recorded as *Barbatia gradata* Sowerby from 12 fathoms, sand, by Berry who now states that the record is extremely doubtful. The name *A. pernoides* (Carpenter), an indeterminate species from San Diego, has also been applied to this shell.]

PINNIDAE

Philobrya setosa (Carpenter)—5-40 fathoms, on sea mosses and calcareous algae, off Pacific Grove and Monterey; common.

OSTREIDAE

Ostrea laperousii Schrenck—Elkhorn Slough; introduced for commercial propagation. Syn. *O. gigas* Thunberg, not *O. gigas* Meuschen.

Ostrea lurida Carpenter—Sub-littoral in the Bay, in mud and on rocks and shells; fairly common.

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* An asterisk preceding a species' name in the checklist indicates the Monterey region is the type locality. Brackets ([]) indicate erroneous or doubtful records. Since the manuscript was completed several years prior to date of publication changes in some names have been recommended. It has not been practicable to make these and a few other minor alterations such as to bring all information strictly up to date.

Ostrea lurida expansa Carpenter—Monterey Harbor (Dall). Possibly a situs form of the preceding species.

Ostrea virginica Gmelin—Elkhorn Slough; introduced for commercial use.

PECTINIDAE

Pecten (Pecten) diegensis Dall—10-40 fathoms, in sand and on shale; fairly common. Like the rest of the Monterey pectens it is often found free-swimming.

[*Pecten (Plagioctenium) circularis* Sowerby—Monterey (Dall). According to Hertlein this must be considered a doubtful record, as true *circularis* is not known to range into California. The southern California shell is the subspecies *aequisulcatus* Carpenter, also not found in the Bay.]

Pecten (Chlamys) hastatus Sowerby—10-40 fathoms, in sand and on shale and corallines, sometimes encased in sponge; fairly common.

Pecten (Chlamys) hericeus Gould—10-20 fathoms, in sand. Fine living specimens were taken years ago by trawl fishermen but recent dredging has failed to locate any bed and has produced only a few valves.

Pecten (Chlamys) hericeus pugetensis I. S. Oldroyd—40 fathoms off Monterey, on shale (Burch).

[*Pecten (Chlamys) hindsii* Carpenter—Monterey (Cooper, Dall); beach at Pt. Lobos, as *navarchus* (Leitch). Not taken recently and the records need confirming. Young *Hinnites multirugosus* Gale or worn valves of *P. hastatus* Sowerby or *P. hericeus* Gould may have been mistaken for this species. Syn. *P. h. navarchus* Dall.]

[*Pecten (Leptopecten) latiauratus* Conrad—Monterey (Dall). Dall's immature specimen is the only record of this common southern California pecten.]

Pecten (Leptopecten) latiauratus monotimeris Conrad—Fan Shell Beach, near Cypress Point; 15-40 fathoms in Monterey Bay, on calcareous algae; common. This is the small form with prominently laminated interspaces named as *P. l. delosi* Arnold although the smoother form is collected occasionally. Syn. *P. l. delosi* Arnold.

Pecten (Delectopecten) randolphi tillamookensis Arnold—659 fathoms off Point Pinos, in green mud (USFC Sta. 5699); one specimen.

Pecten (Delectopecten) vancouverensis Whiteaves—15-220 fathoms, on calcareous algae and bryozoans; scarce.

Hinnites multirugosus (Gale)—Low tide to 12 fathoms; free-swimming when young, the adults cement themselves to rocks. 30 fathoms (Cooper). Fairly common. Syn. *H. giganteus* Gray.

LIMIDAE

Lima dehiscens Conrad—10-35 fathoms, nesting in sand or free-swimming; fairly common.

Lima subauriculata (Montagu)—20 fathoms off Monterey, on shale (Burch). 25 fathoms off Carmel; in sand; scarce.

ANOMIIDAE

[*Anomia peruviana* d'Orbigny—60 fathoms (Cooper). A doubtful record for this southern species.]

Pododesmus macrochismus (Deshayes)—Low tide to 20 fathoms, on rocks, on living abalones and in dead shells, especially mussels; common.

MYTILIDAE

Mytilus californianus Conrad—On rocks at low tide, especially along the ocean front; abundant.

Mytilus edulis Linnaeus—On wharf piles, Monterey Municipal Pier and Moss Landing; abundant. "Santa Cruz near river" (Cooper).

Septifer bifurcatus (Conrad)—Under rocks at low tide; fairly common.

[*Volsella capax* (Conrad)—Elkhorn Slough (McGinitie). Based on young specimens, which may have been *V. fornicatus* Carpenter. We have seen no authentic specimens of *capax* from the vicinity of Monterey. Syn. *Modiolus capax* Conrad.]

Volsella flabellata (Gould)—15-40 fathoms off Moss Landing and Santa Cruz, in sand; rare. Dr. Berry has a large specimen from Moss Landing measuring 210 mm. in length. Syn. *Modiolus flabellatus* (Gould).

Volsella diegensis (Dall)—With *Mytilus edulis,* Monterey Municipal Pier; in rock fill at Elkhorn Slough; fairly common. Also 12 fathoms off Del Monte, on shale; scarce. This species is not a boring mollusk and we believe it to be a *Volsella* rather than a *Botula.* Syn. *Botula diegensis* Dall.

Volsella fornicata (Carpenter)—Low tide to 40 fathoms, nestling among rocks, shells, and in fine gravel; abundant. While dredging in 5-15 fathoms in the lee of Point Pinos over a sand and broken shell bottom the shells brought up in the dredge were largely worn and broken valves of this species. Syn. *Modiolus fornicatus* Carpenter.

[*Volsella modiola* (Linnaeus)—Monterey (Cooper). A doubtful record for this northern species that needs confirming. Syn. *Modiolus modiolus* (Linnaeus).]

Volsella pallidula (Dall)—41-142 fathoms, in mud; fairly common. Syn. *Modiolus pallidulus* Dall.

Volsella recta (Conrad)—Elkhorn Slough, in mud at low tide; 10-20 fathoms, in sand; common. Syn. *Modiolus rectus* Conrad.

Botulina denticulata (Dall)—5-40 fathoms, in sand, shale, and broken shells; scarce. Shells we identify as this species have until recently been called *Modiolus opifex* Say, an East Coast species. Specimens from the West Coast are provisionally included under *denticulata,* although those from Monterey and other localities in California are lighter in color and smaller than typical specimens from Lower California, and may be separable.

Botula californiensis (Philippi)—8-15 fathoms, boring in shale; scarce.

**Botula falcata* (Gould)—Low tide at Santa Cruz, in shale; also 10-15 fathoms off Del Monte, boring in shale; common.

[*Lithophaga attenuata* (Deshayes)—Monterey (Dall). Dall's record was based on senile specimens of *L. plumula* (Hanley). San Ignacio Lagoon, Lower California, is the northernmost record for this species in the California Academy Collection.]

Lithophaga plumula (Hanley)—Low tide to 35 fathoms, boring in shale and occasionally in shells; common.

[*Modiolaria protracta* (Dall)—Monterey (Dall). Dall's record was based on a small worn valve of *Botulina denticulata* (Dall), dredged by Berry in 12 fathoms off Del Monte.]

Crenella columbiana Dall—15-40 fathoms, in sand and mud; fairly common.

Crenella decussata (Montagu)—15-30 fathoms, in sand; scarce.

[*Crenella inflata* Carpenter—25 fathoms (Berry). A doubtful record for this Cape San Lucas species.]

Anomalodesmacea

PERIPLOMATIDAE

Periploma discus Stearns—15-25 fathoms off Del Monte, in sand; rare.

THRACIIDAE

Thracia challisiana Dall—Beach at Pacific Grove (Gordon, Mrs. Fackenthall); rare.

Thracia curta Conrad—25 fathoms off Pacific Grove (Berry).

Thracia trapezoides Dall—A single young specimen from 35 fathoms off Seaside, in mud (Gordon).

Cyathodonta undulata Conrad—Fragments from 12 fathoms off Del Monte, in sand (Gordon).

PANDORIDAE

Pandora bilirata Conrad—41-142 fathoms, in mud, clay and gravel; fairly common.

Pandora filosa (Carpenter)—40-202 fathoms off Watsonville Beach and Point Pinos, in dark green or soft dark gray mud and in coarse sand, shells and rocks (USFC Stas. 3204, 4457, 4464, 4549); scarce.

Pandora punctata Conrad—10-15 fathoms, in sand; common.

LYONSIIDAE

Lyonsia californica Conrad—10-40 fathoms, in sand; common.

Lyonsia gouldii Dall—5-15 fathoms, in sand (Gordon); rare.

Entodesma inflatum (Conrad)—At low tide, in sponges and ascidians, to 40 fathoms, on shale; rare.

Entodesma saxicola (Baird)—Between tides, under boulders and in rock crevices; fairly common.

Mytilimeria nuttallii Conrad—In compound ascidians (*Amaroucium californicum* and other species), usually in colonies at low tide. Also dredged from 10-20 fathoms off Monterey (Burch). Fairly common.

POROMYACIDAE

**Dermatomya buttoni* Dall—581 fathoms off mouth of Salinas River, in mud (USFC Sta. 3670); rare.

**Dermatomya tenuiconcha* (Dall)—66-73 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4552); 659 fathoms off Point Sur, in green mud (USFC Sta. 5699); rare.

CUSPIDARIIDAE

Cuspidaria apodema Dall—70 fathoms, in mud (McGinitie); 85-158 fathoms off Point Pinos, in soft green mud (USFC Sta. 4475); scarce.

Cardiomya californica (Dall)—34-73 fathoms off Point Pinos, in mud and rocks (USFC Stas. 4457, 4474, 4552). Syn. *Cuspidaria californica* Dall.

Cardiomya pectinata (Carpenter)—66-69 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4555). Syn. *Cuspidaria pectinata* (Carpenter).

Cardiomya planetica (Dall)—40-202 fathoms off Point Pinos, Watsonville Beach and Santa Cruz, in soft green mud and sand (USFC Stas. 3204, 4475, 4482, 4483, 4485). Syn. *Cuspidaria planetica* Dall).

VERTICORDIIDAE

Verticordia ornata (d'Orbigny)—25 fathoms, in sand, Monterey and Carmel Bays; scarce.

TELEODESMACEA

CARDITIDAE

Glans carpenteri Lamy—Shore to 15 fathoms, under rocks and among rubble and broken shells; abundant. Syn. *Cardita subquadrata* (Carpenter).

[*Cardita crebricostata* (Krause)—Monterey (Dall). Dall's specimens belong under *C. ventricosa montereyensis* Smith and Gordon, new subspecies. True *crebricostata* does not appear to have been recorded south of Oregon.]

Cardita prolongata (Carpenter)—5-25 fathoms off Pacific Grove and 25 fathoms, in sand; rare.

**Cardita ventricosa montereyensis* Smith and Gordon, new subspecies. Described on page 212; see text figs. 2, 3; 35-139 fathoms, in mud and fine sand; fairly common.

Milneria kelseyi Dall—China Point, under rocks, and 10 fathoms off China Point on sand and broken shell bottom; scarce.

**Milneria minima* Dall—10-15 fathoms, in sand and shells; rare.

CHAMIDAE

[*Chama buddiana* C. B. Adams—Monterey (Dall). This record was based upon a specimen of *Pseudochama granti* Strong.]

Chama pellucida Broderip—Between tides, cemented to rocks, often on their undersides; fairly common. Specimens from Monterey Bay generally are small and lack the pink color of those found farther to the south.

Pseudochama exogyra (Conrad)—With the above, but found only on the upper faces of rocks. Once fairly common, this species is now hard to find.

Pseudochama granti Strong—25-60 fathoms in Monterey Bay, on rocks and shells; 25 fathoms, in Carmel Bay; fairly common.

THYASIRIDAE

Axinopsis sericatus (Carpenter)—15-25 fathoms, in sand and mud; fairly common.

Axinopsis viridis Dall—36-85 fathoms off Point Pinos, in soft dark gray and green mud (USFC Stas. 4464, 4475); 298 fathoms off Point Sur, in yellow sand and mud (USFC Sta. 3187).

UNGULINIDAE (DIPLODONTIDAE)

Taras orbellus (Gould)—Occasionally found at low tide and in beach drift. 3-15 fathoms, in sand and rocks; scarce. Usually nestles in borer holes. Syn. *Diplodonta orbella* (Gould).

Taras sericatus (Reeve)—15 fathoms, in sand; one young specimen (Gordon). Dredged off Monterey (Burch). Syn. *Diplodonta sericata* (Reeve).

LUCINIDAE

Lucina annulata Reeve—8-10 fathoms (Dall). Fragments dredged in 25 fathoms in sand (Gordon). A young specimen from a kelp holdfast in 10 fathoms (Smith).

Lucina approximata (Dall)—10-70 fathoms, in sand and mud; fairly common.

Lucina californica Conrad—Shore to 40 fathoms, in sand and gravel; common.

Lucina nuttalli Conrad—15 fathoms, in sand; rare.

Lucina tenuisculpta (Carpenter)—19 fathoms off Watsonville Beach, in mud, fine sand and stones (USFC Sta. 3138); rare.

[*Divaricella perparvula* Dall—"Monterey" (Gabb). This record is unquestionably erroneous.]

ERYCINIDAE (LEPTONIDAE)

Kellia laperousii (Deshayes)—Shore to 35 fathoms, nestling in kelp foldfasts; rock crevices, and borer holes; also in salt-water tank at the Hopkins Marine Laboratory; abundant.

Kellia suborbicularis (Montagu)—With the preceding species and may include it. Apparently this name has been used as a catch-all for West American shells of *K. laperousii* tending toward the orbicular.

Rochefortia aleutica (Dall)—10-35 fathoms, in fine sand and shale fragments; fairly common.

Rochefortia tumida (Carpenter)—Shore to 40 fathoms (Berry). We have not collected it and suspect Berry's shells may be the preceding species.

Serridens oblonga (Carpenter)—Monterey, commensal on *Ischnochiton heathiano* (Berry); rare (Chace).

**Sportella* (?) *californica* Dall—15-25 fathoms off Pacific Grove and Point Pinos, in fine sand; scarce. This shell is not a *Sportella* and may be a species of *Pseudopythina*.

[*Pseudopythina compressa* Dall—Elkhorn Slough (McGinitie). The single specimen so identified is actually a large pathologic individual of *P. rugifera* (Carpenter.).]

Pseudopythina rugifera (Carpenter)—Elkhorn Slough, commensal on shrimps of the genus *Upogebia* (McGinitie). 60-70 fathoms off Monterey, in mud, on the undersides of *Aphrodite* worms.

Bornia retifera Dall—Monterey Harbor (Dall). Not taken recently.

Lasaea cistula Keen—In kelp foldfasts and nestling among mussels; common. This species, and *L. subviridis* Dall, are frequently found in collections under the incorrect name *L. rubra* (Montagu).

Lasaea subviridis Dall—In kelp holdfasts; also 5-15 fathoms, in sand. Less common than the preceding species.

**Anisodonta pellucida* Dall—12 fathoms off Del Monte, in sand (Berry). Known only from the type specimen.

CHLAMYDOCONCHIDAE

Chlamydoconcha orcutti Dall—Between tides, on rocks (Heath); rare.

CARDIIDAE

Cardium (Trachycardium) quadragenarium Conrad—12-30 fathoms, in sand and shale fragments; fairly common.

Cardium (Clinocardium) fucanum Dall—10-40 fathoms, in sand; fairly common. This species is often misidentified as *C. californiense* Deshayes, which is a northern species not found in California in spite of its name.

Cardium (Clinocardium) nuttallii Conrad—Elkhorn Slough, in mud; common. Dredged in depths under 20 fathoms (Burch). This species has been incorrectly called *C. corbis* (Martyn).

[*Cardium (Laevicardium) substriatum* Conrad—Monterey (Cooper). A doubtful record.]

**Nemocardium centifilosum* (Carpenter)—10-40 fathoms in Monterey Bay, in mud and sand, scarce; 15 fathoms off Carmel (Cooper). Syn. *Protocardia centifilosa* (Carpenter).

VESICOMYACIDAE

Vesicomya gigas (Dall)—659 fathoms off Point Sur, in green mud (USFC Sta. 5699); a single specimen.

Vesicomya ovalis (Dall)—415-659 fathoms off Point Sur, in green mud (USFC Stas. 5698, 5699); rare.

VENERIDAE

Tivela stultorum (Mawe)—Moss Landing, in sand at low tide; fairly common. Reported as common at Santa Cruz in 1861 by Cooper but now found there rarely, if at all.

Transennella tantilla (Gould)—Low tide to 20 fathoms, in sand; abundant.

Pitar newcombianus (Gabb)—30 fathoms, in sand (Cooper). No specimens appear to have been collected recently.

Antigona fordii (Yates)—6-40 fathoms, in sand and shale fragments; rare.

Saxidomus giganteus (Deshayes)—10-12 fathoms off Del Monte, in sand; rare.

Saxidomus nuttalli Conrad—Pacific Grove, in sand and small rocks at low tide; scarce. Elkhorn Slough; common in mud and gravel. Many young specimens dredged down to 20 fathoms, in sand.

Compsomyax subdiaphana (Carpenter)—10-40 fathoms, in sand and mud; common. Syn. *Marcia subdiaphana* (Carpenter).

Humilaria kennerleyi (Reeve)—Dredged in shallow water off Monterey (Burch); Beach at Carmel, one valve (Keep); a few miles south of Carmel (Chace). Syn. *Marcia kennerleyi* (Reeve).

[*Chione succincta* (Valenciennes)—Three young specimens, listed as *C. simillima* Sowerby, 30 fathoms in Carmel Bay, in mud (Cooper). This is a doubtful record for this southern species. Cooper's shells may have been the young of *Protothaca staminea ruderata* (Deshayes.)]

Protothaca laciniata (Carpenter)—10-20 fathoms off Del Monte, in sand; valves and fragments only. Syn. *Paphia laciniata* (Carpenter).

Protothaca staminea (Conrad)—Between tides, in sand and gravel; also to 25 fathoms in sand and shale fragments or nestling in borer holes in shale. Distorted specimens growing in borer holes have been named *P. s. orbella* (Carpenter) and *P. s. petitii* (Deshayes). The frilled variety, *P. s. ruderata* (Deshayes), may be subgenerically distinct. Syn. *Paphia staminea* (Conrad).

Protothaca tenerrima (Carpenter)—Elkhorn Slough; rare. Cooper reported one valve in 20 fathoms and said "it lives below low tide at Santa Cruz." Immature valves in 12 fathoms (Berry). Syn. *Paphia tenerrima* (Carpenter).

**Irus lamellifer* (Conrad)—Low tide to 35 fathoms, in gravel or nestling in borer holes; common. Syn. *Venerupis lamellifera* (Conrad).

Gemma gemma (Totten)—15 fathoms off Pacific Grove, in sand; one specimen (Gordon). Introduced with oysters from the East Coast.

Psephidia brunnea Dall—Monterey (Dall). We have not collected it.

Psephidia lordi (Baird)—10-30 fathoms, in sand and mud; fairly common.

[*Psephidia ovalis* Dall—12 fathoms (Berry). This record needs confirming.]

Psephidia salmonea (Carpenter)—10 fathoms off China (Cabrillo) Point, in sand; fairly common (Smith).

PETRICOLIDAE

Petricola carditoides (Conrad)—Low tide to 40 fathoms, in borer holes; common.

[*Petricola californiensis* Pilsbry and Lowe—Reported as *P. denticulata* Sowerby from 25 fathoms by Berry, on Dall's identification. Berry's specimens, on analysis, prove to be young valves of the preceding species.]

COOPERELLIDAE

Cooperella subdiaphana (Carpenter)—15-40 fathoms, in sand; fairly common.

TELLINIDAE

Tellina bodegensis Hinds—Below low tide to 15 fathoms, in sand; fairly common.

Tellina buttoni Dall—10-25 fathoms, in sand; common.

Tellina carpenteri Dall—15-75 fathoms, in sand and mud; scarce.

Tellina modesta (Carpenter)—15-25 fathoms, in sand; scarce.

Tellina salmonea (Carpenter)—5-40 fathoms, in coarse sand; fairly common.

Macoma calcarea (Gmelin)—36-51 fathoms off Point Pinos, in soft dark gray mud (USFC Sta. 4464); one specimen.

Macoma carlottensis Whiteaves—40-286 fathoms off Point Pinos and mouth of Salinas River, in soft green or gray mud, gray sand, and a combination of mud, sand and boulders (USFC Stas. 3666, 4457, 4475, 4509, 4522, 4523, 4555); common.

Macoma expansa Carpenter—Monterey (Hannibal). 45 fathoms off Santa Cruz, in soft green mud (USFC Sta. 4483).

Macoma inconspicua (Broderip and Sowerby)—Elkhorn Slough, in mud, to 10 fathoms, in sand. Originally described as *Tellina inconspicua* Broderip and Sowerby.

Macoma indentata Carpenter—9-25 fathoms, in coarse to fine sand; rare.

Macoma irus Hanley—Common at Elkhorn Slough, in mud. Syn. *M. inquinata* (Deshayes).

Macoma nasuta (Conrad)—Abundant in Elkhorn Slough, in mud and fine sand. Dredged down to 25 fathoms off Monterey (Burch).

Macoma quadrana Dall—40-153 fathoms, in mud; scarce.

Macoma secta (Conrad)—Abundant in Elkhorn Slough, in mud and sand.

Macoma yoldiformis Carpenter—10-25 fathoms, in sand and shale fragments; common. 40 fathoms off Moss Landing (Berry).

SEMELIDAE

Semele incongrua Carpenter—5-25 fathoms, in coarse to fine sand or nestling in borer holes in the shale; common. 20-30 fathoms in muddy sand, Carmel Bay (Cooper).

[*Semele pulchra* (Sowerby)—Monterey Bay (Dall). Dall's record is based on a single valve. This record needs confirming.]

**Semele rubropicta* Dall—Low tide to 35 fathoms off Monterey and Soquel; beach at Point Pinos and Carmel. While valves of this fine red-rayed species are found occasionally, good living specimens are rare.

**Semele rupicola* Dall—Nestling in borer holes in shale, 15-25 fathoms off Del Monte, scarce; shore at Pacific Grove and Santa Cruz, valves only.

Cumingia californica Conrad—Nestling among small rocks and gravel, and in borer holes, low tide to 35 fathoms; fairly common.

SANGUINOLARIIDAE

Gari californica (Conrad)—Between tides, in coarse granitic sand, gravel and granite boulders. Young specimens down to 15 fathoms off Pacific Grove, in fine sand; scarce. Syn. *Psammobia californica* Conrad.

Sanguinolaria nuttallii Conrad—Elkhorn Slough; in mud; rare.

Heterodonax bimaculatus (Linnaeus)—Below low tide at Fan Shell Beach, near Cypress Point, (Dall; Mrs. Fackenthall); rare. Only separate valves have been collected.

Tagelus californianus (Conrad)—Elkhorn Slough; one valve (Hanna).

SOLENIDAE

Solen sicarius Gould—Low tide to 40 fathoms, in mud and sand; fairly common. Elkhorn Slough, in mud; scarce.

Ensis californicus Dall—Young specimens taken in 15 fathoms off Pacific Grove, in sand (Gordon).

Siliqua lucida (Conrad)—10-25 fathoms off Monterey, in sand; fairly common.

Siliqua patula (Dixon)—Beach at seaside, valves only; mouth of Elkhorn Slough; scarce. Syn. *S. patula nuttallii* (Conrad).

MACTRIDAE

Mactra californica Conrad—Elkhorn Slough (McGinitie). Reported common on the beach at Santa Cruz by Cooper. 12 fathoms off Del Monte, in sand and shale fragments; one specimen (Smith).

Spisula catilliformis (Conrad)—Off Soquel, in sand (Stanford Collection). 40 fathoms off Moss Landing (Berry). A rare species in the Bay.

Spisula falcata Gould—15 fathoms off Pacific Grove, in sand (Gordon); rare. Valves in 10 fathoms and living "toward Salinas River" (Cooper).

Spisula hemphilli Dall—15 fathoms off Cabrillo Point, in sand; one valve (Gordon).

Spisula planulata Conrad—Elkhorn Slough, in mud; scarce. 12 fathoms off Del Monte; common (Berry).

Schizothaerus nuttallii (Conrad)—Abundant in Elkhorn Slough. In borer holes in a shale boulder at Del Monte (Chace). Living young and valves off Monterey in 20 fathoms (Burch).

MYACIDAE

Mya arenaria Linnaeus—Elkhorn Slough, in mud; common. Introduced.

[*Mya intermedia* Dall—Monterey (Dall). Two young specimens, one from Monterey and the other from 45 fathoms off Point Año Nuevo are the basis for this record. Whether they are the young of this or another species is difficult to determine.]

Cryptomya californica (Conrad)—Nestling in rocks and gravel at low tide at Pacific Grove; fairly common. Abundant at Elkhorn Slough, where it extends its siphons into the burrows of shrimps of the genera *Callianassa* and *Upogebia,* and the worm *Urechis caupo.* Beach to 20 fathoms (Cooper). Nestling in borer holes in shale at Del Monte (Chace).

Sphenia pholadidea Dall—Beach at Monterey, as *S. nana* (Oldroyd), and at the Hopkins Marine Station, as *S. globula,* one valve (Keen); 8-35 fathoms off Pacific Grove and Monterey, boring in shale; fairly common. The California sphenias appear to have been divided into too many species and we are of the opinion that there is but one in the Monterey region. In this connection there has been some confusion between *S. nana* (Oldroyd) and *S. globula* Dall. According to Dr. Keen, there are two paratypes of *globula* in the Stanford Collection, which, with the holotype in the National Museum, were collected at Bolinas by Hemphill. The Monterey specimen of *globula* cited by Mrs. Oldroyd (1927, 1:201) is a young *Platyodon cancellatus* (Conrad). Because of the variable shape of shells of this genus that are referable to the species named above, this becomes a questionable character for diagnosis and we are therefore relegating *S. nana* and *S. globula* to the synonymy of *S. pholadidea* after a study of photographs of the type specimen of the latter species, which were kindly furnished by Dr. Keen. We have not collected *S. fragilis* Carpenter at Monterey, the only material in the Academy Collection being from south of San Diego, which shows this species to be quite different from *pholadidea.* No shells of *S. ovoidea* Carpenter have been available for comparison of our Monterey material with this species. Syns. *Cuspidaria nana* Oldroyd; *S. nana* (Oldroyd); *S. globula* Dall.

Platyodon cancellatus (Conrad)—Low tide at Santa Cruz, in shale; fairly common.

ALOIDIDAE (CORBULIDAE)

[*Aloidis fragilis* (Hinds)—Monterey (Dall). Dall's single beach-worn valve of this Panamic species is probably adventitious. Syn. *Corbula fragilis* Hinds.]

Aloidis luteola (Carpenter)—25 fathoms off Carmel, in sand; a single specimen. Syn. *Corbula luteola* Carpenter.

SAXICAVIDAE

Panope generosa Gould—Beach at Del Monte (Gordon); Elkhorn Slough (Ricketts). A young dead specimen, 15 fathoms off Monterey, in sand (Smith). Scarce.

Saxicava arctica (Linnaeus)—Shore to 63 fathoms, nestling in kelp holdfasts, borer holes, and other sheltered places; abundant.

Saxicava pholadis (Linnaeus)—8-25 fathoms, in borer holes in shale; scarce.

Saxicavella pacifica Dall—Valves in 25 fathoms off Carmel, in sand; rare.

PHOLADIDAE

Zirfaea pilsbryi Lowe—Elkhorn Slough, in mud; scarce. Formerly identified as *Z. gabbi* Tryon.

Parapholas californica (Conrad)—8-25 fathoms, in shale. Also in shale boulders washed ashore at Del Monte. A large specimen in the Berry Collection measures 145x71x68 mm.

**Pholadidea ovoidea* (Gould)—8-25 fathoms, in shale. Common in 12 fathoms.

Pholadidea parva (Tryon)—Boring in shells of the red abalone; common.

Pholadidea penita (Conrad)—8-40 fathoms, in shale; fairly common.

Pholadidea penita concamerata Deshayes. There appear to be no recent authentic records of this subspecies from the region.

**Pholadidea penita sagitta* Dall—Found with the typical variety; abundant. According to Dr. Keen, this subspecies is the predominant form of *penita* in the Bay.

Pholadidea rostrata (Valenciennes)—8-25 fathoms, in shale; fairly common. This species has been misidentified as the South American *P. darwinii* (Sowerby), which is a very different shell.

Navea subglobosa Gray—Monterey Harbor (Dall); boring in shells of the red abalone, fairly common (Keen); 10-40 fathoms in shale; common.

*_Xylophaga californica_ Bartsch—75-108 fathoms off Point Pinos, in soft dark mud (USFC Sta. 4523).

Xylophaga mexicana Dall—Monterey (Dall). We have not collected it.

TEREDIDAE

Bankia setacea (Tryon)—In wharf pilings; common.

Teredo diegensis Bartsch—Elkhorn Slough (R. C. Miller).

SCAPHOPODA

Solenoconcha

DENTALIIDAE

*_Dentalium berryi_ Smith and Gordon, new species. Described on p. 216, see pl. 3, figs. 1-4; 20-40 fathoms off Monterey, in mud and sand; scarce.

Dentalium neohexagonum Sharp and Pilsbry—9-40 fathoms, in sand; abundant.

Dentalium pretiosum Sowerby—Off Monterey (Cooper); 20 fathoms off Carmel, in sand; rare (Smith). The Carmel specimens are longer, more slender, more widely curved, and more pointed than typical shells of this species from Puget Sound and Alaska; one has a slit on the outside of the curve, which is a feature not present in any specimens of *D. pretiosum* we have examined. They are therefore referred to *pretiosum* with some doubt. Cooper's shells may have been these, or *D. berryi* Smith and Gordon.

Dentalium rectius Carpenter—35-70 fathoms, in mud; common.

Dentalium semipolitum Broderip and Sowerby—9-35 fathoms off Monterey and Pacific Grove, in coarse to fine sand; scarce. Although the original description calls for "no notch or slit," several adult specimens we have examined have a prominent notch at the apex on the outside of the curve; young shells occasionally have a deep narrow slit. These occur together with specimens having no notch. Therefore, we believe that *D. hannai* Baker, proposed for shells differing from *D. semipolitum* only in the notch, is synonymous with the latter species.

Dentalium vallicolens Raymond—161-265 fathoms off Point Pinos, in mud (USFC Sta. 4462); a fragment.

Cadulus fusiformis Pilsbry and Sharp—10-40 fathoms, in sand; abundant.

Cadulus hepburni Dall—43-45 fathoms off Santa Cruz, in soft green mud (USFC Stas. 4482, 4483); 80 fathoms off Point Pinos, a single specimen (Gordon). Scarce.

Cadulus perpusillus (Sowerby)—36-69 fathoms off Point Pinos, in soft green and dark gray mud and rocks (USFC Stas. 4464, 4483); scarce.

Cadulus tolmiei Dall—627 fathoms off Monterey, in blue mud (USFC Sta. 3128); rare.

GASTROPODA

Pteropoda

SPIRATELLIDAE

*_Spiratella pacifica_ (Dall)—Pelagic. Monterey, dead on the beach, 1866 (Dall).

CAVOLINIDAE

Cavolina tricuspida (Rivers)—Pelagic. Occasionally found on shore after winter storms. Syn. *C. occidentalis* Dall.

CYMBULIIDAE

Corolla spectabilis Dall—Pelagic. Monterey (Dall).

Corolla vitrea (Heath and Spaulding)—According to Heath (1901), a large number of individuals of this species were taken at or near the surface of Monterey Bay and twice since that time (December 27, 1900) great shoals have been noted in the same locality. Syn. *Cymbuliopsis vitrea* Heath and Spaulding.

PNEUMODERMATIDAE

**Pneumoderma pacifica* Dall—Pelagic off the coast (Dall).

OPISTHOBRANCHIATA

ACTEONIDAE

**Acteon punctocaelata* (Carpenter)—3-25 fathoms, in sand; common.

Microglyphis breviculus Dall—66-73 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4552); rare.

ACTEOCINIDAE

Acteocina culcitella (Gould)—10-25 fathoms, in sand; scarce.

Acteocina culcitella intermedia Willett—10-30 fathoms, in sand; common.

Acteocina eximia (Baird)—20-158 fathoms, in mud and fine sand; fairly common.

[*Acteocina inculta* (Gould)—Monterey (Dall). This record is based on a worn specimen of *Retusa harpa* (Dall).]

**Retusa harpa* (Dall)—10-40 fathoms, in fine sand and mud; common. Found frequently in beach drift.

**Retusa montereyensis* Smith and Gordon, new species. Described on p. 217; see pl. 3, fig. 11; 15 fathoms off Del Monte, in sand; 25 fathoms off Pacific Grove; rare.

Volvulella californica Dall—45 fathoms off Santa Cruz, in soft green mud (USFC Sta. 4483); 298 fathoms off Point Sur, in mud and yellow sand (USFC Sta. 3187); rare.

Volvulella cooperi Dall—Point Sur (Dall).

Volvulella cylindrica (Carpenter)—15-63 fathoms, in sand and mud; scarce.

DIAPHANIDAE

Diaphana californica Dall—10-25 fathoms, in sand and kelp holdfasts; rare (Smith).

[*Cylichna alba* (Brown)—Monterey (Dall). Probably the following, as we have seen only one species of *Cylichna* from the Monterey region.]

Cylichna attonsa (Carpenter)—10-40 fathoms, in sand and mud; common. Until better evidence is at hand we are tentatively referring the common Monterey shell to this species.

AKERIDAE

Haminoea vesicula (Gould)—Elkhorn Slough; seasonally abundant. Santa Cruz, living in Soquel Creek estuary (Cooper).

GASTROPTERIDAE

Gastropteron pacificum Bergh—Dredged in Monterey Bay; rare (MacFarland).

AGLAJIDAE

Navanax inermis (Cooper)—Elkhorn Slough; rare (McGinitie).

Aglaja diomedea (Bergh)—Elkhorn Slough (McGinitie).

APLYSIIDAE

Tethys californicus (Cooper)—Shore to 5 fathoms, on kelp. Elkhorn Slough (McGinitie).

Tethys californicus (subspecies?)—According to Berry, a small red form, very different from the shore form in appearance, was dredged by him in 12 fathoms. It may prove to be distinct.

Phyllaplysia taylori Dall—On eel-grass of the genus *Zostera,* near Monterey (McFarland); Elkhorn Slough (McGinitie).

PLEUROBRANCHIDAE

Pleurobranchus californicus Dall—Pacific Grove, at low tide under rocks; rare (Smith).
Pleurobranchaea (species?)—Dredged (MacFarland).

NUDIBRANCHIATA

DUVAUCELIIDAE

**Duvaucelia exsulans* (Bergh)—Dredged off Año Nuevo Point and in Monterey Bay (MacFarland).

**Duvaucelia (Tritonia) festiva* (Stearns)—Monterey to Point Lobos and Point Sur (MacFarland). Point Pinos (Stearns, Costello).

Duvaucelia tetraquetra (Pallas)—Dredged in Monterey Bay (MacFarland).

POLYCERIDAE

**Aegirus (Aegires) albopunctatus* MacFarland—Monterey to Point Lobos (MacFarland); low tide at Pacific Grove (Berry); extreme low water, on stones, at Santa Cruz (Cooper).

**Laila cockerelli* MacFarland—Cabrillo Point; Point Aulon; Point Pinos to Point Lobos; scarce (MacFarland).

**Triopha carpenteri* (Stearns)—Monterey to Point Sur; common in tide pools (MacFarland); Point Pinos (Stearns); common on brown kelp (Costello).

Triopha catalinae Cooper—Santa Cruz; rare on stones at extreme low water (Cooper). Not reported by MacFarland.

**Triopha grandis* MacFarland—Cabrillo Point to Point Sur, on kelp beds of the genus *Macrocystis* off shore along the coast (MacFarland).

**Triopha maculata* MacFarland—Cabrillo Point to Point Lobos; common in rocky tide pools along the coast (MacFarland).

**Polycera atra* MacFarland—Cabrillo Point; abundant. Also common from Point Pinos to Cypress Point (MacFarland).

**Acanthodoris brunnea* MacFarland—5-10 fathoms off Monterey; scarce (MacFarland). 12 fathoms off Del Monte (Berry).

**Acanthodoris hudsoni* MacFarland—Point Pinos; rare in tide pools at extreme low water (MacFarland).

**Ancula pacifica* MacFarland—In tide pools at Cabrillo Point, Point Pinos, Cypress Point, and Point Lobos; rare (MacFarland).

**Hopkinsia rosacea* MacFarland—Common in tide pools at Cabrillo Point, Point Pinos, Cypress Point, and Point Lobos (MacFarland).

CORAMBIDAE

**Corambe pacifica* MacFarland and O'Donoghue—Common off Monterey and Pacific Grove, on brown kelp bearing colonies of the bryozoan *Membranipora villosa* Hincks (MacFarland).

DORIDIDAE

**Cadlina flavomaculata* MacFarland—Cabrillo Point to Pescadero Point; scarce. (MacFarland, Costello).

**Cadlina marginata* MacFarland—In tide pools all along the coast from Cabrillo Point to beyond Point Lobos, scarce (MacFarland); shore to 25 fathoms (Berry).

Glossodoris (Chromodoris) californiensis (Bergh)—Point Pinos, very rare (MacFarland); fairly common in tide pools near Monterey (Snook and Johnson).

**Glossodoris (Chromodoris) porterae* (Cockerell)—Point Pinos; rare (MacFarland).

**Rostanga pulchra* MacFarland—Abundant at Cabrillo Point, Point Aulon, and Point Pinos; less so at Cypress Point, Pescadero Point, and Point Lobos (MacFarland).

Aldisa sanguinea (Cooper)—Common in rocky tide pools from Monterey to Point Lobos (MacFarland).

**Archidoris montereyensis* (Cooper)—Abundant in tide pools and on wharf piles (MacFarland). 7 fathoms on rock (Cooper). 25 fathoms (Berry).

**Anisodoris nobilis* (MacFarland)—Abundant in tide pools all along the shore of Monterey Bay, and to the northward and southward (MacFarland).

Diaulula sandiegensis (Cooper)—Common in tide pools (MacFarland).

**Discodoris heathi* MacFarland—Scarce in tide pools at Cabrillo Point, Point Pinos, Pescadero Point, and Cypress Point (MacFarland).

**Dendrodoris (Doriopsis) fulva* (MacFarland)—Common all along the coast in rocky tide pools (MacFarland). Shore to 25 fathoms (Berry).

ARMINIDAE

Armina (Pleurophyllidia) californica (Bergh)—Dredged off Monterey on sandy bottom (MacFarland).

DIRONIDAE

**Dirona albolineata* MacFarland—Cabrillo Point and Point Pinos, in rocky tide pools; rare.

**Dirona picta* MacFarland—Common in rocky tide pools from Monterey to Point Sur (MacFarland).

DENDRONOTIDAE

Dendronotus giganteus O'Donoghue—Dredged in deep water at various stations in Monterey Bay (MacFarland).

FIMBRIIDAE

Melibe leonina (Gould)—On kelp beds; scarce. (MacFarland, Fewkes).

HANCOCKIIDAE

**Hancockia californica* MacFarland—Common at Cabrillo Point; less so at Point Pinos and Cypress Point (MacFarland).

FLABELLINIDAE

Flabellina iodinea (Cooper)—On wharf piles at Monterey and in rocky tide pools at Cabrillo Point and Point Pinos; scarce (MacFarland); rare on algae at extreme low water at Santa Cruz (Cooper).

FIONIDAE

Fiona pinnata (Eschscholtz)—On driftwood bearing cirripede colonies in Monterey Bay and the open ocean (MacFarland).

AEOLIDIIDAE

Hermissenda crassicornis (Eschscholtz)—Common on wharf piles, old boat hulls, and in tide pools in Monterey Bay and all along the coast (MacFarland); Elkhorn Slough (McGinitie).

Aeolidia hercules Bergh—On sea anemone beds near the mouth of Waddell Creek, north of Santa Cruz; tide pools in Monterey Bay, south to Point Sur and beyond (MacFarland). Elkhorn Slough (McGinitie). This may be *A. papillosa* (Linnaeus) according to MacFarland.

PULMONATA

ELLOBIIDAE

Phytia setifer (Cooper)—Elkhorn Slough, 2 miles above the highway bridge, in *Salicornia;* abundant (Hanna).

Melampus olivaceus Carpenter—Mouth of the Salinas River (Dall). We have not collected it and have seen no specimens from this locality. There is a possibility that it may be found living in Elkhorn Slough.

TRIMUSCULIDAE (GADINIIDAE)

Trimusculus reticulatus (Sowerby)—Low tide, under rocks; scarce. Also large colonies on the roofs of caves exposed at low tide between Point Pinos and Point Lobos. Syn. *Gadinea reticulata* (Sowerby).

SIPHONARIIDAE

Williamia peltoides (Carpenter)—Below low tide mark. Living in 10-12 fathoms; scarce. (Berry, Smith).

**Williamia vernalis* (Dall)—Low tide to 12 fathoms, on rocks and shale fragments; fairly common. Also common in beach drift.

CTENOBRANCHIATA

CONIDAE

Conus californicus Hinds—Low tide, in sand pockets among rocks, to 15 fathoms; scarce.

TURRIDAE

Megasurcula carpenteriana (Gabb)—12-204 fathoms, in mud and fine sand; fairly common.

**Megasurcula granti* Bartsch—Monterey, Stearns Collection (Bartsch).

Megasurcula stearnsiana (Raymond)—20-55 fathoms, in mud; rare. In the Berry Collection is a splendid specimen from 20 fathoms off the Hopkins Marine Laboratory measuring 64.1 x 25.3 mm. (SSB No. 1991).

Megasurcula tremperiana (Dall)—Occurs with *M. carpenteriana* and may be only a variant of it. Its relationship to *M. granti* may be very close.

**Irenosyrinx amycus* (Dall)—795-871 fathoms off Point Pinos, in hard gray sand (USFC Sta. 4538); rare. Syn. *Leucosyrinx amycus* Dall.

[*Ophiodermella halcyonis* (Dall)—Monterey (Dall). See *O. montereyensis* Bartsch. Syn. *Clathrodrillia halcyonis* (Dall).]

**Ophiodermella montereyensis* Bartsch—Type from 13 fathoms, in fine sand and mud (USFC Sta. 3134); also 13-19 fathoms, on sand and mud and rock bottom (USFC Stas. 3138, 3142); 3 specimens. 10-50 fathoms, in sand; scarce. Shells from Monterey Bay identified as *O. halcyonis* (Dall) probably belong to this species.

Ophiodermella ophioderma (Dall)—From depths between 5 and 12 fathoms we have dredged specimens that do not appear to differ in any marked particulars from those collected in the San Pedro region. Santa Cruz (Cooper). It is scarce in the Bay. Syn. *Clathrodrillia incisa ophioderma* Dall.

[*Pseudomelatoma moesta* (Carpenter)—Monterey (Dall). Bartsch states there is no specimen from Monterey in the National Museum. The record needs confirming.]

**Pseudomelatoma torosa* (Carpenter)—Low tide to 35 fathoms, on rocks; scarce in shallow water but fairly common on the shale at 35 fathoms. Santa Cruz (Cooper). Includes the color form *P. t. aurantia* (Carpenter).

**Crassispira montereyensis* (Stearns)—Below low tide mark, in rock crevices and kelp holdfasts; rare.

**Carinoturris adrastia* (Dall)—581 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3670); rare. Syn. *Cryptogemma adrastia* Dall.

**Carinoturris fortis* (Bartsch)—Type specimen from 298 fathoms, in yellow sand and mud (USFC Sta. 3187). Known only from the type.

**Rhodopetoma amycus* (Dall)—581 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3670); known only from the type specimen. Syn. *Antiplanes amycus* (Dall).

**Antiplanes diomedea* Bartsch—328 fathoms off Point Sur, in black sand and mud (USFC Sta. 3186). Known only from the type specimen.

Antiplanes major Bartsch—43-278 fathoms off Point Año Nuevo and at several stations in Monterey Bay, on bottoms composed of various grades of mud and sand (USFC Stas. 3115, 3129, 3147, 3666, 3669, 4483). Sometimes taken on a clay or gravel bottom. About 200 fathoms, 14 miles off Davenport, Santa Cruz County, brought up by set-line fishermen, whose hooks occasionally snag a species of sea anemone growing on the shell (Strohbeen). Appears to be fairly common in depths between 50 and 75 fathoms.

[*Antiplanes perversa* (Gabb)—As now considered by Bartsch, this species has so far only been dredged off Catalina Island. Records of *A. perversa* from Monterey Bay should probably be referred to the preceding species.]

Antiplanes profundicola Bartsch—659 fathoms off Point Sur, in green mud (USFC Sta. 5699); two specimens.

[*Rectiplanes santarosana* (Dall)—Point Sur (Dall). The shells on which this record is based could not be found in the National Museum and according to Bartsch it is doubtful, at best, for this southern California species. Syn. *Antiplanes santarosana* (Dall).]

**Borsonella pinosensis* Bartsch—40-50 fathoms off Point Pinos, in green mud and fine sand (USFC Stas. 4452, 4457); 3 specimens.

**Propebela casentina* (Dall)—795-871 fathoms off Point Pinos, in hard gray sand (USFC Sta. 4538); rare. Syn. *Lora casentina* Dall.

**Propebela diomedea* Bartsch—581 fathoms off mouth of Salinas River, Monterey Bay, in mud (USFC Sta. 3670); type and three topotypes. Recorded from Monterey by Dall as *Lora exarata* (Möller).

**Propebela monterealis* (Dall)—With the preceding species; rare. Syn. *Lora monterealis* Dall.

**Propebela pitysa* (Dall)—66-73 off Point Pinos, in green mud and rocks (USFC Sta. 4552); 4 specimens. (Syn. *Lora pitysa* Dall).

**Propebela profundicola* Bartsch—Type specimens from 871 fathoms off Point Pinos, on gray sand and rock bottom (USFC Sta. 4538). Listed from Monterey Bay as *Lora popovia* Dall, which is now considered as strictly Aleutian by Bartsch.

**Propebela smithi* Bartsch—Type specimen from 293-386 fathoms off Point Pinos, in soft green mud (USFC Sta. 4508). Known only from the type.

**Propebela surana* (Dall)—298 fathoms off Point Sur, in yellow sand and mud (USFC Sta. 3187); 6 specimens. Syn. *Lora surana* Dall.

[*Propebela tabulata* (Carpenter)—Monterey (Dall). Except for three beach-worn specimens, which Dall labeled as having been collected by him at Monterey, this species is not known to have been collected south of Neah Bay. We suspect Dall's shells did not come from Monterey. Syn. *Lora tabulata* (Carpenter).]

Glyphostoma cymodoce Dall—80 fathoms, in mud and gravel; one specimen (Gordon). In the National Museum are two lots from Monterey Bay collected by Cooper (6 specimens) and from the Stearns Collection (4 specimens).

**Glyphostoma canfieldi* (Dall)—At low tide, in rocky pockets in sand among eel-grass roots, Pacific Grove and Point Pinos. Syn. *Philbertia canfieldi* (Dall).

Glyphostoma hesione (Dall)—Point Pinos (Dall). According to Bartsch there are no specimens from Monterey in the National Museum. Its occurrence in the Monterey fauna needs confirming. Syn. *Philbertia hesione* Dall.

**Kurtzia gordoni* Bartsch—10-20 fathoms, in sand; fairly common. Type and 3 topotypes from 43-46 fathoms off Santa Cruz, in green mud (USFC Sta. 4482). 40-158 fathoms off Santa Cruz and Point Pinos, generally on mud bottom (USFC Stas. 4457, 4464, 4475, 4483); 9 specimens. Shells of this species from Monterey have been identified by Dall and others as *Mangelia arteaga roperi* Dall.

**Kurtzina beta* (Dall)—Type dredged in 56 fathoms off Point Año Nuevo, in brown mud (USFC Sta. 3147); 40-46 fathoms off Point Pinos, in dark green mud (USFC Sta. 4457), 1 specimen; 60 fathoms off Point Pinos in soft dark gray mud (USFC

Sta. 4464), 2 specimens. Taken rarely in 40 fathoms, in mud or on a sand bottom. Syn. *Mangelia beta* Dall.

Mangelia barbarensis Oldroyd—10-50 fathoms, in mud and sand; common. Syn. *M. angulata* Carpenter.

Mangelia hecetae Dall and Bartsch—10-15 fathoms, in sand; rare. There is one lot in the National Museum from Monterey. Originally, we identified these shells as *M. crebricostata* Carpenter, but Dr. Bartsch believes they belong under *M. hecetae.*

**Mangelia interlirata* Stearns—Beach drift and at low tide; occasional.

[*Mangelia levidensis* Carpenter—Monterey (Dall). This should be considered a doubtful record, as Bartsch states there are no specimens in the National Museum from Monterey.]

**Mangelia perattenuata* Dall—10-45 fathoms, in mud (Woodworth). Known only from the type, which is a badly worn shell.

**Mangelia philodice* Dall—65-71 fathoms off Point Pinos, in green mud, sand, and gravel (USFC Sta. 4454); rare.

Mangelia variegata Carpenter—Below low tide mark. Syns. *M. pulchrior* Dall; *M. nitens* Carpenter.

Cytharella hexagona (Gabb)—10-20 fathoms, in sand, off Monterey; rare. Carmel Bay (Cooper).

[*Cytharella merita* (Hinds)—Monterey (Dall). This record is probably an error as the species is found farther to the south.]

**Daphnella fuscoligata* Dall—5-15 fathoms, in rocky and shale crevices; also in kelp holdfasts and in the beach drift; rare. Syn. *Mangelia (Mitromorpha) crassaspera* Grant and Gale.

CANCELLARIIDAE

Cancellaria cooperi Gabb—15-300 fathoms, in mud; rare. Recently Mr. John Strohbeen has obtained nearly a dozen specimens from fishermen operating set-lines for sable fish in about 200 fathoms off Davenport, Santa Cruz County. The living shells are occasionally brought up when a species of sea anemone that grows on them, apparently attaches itself to the bait. This is one of the most striking and sought after species in the Bay.

Cancellaria crawfordiana Dall—50-70 fathoms, in mud; scarce.

Admete couthouyi (Jay)—45 fathoms off Santa Cruz, in soft green mud (USFC Sta. 4483); 52-59 fathoms off Point Pinos, in green mud (USFC Sta. 4446); rare.

Admete couthouyi (subspecies?)—394-406 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4514). The deep-water form has much finer sculpture than the preceding, approaching *A. middendorffiana* Dall; rare.

Admete rhyssa Dall—65-71 fathoms off Point Pinos, in green mud, sand, and gravel (USFC Sta. 4554); rare. Although labeled *A. californica* (Dall), this lot in the U. S. National Museum appears to be *A. rhyssa.*

**Admete woodworthi* Dall—10-45 fathoms (Woodworth). Also 50 fathoms off Point Pinos, in green mud and fine sand (USFC Sta. 4552). Evidently a rare species as we have not dredged it in the Bay.

OLIVIDAE

Olivella biplicata (Sowerby)—In colonies at low tide, in sand; abundant. Dredged down to about 20 fathoms (Burch).

Olivella baetica Carpenter—5-40 fathoms in Monterey and Carmel Bays, in sand; common. In older collections, shells of this species were often labeled *O. pedroana* Conrad. Following T. S. Oldroyd's classification (Nautilus, 34(4):117) they would be called *O. baetica diegensis* T. S. Oldroyd. Large shells, typical of *O. baetica* from Alaska, have not been reported from Monterey.

[*Olivella pedroana* (Conrad)—This species was based on a Pleistocene fossil from San Pedro. As the type has been lost it appears to be unidentifiable and so we are eliminating it from this list as an authentic species found within the Monterey region. We are referring shells formerly called *O. pedroana* to *O. baetica* Carpenter. Study of a series of Olivellas from the San Pedro Pleistocene in the Academy's collection leads us to the suspicion that *O. pycna* Berry and *O. pedroana* (Conrad) may be synonymous.]

Olivella pycna Berry—Living at low tide, in sand, on the beach below "Pop Ernest's" famous restaurant at Monterey (D. S. and E. W. Gifford); 10-15 fathoms in sand, Monterey Bay; 20 fathoms, in sand, Carmel Bay; fairly common. This is the species that has sometimes been labeled *O. intorta* Carpenter, which is a Mexican shell.

MARGINELLIDAE

Marginella jewettii Carpenter—Beach drift; common. Living shells rarely found in small colonies, in sand, at the roots of eel-grass among rocks at low tide. Dredged down to 20 fathoms.

Marginella regularis Carpenter—Shore to 20 fathoms, living on or under rocks; fairly common.

Marginella subtrigona Carpenter—Monterey (Dall). Beach drift at Pacific Grove (Smith).

Cypraeolina pyriformis (Carpenter)—In tide pools and at low tide in algae and sea mosses; abundant. Dredged down to about 40 fathoms (Burch).

VOLUTIDAE

[*Scaphella arnheimi* Rivers—According to Dall (U. S. Geol. Surv. Prof. Paper 59, 1909, p. 210) "the shell is really from Magellan Straits" and in an unpublished note by him in the National Museum it is stated that a specimen of *S. magellanica* (Sowerby), dredged by the *Albatross* in the Straits of Magellan, was stolen by a sailor and sold to J. J. Rivers as a Monterey Bay shell. Rivers mistakenly described it as new. The specimen was destroyed in the San Francisco fire of 1906.]

MITRIDAE

**Mitra montereyi* Berry—Dead shells rare in beach drift. Living specimens dredged from 5-40 fathoms, on shale; scarce. The southern analog of this species is *M. idae* Melvill, which has a slenderer shell with somewhat rougher sculpture.

**Mitromorpha aspera* (Carpenter)—Shore to 15 fathoms, on rocks, in shale fragments, and in beach drift; fairly common. May include *M. interfossa* (Carpenter).

Mitromorpha filosa (Carpenter)—At low tide, under rocks; rare.

**Mitromorpha gracilior* (Tryon)—Low tide to 15 fathoms; common. Syn. *M. intermedia* Arnold.

PTYCHATRACTIDAE

Ptychatractus californicus Dall—36-51 fathoms off Point Pinos, in soft dark gray mud (USFC Sta. 4464); one young specimen.

**Metzgeria montereyana* Smith and Gordon, new species. Described on p. 218; see pl. 3, fig. 6; 15 fathoms, in fine sand and shale fragments, off Del Monte. Known only from the type specimen.

FUSINIDAE

Fusinus barbarensis (Trask)—63-80 fathoms, in gravel; scarce.

[*Fusinus kobelti* (Dall)—Monterey (Dall). This record, based on an immature living specimen collected by Stearns, is subject to doubt. We have not seen this species from the Bay.]

**Fusinus luteopictus* (Dall)—Low tide, under rocks, to 15 fathoms; fairly common but not nearly so abundant as in southern California and seems near to the northern end of its range.

Fusinus monksae Dall—8-35 fathoms off Del Monte, on shale; fairly common. There is a question whether shells from Monterey Bay usually so named are really *F. monksae* or a new species. Syn. *F. robustus* (Trask).

NEPTUNEIDAE (CHRYSODOMIDAE)

[*Macron lividus* (A. Adams)—4 specimens of this southern California species in the National Museum are labeled as coming from Monterey. We have never taken it and regard the record as extremely doubtful.]

Mohnia vernalis Dall—581 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3670); rare.

Exilioidia rectirostris (Carpenter)—389-456 fathoms off Point Pinos, in green mud (USFC Sta. 4513); rare. Syn. *Exilia rectirostris* (Carpenter).

Plicifusus griseus Dall—381-633 fathoms off Point Pinos, in green mud and sand (USFC Stas. 4513, 4541); scarce.

Colus aphelus (Dall)—750-766 fathoms off Point Pinos, in green mud and sand (USFC Sta. 4517); one specimen.

Colus clementinus Dall—627 fathoms off Point Pinos, in blue mud (USFC Sta. 3128); rare.

Colus georgianus Dall—750-766 fathoms off Point Pinos, in green mud and sand (USFC Sta. 4517); rare.

Colus halidonus Dall—331-633 fathoms off Point Pinos, in hard sand and green mud (USFC Stas. 4541, 4542); rare.

Colus jordani (Dall)—633 fathoms (Dall). In the National Museum there is a single specimen from 381-633 fathoms off Point Pinos, in green mud and sand (USFC Sta. 4541), and a lot of four specimens from 581 fathoms off mouth of Salinas River, in green mud and fine sand (USFC Sta. 3670), under this name. They probably represent a new species, allied to but not identical with *C. jordani.*

**Colus severinus* (Dall)—278 fathoms off mouth of Salinas River, in green mud and fine sand (USFC Sta. 3669); 296 fathoms off Point Año Nuevo, in fine gray sand (USFC Sta. 3112); scarce.

Colus trophius (Dall)—750-766 fathoms off Point Pinos, in green mud and sand (USFC Sta. 4517); rare.

Neptunea amianta Dall—One dead specimen in 42 fathoms off Pigeon Point (Bolin); 278-871 fathoms off Point Pinos and mouth of Salinas River, in green mud and various grades of sand (USFC Stas. 3127, 3669, 3670, 4513, 4517, 4538); fairly common. About 200 fathoms, 14 miles off Davenport, Santa Cruz County, brought up by set-line fishermen; about ten specimens of all sizes (Strohbeen).

**Neptunea ithia* Dall—204-382 fathoms off Point Sur, Point Pinos, and mouth of Salinas River, in green and soft gray mud and black and fine sand (USFC Stas. 3186, 3202, 3669, 4526); scarce. Brought up by set-line fishermen with the preceding species; about a dozen specimens (Strohbeen).

Neptunea lirata (Martyn)—755-847 fathoms off Point Pinos, in soft gray mud (USFC Sta. 4530); one immature specimen.

Neptunea tabulata (Baird)—Worn shell from the beach at Seaside; 50-80 fathoms off Moss Landing, in mud, clay, and gravel; 202 fathoms off Watsonville Beach, in black sand (USFC Sta. 3204). Brought up by set-line fishermen; 15 specimens (Strohbeen). Scarce.

Searlesia dira (Reeve)—Monterey (Dall). Dall's very worn dead specimen in the National Museum is the only record from the Bay. We have not taken it there or elsewhere in the Monterey region, although it occurs a few miles north of Pigeon Point.

BUCCINIDAE

Buccinum strigillatum Dall—278 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3669); one specimen.

Buccinum viridum Dall—331-871 fathoms off Point Pinos and mouth of Salinas River, principally in green mud but occasionally on a sand bottom (USFC Stas. 3670, 4513, 4514, 4516, 4517, 4538, 4540, 4541, 4542); common.

NASSARIIDAE (ALECTRIONIDAE)

Nassarius californianus (Conrad)—30-40 fathoms off Moss Landing and Soquel Point, in mud and sand; rare.

Nassarius cooperi (Forbes)—3-25 fathoms, in sand; abundant.

Nassarius fossatus (Gould)—Elkhorn Slough, common; 10 fathoms off Monterey, in sand, rare.

Nassarius insculptus (Carpenter)—40-73 fathoms off Point Pinos, in green mud, sand, and gravel (USFC Stas. 4452, 4454, 4457); scarce.

Nassarius mendicus (Gould)—With *N. cooperi;* abundant.

Nassarius perpinguis (Hinds)—5-25 fathoms, in sand; common.

PYRENIDAE (COLUMBELLIDAE)

Anachis penicillata Carpenter—Monterey (Cooper). We have not taken it although the range of this species has been extended as far north as Pescadero (Smith).

**Mitrella aurantiaca* Dall—At low tide, on rocks and among sea mosses; scarce.

Mitrella carinata (Hinds)—Shore to 15 fathoms, on rocks and kelp; common.

Mitrella carinata californiana (Reeve)—With the preceding, but more plentiful.

Mitrella carinata hindsii (Reeve)—With *carinata;* less common.

Mitrella gausapata Gould—With *carinata;* abundant.

Mitrella gouldii (Carpenter)—39-356 fathoms off Point Pinos, mouth of Salinas River, and Santa Cruz, in soft green and dark gray mud, sand, and shells (USFC Stas. 3666, 4475, 4485, 4508, 4522, 4523); fairly common. This and *M. lutulenta* were formerly placed in the genus *Nitidella.*

Mitrella hypodra Dall—One beach-worn specimen at Monterey (Dall).

Mitrella lutulenta (Dall)—10-73 fathoms, in mud and fine sand; common. This species is separated with some difficulty from *M. gouldii* on the basis of smaller size and shorter spire.

Mitrella tuberosa (Carpenter)—Shore to 20 fathoms, in sand and rocks. Santa Cruz, living at low water (Cooper). Specimens dredged in abundance off Monterey have transverse finlike ridges of epidermis on the body whorl.

[**Aesopus goforthi* Dall—Monterey? (Goforth). We suspect that Goforth's single specimen of questioned locality came from more southern waters.]

**Amphissa bicolor* Dall—66-356 fathoms off Point Pinos and mouth of Salinas River, in soft green and gray mud and sand (USFC Stas. 3666, 4462, 4508, 4509, 4526, 4552); common. Also 298 fathoms off Point Sur, in yellow sand and mud (USFC Sta. 3187), which is the locality of the figured type.

Amphissa columbiana Dall—A large form of *Amphissa,* which is definitely not *A. versicolor* Dall, is found rarely under rocks at low tide. It is provisionally referred to *columbiana,* although it is quite different from typical northern shells of this species.

Amphissa reticulata Dall—10-60 fathoms, in sand and mud; scarce. The relationship between this species and *A. versicolor incisa* Dall seems close.

**Amphissa versicolor* Dall—Shore to 15 fathoms, on rocks; abundant at low tide. Two color varieties, described as *A. v. cymata* Dall and *A. v. lineata* Stearns, are also found occasionally. Many other color forms of this handsome little species could be named from Monterey but they would have small scientific validity.

Amphissa versicolor incisa Dall—10-12 fathoms off Del Monte, in sand and shale fragments; rare.

Amphissa undata (Carpenter)—15-40 fathoms, in sand; scarce.

MURICIDAE

**Murex carpenteri* (Dall)—7-35 fathoms, on shale, off Pacific Grove, Monterey, and Del Monte; fairly common. This is the shell that some collectors have been calling *M. petri* Dall, although the true *petri* (Syn. *M. rhyssus* Dall) is a southern species not certainly reported from the Montery region.

Murex tremperi Dall—With the preceding species, but scarce. There has been much confusion between this species and *M. carpenteri* owing to Dall's error in figuring a San Diego specimen as *carpenteri.* Monterey Bay specimens of *tremperi* are less delicately frilled and larger than *carpenteri.* From southern California shells of this species they differ by being more imbricate and the varices have frequent and more pointed digitations, which are often strongly recurved at the tips. The name *tremperi* was proposed by Dall for a banded color variety of the southern California form, the types of which are in the California Academy's collection. Syn. *M. carpenteri tremperi* Dall.

Purpura foliata Martyn—Shore at low tide, among rocks under kelp, to 15 fathoms; fairly common. Dredged specimens are beautifully frilled, of which there are several in one of the main cases of the Pacific Grove Museum.

[*Purpura nuttalli* (Conrad)—Recorded from Monterey by Dall and Berry. The latter now states that his shell is undoubtedly a form of *P. foliata* (Martyn). We have not seen specimens of true *nuttalli* from the Monterey region and consider the record to be an exceedingly doubtful one.]

Ocenebra barbarensis (Gabb)—10-40 fathoms, on shale fragments; scarce. The group of species listed under *Ocenebra* have previously been described under *Ocinebra* (mistake in spelling) and *Tritonalia.*

**Ocenebra beta* (Dall)—8-35 fathoms on rocks and shale; common. Specimens submitted to the National Museum for comparison with the type establish its identity as *beta* instead of a new species as previously supposed. It is the shallow water analog of *O. barbarensis,* from which it differs mainly in its heavier shell, with shorter spire and canal. It is not related to *O. interfossa* (Carpenter), although described as a subspecies of it.

**Ocenebra circumtexta* Stearns—Between tides, on rocks, especially those a short distance off shore; common.

[*Ocenebra foveolata* (Hinds)—Monterey (Dall). Whether typical *foveolata* actually occurs in the Monterey region seems to depend on the range of variation allowed the species. As we have not collected adult shells identical with the usual southern California form, we are provisionally assigning the Monterey shells of this group to *O. fusconotata* (Dall).]

**Ocenebra fusconotata* (Dall)—3-15 fathoms, on rocks and in shale and kelp holdfasts; scarce. Differs from *foveolata* in its smaller size, brown markings on a ground color of dirty white, and in being more strongly imbricate and elegantly sculptured.

Ocenebra gracillima Stearns—Between tides, on rocks; scarce. Monterey specimens have coarser sculpture than is found on shells of this species collected in southern California. They were described as *O. stearnsi* Hemphill, which becomes a synonym of *gracillima. O. gracillima obesa* (Dall), also reported from Monterey, appears to be of doubtful taxonomic value.

FIG. 1. *Ocenebra beta* (Dall). Hypotype. C.A.S. Paleo. Type Coll. No. 8563. Length, 15.8; max. diam., 9.0 mm. (G. D. Hanna, del.)

**Ocenebra interfossa* Carpenter—Shore at moderately low tide, to 10 fathoms, under rocks; commonest of the ocenebras in the Bay. Carpenter's type, in the National Museum, came from Monterey.

Ocenebra interfossa clathrata (Dall)—Shore to 15 fathoms, on shale. From a study of a large growth series, Berry believes this to be a separate species.

Ocenebra lurida aspera (Baird)—Low tide to 10 fathoms, on granite boulders and other rocks; abundant. Monterey shells of this subspecies are not as large or as heavily sculptured as specimens from northern localities. They are brilliantly colored, with yellow and red-brown predominating. There is a possibility that Baird's subspecies is a synonym of the typical form and hence we use his name provisionally for shells from the Monterey region. *O. lurida rotunda* (Dall), found occassionally with *aspera,* is considered to be a variant without real subspecific standing.

Ocenebra lurida munda (Carpenter)—Low tide to 10 fathoms, found with the preceding but much less common.

Ocenebra subangulata (Stearns)—Shore, on granite rocks, to 15 fathoms, on shale; rare. Comparison of Monterey and other northern California specimens with typical shells of *O. michaeli* from Cayucos shows no appreciable differences. Syn. *O. michaeli* Ford.

Urosalpinx cinereus (Say)—Elkhorn Slough; fairly common. Introduced with seed oysters from the Atlantic Coast.

Boreotrophon avalonensis (Dall)—Monterey Bay, in 40 fathoms (Burch).

Boreotrophon calliceratus (Dall)—65-71 fathoms off Point Pinos, in green mud, sand, and gravel (USFC Sta. 4454); one specimen. This is more robust than those from the original lot and strongly resembles *B. triangulatus* (Carpenter).

[*Boreotrophon multicostatus* (Eschscholtz)—20 fathoms (Cooper). As this northern species has not been reported from the Bay in recent years, we believe Cooper's shells were another species, possibly *B. triangulatus* (Carpenter).]

Boreotrophon smithi (Dall)—46-71 fathoms off Point Pinos, in green mud, sand, shells and rocks (USFC Stas. 4535, 4551, 4555, scarce; 75 fathoms off Santa Cruz, with *Laqueus californianus* (Koch) on rock (Bolin). A single specimen with rather high spire from the beach at Point Pinos (Sorensen).

Boreotrophon stuarti (E. A. Smith)—202 fathoms off Watsonville Beach, in black sand (USFC Sta. 3204); rare.

Boreotrophon triangulatus (Carpenter)—20-40 fathoms, on shale; scarce. Syn. *B. peregrinus* (Dall).

**Trophonopsis lasius* (Dall)—152-495 fathoms off Point Pinos, in green mud, coarse sand, and shells (USFC Stas. 4509, 4515); scarce.

Trophonopsis tripherus (Dall)—581 fathoms off mouth of Salinas River, in green mud and sand (USFC Sta. 3670); rare.

**Thais canaliculata compressa* Dall—Scarce between tides, on rocks along the ocean front, but common under beds of mussels exposed at low tide at the tips of Point Pinos, and Pescadero, and Carmelo Points.

Thais emarginata (Deshayes)—On rocks, between tides; abundant. Unusually large and fine shells of this species, varying in color and sculpture, are to be found nearly everywhere.

Thais emarginata ostrina (Gould)—Between tides, on rocks along the ocean front; common.

Thais lamellosa (Gmelin)—Common on the beach at the mouth of Scott Creek, 15 miles north of Santa Cruz (Mr. and Mrs. Harry Turver). Not recorded from Monterey Bay or the ocean front of the Monterey Peninsula. The Scott Creek shells are probably the subspecies *franciscana* Dall.

[*Thais lima* (Martyn)—Monterey (Dall, Berry). We have not collected this Alaskan species at Monterey and suspect that the published records of it there are based on misidentifications of *T. canaliculata compressa* Dall or one of the numerous variations of *T. emarginata* (Deshayes).]

Acanthina spirata (Blainville)—On rocks between tides at Monterey, Elkhorn Slough, Santa Cruz and elsewhere; scarce. The color form *A. s. aurantia* Dall is found rarely.

Acanthina spirata punctulata (Sowerby)—On rocks between tides; abundant. It does not intergrade with the preceding species in the Bay. Formerly identified as *A. lapilloides* (Conrad).

EPITONIIDAE

Opalia chacei (Strong)—Below low tide mark, under granite boulders, scarce. Also in the beach drift. California shells incorrectly identified in collections as *O. wroblewskyi* Mörch) or *O. borealis* (Gould) belong to this species.

Opalia evicta (de Boury)—On shore in beach drift to 35 fathoms, on shale; scarce.

**Opalia montereyensis* (Dall)—25 fathoms off Del Monte, in mud; two specimens (Berry). Strong, Nautilus, 51(1):6, states that this species may prove to be identical with *O. evicta* (de Boury), in which case the latter will become a synonym of *montereyensis*.

Epitonium (Dentiscala) insculptum (Carpenter)—Monterey (Dall). We have not collected it and believe the record to be doubtful for this southern species. Syn. *E. crenimarginatum* (Dall).

Epitonium (Asperiscala) bellastriatum (Carpenter)—10-25 fathoms, in fine dark sand and shale fragments; fairly common.

[*Epitonium (Nodiscala) retiporosum* (Carpenter)—15-25 fathoms, in fine dark sand and shale fragments; rare. May be a synonym of the next species.]

**Epitonium (Nodiscala) spongiosum* (Carpenter)—Monterey, "shell washings" (Cooper). We have seen only one species of the subgenus *Nodiscala* from the California coast and are of the opinion that shells belonging to it are properly identified as *spongiosum*.

**Epitonium (Nitidiscala) berryi* (Dall)—12 fathoms off Del Monte (Berry). Apparently this is only a variety of *E. rectilaminatum* Dall. The type of *berryi* is the only known specimen from Monterey.

Epitonium (Nitidiscala) columbianum Dall—10-20 fathoms off Santa Cruz, in dark sand and rock fragments; rare (Gordon). Off Monterey in 20 fathoms, on shale (Burch).

[*Epitonium (Nitidiscala) cooperi* Strong—Monterey (Dall). We have seen no authentic specimens of this southern California species from Monterey. The record needs confirming. Syn. *E. fallaciosum* Dall.]

[*Epitonium (Nitidiscala) crebricostatum* (Carpenter)—Monterey (Cooper). Strong (1930) states that this species is indeterminate until a type is chosen that agrees with Carpenter's description. He believes it to be possibly an extreme variant of *E. tinctum.* The reference to the type as being in the University of California "State Collection" by Oldroyd (1927, 2, 2:61) is incorrect according to Strong, as the shells probably referred to proved to be *E. tinctum.* The Monterey record is therefore a doubtful one.]

[*Epitonium (Nitidiscala) hexagonum* (Sowerby)—Santa Cruz (Dall). An extremely doubtful record for this Lower California species. Dall's shell may have been *Opalia evicta* (De Boury), with which *hexagonum* might be confused.]

Epitonium (Nitidiscala) indianorum (Carpenter)—65-71 fathoms off Point Pinos, in green mud, sand, and gravel (USFC Sta. 4454). Although stated by Cooper to be common at Santa Cruz, living at low water, in all probability his shells were some other species, possibly *E. tinctum* (Carpenter). We have not collected typical *indianorum* at Monterey, either on shore or by dredging in moderately shallow depths.

Epitonium (Nitidiscala) rectilaminatum (Dall)—10-15 fathoms off Monterey, in fine dark sand and shale fragments; fairly common.

**Epitonium (Nitidiscala) regiomontanum* Dall—10-30 fathoms off Monterey, in sand. We have not collected it.

Epitonium (Nitidiscala) sawinae (Dall)—10-56 fathoms, in fine dark sand and shale fragments; fairly common.

Epitonium (Nitidiscala) tinctum (Carpenter)—Shore to 10 fathoms. This is the most abundant of the ladder-shells or wentletraps in the Bay, which may be found living among colonies of the common small green sea anemone (*Cribrina xanthogrammatica* Brandt) on rocks between tides nearly everywhere. Syn. *E. subcoronatum* (Carpenter), for the shells of this species having coronate varices.

**Epitonium (Crisposcala) acrostephanum* Dall—34-203 fathoms, in mud, clay and gravel; scarce.

Epitonium (Crisposcala) catalinae Dall—A single specimen from 21 fathoms, in mud, off Monterey (Smith).

Epitonium (Crisposcala) regum Dall—Off Monterey, in 15 fathoms (Burch).

Epitonium (Crisposcala) tabulatum Dall—10-25 fathoms, in fine dark sand and shale fragments, scarce; 43-44 fathoms off Santa Cruz, in soft green mud (USFC Sta. 4482).

JANTHINIDAE

Janthina bifida Reeve—Pelagic. Rarely washed ashore on sandy beaches during winter storms. Has been incorrectly called *J. exigua* Lamarck, which is a species originally described without locality information but generally considered to have a wide distribution.

Janthina globosa Swainson—With the preceding; rare (Mrs. Fackenthall).

EULIMIDAE (MELANELLIDAE)

**Balcis berryi* (Bartsch)—10-25 fathoms, in fine dark sand and shale fragments; scarce.

Balcis catalinensis (Bartsch)—25 fathoms, in sand off Carmel; rare.

**Balcis delmontensis* Smith and Gordon, new species. Described on p. 219; see pl. 3, fig. 5; 10-30 fathoms, in fine dark sand and shale fragments; not common.

Balcis micans (Carpenter)—5-25 fathoms, in sand; fairly common. Sometimes found living commensally on starfish.

**Balcis montereyensis* (Bartsch)—10-15 fathoms, in fine dark sand and shale fragments; rare.

Balcis oldroydi (Bartsch)—10-25 fathoms, with the above; rare.

**Balvis rutila* (Carpenter)—15-25 fathoms, in sand; fairly common. Occasionally found living commensally on starfish.

Balcis thersites (Carpenter)—Shore to 20 fathoms, in sand, kelp holdfasts, and among small rocks and shale fragments; common.

PYRAMIDELLIDAE

Owing to the large number of species comprising the Pyramidellid fauna of Monterey Bay and vicinity, we have followed an arrangement of species in alphabetical order under subgenera. We agree with Willett (1937:402) that in the genus *Turbonilla,* the subgenera *Chemnitzia, Strioturbonilla,* and *Pyrgisculus* are weakly defined, and so we follow his arrangement, which is as follows:

Turbonilla (including *Chemnitzia* and *Strioturbonilla*)
Pyrgolampros
Pyrgiscus (including *Pyrgisculus*)
Mormula
Bartschella (including *Dunkeria*)

Turbonillas and odostomias generally live on a bottom consisting of a fine dark sand, fragments of shale, and small pebbles or gravel. Unless the habitat of a particular species occurs in a different ecological niche, it will not be repeated in the list. Backs of abalone shells, often accumulated in large heaps on the Monterey Wharf, are an accessible and often prolific hunting ground for odostomias and other small species provided the abalone shells are reasonably fresh.

Pyramidella (Longchaeus) adamsi Carpenter—Monterey (Dall). According to Dall, the single specimen in the National Museum from Monterey is much smaller and slenderer than the typical form and may prove to be a new species. We have not collected it.

Turbonilla (Turbonilla) asser Dall and Bartsch—15-25 fathoms; scarce.

Turbonilla (Turbonillo) cayucosensis Willett—Shore at Pacific Grove; scarce.

**Turbonilla (Turbonilla) fackenthallae* Smith and Gordon, new species. Described on p. 220; see pl. 3, figs. 7, 8—Dredged in 20-30 fathoms, off Monterey; 3 specimens.

**Turbonilla (Turbonilla) gabbiana* (Cooper)—Monterey (Cooper). Because the type of this species has evidently been misplaced or lost, it is practically impossible now to tell just what shell Gabb described originally and Cooper subsequently renamed. We suspect, however, that it may be the same as *T. cayucosensis* Willett, though Gabb's description calls for a shell with 23 axial ribs, while *cayucosensis* normally possesses 20 to 22. Syn. *Chemnitzia gracillima* Gabb.

**Turbonilla (Turbonilla) gilli delmontensis* Dall and Bartsch—10-25 fathoms; rare.

**Turbonilla (Turbonilla) muricatoides* Dall and Bartsch—15-25 fathoms; rare.

Turbonilla (Turbonilla) santarosana Dall and Bartsch—25 fathoms; rare.

**Turbonilla (Turbonilla) serrae* Dall and Bartsch—10-40 fathoms; common.

Turbonilla (Turbonilla) stylina (Carpenter)—10-40 fathoms; fairly common.

Turbonilla (Turbonilla) torquata (Gould)—10-30 fathoms; scarce.

[*Turbonilla (Pyrgolampros) aurantia* (Carpenter)—12 fathoms (Berry); Monterey (Cooper). As we have not collected this Puget Sound species at Monterey we suspect that these records are based on misidentifications.]

[**Turbonilla (Pyrgolampros) berryi* Dall and Bartsch—39 fathoms off Monterey, in sand; 9-10 fathoms off Santa Cruz, on rocky bottom (USFC Sta. 4564). A study of paratypes in the Berry Collection and a suite of specimens from San Pedro leads us to the conclusion that *T. berryi* and *T. painei* Dall and Bartsch are synonyms of *T. chocolata* (Carpenter).]

Turbonilla (Pyrgolampros) chocolata (Carpenter)—Monterey Bay, 8-39 fathoms; Carmel Bay, 20 fathoms; scarce. Syns. *T. berryi* Dall and Bartsch and *T. painei* Dall and Bartsch.

Turbonilla (Pyrgolampros) halia Dall and Bartsch—12-25 fathoms; rare.

Turbonilla (Pyrgolampros) halibrecta Dall and Bartsch—One specimen in 10 fathoms off Del Monte (Smith).

Turbonilla (Pyrgolampros) halistrepta Dall and Bartsch—Two specimens from 10 fathoms off Del Monte seem referable to this species.

Turbonilla (Pyrgolampros) lowei Dall and Bartsch—10-40 fathoms; common.

Turbonilla (Pyrgolampros) pedroana Dall and Bartsch—10-20 fathoms; rare.

**Turbonilla (Pyrgolampros) skogsbergi* Strong—5 miles north of Monterey in 28 fathoms, in mud. Also 5 fathoms off Capitola, in sand (W. Williams). A rare species.

**Turbonilla (Pyrgolampros) stillmani* Smith and Gordon, new species. Described on p. 221; see pl. 3, fig. 9; 10 fathoms off Del Monte; four specimens.

Turbonilla (Pyrgolampros) valdezi Dall and Bartsch—Shore at Pacific Grove; rare.

**Turbonilla (Pyrgolampros) willetti* Smith and Gordon, new species. Described on p. 222; see pl. 3, fig. 10; 10 fathoms off Del Monte; rare.

Turbonilla (Pyrgiscus) almo Dall and Bartsch—5-40 fathoms; scarce.

Turbonilla (Pyrgiscus) antestriata Dall and Bartsch—40 fathoms, in mud (Burch).

**Turbonilla (Pyrgiscus) aragoni* Dall and Bartsch—10-30 fathoms; scarce.

**Turbonilla (Pyrgiscus) canfieldi* Dall and Bartsch—10-40 fathoms; fairly common.

**Turbonilla (Pyrgiscus) castanella* Dall—10-40 fathoms; common.

**Turbonilla (Pyrgiscus) delmontana* Bartsch—10 fathoms off Del Monte. Known only from the holotype. Syn. *T. (P.) delmontensis* Bartsch.

Turbonilla (Pyrgiscus) mörchi Dall and Bartsch—One specimen in 25 fathoms off Pacific Grove (Burch).

Turbonilla (Pyrgiscus) tenuicula (Gould)—Shore to 20 fathoms; scarce.

Turbonilla (Mormula) tridentata (Carpenter)—10-40 fathoms; common. Also 20 fathoms in Carmel Bay. (Syn. *T. ambusta* Dall and Bartsch).

**Turbonilla (Bartschella) bartschi* Smith and Gordon, new species. Described on p. 222; see pl. 3, fig. 13—Dredged in 25 fathoms off Pacific Grove, in sand. Known only from the type specimen.

**Odostomia (Salassiella) heathi* Smith and Gordon, new species. Described on p. 223; see pl. 3, fig. 14—Dredged in 15 fathoms off Pacific Grove. Known only from the type specimen.

**Odostomia (Chrysallida) astricta* Dall and Bartsch—5-30 fathoms; fairly common.

Odostomia (Chrysallida) clementensis Bartsch—5-15 fathoms off Point Pinos; one specimen (Smith).

**Odostomia (Chrysallida) cooperi* Dall and Bartsch—Shore at Point Pinos, one specimen (Smith); 10-25 fathoms; rare.

Odostomia (Chrysallida) lucca Dall and Bartsch — 15 fathoms off Cabrillo Point (Gordon); rare.

**Odostomia (Chrysallida) montereyensis* Dall and Bartsch—Shore to 30 fathoms; scarce. This species is very close to *O. cooperi* and the two may be conspecific.

Odostomia (Chrysallida) oldroydi Dall and Bartsch—Shore at Cabrillo Point; 10 fathoms off Del Monte; scarce.

Odostomia (Chrysallida) oregonensis Dall and Bartsch—Shore to 15 fathoms; scarce.

**Odostomia (Chrysallida) ornatissima* (Haas)—Washed from sand taken in a tide pool at Point Pinos; two specimens (Haas). In beach drift; rare.

Odostomia (Chrysallida) trachis Dall and Bartsch—Monterey (Dall).
Odostomia (Chrysallida) vicola Dall and Bartsch—Beach drift at Pacific Grove; rare. Shore at Point Pinos; one specimen (Smith).
**Odostomia (Ividella) navisa delmontensis* Dall and Bartsch—10-30 fathoms; rare.
Odostomia (Ivara) turricula Dall and Bartsch—25 fathoms; rare.
Odostomia (Iolaea) amianta Dall and Bartsch—Shore to 30 fathoms; scarce.
**Odostomia (Menestho) churchi* Smith and Gordon, new species—Described on p. 224; see pl. 3, fig. 12; 25 fathoms off Pacific Grove. Known only from the type specimen.
**Odostomia (Menestho) exara* Dall and Bartsch—Pacific Grove (Dall and Bartsch); 5-15 fathoms off Point Pinos; scarce (Smith).
Odostomia (Evalea) angularis Dall and Bartsch—Shore to 15 fathoms; rare.
Odostomia (Evalea) californica Dall and Bartsch—10-30 fathoms; fairly common.
**Odostomia (Evalea) deliciosa* Dall and Bartsch—10-25 fathoms; fairly common.
Odostomia (Evalea) gravida Gould—Monterey (Cooper).
Odostomia (Evalea) inflata Carpenter—Monterey (Cooper).
Odostomia (Evalea) obesa Dall and Bartsch—Between tides; rare.
**Odostomia (Evalea) phanea* Dall and Bartsch—Low tide to 25 fathoms, on rocks and the backs of red abalones; common.
**Odostomia (Evalea) tenuisculpta* Carpenter—Shore to 15 fathoms, on rocks and the backs of red abalones; abundant.
**Odostomia (Evalea) valdezi* Dall and Bartsch—10-25 fathoms; scarce.
**Odostomia (Amaura) canfieldi* Dall—Shore, in beach drift, to 40 fathoms; scarce.
Odostomia (Amaura) kennerleyi Dall and Bartsch—10-30 fathoms; fairly common.

ATLANTIDAE

Oxygyrus rangi (Lovèn)—Pelagic off Monterey (Dall).

AMPHIPERATIDAE

Neosimnia barbarensis Dall—Monterey (Keep, Lowe). One specimen, over an inch long, from fishermen (Berry). According to Schilder (1931, p. 67), this shell is at least a subspecies of *N. loebbeckeana* (Weinkauff).
Neosimnia catalinensis (Berry)—Monterey (Dall). We have not collected it.
Neosimnia inflexa (Sowerby)—20-50 fathoms, on gorgonians; 12 fathoms (Berry). A rather rare species, also to be looked for in the stomachs of fishes taken by set-line fishermen. Syn. *N. variabilis* (C. B. Adams).
**Neosimnia vidleri* (Sowerby)—30 fathoms, on coral and gorgonians; rare.

PEDICULARIIDAE

Pediculariella californica (Newcomb)—20-50 fathoms, on pink coral. Not often taken, generally only when fishermen bring specimens of the coral that have been snagged by trawl nets or set-lines. Syn. *Pedicularia californica* Newcomb.

CYPRAEIDAE

Cypraea spadicea Swainson—A single specimen in Mrs. Fackenthall's collection, taken alive by her on rocks at low tide, represents the only authentic record from the Monterey region. See Ingram, Nautilus 52(1): 1-4, pl. 1, figs. 8-13, 1938. Schilder (1939) classifies this species as *Zonaria spadicea* (Swainson).

ERATOIDAE

Pusula californiana (Gray)—Beach drift and living below low tide mark to 40 fathoms, on rocks; fairly common in beach drift but living shells are scarce. This and the following species have until recently been placed in the genus *Trivia*.
Pusula ritteri Raymond—Monterey (Dall).
Erato columbella Menke—Shore, in beach drift, to 20 fathoms; scarce.
Erato vitellina Hinds—Shore to 35 fathoms; fairly common.

RANELLIDAE

Bursa californica (Hinds)—10-60 fathoms, on rocks and the shale reefs; fairly common. Occasionally brought in by fishermen.

Fusitriton oregonensis (Redfield)—15-60 fathoms; rare. Formerly placed under various related genera, including *Argobuccinum* and *Priene*.

TRIPHORIDAE

**Triphora montereyensis* Bartsch—Beach drift, and living below low tide mark to 15 fathoms in coarse granite sand, off Pacific Grove; scarce.

CERITHIOPSIDAE

Cerithiopsis alcima Bartsch—Off Monterey, in 15 fathoms (Burch).

**Cerithiopsis berryi* Bartsch—5-30 fathoms, in sand and shale fragments; fairly common.

Cerithiopsis columna Carpenter—At low tide, on rocks; rare. Also 10 fathoms off Pacific Grove, in coarse granite sand and pebbles; rare.

Cerithiopsis cosmia Bartsch—Beach drift, and at low tide, on rocks; scarce. Also from a red abalone covered with sponge (Burch).

Cerithiopsis diegensis Bartsch—At low tide, on rocks in the vicinity of Point Pinos, common; 25 fathoms, rare.

**Cerithiopsis fia* Bartsch—Shore to 25 fathoms; rare.

**Cerithiopsis ingens* (Bartsch)—58-85 fathoms off Point Pinos, in soft green mud (USFC Sta. 4475). Known only from two specimens.

**Cerithiopsis montereyensis* Bartsch—Shore, in beach drift and at low tide on rocks, to 25 fathoms; scarce.

Cerithiopsis rowelli Bartsch—25 fathoms, Monterey and Carmel Bays, in sand; rare.

**Cerithiopsis santacruzana* Bartsch—3-30 fathoms, on rocks; rare.

**Cerithiopsis tumida* (Bartsch)—Shore, collected by Canfield and Stearns (Bartsch). We have not collected this species.

Seila montereyensis Bartsch—Living on rocks at low tide, to 30 fathoms; fairly common.

Metaxia diadema Bartsch—Shore to 30 fathoms; rare.

CERITHIIDAE

[*Bittium armillatum* Carpenter—Beach to 20 fathoms (Cooper). We are of the opinion that Cooper's shells were some other species. *B. armillatum* has not been reported from the Bay in recent years and it has not appeared in our dredgings.]

**Bittium attenuatum* Carpenter—Shore to 20 fathoms; common. Several pretty color forms are found in the beach drift, the more common being one of an all over lavender tone, and another white with a dark brown revolving band at the summit of the whorls. Living specimens are to be sought for at low tide in sand among eel-grass roots.

Bittium attenuatum multifilosum Bartsch—With the preceding; rare.

Bittium eschrichtii icelum Bartsch—Monterey, Stearns Collection (Bartsch). Shells of this group that we have collected or studied belong to the following subspecies.

**Bittium eschrichtii montereyense* Bartsch—Shore to 10 fathoms; abundant. Found living in clean coarse granite sand among rocks, at low tide.

Bittium interfossa (Carpenter)—Beach drift and at extreme low tide at Point Pinos; scarce.

Bittium munitum (Carpenter)—12 fathoms off Del Monte, in fine sand and shale fragments (Berry, Smith); rare.

**Bittium paganicum* Dall—292-356 fathoms off Point Pinos, in soft green mud (USFC Sta. 4508); rare.

**Bittium purpureum* (Carpenter)—In beach drift and living at low tide among eel-grass roots, to 30 fathoms in sand and shale fragments; fairly common.

Bittium quadrifilatum Carpenter—Shore to 40 fathoms, with the preceding species; scarce.

Bittium serra Bartsch—66-69 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4555); a single specimen. Syn. *Cerithiopsis sassetta* Dall according to Gordon after comparison of the types of both species in the National Museum.

Bittium subplanatum Bartsch—66-73 fathoms off Point Pinos, in green mud and rocks (USFC Sta. 4552); rare.

CAECIDAE

Caecum californicum Dall—In beach drift and from 3-30 fathoms, in sand; common.

Caecum licalum Bartsch—10-30 fathoms, in sand; rare.

[*Caecum quadratum* Carpenter—12 fathoms Berry, on Dall's identification. A doubtful record for this Mazatlan species.]

Micranellum crebricinctum (Carpenter)—10-40 fathoms, in sand; common.

Micranellum oregonense Bartsch—Monterey (Bartsch).

Fartulum occidentale Bartsch—15 fathoms off Pacific Grove, in sand; rare.

VERMETIDAE

Bivonia compacta Carpenter—Shore to 25 fathoms, found singly or in contorted masses; fairly common.

Aletes squamigerus Carpenter—Between tides, on shells and rocks; common.

Spiroglyphus lituellus (Mörch)—Shore to 20 fathoms; scarce.

Petaloconchus complicatus Dall—Off Monterey, in 20 fathoms (Burch).

Petaloconchus montereyensis Dall—10-25 fathoms, on rocks and shells; common.

Vermiculum anellum (Mörch)—15-25 fathoms, on shale; scarce.

TURRITELLIDAE

Turritella cooperi Carpenter—40-60 fathoms, in mud, sand and gravel; scarce.

Tachyrhynchus lacteolus (Carpenter)—40-63 fathoms, in mud and gravel; scarce.

LITTORINIDAE

Littorina planaxis Philippi—At high tide mark, on rocks; abundant.

Littorina scutulata Gould—Between tides, on rocks; abundant.

LACUNIDAE

Lacuna marmorata Dall—On eel-grass, at low tide; abundant.

Lacuna carinata Gould—With the preceding species; abundant. Syn. *L. porrecta* Carpenter.

Lacuna solidula Lovèn—Beach at Point Pinos (Smith, Chace); rare. Santa Cruz (Cooper).

Lacuna unifasciata Carpenter—On broad-leaved eel-grass at Elkhorn Slough; scarce.

Lacuna variegata Carpenter—Monterey (Dall). On algae (Burch).

FOSSARIDAE

Iselica fenestrata (Carpenter)—10-30 fathoms, in sand; scarce. Santa Cruz (Cooper).

Iselica obtusa (Carpenter)—5-15 fathoms, in coarse granite sand and boulders; rare.

LITIOPIDAE

Alaba serrana Smith and Gordon, new species. Described on p. 225, see pl. 4, figs. 1, 2; 25 fathoms, in Carmel Bay; two specimens.

RISSOELLIDAE

Rissoella hertleini Smith and Gordon, new species. Described on p. 224; see pl. 3, fig. 15; 10 fathoms, in sand, off Pacific Grove; seven specimens.

BARLEEIIDAE

Barleeia haliotiphila Carpenter—In kelp holdfasts. Also, 5-15 fathoms off Point Pinos, in sand and broken shells; fairly common.

**Barleeia marmorea* (Carpenter)—At low tide, living on rocks, to 25 fathoms; common. Syn. *Diala marmorea* Carpenter.

**Barleeia oldroydi* Bartsch—Between tides; abundant. Also in kelp holdfasts. Shore to 15 fathoms (Burch).

Barleeia subtenuis Carpenter—From brackish spring; Carmel only (Cooper).

Diala acuta Carpenter—Shore, under rocks at low tide, to 20 fathoms; common.

RISSOIDAE

**Cingula montereyensis* Bartsch—5-15 fathoms off Point Pinos; rare.

Amphithalamus tenuis Bartsch—Shore to 10 fathoms, in sand; rare.

Alvania acutelirata (Carpenter)—5-30 fathoms, in sand; common.

**Alvania californica* Bartsch—Monterey (Bartsch). We have not collected it.

Alvania compacta (Carpenter)—15 fathoms, in sand; rare.

Alvania carpenteri Weinkauff—Monterey, Oldroyd (Burch).

[*Alvania filosa* Carpenter—"Monterey. 'From shell washings.' Carpenter's list." (Cooper). Possibly a pathologic mutation, according to Bartsch.]

Alvania oldroydae Bartsch—Beach drift, at Pacific Grove; one specimen (Gordon).

**Alvania purpurea* Dall—Low tide, living on rocks, to 30 fathoms, in sand; fairly common.

Alvania rosana Bartsch—25 fathoms, in sand, Carmel Bay; common with *A. acutelirata* Dall.

**Alvania trachisma* Bartsch—Monterey (Bartsch). Not collected recently.

Alvania (Willettia) aequisculpta Keep—Beach drift at Pacific Grove; rare.

**Alvania (Willettia) montereyensis* Bartsch—Under rocks at low tide; fairly common.

**Alvania (Willettia) microglypta* Haas—Point Pinos, washed from sand in a tide pool (Haas). From the published figure and size of the shell we suspect it is not an *Alvania* but possibly the broken tip of a *Bittium.*

RISSOINIDAE

Rissoina bakeri Bartsch—10-30 fathoms, in sand; scarce. Most of the specimens we have seen from Monterey Bay are quite variable and few are typical. They appear to belong to this species, however.

**Rissoina hannai* Smith and Gordon, new species. Described on p. 226; see pl. 4, fig. 4; 25 fathoms, in sand, Carmel Bay; 28 specimens.

**Rissoina keenae* Smith and Gordon, new species. Described on p. 227; see pl. 4, fig. 3; 5-15 fathoms off Point Pinos, in coarse sand and broken shells; three specimens.

Rissoina newcombei Dall—Off Monterey, in 15 fathoms, on shale (Burch).

ASSIMINEIDAE

Assiminea translucens (Carpenter)—Elkhorn Slough, in *Salicornia;* fairly common. Syn. *Syncera translucens* (Carpenter).

HIPPONICIDAE

Hipponix antiquatus (Linnaeus)—In colonies, under rocks at low tide; common.

[*Hipponix antiquatus cranioides* Carpenter—With the preceding. In our opinion, this subspecies is of doubtful standing, as *H. antiquatus* varies considerably to fit the locations where it grows.]

[*Hipponix serratus* Carpenter—Monterey (Dall). A doubtful record of this southern species.]

Hipponix tumens Carpenter—Living at low tide, on rocks, to 20 fathoms; fairly common.

CREPIDULIDAE

Crepidula aculeata (Gmelin)—Monterey (Cooper). This species normally lives to the south of Monterey, although Burch has recently reported having collected it in the Bay.

**Crepidula adunca* Sowerby—Shore to 20 fathoms, on rocks and shells; common.

Crepidula excavata (Broderip)—Monterey (Dall). Although we know of no recent authentic records for this shell in the Monterey region, it should occur there, having been collected both to the north and the south.

[*Crepidula onyx* Sowerby—Monterey (Dall). We have neither seen nor collected unquestioned specimens of this species at Monterey and believe Dall's record to be a doubtful one.]

Crepidula perforans (Valenciennes)—At low tide, under rocks and in the apertures of the larger gastropod shells inhabited by hermit crabs; common. *C. exuviata* Nuttall, described from Monterey, is a synonym. We believe that *C. fimbriata* Reeve is merely a situs form, and use *perforans* as it is the oldest name for this variable shell. *C. nummaria* Gould is a different species, easily separable from the other white California crepidulas by its heavy golden-brown periostracum. We have found no authentic records of *nummaria* from the Monterey region although it should occur there. Monterey records for *C. navicelloides* Sowerby published by Keep and others should probably be referred to *perforans*. *C. nivea* C. B. Adams, which was described originally from Panama, has not certainly been reported from as far north as Monterey Bay.

Crepipatella lingulata (Gould)—Living at low tide, under rocks and on shells, to 40 fathoms on shale rocks and stones; abundant. Syn. *Crepidula lingulata* Gould.

Crepipatella orbiculata (Dall)—52-55 fathoms off Point Pinos, on rock; two specimens (Gordon). These and two other specimens examined show evidences of a nuclear sculpture consisting of extremely fine, sharp, spiral lirae, which scale off easily and may not be present on some adult shells. We suspect that *Verticumbo charybdis* Berry, from the lower Pleistocene of San Pedro and about 50 fathoms off Redondo, California, is a close relative of *C. orbiculata* if the two species are not actually conspecific. Syn. *Crepidula orbiculata* Dall.

CALYPTRAEIDAE

[*Crucibulum spinosum* (Sowerby)—Monterey; nine specimens (Wood: 1893). This is not a species of the Monterey fauna. Wood's record is the only one known and must be considered doubtful until confirmed by other collectors.]

**Calyptraea burchi* Smith and Gordon, new species. Described on p. 227; see pl. 4, figs. 11-13; 15-40 fathoms, on shale; scarce. Carmel (CAS Collection).

**Calyptraea contorta* (Carpenter)—15-40 fathoms, on shale; rare. Distinguished from young shells of the preceding species by a white instead of a yellow nucleus.

[*Calyptraea fastigiata* Gould—8-20 fathoms (Cooper). We have not collected this Puget Sound shell at Monterey and believe Cooper's shells may possibly have been *C. burchi*].

NATICIDAE

Natica clausa Broderip and Sowerby—389-871 fathoms off Point Pinos and mouth of Salinas River, in green mud and sand (USFC Stas. 3670, 4513, 4517, 4538, 4540); fairly common.

**Polinices acosmitus* (Dall)—627 fathoms off Point Pinos, in blue mud (USFC Sta. 3128); rare.

Polinices caurinus (Gould)—278-581 fathoms off mouth of Salinas River, in green mud and sand (USFC Stas. 3669, 3670). 500 fathoms off Monterey, from fishermen; one specimen (Gordon). A scarce species in the Bay.

Polinices draconis (Dall)—12-50 fathoms off Monterey, in mud and fine sand; fairly common. Generally taken in deeper water than *P. lewisii* (Gould).

Polinices groenlandicus (Möller)—296 fathoms off Point Año Nuevo, in fine gray sand (USFC Sta. 3112); 121-766 fathoms off Point Pinos, in green mud and sand (USFC Stas. 4462, 4517); scarce.

Polinices lewisii (Gould)—Below low tide to 25 fathoms off Monterey, in fine sand. Also in Elkhorn Slough, in mud; fairly common.

[*Polinices reclusianus* (Deshayes)—Monterey (Dall). A doubtful record for this southern California species. No specimens have been collected recently.]

[*Polinices reclusianus altus* (Dall)—Monterey (Dall). The preceding comment also applies to this subspecies.]

Sinum scopulosum (Conrad)—Below low tide (Mrs. Fackenthall); rare. Syn. *S. californicum* Oldroyd.

Eunaticina oldroydii (Dall)—30-70 fathoms, in mud; fairly common. Sometimes brought in by fishermen operating drag boats for flat-fish. A large specimen in the Stanford University Collection, taken in the Bay, measures: height, 81.3; width, 71.5; height of aperture, 63.5 mm.

LAMELLARIIDAE

Lamellaria rhombica Dall—Low tide to 15 fathoms off Pacific Grove; rare.

Lamellaria stearnsii Dall—At low tide, under rocks; scarce. The subspecies *orbiculata* Dall is found with the typical form and appears to have no value taxonomically.

VELUTINIDAE

Velutina granulata Dall—28-35 fathoms off Point Pinos, in black mud, sand, and shells (USFC Sta. 4441); known only from the type specimen.

Velutina laevigata (Müller)—Low tide to 12 fathoms, under rocks and on shale; fairly common.

[*Velutina prolongata* Carpenter—Monterey (Dall). Dall's specimen in the National Museum looks like an abnormal *V. laevigata*. The record must remain doubtful until confirmed.]

[*Velutina zonata* Gould—Monterey (Dall). As this is the only record for the species south of the Pribilof Islands it is in need of confirmation.]

ACMAEIDAE

Acmaea asmi (Middendorff)—Between tides, generally on the base or periphery of living shells of *Tegula funebralis* (A. Adams); common.

[*Acmaea depicta* (Hinds)—One doubtful Monterey record (Ricketts). We have seen no authentic specimens from the region.]

Acmaea fenestrata cribraria Carpenter—Monterey (Test). Appears to be a scarce form in the Bay.

Acmaea digitalis Eschscholtz—Between tides, on rocks; common. Syns. A. *textilis* Gould, and *umbonata* Reeve.

Acmaea funiculata (Carpenter)—5-35 fathoms off Pacific Grove and Point Pinos; also 25 fathoms in Carmel Bay. This species is rare and we have taken only one live specimen. Young shells of *A. mitra* Eschscholtz from the Monterey region show no tendency toward intergradation with *funiculata*.

Acmaea insessa (Hinds)—Between tides, living on "ribbon" kelp *Egregia menziesii* Aresch.; common.

Acmaea instabilis (Gould)—At low tide, living on the round, stiff stalks of the alga *Laminaria andersonii* Farlow; scarce.

Acmaea limatula Carpenter—Between tides, on rocks; common. *A. limatula mörchii* Dall, a single specimen of which was collected at Elkhorn Slough, is not a good subspecies but merely an ecologic variant according to Mrs. Test (1945:405).

Acmaea mitra Eschscholtz—Low tide, on rocks and in deep tide pools, to 20 fathoms. Dredged specimens are generally young. This shell is the common "White Cap" found on the beaches.

**Acmaea ochracea* (Dall)—Living on smooth stones or boulders at extreme low water; scarce. Syn. *A. peramabilis* Dall.

Acmaea paleacea Gould—Living on the blades of the narrow-leaved eel-grass *Phyllospadix torreyi* Watson; fairly common.

Acmaea pelta Eschscholtz—Between tides, on rocks; abundant. *A. cassis nacelliodes* (Dall) is considered to be merely a situs form of young *pelta* commonly found living on kelp holdfasts. Other synonyms are: *A. cassis* Eschscholtz, *monticola* Dall, *olympica* Dall, *pintadina* Gould, and var. *hybrida* Shepard (Naut., 9:72, 1895).

Acmaea persona Eschscholtz—Between tides, on rocks; scarce. Burch (Minutes, So. Calif. Conch. Club, No. 57, p. 10, Feb. 1946) cites *A. persona strigatella* Carpenter with a range extending north to Monterey, but there is some question whether this subspecies is a valid one.

Acmaea rosacea Carpenter—Low tide to 35 fathoms, living on rocks and shale; fairly common. Dead shells of this species are often found in beach drift.

Acmaea scabra (Gould)—Between tides, on rocks; common. Syn. *A. spectrum* Reeve.

Acmaea scutum Eschscholtz—Between tides, on rocks; abundant. Cited as a subspecies of the circumboreal *A. testudinalis* (Müller) by Mrs. Test. Syns. *A. patina* Eschscholtz, *pintadina* (Gould), *parallela* Dall, and *emydia* Dall.

**Acmaea triangularis* (Carpenter)—Low tide to 30 fathoms, generally living on the pinkish calcareous alga *Amphiroa tuberculosa* Decaisne but occasionally on rocks and shale; fairly common. The method used by the Chaces in collecting this small limpet in quantity is to obtain a pailfull of the alga and allow it to stand over night in fresh water. Subsequent washing and shaking cause the limpets to drop off and sink to the bottom of the pail, where they may be gathered with ease.

Lottia gigantea Sowerby—Between tides, on rocks, especially along the ocean front. We include *L. gigantea albomaculata* Dall as a synonym on the basis that this is merely a color form. "Owl" limpets have been so much sought after that fine full-grown specimens are now hard to find where they were once common. Immature shells are still to be commonly collected.

PHASIANELLIDAE

[*Phasianella compta* Gould—Monterey (Berry, on Dall's identification). See *P. substriata* (Carpenter). According to Strong (1928, p. 192), this species does not appear to range as far north as Monterey.]

Phasianella pulloides Carpenter—Low tide to 20 fathoms; abundant. Santa Cruz, living at low water (Cooper).

Phasianella rubrilineata Strong—Shore to 15 fathoms; scarce. Fresh living shells are sometimes sculptured with exceedingly fine, closely-spaced striations that are visible only under proper light with fairly high magnification.

[*Phasianella substriata* (Carpenter)—Shore to 15 fathoms (Berry). All specimens of the subgenus *Eulithidium* from Monterey that we have examined are imperforate and belong to the preceding species. A re-examination of Berry's shells by him and A. M. Strong showed that they are *P. pulloides* Carpenter, as are also the shells reported from Monterey on U. S. National Museum authority as *P. compta* Gould and *Eucosmia variegata* Carpenter.]

TURBINIDAE

Astraea inaequalis (Martyn)—Low tide to 35 fathoms, on rocks and shale; common inshore at certain times of the year. Syn. *A. inaequalis montereyensis* Oldroyd.

Homalopoma baculum (Carpenter)—Between tides, under rocks; common. Syn. *Leptothyra bacula* Carpenter.

Homalopoma carpenteri (Pilsbry)—Low tide to 20 fathoms, under rocks and on shale; abundant. Syn. *Leptothyra carpenteri* Pilsbry.

**Homalopoma paucicostatum* (Dall)—Living at low tide, under rocks, to 15 fathoms, in sand and broken shells; fairly common. Syn. *Leptothyra paucicostata* Dall.

Homalopoma paucicostatum fenestratum (Bartsch)—With the preceding. Shells referred to the subspecies are but weakly differentiated from the typical. These may not be good examples, however, as Berry believes that *fenestratum* is distinct enough to warrant raising it to specific rank.

LIOTIIDAE

Liotia fenestrata Carpenter—Beach drift, and living at low tide, under rocks; scarce.

Arene acuticostata (Carpenter)—Shore to 15 fathoms; rare. Syn. *Liotia acuticostata* Carpenter.

TROCHIDAE

Norrisia norrisi (Sowerby)—One young specimen taken in 12 fathoms by Berry, which appears to be the only authentic Monterey record of this southern species.

**Halistylus pupoideus* (Carpenter)—10-40 fathoms, in sand and shale fragments; common. Syn. *H. subpupoideus* (Tryon).

Tegula brunnea (Philippi)—Between tides, on rocks and ribbon kelp; off shore in the kelp beds on the fronds near the surface; abundant. This species lives a little farther out than *T. funebralis* (A. Adams), with good living specimens generally found only at extreme low tide. A subspecies, *T. brunnea fluctuosa* (Dall), has been described but at best it is only a weakly differentiated form having doubtful taxonomic value.

Tegula funebralis (A. Adams)—On and under rocks between tides; abundant. We include the subspecies *T. funebralis subaperta* (Carpenter), there being a question on its valid standing.

[*Tegula gallina* (Forbes)—Monterey (Dall). Dall's specimens in the National Museum are correctly identified, yet we know of no recent authentic record of this southern species from the Monterey region. The record needs confirming.]

[*Tegula ligulata* (Menke)—The preceding comment also applies to this species.]

Tegula montereyi (Kiener)—On kelp fronds at low tide; scarce. The finest specimens have been collected by searching the offshore kelp beds in a boat, where it occurs with *T. brunnea* but generally farther down the stalks. A large specimen taken in this habitat measures: height, 40.0; major diameter, 43.2 mm. (AGS No. 242).

Tegula pulligo (Martyn)—With the above, but scarcer. Young specimens, brilliantly maculated with lavender and brown, are occasionally taken alive under rocks at low tide and dredged down to 15 fathoms on the shale bed. It is possible that true *pulligo* is a northern race with a rounded basal periphery (syn. *T. pulligo taylori* Oldroyd), and that the Monterey shells with a sharply keeled periphery may be *T. marcida* (Gould).

Calliostoma annulatum (Martyn)—Found sparingly on the fronds of the giant kelp, off shore. In 1913, accompanied by Mrs. Fackenthall, the senior author collected fine large specimens in considerable quantity off Pacific Grove in July, following several warm, quiet, sunny days during which the calliostomas has evidently crawled up the kelp stems from deeper down. Young, brilliantly marked specimens have been dredged on the shale in 8-15 fathoms off Del Monte. A scarce species. *C. annulatum* is without doubt one of the most beautiful among the mollusks in the Monterey region.

Calliostoma canaliculatum (Martyn)—On kelp, off shore, with *C. annulatum, C. costatum* (Martyn), *Tegula brunnea, T. montereyi,* and *T. pulligo;* sometimes abundant. Young specimens occasionally collected alive at low tide, on kelp, and dredged down to 20 fathoms. The color variety *C. canaliculatum nebulosum* Dall, which is found only immature in the Monterey region, appears to have little taxonomic value as a subspecies.

Calliostoma costatum (Martyn)—Low tide to 20 fathoms, under rocks and on shale. Fine, large specimens occasionally collected off shore on the fronds of the giant kelp, well down on the stalks. On shore it is a common species. With the typical form we include the color varieties *C. costatum caeruleum* Dall and *C. costatum pictum* Dall.

**Calliostoma gloriosum* Dall—3-20 fathoms, on rocks and shale; scarce.

Calliostoma platinum Dall—198-495 fathoms off Point Pinos, in green mud, coarse sand, and shells (USFC Sta. 4515); 120 fathoms (Oldroyd); 220 fathoms off Monterey, on rock (Hopkins Marine Laboratory). Brought up by set-line fishermen from about 200 fathoms off Davenport, Santa Cruz County, when a small species of anemone growing on the shells attaches itself to the baited hooks; four specimens, of which the largest measures: height, 39.0; major diameter, 35.5 mm. (Strohbeen). A rare species.

Calliostoma splendens Carpenter—Shore to 40 fathoms, on rocks and shale; scarce. This pretty species is sometimes difficult to distinguish from the young of *C. costatum*. In sculpture, it is closer to the southern *C. supragranosum* Carpenter, but is much darker in color.

[*Calliostoma supragranosum* Carpenter—Monterey and Santa Cruz, dredged (Cooper). Low tide to 12 fathoms (Berry, on Dall's identification). We have seen no typical specimens from the Monterey region. It is possible that shells under this name from Monterey belong to the preceding species.]

Calliostoma tricolor Gabb—10-40 fathoms, on rocks and shale; scarce.

Calliostoma variegatum Carpenter—Young specimens dredged in 15-20 fathoms; rare.

**Turcica caffea* Gabb—10-35 fathoms off Monterey, on shale. Also found occasionally in kelp holdfasts; scarce.

Turcicula bairdii Dall—418-581 fathoms off Point Pinos, in mud and sand (USFC Stas. 3127, 3670). Apparently a common shell at this depth range.

Cidarina cidaris (A. Adams)—53-93 fathoms off Point Pinos, in hard sand, green mud and rocks (USFC Stas. 4543, 4552); rare.

Solariella nuda Dall—278-627 fathoms off Point Pinos and mouth of Salinas River, in sand and mud (USFC Stas. 3128, 3669); 298 fathoms off Point Sur (USFC Sta. 3187); scarce.

Solariella peramabilis Carpenter—40 fathoms, on shale; rare. Carmel Bay in 20 fathoms (Cooper).

Margarites acuticostatus (Carpenter)—Shore (beach drift) to 12 fathoms, in sand and shale fragments; fairly common. Some of our specimens approach Dall's figure (USNM Bull. No. 112, pl. 18, fig. 5) but may belong to the variable *M. optabilis* (Carpenter).

**Margarites keepi* Smith and Gordon, new species. Described on p. 228; see pl. 4, figs. 5-7; 25 fathoms off Cabrillo Point, in sand; five specimens.

Margarites lirulatus (Carpenter)—Shore, at low tide among rocks and gravel, to 15 fathoms; abundant.

Margarites optabilis (Carpenter)—Rare in beach drift. Living from 5-15 fathoms in coarse sand and rocks and also in fine sand and shale fragments; common.

Margarites parcipictus (Carpenter)—Shore, on rocks and among algae and seaweed everywhere; abundant. Dredged down to 40 fathoms.

[*Margarites pupillus* (Gould)—Beach to 20 fathoms (Cooper). This typical northern species does not appear to live in the Monterey region. Cooper's specimens may have been confused with the following species.]

**Margarites salmoneus* (Carpenter)—Low tide, under rocks, to 20 fathoms; common.

**Margarites smithi* Bartsch—Shore at Pacific Grove; one specimen (Smith). The type lot of nine specimens was dredged in 10 fathoms off China (Cabrillo) Point (Smith).

Margarites succinctus (Carpenter)—Low tide to 20 fathoms; abundant.

[**Gibbula canfieldi* Dall—Monterey, dead on the beach (Dall). Known for certain only from the type specimen. We have diligently sought for this species without success, and suspect it may be adventitious.]

VITRINELLIDAE

**Vitrinella berryi* Bartsch—8-12 fathoms off Del Monte, in sand and shale fragments; rare.

Vitrinella eschnauri Bartsch—12 fathoms (Berry).

Vitrinella oldroydi Bartsch—Fairly common living on the mantles of *Ischnochiton heathiana* Berry—15 fathoms off Pacific Grove, in fine dark sand and shale fragments; rare.

**Vitrinella stearnsi* Bartsch—5-15 fathoms off Point Pinos, in clean granite sand, and off Del Monte, in fine sand and shale fragments; rare.

Skenea californica (Bartsch)—10-30 fathoms, in fine dark sand and shale fragments; rare. This may prove to be the same as *D. coronadoensis* Arnold. Syn. *Cyclostremella californica* Bartsch.

**Skenea carmelensis* Smith and Gordon, new species. Described on p. 229; see pl. 4, figs. 8-10; 25 fathoms, in sand, in Carmel Bay; rare.

Scissilabra dalli Bartsch—8-10 fathoms off Del Monte and 15 fathoms off Soquel, in fine muddy sand; scarce.

Teinostoma invallatum (Carpenter)—Monterey (Dall). A single specimen from the mantle of *Ischnochiton heathiana* Berry. 5 miles south of Carmel (Gordon).

Teinostoma supravallatum (Carpenter)—Monterey (Dall). We have not collected it.

HALIOTIDAE

Haliotis assimilis Dall—2 small but full-grown shells and one immature shell from the beach at Seaside (Gordon). One full-grown shell from the beach at Carmel (Smith). Several specimens from about 10 fathoms off Yankee Point, south of Carmel (Sorensen), which Bartsch has recently described as *H. aulaea.* Until lately this species has not been well known from the Monterey region although reported as having been taken from as far north as the Farallone Islands. Mr. A. Sorensen writes: " . . . I learned that a young Japanese abalone diver had brought in several *H. assimilis* and *H. wallalensis* . . . He said he was getting them from Yankee Point south, in deep water, 10 to 18 fathoms. He had been out to about 20 fathoms, but there were no *H. rufescens* deeper than about 12 fathoms, while there were no *H. assimilis* and *H. kamtschatkana* inside of 8 to 12 fathoms. Hence the abalone divers know them generally as 'deep sea' abalones." Specimens of *H. assimilis* from the Monterey region are lower arched and less corrugated in sculpture than typical shells of the species from southern California. Some of the younger specimens show a remarkable resemblance to *H. kamtschatkana* Jonas and it is sometimes difficult to distinguish them from this latter species. Based on the material we have seen so far we are of the opinion that *H. aulaea* Bartsch should be considered as a synonym, at least until the anatomical relationships have been worked out.

[*Haliotis corrugata* Gray—Monterey (Dall). We have seen no authentic specimens of this species from the Monterey region. The record is in need of confirmation.]

Haliotis cracherodii Leach—At low tide, under rocks and in rock crevices; common. Fine large specimens are now hard to find.

Haliotis fulgens Philippi—The California Academy Collection contains a lot of 8 shells, which appear to be this species, collected by Hemphill at Monterey (C.A.S. No. 29161). These are all small, the largest being about 2¾ inches in length. Two other similar shells have been collected by Gordon at Point Lobos. Shells with the animal in alcohol are needed to prove whether this is a depauperate race of *fulgens* or another and possibly new species. Wood recorded one specimen of *fulgens* from

Monterey in 1893. Keep (1896) says: "The only live one I ever saw was an aged specimen which was found on the rocks at Cypress Point. Monterey Bay seems to mark its extreme northern location, and even then I have never found a specimen in the Indian shell-heaps, though *rufescens* and *Cracherodii* are found by the thousands in all stages of decomposition."

Haliotis kamtschatkana Jonas—A few specimens of small size are occasionally washed on shore after winter storms (Sorensen); 10-15 fathoms, on shale, dead shells only, rare; taken sparingly by abalone divers from about 10-20 fathoms off Yankee Point, south of Carmel (Sorensen). A single young specimen, dredged on the shale in 35 fathoms, is provisionally assigned to this species.

Haliotis rufescens Swainson—Low tide, under rocks and in rock crevices, to about 12 fathoms. Once abundant along the rocky shores from Monterey to Point Pinos and along the ocean front from there south, the red abalone of commerce is now hard to find in adult sizes of legal dimensions. The commercial aspects have been discussed elsewhere in this paper.

Haliotis wallalensis Stearns—The "Sunset Abalone" is rarely taken in the Monterey region although it is not uncommon at extreme low water north of Point Reyes and along the Mendocino County coast. The California Academy Collection has two shells collected at Monterey by Hemphill (C.A.S. No. 15107), the largest measuring about 3 inches in length. Four specimens have been taken by an abalone diver in about 10 fathoms off Yankee Point (Sorensen). The southern range of *wallalensis* has recently been extended to Point Buchon, just south of Morro Bay, in San Luis Obispo County (Sorensen).

FISSURELLIDAE

Fissurella volcano Reeve—Low tide and in deep tide pools, to 20 fathoms, on rocks; common. The color form *F. v. crucifera* Dall, which we believe should have no standing as a subspecies, is found rarely with the typical form. Syn. *Hemitoma golischae* (Dall).

**Megathura crenulata* (Sowerby)—Low tide to 5 fathoms, on rocks. Giant key-hole limpets appear to have become less common in recent years.

**Megatebennus bimaculatus* (Dall)—Low tide to 20 fathoms, especially in rock crevices and under rocks; fairly common.

[*Lucapinella callomarginata* (Dall)—Monterey (Stearns). Dall believed that a living specimen collected by Stearns might be this species. It is a shell found farther south than Monterey. The record seems doubtful.]

Diodora aspera (Eschscholtz)—Shore, under rocks, to 20 fathoms, on shale; common. A large specimen in the Berry Collection measures: length, 88.8; width, 60.3 mm. The subspecies *D. aspera densiclathrata* (Reeve) was said by Cooper to be found in deeper water, but those we have dredged appear to be more delicately sculptured, young specimens of the typical form. Cooper also reported that the animal differs from *aspera* but we suspect he may have confused his shells with *D. murina*. Syn. *D. aspera densiclathrata* (Reeve).

Diodora murina (Dall)—Beach drift; fairly common. Living, 5-35 fathoms off Pacific Grove and Monterey, on rocks and shale; only occasionally taken alive.

Puncturella cooperi Carpenter—10-25 fathoms, on shale; scarce.

Puncturella cucullata (Gould)—10-40 fathoms, on rocks and shale; fairly common.

Puncturella galeata (Gould)—52-55 fathoms off Point Pinos, on rock; one specimen (Gordon).

**Hemitoma bella* (Gabb)—Young dead shells and fragments dredged in 5-20 fathoms off Point Pinos, in clean granite sand and broken shells; also, 15 fathoms off Del Monte, on shale. Two large specimens in 20 fathoms (Burch). Although several beach-worn specimens of this scarce species have been found, all of the few fine living specimens have been brought in by fishermen. The type specimen of *bella,* an immature dead shell in the collection of the University of California at Berkeley, is shown on pl. 4, figs. 14-16. There appears to be but one species of *Hemitoma* from the California coast, *H. yatesii,* which was also described from Monterey Bay, being merely the adult stage of *bella.* There are several specimens in the original lot obtained from fishermen by J. K. Oliver, a curio dealer in Monterey. In addition to the type in the National Museum, another is on display in the Pacific Grove Museum, and a third is in the Berry Collection in Redlands, California. Syn. *H. yatesii* (Dall).

AMPHINEURA

POLYPLACOPHORA

LEPIDOPLEURIDAE

[*Leptochiton ambustus* (Dall)—12 fathoms off Del Monte, on shale fragments (Berry, on Dall's identification). This record needs confirming as the specimens dredged by Berry are quite likely to be *L. heathi* Berry.]

Leptochiton cancellatus (Sowerby)—20-50 fathoms, on rocks and shale (Burch, Gordon, A. G. Smith). Off Point Joe, Monterey Peninsula, in 65 fathoms, from fishermen (Hunter). Scarce. The deeper-water leptochitons from the Monterey region have somewhat stronger sculpture than typical *cancellatus* from Puget Sound and are referred to this species with some doubt.

**Leptochiton heathi* (Berry)—10-35 fathoms off Monterey, on shale; common.

[*Leptochiton nexus* Carpenter—Pacific Grove (Heath, on Pilsbry's identification). The record needs confirming.]

**Leptochiton oldroydi* (Dall)—25 fathoms; rare (Gordon).

Leptochiton rugatus (Pilsbry)—At low tide or in deep tide-pools, under rocks buried in sand; fairly common.

Oldroydia percrassa (Dall)—12-40 fathoms, on shale; scarce.

[*Hanleya hanleyi* (Bean)—Monterey (Dall). May refer to the following species.]

**Hanleya spicata* Berry—33 fathoms off Point Pinos, on a rock ledge (Heath). Known only from the type specimen.

LEPIDOCHITONIDAE

Tonicella lineata (Wood)—In tide pools and at low tide, to 35 fathoms; common. Specimens from the Monterey region are not as large and fine as those living along the Mendocino County coast. The color markings on this species are quite variable. Specimens from deeper water are quite small.

Tonicella ruber (Linnaeus)—12 fathoms; one specimen (Berry, on Dall's identification). Not collected recently.

Tonicella submarmorca (Middendorff)—Off Monterey, in 10 fathoms (Burch); a single small specimen. The occurrence of this minutely granulated northern species in the Bay is the occasion for some surprise.

**Cyanoplax fackenthallae* Berry—Shore at Pacific Grove (Mrs. Fackenthall). It has been found living sparingly in the holdfasts of ribbon kelp at low tide in the "Great Tide Pool" near Point Pinos, on the ocean side. It mimics the kelp roots in color so closely that it is easily overlooked. Discovery of the habitat of *fackenthallae* is due to the efforts of the Rev. Elwood B. Hunter and Mr. and Mrs. Emery P. Chace. The species is very closely related to *C. lowei* (Pilsbry), a southern California form.

**Cyanoplax hartwegii* (Carpenter)—Between tides, on rocks hidden under seaweed, to 5 fathoms; common. The subspecies *C. h. nuttalli* (Carpenter) has now been recognized as the young stage and therefore is not separable from the typical form.

Cyanoplax raymondi (Pilsbry)—Found with the above, and also on the backs of red abalones; fairly common.

Nuttallina californica (Reeve)—Between tides on rocks, generally along the ocean front; abundant.

**Nuttallina thomasi* Pilsbry—Between tides, on rocks and in small tide pools at Pacific Grove, Cypress Point, Pescadero Point, and Point Lobos (Heath, Gordon); rare.

MOPALIIDAE

Basiliochiton flectens (Carpenter)—12-20 fathoms, on shale off Monterey; scarce.

**Basiliochiton heathii* (Pilsbry)—Low tide to 17 fathoms; scarce. Rare under rocks at low water mark and only occasionally collected in deeper water.

[*Dendrochiton gothicus* (Carpenter)—Monterey (Dall). A doubtful record for this southern California species. We have not collected it in the Bay.]

**Dendrochiton thamnoporus* (Berry)—Low tide, under rocks, Point Pinos and Carmel; 10-40 fathoms off Del Monte, on shale; scarce.

Mopalia acuta (Carpenter)—10-35 fathoms off Del Monte, on shale fragments; scarce. This species is not closely related to *M. muscosa* Gould, at least in the Monterey region and so we show it as a separate species.

Mopalia ciliata (Sowerby)—At low tide, under rocks, in rock crevices, and caves; fairly common. In the Monterey region this species exhibits a puzzling variation in shape, girdle armature, and color markings. Small to medium-sized specimens, usually marked with brilliant red or occasionally entirely red, have been dredged down to 35 fathoms. Along with these are found small, high-arched, red-marked chitons that are related to *ciliata* and may be a separate species. Adequate identification of this and perhaps of other related Monterey forms depends upon a thorough study of the group.

Mopalia ciliata wosnessenskii (Middendorff)—12 fathoms; one specimen (Berry).

Mopalia hindsii (Reeve)—At low tide, on and under rocks; common in favorable locations, where it grows very large. In the Monterey region, *hindsii* is quite different from *M. muscosa* (Gould) and we have seen no intergrades between the two.

Mopalia imporcata Carpenter—10-25 fathoms off Monterey and Del Monte, on shale fragments; scarce.

Mopalia lignosa (Gould)—Between tides, on and under rocks; fairly common. Apparently does not intergrade with *muscosa*.

Mopalia muscosa (Gould)—Between tides, on rocks, generally those covered with seaweed; also in tide pools; common.

**Mopalia phorminx* Berry—33 fathoms off Point Pinos, on a rock ledge (Heath). Known only from the type specimen.

Mopalia sinuata Carpenter—12-35 fathoms, on shale; rare.

Placiphorella velata Dall—At low tide, under rocks; immature specimens occasionally found on the backs of red abalones; fairly common.

Katharina tunicata (Wood)—Between tides, on rocks, especially those along the ocean front; common.

ACANTHOCHITONIDAE

Acanthochitona avicula (Carpenter)—Monterey (Cooper). This old record has been confirmed recently by Burch, who dredged a single specimen in 20 fathoms off Monterey.

Cryptochiton stelleri (Middendorff)—At low tide, generally along the ocean front but occasionally in the Bay; scarce. The "Giant Chiton" or "China Abalone" is much less common in the vicinity of Monterey than farther to the north.

CHAETOPLEURIDAE

**Chaetopleura gemma* Dall—Low tide under rocks, to 15 fathoms on shale; common.

ISCHNOCHITONIDAE

[*Ischnochiton (Stenoplax) conspicuus* (Dall)—Monterey (Dall). A doubtful record for this southern species. Occasional immature specimens of *I. heathiana* (Berry) have a rugose sculpture suggesting that of *conspicuus*.]

**Ischnochiton (Stenoplax) fallax* Pilsbry—Low tide at Pacific Grove, Carmel, and five miles south of Carmel, under smooth rocks imbedded in sand; scarce; 10 fathoms (Sorensen). A highly-colored species, of which the major color forms include light yellow-brown, wine-red, and wine-red with green maculations.

**Ischnochiton (Stenoplax) heathiana* (Berry)—Same habitat as the preceding species and found with it; common. Formerly identified as *I. magdalenensis* (Hinds), which Berry (1946a) has shown to belong to a more southern fauna.

**Ischnochiton (Ischnochiton) decipiens* Carpenter—Monterey (Dall). An insufficiently known species that can hardly be identified from Carpenter's meager description. It has probably been described subsequently under other species names.

Ischnochiton (Ischnochiton) interstinctus (Gould)—Monterey (Cooper, Dall). Probably a deeper water species to be dredged in 40 fathoms or more in the Monterey region. We have not collected specimens that can be referred to this name with any certainty.

**Ischnochiton (Ischnochiton) marmoratus* Dall—Pacific Grove (Dall). According to Berry this is probably not an *Ischnochiton* as Dall's description reads more like a species of *Chaetopleura,* close to or identical with *C. gemma* Dall. The type has not been figured.

**Ischnochiton (Ischnochiton) radians* Carpenter—Low tide under rocks, to 35 fathoms, on shale; occasional near shore but common in deeper water. Many color forms of this pretty chiton are to be found, some with white and brown markings, others marked with bright blue.

**Ischnochiton (Rhombochiton) regularis* (Carpenter)—At low tide under rocks; fairly common.

**Ischnochiton (Lepidozona) berryi* Dall—10-25 fathoms off Del Monte, on rocks and shale; common. This species seems closely related to *I. sinudentatus* Carpenter and may prove to be a deeper-water analog of it.

[*Ischnochiton (Lepidozona) californiensis* Berry—Monterey (Keep, Dall), as *I. clathratus* (Reeve). Berry's specimens, determined by Dall, are *I. sinudentatus* Carpenter and Keep's record may also be based on this other species. Berry (Proc. Mal. Soc. London, 1915; 255-258, pl. 29, figs. 1, 2, 1931) has shown that true *clathratus* is Lower Californian.]

Ischnochiton (Lepidozona) catalinae Willett—40 fathoms off Monterey, on shale; a single specimen (Smith). This species seems closely related to *I. willetti* Berry from southern Alaska.

Ischnochiton (Lepidozona) cooperi Dall—At low tide under rocks, to 25 fathoms on shale; common.

Ischnochiton (Lepidozona) golischi Berry—Low tide, under rocks at Carmel (Hunter); 12 fathoms off Del Monte, on shale (Smith); 80 fathoms, from fishermen (Berry). The shore specimen collected by Hunter is close to, if not actually *I. sinudentatus* Carpenter. The single specimen from 12 fathoms occurred with a sizeable series of *I. berryi* Dall, from which it differs only in the peculiar color markings. We suspect that *golischi* may be only a rare color variant of *sinudentatus* or *berryi,* or both, which is evidence of the close relationship, if not the identity of these three species. The entire group needs careful working over.

Ischnochiton (Lepidozona) mertensii (Middendorff)—Low tide under rocks, to 35 fathoms on shale; common.

Ischnochiton (Lepidozona) retiporosus Carpenter—80 fathoms, from fishermen (Berry).

**Ischnochiton (Lepidozona) sinudentatus* Pilsbry—Low tide under rocks, to 35 fathoms on shale. Scarce on shore but common in 35 fathoms on the shale bed. See remarks under *I. berryi* and *I. golischi.*

[*Ischnochiton (Lepidozona) veredentiens* Carpenter—Point Año Nuevo (Dall). Berry states that this record is based on poor material and needs confirming.]

Callistochiton connelleyi Willett—Low tide in the "Great Tide Pool" near Point Pinos, under rocks; rare (Chace). This may be the young of the following species.

**Callistochiton crassicostatus Pilsbry*—Low tide under rocks, to 15 fathoms on shale; fairly common.

[*Callistochiton decoratus punctocostatus* Pilsbry—Monterey (Button). This record for a more southern species needs confirmation. We have not taken it.]

[*Callistochiton infortunatus* Pilsbry—Monterey (Dall). According to Dr. Berry, the record is unquestionably erroneous.]

Callistochiton palmulatus Pilsbry—Low tide under rocks, to 35 fathoms on shale; scarce.

Callistochiton palmulatus mirabilis Pilsbry—With the preceding; fairly common.

APLACOPHORA

CHAETODERMATIDAE

**Chaetoderma montereyense* Heath—39-356 fathoms off Santa Cruz and Point Pinos, mostly in soft mud and sand (USFC Stas. 4485, 4508, 4522, 4523, 4524, 4525); a total of 1555 specimens (Heath).

**Chaetoderma scabrum* Heath—795-871 fathoms off Point Pinos, in hard gray sand (USFC Sta. 4538); a single specimen (Heath).

CEPHALOPODA

ONYCHOTEUTHIDAE

Moroteuthis robusta (Verrill)—Cast on shore near Monterey (Phillips). According to Berry (1910), it was previously reported from Unalaska, the type locality, where one specimen cast on shore had an over-all length of over 14 feet, thus making it the largest mollusk and perhaps even the largest invertebrate known from western North America.

Onychoteuthis banksii (Leach)—Monterey Bay (Phillips). Not previously reported by Berry from western North America.

GONATIDAE

Gonatus sp., cf. *G. fabricii* (Lichtenstein)—32-1000 fathoms off Point Pinos (USFC Stas. 4468, 4512, 4517, 4530, 4544; seven specimens.

HISTIOTEUTHIDAE

Calliteuthis (Meleagroteuthis) heteropsis Berry—724-1000 fathoms off Point Pinos (USFC Stas. 4538, 4544); two specimens. Previously recorded as *Meleagroteuthis hoylei* Peffer.

OMMASTREPHIDAE

Dosidicus gigas (d'Orbigny)—Occasional in Monterey Bay prior to August, 1935, but common since then.

CRANCHIIDAE

Galiteuthis armata Joubin—780-799 fathoms off Point Pinos (USFC Sta. 4529); one specimen. Syn. *G. phyllura* Berry.

LOLIGINIDAE

Loligo opalescens Berry—Abundant in April, May, and June in Monterey Bay, which is the squid season, with the commercial catch in the Bay averaging from 100 to 150 tons annually (W. L. Scofield).

SEPIOLIDAE

Rossia pacifica Berry—20-142 fathoms at various stations in Monterey Bay dredged by the U. S. Fisheries Commission steamer *Albatross*. It is not unusual for trawl fishermen to bring up this species in their nets. A fairly common squid in the Bay.

CIRROTEUTHIDAE

Cirroteuthis macrope Berry—One specimen taken by Santa Cruz fishermen in September, 1932 (Phillips). The type locality is 2113-2259 fathoms off San Diego (USFC Sta. 4393).

OCTOPODIDAE

Octopus sp., cf. *O. apollyon* Berry—Monterey Bay and along the ocean front; common. According to Berry the name *O. hongkongensis* Hoyle, though previously used for this cephalopod, is not properly applied to the large Pacific Coast species. The main commercial fishing locality is off the rocky shores of the open coast between Point Pinos and Carmel, in 10-30 fathoms (Phillips).

[*Octopus californicus* Berry—Monterey (Keep). A doubtful record for this southern California species.]

Octopus sp., cf. *O. californicus* (Berry)—1006-1041 fathoms off Point Pinos (USFC Sta. 4536); one young specimen. The identity of this octopus with *californicus* is not fully established, according to Dr. Berry.

Octopus leioderma (Berry)—204-239 fathoms off Point Pinos (USFC Sta. 4526); one specimen.

**Octopus pricei* Berry—From the stomach of a salmon off Point Pinos.

Octopus sp.—A young specimen, taken in 50-57 fathoms off Point Pinos (USFC Sta. 4550), has been reported by Berry as probably representing a new species.

ARGONAUTIDAE

Argonauta pacifica Dall—Monterey (Dall). We know of no recent record of the paper nautilus from the Monterey region.

BRACHIOPODA

LINGULIDAE

Glottidia albida (Hinds)—10-40 fathoms, in sand; fairly common.

RHYNCHONELLIDAE

Frieleia halli Dall—659 fathoms off Point Sur, in green mud (USFC Sta. 5699); six specimens.

TEREBRATULIDAE

Terebratulina kiiensis Dall and Pilsbry—52-55 fathoms off Point Pinos, in fine dark sand and pebbles; one dead specimen (Gordon). Also from fishermen in 60 to 80 fathoms; three living specimens (Gordon). 240 fathoms off Watsonville Beach, in black sand and rocks (USFC Sta. 3205?); five specimens.

**Terebratulina unguicula* (Carpenter)—10-40 fathoms, on shale; common at the deeper depths. A large slab of shale, dredged in about 40 fathoms near Humpback Rock, off Monterey, had more than a hundred specimens growing on it. Also 240 fathoms off Watsonville Beach, in black sand and rocks (USFC Sta. 3205?); one specimen.

TEREBRATELLIDAE

Morrisia hornii Gabb—25 fathoms off Carmel, in sand and broken shells, nine specimens; 46-56 fathoms off Point Pinos, in coarse sand, shells, and rocks (USFC Sta. 4551), one specimen. Syns. *Platidia hornii* (Gabb); *Platidia seminula radiata* Dall.

[*Terebratalia occidentalis* (Dall)—Monterey (Cooper, Dall). These are old records that have not been confirmed by recent collecting.]

[*Terebratalia transversa* (Sowerby)—One very worn valve, Monterey (Dall). Lamp shells of this group that we have collected belong to the following subspecies.]

Terebratalia transversa caurina (Gould)—10-40 fathoms, on rocks and shale; fairly common.

Laqueus californianus (Koch)—30-80 fathoms, on rocks; common locally. Also, 861-1062 fathoms off Point Pinos, in hard sand and mud (USFC Sta. 4537); a fragment.

SUPPLEMENTARY LIST

The following 95 species and subspecies, arranged alphabetically by genera, represent possible additions to the preceding list as their ranges along the West Coast, as reported, include the Monterey region although apparently none of them has been collected there. They should be looked for by collectors. Many of them will be found only by deep dredging.

Pelecypoda

Barnea pacifica (Stearns)
Calyptogena pacifica Dall
Cardiomya beringensis (Leche)
Cardiomya oldroydi (Dall)
Lyonsia californica haroldi Dall
Lyonsiella alaskana Dall
Macoma incongrua (von Martens)
Martesia intercalata Carpenter
Martesia xylophaga (Valenciennes)
Nucula bellottii A. Adams
Nuculana minuta (Fabricius)
Nuculana navisa (Dall)
Pecten alaskensis Dall
Pecten randolphi Dall
Rochefortia compressa Dall
Rochefortia ferruginosa Dall
Solemya agassizii Dall
Solemya johnsoni Dall
Sphenia ovoidea Carpenter
Thyasira barbarensis (Dall)
Thyasira excavata Dall
Thyasira gouldii (Philippi)
Thyasira trisinuata (d'Orbigny)
Thyasira trisinuata polygona (Jeffreys)
Tindaria kennerleyi Dall
Tindaria martiniana Dall
Turtonia minuta (Fabricius)
Vesicomya lepta (Dall)
Yoldia cecinella Dall
Yoldia limatula (Say)
Yoldia martyria Dall
Yoldia orcia Dall
Yoldia sanesia Dall

Scaphopoda

Cadulus californicus Pilsbry and Sharp
Cadulus stearnsii (Pilsbry and Sharp)
Dentalium dalli Pilsbry and Sharp
Dentalium inversum Deshayes
Dentalium watsoni Sharp and Pilsbry

GASTROPODA

Acmaea persona strigatella Carpenter
Admete couthouyi gracilior Carpenter
Ancistrolepis californicus Dall
Bittium oldroydae Bartsch
Carinoturris pernodata (Dall)
Carinoturris polycaste (Dall)
Chaetopleura beanii (Carpenter)
Cingula californica (Tryon)
Clio occidentalis (Dall)
Cocculina agassizii Dall
Colus adonis Dall
Colus halimeris (Dall)
Colus hallii (Dall)
Crepidula nummaria Gould
Diala exilis (Tryon)
Epitonium caamanoi (Dall and Bartsch)
Epitonium densiclathratum Dall
Exilioidea kelseyi (Dall)
Fartulum bakeri Bartsch
Haminoea olgae Dall
Hipponix barbatus Sowerby
Homalopoma luridum (Dall)
Lacuna divaricata (Fabricius)
Lepidochitona alba (Linnaeus)
Lepidochitona sacharrina (Dall)
Leptochiton farallonis (Dall)
Leptochiton internexus (Carpenter)
Leptochiton luridus (Dall)
Leucosyrinx? persimilis leonis (Dall)
Margarites helicinus (Phipps)
Margarites lacunatus (Carpenter)
Margarites rhodia Dall
Mitra catalinae (Dall)
Mitrella permodesta (Dall)
Mopalia porifera Pilsbry
Ocenebra interfossa atropurpurea (Dall)
Ocenebra painei (Dall)
Ocenebra sclera (Dall)
Placiphorella stimpsoni (Gould)
Polinices canonicus (Dall)
Polinices nanus (Möller)
Propebela lotta (Dall)
Puncturella multistriata Dall
Rectiplanes? briseis (Dall)
Rectiplanes? hyperia (Dall)
Rectiplanes? litus (Dall)
Rectiplanes? rotula smithi (Dall)
Scissurella kelseyi Dall
Solariella varicosa (Mighels and Adams)
Tachyrhynchus lacteolus subplanatus (Carpenter)
Tachyrhynchus pratomus Dall
Taranis strongi (Arnold)
Trophon pacificus (Dall)
Trophon staphylina (Dall)
Trophon tenuisculptus Carpenter
Turritellopsis acicula stimpsoni Dall
Volutomitra alaskana Dall

DESCRIPTION OF NEW SPECIES AND SUBSPECIES

Cardita (Cyclocardia) ventricosa montereyensis Smith and Gordon, new species

Text figures 2, 3.

Description of the holotype: Shell solid, rounded-triangular in outline, moderately compressed laterally; anterior margin rounded, with the dorsal and posterior margins gently curved and merging with no marked change in curvature; ventral margin gently curved also and oblique to the lower margin of the hinge-plate. Beaks anterior to the middle of the shell, depressed, not conspicuous, slightly prosogyrate, somewhat eroded. Valves thick, ornamented on the outside with about eighteen well-defined, low, rounded, radiating costae, with rather narrow interspaces, crossed by numerous concentric lirations that are stronger on the upper portion of the shell although inconspicuous in the intercostal spaces. Just anterior to the beaks is a small, depressed, slightly elongately-cordate, unornamented lunule. Posterior to the beaks is a long, narrow, escutcheon-like depression in which the ligament is situated. Periostracum greenish-brown and velvety in appearance, the pile set in radiating lines although appearing to be concentrically lamellose, especially near the ventral margin of the shell. Hinge-plate thick, its lower edge somewhat beveled; right valve with a solid triangular cardinal tooth immediately below the beak, its apex detached from the shell-margin and beveled above, set off by a furrow on each side forming a chevron into which the two cardinal teeth of the left valve fit; anterior cardinal tooth a small inconspicuous monticule in front of the anterior furrow; posterior cardinal a narrow elongate flange bordering the posterior furrow, separated by a shallow groove from the nymph on which the ligament is seated. Hinge-plate in the left valve with two cardinal teeth diverging in a chevron, the anterior small and subtriangular, the posterior a nearly straight alar flange terminating obliquely at the hinge-margin and separated by a moderately-wide groove from the nymph carrying the ligament; at the intersection of the hinge-margin and the anterior margin is a short, low, rounded ridge, which probably represents a rudimentary anterior lateral tooth; similarly, there is an irregularity at the intersection of the hinge-margin and the posterior margin. Muscle impressions in both valves deep-seated, the posterior pair roughly tear-shaped and the anterior pair somewhat reniform in shape, narrower at the upper ends; just above the anterior pair is another pair of small, impressed, ovate pedal-retractor impressions. The pallial line is simple, connecting the lower ends of the muscle impressions in each valve in a curve generally parallel to the ventral margin of the shell. This margin is sculptured internally by quadrangular excavations that coincide with the ends of the external ribs. Dimensions: length, 25.8; width, 16.0; height, measured from the umbo in a line perpendicular to a line bisecting the muscle impressions, 23.0; oblique height, measured from the umbo to the posterior bulge, 25.2 mm.

Holotype: Calif. Acad. Sci., Paleo. Type Coll., No. 8518, dredged in 63 fathoms about **4.6 miles northwest of Point Pinos,** in fine sand, sand pellets, and pebbles, **Monterey Bay, California,** August 22, 1932, by Mackenzie Gordon, Jr. The type lot consists of six specimens.

Paratypes: These include the five specimens collected with the type; four specimens and one valve from 52-55 fathoms, about 3.1 miles northwest of Point Pinos, in fine dark sand and pebbles, August 8, 1932, dredged by Mackenzie Gordon, Jr.; and five specimens dredged in 70 fathoms off Monterey by G. E. McGinitie. Paratype specimens have been placed in the California Academy of Sciences (Type Coll. Nos. 8519-8523, incl.), Stanford University, the U. S. National Museum, the Los Angeles Museum, and the private collections of S. S. Berry and Mr. and Mrs. E. P. Chace.

Range: Fort Bragg, Mendocino County, to Ventura, California, in 30-70 fathoms. A lot of over 100 specimens from the northern limit of the range (C.A.S. Locality No. 31141) shows intergradation with the typical *C. ventricosa.* The lot from Ventura (C.A.S. Locality No. 31700) consists of five small specimens that show no tendency to intergrade with the southern form of *C. ventricosa.*

Remarks: The cyclocardias of the west coast of North America are a difficult group with a comparatively limited range of variation. Unfortunately, there has been much taxonomic confusion regarding them.

Cardita ventricosa (Gould, 1850) was described from shells collected in Puget Sound, Washington, by members of the United States Exploring Expedition under Wilkes. There were two separate species in the type lot (U. S. National Museum No. 3373). The first, represented by several specimens, was a transversely ovate shell with a moderately weak hinge-arrangement. The second, represented by a single specimen, was a plump, elevated shell with high beaks and a strong hinge-arrangement.

According to Dall, Gould's diagnosis refers partly to both species, although this is not altogether clear from reading the original description. At any rate, Gould's dimensions of the specimen described, and his subsequent figure of it (Gould, 1852), can only be referred to the transversely ovate species and apparently also only to the largest specimen of the lot, which should be selected as the lectoholotype. Stearns (1890), however, mistakenly figured the single specimen belonging to the second species as Dr. Gould's type of *C. ventricosa,* at the same time assigning the species to the genus *Venericardia,* in which he was followed by Dall. Later, Dall (1902) pointed out Stearns' error and designated Stearns' figured specimen as the type of a new species, which he called *Venericardia (Cyclocardia) stearnsii.*

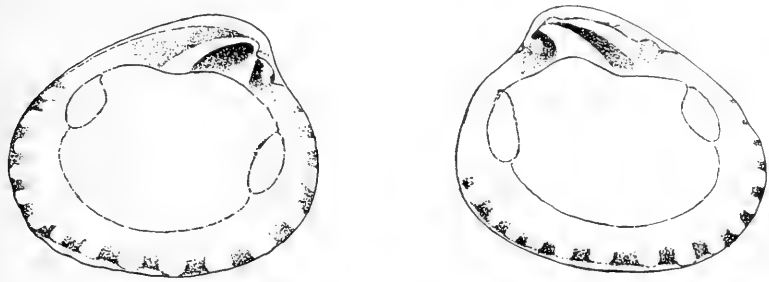
Cardita stearnsii (Dall) appears to be a scarce but distinct species so far found only in the inland waters of British Columbia and northern Washington at depths of from 20 to 30 fathoms. The Gordon Collection in the California Academy contains two specimens from Puget Sound, which were in a lot of typical *ventricosa,* collected at the same time and location by T. S. Oldroyd. The species can be distinguished from *ventricosa* and its allies by its greater height with respect to length; its elevated, more strongly-prosogyrate beaks; its deeply-impressed lunule, and its strong elevated hinge, which, in the left valve, bears a prominently-developed anterior cardinal tooth behind the lunule, and a perceptibly curved posterior cardinal tooth. The periostracum of *C. stearnsii,* although radially pilose, lacks the velvety appearance of the periostracum of shells of the *ventricosa* group.

The writers recognize three forms of *C. ventricosa* (Gould) on the west coast of North America—the typical species and two subspecies. These have the following characters in common: the number of external ribs (18 to 20); the slightly prosogyrate beaks; the moderately-depressed lunule; the general form and structure of the hinge-plate; and the velvety-appearing periostracum. They differ principally in shell outline and in minor particulars of the hinge-plate.

In outline, the typical northern form of *C. ventricosa* is ovate; *C. ventricosa montereyensis,* found off the central California coast, is subtriangular and extended posteriorly; and the form found off the coast of southern California is subquadrangular and more ventricose. For this latter form Burch proposes the name *redondoensis* (Minutes, Conch. Club of Southern California, No. 39, pp. 14, 15, Sept., 1944, and No. 45, p. 11, March, 1945).

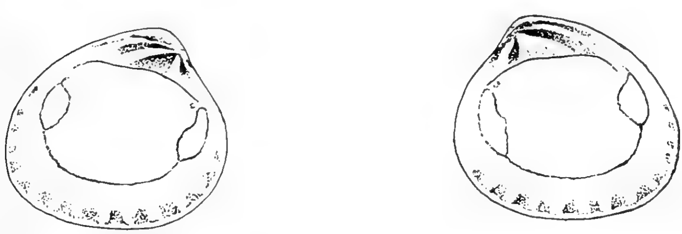
Cardita ventricosa montereyensis differs from the typical *C. ventricosa* also in the hinge-plate, in which the lower margin slopes anteriorly instead of being roughly parallel to the ventral margin of the shell; the posterior cardinal tooth in the left valve is somewhat stronger; the shell is more compressed with the beaks slightly less tumid, resulting in a smaller space behind the hinge-plate and a more heavily-buttressed support behind the anterior cardinal tooth in the left valve; and the central cardinal tooth of the right valve is beveled above rather than acute. This last character, however, may be modified by one or two grooves in some individuals of either the species or the subspecies.

The difference in shape between *C. ventricosa montereyensis* and the southern form is due to the greater posterior attenuation and consequently more sharply-rounded posterior end of *montereyensis,* while *redondoensis* has a much more broadly-rounded posterior end. Also, *redondoensis* is more ventricose than either of the others; the central California form is the least ventricose. The range of *redondoensis,* based on several lots totalling about 30 specimens



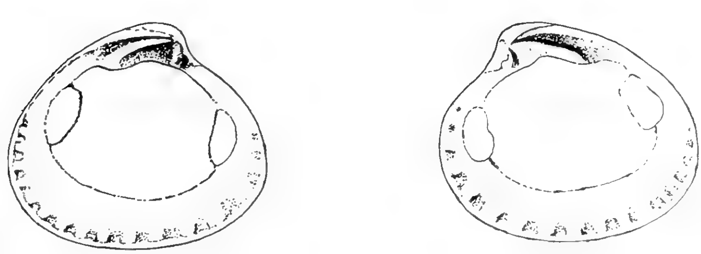
A B

Fig. 2. *Cardita ventricosa montereyensis* Smith and Gordon, n.ssp. Holotype, C.A.S. Paleo. Type Coll. No. 8518. Length, 25.8; width, 16.0; height, 23.0; oblique height, 25.2 mm. A, interior view of left valve; B, same, right valve. (G. D. Hanna, del.)



A B

Fig. 3. *Cardita ventricosa montereyensis* Smith and Gordon, n.ssp. Paratype, C.A.S. Paleo. Type Coll. No. 8519. Length, 17.0; width, 10.0; height, 15.7; oblique height, 16.9 mm. A, interior view of left valve; B, same, right valve. (G. D. Hanna, del.)



A B

Fig. 4. *Cardita ventricosa* (Gould). Hypotype from Puget Sound, the type locality. C.A.S. Paleo. Type Coll. No. 8524. Length, 19.7; width, 11.9; height, 17.8; oblique height, 18.8 mm. A, interior view of left valve; B, same, right valve. (G. D. Hanna, del.)

in the collection of the California Academy, is from off Santa Cruz Island in 250 fathoms to Cortez Bank in 40 to 60 fathoms. Burch cites it from off Redondo Beach, in 100 fathoms.

From the fossil species of *Cardita, C. ventricosa* and its subspecies differ mainly in the number of radial ribs, as follows:

Species	No. of Ribs
Cardita ventricosa group	18-20
Cardita occidentalis Conrad	15
Cardita monilicosta Gabb	14-17
Cardita californica (Dall 1903, not Deshayes 1854)	14-16
Cardita hilli Willett	25-27

From the living species *C. longini* Baily (1945), they differ by having more ribs, *longini* having 13 to 15, and also in the fact that adult shells of *longini* average about half the size. The velvety-appearing epidermis further serves to distinguish the *ventricosa* group from all other living cyclocardias on the west coast of North America.

Dentalium berryi Smith and Gordon, new species

Plate 3, figures 1-4.

Description of the holotype: Shell relatively large for the genus on the Pacific Coast, fairly heavy, moderately curved throughout its length, attenuated toward the apex, the gradually diminishing diameter beginning at about the middle. Color of the upper half chalky white with a very pale brownish stain; of the lower half milk white, somewhat polished and shining. Upper half somewhat eroded. Sculpture consists of irregularly-spaced growth rings that mark the resting stages in the development of the shell; longitudinal striae absent. Aperture circular, thin-edged, not oblique. Exterior of apex also circular. Anal orifice a narrow slit, subrectangular in shape, with the long axis on the dorsal side of the shell. The slit appears to have been formed by the building up of layers of shell inside the orifice. Length 46.7 mm.; diameter of aperture, 3.7 mm.; diameter of apex, 1.4 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll. No. 8525, dredged in about 40 fathoms in fine muddy sand and shale fragments on **Humpback Reef, Monterey Bay, California,** by A. G. Smith, John Q. Burch, and Tom Burch, August, 1937. The type lot consists of three additional living adults, one dead imperfect adult, and two immature dead shells.

Paratypes: Specimens collected with the holotype and another lot consisting of one adult and one broken shell dredged in 20 fathoms in fine sand near the bell buoy off Cabrillo Point, Monterey Bay, by Mackenzie Gordon, Jr., August, 1932, are designated as paratypes. These have been placed in the California Academy of Sciences, the U. S. National Museum, Academy of Natural Sciences of Philadelphia, and in the private collections of S. S. Berry, John Q. and Tom Burch, and A. G. Smith.

The three living adults are all remarkably like the holotype except for a difference in length and that two of them have a plain circular anal orifice, without notch or slit. The immature shells taper to a fine point and are more curved in the upper portion than the adult shells. One of these, a dead specimen, has the anal orifice slightly notched, with the notch prolonged on the dorsal side into a deep narrow slit.

Remarks: This species is unusual for the chalky upper portion of the adult shell, which lacks all traces of longitudinal striations. Evidently the curved tip, which is a feature of the immature stage, is eroded or broken off at a later stage, after which a slit and shallow notch may be formed by the adult shell in some instances. *D. berryi* differs from *D. semipolitum* Broderip and Sowerby by having a proportionally heavier shell, by the lack of longitudinal striations, by being more evenly curved throughout its length, and by having a chalky and more or less eroded upper portion. *D. semipolitum* appears to be a form found in shallower water, being dredged in 10-20 fathoms, although it has been taken with *D. berryi* in deeper water. From *D. pretiosum* Sowerby, *D. berryi* differs by being longer and more slender, and particularly in its chalky texture.

Retusa (Sulcularia) montereyensis Smith and Gordon, new species

Plate 3, figure 11.

Description of the holotype: Shell minute, white, translucent, with a pale straw-colored periostracum; subcylindrical, narrow anteriorly, slightly compressed at the center; base somewhat inflated. Apex deeply sunken; spire concealed; aperture narrowed posteriorly, rounded, extending well beyond the apex, while anteriorly it becomes wider, terminating in a rounded flare. Sculpture consisting of close-set, subequally spaced, rounded, somewhat sinuous, vertical, occasionally branching axial ribs, spaced about 24 to the millimeter; interspaces almost equal to the ribs in width, cut into squares by very fine, subequally spaced spiral lines, which do not pass over the ribs themselves. On the holotype this sculpture is hardly distinguishable on the base, but on other specimens it continues to the columella. Outer lip thin, somewhat sinuous and compressed at the center, smooth inside; pillar lip also thin; columella slightly thickened, almost straight. Body of shell has a slight glaze. Length, 2.8 mm.; maximum diameter, 1.1 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll. No. 8527, C.A.S. Loc. No. 23,820, dredged in 25 fathoms, in fine sand and shell fragments **near the bell buoy off Cabrillo Point, Monterey, California,** by G. D. Hanna and C. C. Church.

Paratypes: Specimens so designated are as follows: nine shells dredged in 8-15 fathoms, in fine sand and broken shale off Del Monte, by Mackenzie Gordon, Jr., and G. E. McGinitie, August, 1932; a single specimen dredged in the same general locality in 15 fathoms, by G. D. Hanna, J. L. Nicholson, and A. G. Smith, July, 1930. These have been distributed to the U. S. National Museum, Stanford University, Los Angeles Museum, and the private collections of S. S. Berry, and A. G. Smith.

Remarks: At first we believed this little Monterey *Retusa* was referable to *R. xystrum* Dall. However, comparison of specimens with a hypotype of *xystrum* from San Pedro (No. 6414, Stanford Univ. Paleo. Type Coll.), which was rather poorly figured by Oldroyd (1927, vol. 2, pt. 1, pl. 2, fig. 10) has convinced us that the Monterey shell is a different species. The specimen of *R. xystrum* measures: length, 2.7 mm.; maximum diameter, 1.2 mm. It possesses faint threadlike spiral lirae between the axial ribs, a character overlooked by Dall in the original description (Proc. U.S.N.M., 1920, 56:297). The axial ribs are spaced 18 to the millimeter, there being approximately 50 on the last whorl. In *R. montereyensis* the ribs are spaced 24 to the millimeter, with almost 70 on a paratype of equivalent length. Also, the spiral striations of *montereyensis* are more closely spaced than on *xystrum*. There is practically no variation in the spacing of the axial ribs and the spiral lirae in all specimens of *montereyensis* we have examined, and in general it has a constantly more delicate sculpture than *xystrum*.

Metzgeria montereyana Smith and Gordon, new species

Plate 3, figure 6.

Description of the holotype: Shell moderately small, whitish, with a brown, minutely wrinkled, conspicuous periostracum. Nucleus with one and one-half whorls, small, depressed-turbinate, white, the tip smooth with weak transverse ribs appearing on the last half turn, the axis slightly oblique. Post-nuclear whorls four and one-quarter, evenly rounded, rather high and slightly obliquely inclined from the horizontal, separated by a moderately deep suture. Axial sculpture consists of 12 to 13 prominent, rounded, elevated axial ribs extending between the sutures and on the last whorl crossing the periphery to about the middle of the base, separated by slightly narrower interspaces. These are crossed by seven to eight narrow, rounded, elevated, spiral cords, which are strongest over the center of the whorl and weaker toward the sutures and separated by wider interspaces. Periphery well-rounded, marked by a continuation of the axial and spiral sculpture. Base and canal have 16 spiral cords that become successively closer spaced toward the end of the canal. Aperture less than half as long as the shell; outer lip thin (partly broken off in the holotype), smooth and whitish within; pillar whitish, somewhat recurved anteriorly, ornamented behind the angle by three distinct, subequally spaced, oblique plaits, the posterior one weaker than the other two; canal slightly oblique, open, and moderately wide. Length of shell, 12.4 mm.; of aperture and canal, 5.7 mm.; maximum diameter, 4.8 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8530; a single dead specimen dredged in 15 fathoms, in fine sand and broken shale **off Del Monte, Monterey Bay, California,** by Mackenzie Gordon, Jr., August, 1932.

Remarks: This species is the second *Metzgeria* to be described from the California coast. It differs from *M. californica* Dall in having three to four less axial ribs on the whorls, in lacking the inflated whorls, and in having a shorter, more oblique canal.

Balcis delmontensis Smith and Gordon, new species

Plate 3, figure 5.

Description of the holotype: Shell small, broadly conic, vitreous, yellowish to milk-white. Axis of whorls appears straight at first glance but actually curves slightly to the right. Nuclear whorls two and one-half, smooth, and well-rounded, the first helicoid and loosely coiled. Post-nuclear whorls six, gently rounded except the last, which is subangulated about one-quarter of the distance below the suture. Whorls polished, with a few weak, irregularly situated varices. Periphery of the last whorl inflated and sharply rounded. Base short, gently rounded, smooth. Aperture moderately large, ovate, the posterior angle acute; outer lip thin at the edge, somewhat produced; inner lip thick, strongly curved, reflected over the base and appressed to it posteriorly; parietal wall glazed with a thin callus. Length, 4.5 mm.; maximum diameter, 2.2 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8531; dredged in 10 fathoms, in fine sand and shale fragments **off Del Monte, Monterey Bay, California,** by A. G. Smith and C. S. Fackenthall, August, 1913.

Paratypes: Specimens so designated consist of the following lots: Three shells dredged in 10 fathoms, in granite sand and broken shells off Cabrillo Point, by A. G. Smith, August, 1913 (AGS No. 5087); two specimens dredged in 10 fathoms off Del Monte, by Mackenzie Gordon, Jr., August, 1932; seven immature shells (C.A.S. Paleo. Type Coll. Nos. 8532-8538, incl.) dredged in 25 fathoms near the bell buoy off Cabrillo Point; a single immature specimen dredged in 8-10 fathoms in sand off Del Monte (AGS No. 5089); and two specimens from a seaweed holdfast off Del Monte (AGS No. 8266). Distribution of paratypes has been made, in addition to those in the Academy's collection to the U. S. National Museum, Stanford University, Los Angeles Museum, and the private collections of S. S. Berry, John Q. and Tom Burch, and A. G. Smith.

Remarks: This species is nearest to *B. tacomaensis* (Bartsch), but is more broadly conic, has a more inflated base, and lacks the conspicuously false suture of the latter species. It may be readily distinguished from other melanellas found in Monterey Bay by its inflated base and its straight columella.

Turbonilla (Turbonilla) fackenthallae Smith and Gordon, new species

Plate 3, figures 7, 8.

Description of the holotype: Shell rather large for the subgenus, robust, broadly conic, milk-white. Nuclear whorls helicoid, two and one-half, at right angles to and about one-third immersed in the first post-nuclear turn. Post-nuclear whorls 10, well rounded, very narrowly tabulate at the summits, especially on some of the whorls where the axial ribs are posteriorly truncated. Sutures prominent. The sculpture consists of broad, rounded, prominent, moderately protractive axial ribs, of which there are 10 on the first, 12 on the second to fifth, 14 on the sixth, 12 on the seventh, 10 on the eighth, 12 on the ninth, and 16 on the last whorl where they are slightly less prominent than on the others. The ribs are separated by well marked, rounded interspaces, from one-half to five-sixths the width of the ribs, and which just start to die out as they reach the suture. Axial sculpture crossed by numerous, faintly-incised spiral lines, discernible only under fairly high magnification. Periphery well rounded; base rather elongate, gently rounded and sculptured by lines of growth and the fine spiral lines. Aperture subquadrate; posterior angle acute; outer lip thin, showing the axial sculpture within. Columella thin, gently curved, inclined in the same plane as the axial ribs. Length, 7.7 mm.; maximum diameter, 1.9 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8539, Locality No. 24,147, dredged in 20-30 fathoms, in sand, **between the bell buoy off Cabrillo Point and the shale bed off Del Monte, California,** by G. D. Hanna, J. L. Nicholson, and A. G. Smith, June, 1930.

Paratypes: Two specimens were collected with the holotype, one of which has been placed in the U. S. National Museum. This latter shell has 10 whorls, the nuclear whorls being lost. It differs from the holotype in the following particulars: Rib count the same except for 11 on the sixth, 11 on the eighth, and 15 on the last whorl; the interspaces do not quite reach the sutures, leaving a smooth narrow band just below them; on the early whorls this character affects the whorl below so that the narrow tabulation at the summits of the whorls is almost lacking, except when some of the ribs tend to be truncated posteriorly. The second paratype is in the collection at Stanford University.

Remarks: This species can be identified easily by the robust shape of the shell; the broad, prominent, moderately protractive axial ribs; and its relatively large size. Named in memory of the late Mrs. Charles S. Fackenthall, who collected shells for many years in the Monterey region.

Turbonilla (Pyrgolampros) stillmani Smith and Gordon, new species

Plate 3, figure 9.

Description of the holotype: Shell small, narrowly conic, flesh-colored, with a narrow indistinct brown band at the periphery, and another less distinct pale brown band just below the suture. Nuclear whorls one and three-quarters, depressed, helicoid, with the axis almost at right angles to that of the succeeding turns, in the first of which they are approximately one-fourth immersed. The five post-nuclear whorls appear to be gently rounded but on close inspection they are actually almost flattened laterally and strongly rounded above. Sutures deeply channeled. Axial sculpture consists of broadly rounded, elevated, straight, very slightly retractive ribs, of which there are 20 on the second, 18 on the third, 22 on the fourth, and 26 on the fifth whorl. These are separated by narrower, shallowly-channeled interspaces. On the last whorl the ribs are somewhat enfeebled and split. Axial sculpture crossed by exceedingly fine, lightly-incised spiral striae, hardly perceptible except under fairly high magnification. Periphery of the last whorl rounded, moderately inflated. Base rounded, marked by feeble continuations of the axial ribs and the spiral striae. Aperture suboval; posterior angle acute; outer lip thin; columella slender, slightly twisted; inner lip reflected anteriorly and appressed to the base. Length, 3.5 mm.; maximum diameter, 1.1 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll. No. 8540, dredged in 10 fathoms, in sand and shale fragments, **one-half mile off Del Monte Pier, Monterey Bay, California,** by Mackenzie Gordon, Jr. and G. E. McGinitie, August, 1932. Two other specimens were collected.

Paratypes: Specimens so designated include the two collected with the holotype; a single specimen from about the same locality dredged by A. G. Smith and C. S. Fackenthall, July, 1913; and a specimen from Monterey collected by George Willett. They are placed in the collections at Stanford University and the U. S. National Museum, and the private collections of George Willett and S. S. Berry.

Remarks: This species is related most closely to *T. pesa* Dall and Bartsch but is distinguished from it in having a more elongate base, better defined axial ribs, and broader early post-nuclear whorls. It resembles none of the southern California species closely. Tentatively referred to this species also is a single specimen dredged in 25 fathoms off Coronado Beach, California, by Mackenzie Gordon, Jr., September, 1933. Named in honor of Dr. S. Stillman Berry, of Redlands, California, whose work on the molluscan fauna of Monterey Bay is thus signalized. The name was also chosen in partial compensation for the necessity of placing *T. berryi* Dall and Bartsch in the synonymy of *T. chocolata* (Carpenter).

Turbonilla (Pyrgolampros) willetti Smith and Gordon, new species

Plate 3, figure 10.

Description of the holotype: Shell small, rather broadly conic. Color light brown, with a narrow dark brown band just above the periphery showing on all the whorls, a wider but fainter brown band just below the periphery, and a small but still paler colored area at the columella. Nuclear whorls helicoid, two and one-half, at right angles to and about one-fourth immersed in the first post-nuclear turn. Post-nuclear whorls eight, very gently rounded but more so at the summits, with narrow but distinct tabulations. Sutures well incised and prominent. Axial sculpture consists of broad, rounded, generally vertical ribs, of which there are 12 on the second, 14 on the third, 16 on the fourth, fifth, and sixth, 18 on the seventh, and 20 on the last whorl. On some of the whorls the ribs are slightly protractive. They are separated by narrow, moderately deep interspaces that are usually about one-half the width of the ribs. On the last whorl the ribs are not so strongly developed as on those preceding it. Ribs and interspaces crossed by numerous fine, wavy, spiral lines. Aperture pyriform; posterior angle acute; outer lip thick (slightly broken away), rounding with a slight flare into the straight, fairly thick, revolute, oblique columella. Length, 5.8 mm.; maximum diameter, 1.6 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8541, dredged in 10 fathoms, in sand and shale fragments, **one-half mile off Del Monte Pier, Monterey Bay, California,** by Mackenzie Gordon, Jr., and G. E. McGinitie, August, 1932.

Remarks: This species is known so far only from the holotype, which is sufficiently different from others described under the subgenus *Pyrgolampros* that we have no hesitancy in naming it as new. The narrow tabulation of the whorls is a particular feature. In this it is probably closest to *T. strongi* Willett although the latter is a much less robust shell. The holotype of *willetti* has been compared with paratypes of *strongi* in the Willett collection. Named in honor of the late George Willett, former Curator of Conchology and Ornithology, Los Angeles Museum.

Turbonilla (Bartschella) bartschi Smith and Gordon, new species

Plate 3, figure 13.

Description of the holotype: Shell small, elongate-conic, cream-white. Nuclear whorls two and one-half, helicoid, with the axis set obliquely to that of the next succeeding turn in which it is about one-third immersed. Post-nuclear whorls six, well rounded, strongly constricted at the sutures. Sculpture consists of strong, narrow, sharp, subequally spaced, raised, sinuous, axial ribs, of which there are 17 on the first, 21 on the second and third, 25 on the fourth, and 30 on the last whorl. The ribs are protractive over most of the whorl but at the summit and at the suture they are somewhat retractive. The whorls are also sculptured by nine spiral cords, equal in strength to the ribs and rendering them somewhat nodulous at the points where they cross. The intercostal spaces are twice the width of the ribs and are in the form of deep squarish pits. Periphery of the last whorl gently rounded. Base marked by continuations of the axial ribs, which reach almost to the umbilical area, and sculptured by eight spiral cords that are progressively more closely spaced and become progressively weaker as the umbilicus is approached. Aperture large, pyriform; posterior angle acute; columella slender, curved; umbilical chink present. Length, 2.0 mm; maximum diameter, 0.7 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8542, Locality No. 23,820, dredged in 25 fathoms near the bell buoy **off Cabrillo Point, Monterey Bay, California,** by G. D. Hanna and C. C. Church.

Remarks: This species is known so far only from the holotype. It is unique in the further sense of being the only *Bartschella* from the West Coast of North America with such sharp sinuous ribs. Named in honor of Dr. Paul Bartsch whose valuable work with Dr. W. H. Dall on the western American Pyramidellidae now serves as a starting point for all future studies of this group.

Odostomia (Salassiella) heathi Smith and Gordon, new species

Plate 3, figure 14.

Description of the holotype: Shell small, conic, milk-white, with a narrow brownish band just below the center of the whorls. Nuclear whorls two and one-half, with the axis almost at right angles to the succeeding turns, in the first of which it is approximately one-third immersed. Post-nuclear whorls four and one-half, moderately rounded and shouldered at the summits, marked by slightly flexuous, lamellar, axial ribs, which are but feebly present on the first half turn. There are 28 of these ribs on the second and third, 25 on the fourth, and 24 on the last whorl. The intercostal spaces are about one-third as wide as the ribs and are moderately well impressed. Varices are sparse and irregularly placed, being best developed on the earlier whorls, and extend strongly to the sutures. Periphery of whorls subangulate; sutures well impressed. Base rounded, marked by feeble continuations of the axial ribs almost to the umbilical area, which is relatively smooth. Aperture subpyriform; posterior angle acute; outer lip moderately thin, smooth within; columella almost straight, slender, provided with a weak fold at its insertion. Length, 2.8 mm.; maximum diameter, 1.0 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8543, dredged in 15 fathoms near the bell buoy **off Cabrillo Point, Monterey, California,** by Mackenzie Gordon, Jr.

Remarks: Known only from the holotype. This is the first species of the subgenus *Salassiella* found north of San Pedro, California. It differs from other West American representatives of the subgenus by the greater number of axial ribs on the earlier whorls. Named for Dr. Harold Heath, well-known biologist (now emeritus) of the Hopkins Marine Biological Laboratory at Pacific Grove, California.

Odostomia (Menestho) churchi Smith and Gordon, new species

Plate 3, figure 12.

Description of the holotype: Shell small, subcylindrical, translucent, white. Nuclear whorls smooth, two and one-half, prominent, obliquely immersed in the next succeeding turn. Post-nuclear whorls nearly four, moderately rounded, with a sloping shoulder that gives the shell a tabulated aspect. There is a slight suggestion of a constriction at the periphery of the whorls. Sculpture consists of about 25 low, flattened, subequal, spiral cords, which are separated, in turn, by fine, wavy, well-impressed, spiral grooves. In addition to these there are numerous and very fine axial and spiral striae that form a network over the entire shell, visible only under high magnification. Periphery and base well rounded and, like the spire, sculptured by spiral cords, of which there are about 15, and the reticulate striae. Aperture pyriform, entire; outer lip thin, the sculpture showing through. Columella strong, greatly reflected; posterior angle obtuse. Length, 1.8 mm.; maximum diameter, 0.5 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8544, dredged in 25 fathoms near the bell buoy **off Cabrillo Point, Monterey Bay, California,** by G. D. Hanna and C. C. Church.

Remarks: This species is known so far only from the holotype. It suggests *O. (Ivara) turricula* Dall and Bartsch, but is much more elongate and lacks the feeble axial ribs of the latter species. It is also rather like *O. (Menestho) pharcida* Dall and Bartsch, but is more shouldered and has more spiral lirae. Named for Mr. Clifford C. Church, paleontologist with the Tidewater-Associated Oil Company, one of the collectors of the holotype.

Rissoella hertleini Smith and Gordon, new species

Plate 3, figure 15.

Description of the holotype: Shell small, subglobose, translucent, light yellowish-brown. Nuclear whorls one and one-quarter, well rounded, smooth. Post-nuclear whorls three, rounded, but with a slight posterior flattening, smooth except for minute irregularities caused by normal lines of growth and by stopping points in the development of the shell. Sutures moderately constricted. Periphery strongly rounded, marked like the spire, and with a small umbilicus. Umbilical area bounded above by a moderate angulation. Aperture semi-lunar, the posterior angle almost a right angle; outer lip thin, well rounded, meeting the inner lip at an obtuse angle; inner lip thin above, strongly reflected below, prominently channeled behind, and appressed to the base at the extreme lower end; peritreme completed by a fairly heavy callus on the parietal wall. Operculum corneous, thin, imbricate, with a submarginal clawlike process on the posterior side. Length, 2.2 mm.; maximum diameter, 1.5 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8545, dredged in 10 fathoms, in sand, **off Cabrillo Point, Monterey Bay, California,** by A. G. Smith, July, 1913. Six additional specimens, similar in all respects to the holotype, were collected with it.

Paratypes: Specimens so designated are the six just mentioned. They have been placed in the U. S. National Museum, the Los Angeles Museum, the San Diego Society of Natural History, Stanford University, and the private collections of S. S. Berry, and A. G. Smith (No. 2010).

Remarks: This species is closely related to those already described from the west coast of Lower California. The operculum has the same characters as those of the genotype (See Tryon, Man. Conch., vol. 9, pl. 54, figs. 96, 97). It may be identified easily by its subglobose shape, channeled umbilical area, and lack of distinctive sculpture. Named for Dr. Leo G. Hertlein, Assistant Curator of Paleontology, California Academy of Sciences, San Francisco.

Alaba serrana Smith and Gordon, new species

Plate 4, figures 1, 2.

Description of the holotype: Shell small, elongate-conic, light cream-white. Whorls 10 (the last imperfect), the early ones rounded, the later ones with a sloping shoulder that forms a slight angulation about one-quarter of the distance below the suture. On the last entire whorl three more faint angulations or subobsolete carinae are spaced equally between the shoulder edge and the periphery. No incised lines are present. Axial sculpture consists of fine, sinuous, protractively slanting lines of growth. Varicial thickenings make their appearance on the second whorl, where they are feebly developed, although they increase in strength on the succeeding turns. Periphery subangulate; base gently rounded. Aperture broken away, suboval; outer lip thin; posterior angle obtuse. Columella curved, the parietal wall covered by a thin callus. Length, 5.2 mm.; maximum diameter, 1.8 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8546. Locality No. 24,830, dredged in 25 fathoms, **Carmel Bay, California,** with a tow net that accidentally scraped bottom, by W. L. Scofield of the California Division of Fish and Game, who turned the material so obtained over to Dr. Harold Heath.

Paratype: Calif. Acad. Sci. Paleo. Type Coll. No. 8547; a single specimen dredged with the holotype. It is immature, shining, translucent, and more slender than the holotype, with sculpture consisting of fine, closely-spaced punctations on the earlier whorls. It has eight whorls and measures: length, 3.4 mm.; maximum diameter, 1.2 mm.

Remarks: This species is most nearly related to *A. catalinensis* Bartsch, from which it differs by its subangulate spiral sculpture. It represents a considerable extension northward of the range of the genus. Named for Padre Junipero Serra, who founded the mission at Carmel.

Rissoina hannai Smith and Gordon, new species

Plate 4, figure 4.

Description of the holotype: Shell small, elongate-conic, translucent, milk-white. Nuclear whorls two, well rounded, smooth. Post-nuclear whorls five, moderately rounded, appressed at the summits, giving the appearance of having a double suture. Under low magnification the whorls appear to be devoid of sculpture, but under higher power the sculpture is seen to consist of numerous, extremely fine, closely spaced axial striae or lines of growth. Occasionally a small, obsolete axial rib begins to develop near the suture but dies out immediately and is overridden by the axial striae. Under still higher magnification a number of tiny, irregularly-spaced punctations make their appearance. Periphery and base gently rounded, marked like the spire. Aperture large, effuse, slightly channeled at the posterior angle; outer lip moderately thick and effuse; inner lip also fairly thick, curved, and appressed to the base; parietal wall covered by a callus that renders the peritreme complete. Length, 2.7 mm.; maximum diameter, 1.3 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8548, Locality No. 24,830, dredged in 25 fathoms in **Carmel Bay, California,** with a tow net by W. L. Scofield of the California Division of Fish and Game and sent to the Academy by Dr. Harold Heath. In addition to the holotype, 27 other specimens were taken.

Paratypes: Specimens so designated have been placed in the California Academy of Sciences (Type Nos. 8549-8552, inc.), the U. S. National Museum, the Philadelphia Academy of Sciences, Stanford University, the San Diego Society of Natural History, the Los Angeles Museum, and in the private collections of S. S. Berry, A. G. Smith, E. P. and E. M. Chace, and Tom and John Q. Burch.

Remarks: This species is nearest to *R. cerrosensis* Bartsch, but its shape is elongate-conic while the latter species is decidedly ovate. From all other described West American species it differs in having no apparent sculpture under low magnification. Named for Dr. G. Dallas Hanna of the California Academy of Sciences.

Rissoina keenae Smith and Gordon, new species

Plate 4, figure 3.

Description of the holotype: Shell small, elongate-conic, subdiaphanous, milk-white. Nuclear whorls two, smooth and shining. Post-nuclear whorls four, strongly rounded, very narrowly and feebly beveled at the sutures, marked by almost vertical, generally straight, closely-spaced, axial threads, which vary somewhat in strength, and which are equally spaced except occasionally when two or more coalesce or where there is a variation in strength. The axial threads are weakly defined on the first post-nuclear whorl, become stronger on the second, and reach maximum development on the last two, on which there are 56 to 58 of them. Intercostal spaces are generally less than half the width of the threads. There is occasional splitting of the threads also, with the result that some of them are not continuous across the entire whorl. Sutures strongly impressed. Base slightly concave posteriorly, marked by continuations of the axial threads, which extend without diminution in strength to the umbilical area. Aperture large, somewhat oblique, suboval. Outer lip reinforced by a thick varix immediately behind the edge, the posterior portion being slightly reflected. Inner lip thin, gently curved, reflected over and appressed to the base, making the peritreme complete. Length, 2.8 mm.; maximum diameter, 1.1 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8553, dredged in 5-15 fathoms **off Point Pinos, Monterey Bay, California,** in coarse granite sand and broken shells, by A. G. Smith and Mackenzie Gordon, Jr., September, 1932. Two additional specimens were collected with the holotype.

Paratypes: Specimens so designated are the two just mentioned, and two others dredged in 15 fathoms, in fine sand near the bell buoy off Cabrillo Point by Mackenzie Gordon, Jr. They have been placed in the U. S. National Museum, Stanford University, and the private collections of S. S. Berry and A. G. Smith.

Remarks: This species differs from others described from the Pacific Coast by having a larger number of axial threads of relatively equal strength that cross the post-nuclear whorls. It has the well-rounded whorls of *R. bakeri* Bartsch, but lacks the strong axial ribs of that species. From *R. newcombei* Dall it differs by having more rounded whorls, with more and closer-spaced axial threads. All of the specimens collected show no marked deviation in shape or sculpture. Named for Dr. A. Myra Keen, Curator of the Paleontological Collections, Stanford University.

Calyptraea burchi Smith and Gordon, new species

Plate 4, figures 11-13.

Description of the holotype: Shell of medium size, low, broadly conic, with a circular aperture and slightly concave sides. Exterior whitish, chalky, and covered with a thin yellowish-brown epidermis. Nuclear whorls a little over one and one-half, smooth, yellowish-brown; the first oblique, rounded, and set off by a prominent suture, giving the shell a mammillate aspect. The post-nuclear portion of the shell expands rapidly and is marked externally only by circular lines of growth. Interiorly the shell carries the spiral septum usual in the genus, which is white, markedly sinuate at the edge, and which shows closely-spaced, sinuate lines of growth that are alternately an opaque milk-white and translucent. Toward the columella the septum margin becomes recurved and finally folded back on the columella itself, to which it is appressed and fused. Remainder of the interior smooth and polished, but under medium magnification both this and the septum have finely-granulated microscopic sculpture. Color of the interior light yellowish-brown marked by many flecks and flammulations of darker brown. Margin thin. Maximum diameter, 16.3 mm.; height, 6.4 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8554, Locality No. 24,147, dredged in 20-30 fathoms **between the bell buoy off Cabrillo Point and the shale bed off Del Monte, Monterey Bay, California,** by G. D. Hanna, J. L. Nicholson, and A. G. Smith, July, 1930. The type lot consists of the holotype and two immature shells.

Paratypes: Specimens so designated include the two young shells just mentioned and the following additional lots: four adult and four immature specimens in the A. G. Smith (No. 5748) and the J. Q. Burch collections, dredged in 35-40 fathoms, on shale, at Humpback Reef, off Monterey; an imperfect adult and two young shells dredged in 15 fathoms off Del Monte on the shale bed, by A. G. Smith (No. 3644); one young shell dredged in the same locality by Mackenzie Gordon, Jr.; and two dead specimens from 25 fathoms, in shelly sand, off Del Monte in the Berry collection (SSB No. 1677).

Remarks: Two additional small lots that appear to be this species are in the California Academy's Collection. They are from Carmel. Differs from *C. fastigiata* Gould in its smaller size and in the brown markings, which also show on the outside of the shell on some of the paratypes. Differs from *C. contorta* (Carpenter) by having a colored nuclear apex instead of a white one, by its larger size, and also in its brown markings. All shells of these two other species in the lots we have seen from the West Coast north of San Pedro are white and otherwise uncolored. Named for John Q. and Tom Burch of Redondo Beach, California.

Margarites keepi Smith and Gordon, new species

Plate 4, figures 5-7.

Description of the holotype: Shell small, broadly conic, whitish with occasional dark flammulations. Nuclear whorls one and one-half, somewhat oblique, smooth. Post-nuclear whorls three, sloping, tabulate, marked by three spiral keels. The first of these keels consists of a thin, raised, spiral thread adjacent to the suture; the second and third are prominent, of equal strength, and divide the whorl into three equal parts. Periphery marked by a strong cord of about the same prominence as the second and third keels. The keels are crossed by about 24 raised, retractive, axial riblets of slightly lesser strength than the keels, forming well-developed tubercles at the points of crossing. The axial riblets die out at the periphery, beyond which the base slopes gently to the umbilicus. Base sculptured with seven spiral cords that decrease successively in strength toward the umbilical region, the outer four being well developed. The basal cords are crossed by very fine, closely-spaced, slightly retractive, axial lines. Aperture suboval; outer lip thin, crenulated by the spiral keels; columella moderately thin, curved, and reflected so that it partially closes the umbilicus; posterior angle obtuse; parietal wall covered by a thin wash of callus. Height, 2.0 mm.; maximum diameter, 2.1 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8557, Locality No. 23,820, dredged in 25 fathoms, in sand, near the bell buoy **off Cabrillo Point, Monterey Bay, California,** by G. D. Hanna and C. C. Church. Four additional specimens were taken with the holotype.

Paratypes: Specimens so designated have been placed in the California Academy's collection (Nos. 8558, 8559), the U. S. National Museum, and the private collection of A. G. Smith. They are part of the type lot.

Remarks: This species is unique among the *Margarites* described from the West Coast of North America, there being no other with such strong axial ribbing and tuberculation. Named in honor of Professor Josiah Keep, formerly of Mills College, who did so much to advance the knowledge of the shells of the West Coast.

Skenea carmelensis Smith and Gordon, new species

Plate 4, figures 8-10.

Description of the holotype: Shell small, depressed, turbinate, white. Nuclear whorls one and one-half, helicoid, smooth. Post-nuclear whorls one and one-half, well rounded, sloping posteriorly, marked by a number of narrow, slightly raised, rounded, spiral cords, separated by V-shaped or U-shaped grooves, and crossed by irregularly-spaced lines of growth. Periphery of the last whorl strongly rounded. The base slopes gently into the umbilical angle and is sculptured by many spiral cords of lesser dimension but more closely spaced than those on the spire. The spiral cords continue weakly but a short distance beyond the umbilical angle into the rather narrow umbilicus, which is marked mainly by continuations of the lines of growth. Aperture nearly circular; posterior angle obtuse; outer lip thin, minutely crenulated by the spiral cords; inner lip thin, curved, appressed to the base above, slightly reflected over the umbilicus, and also reflected and grooved below; parietal wall covered by a thin callus, making the peritreme complete. Height, 1.3 mm.; maximum diameter, 1.7 mm.

Holotype: Calif. Acad. Sci. Paleo. Type Coll., No. 8560, Locality No. 24,830, dredged in 25 fathoms, in sand, **in Carmel Bay, California,** with a tow net by W. L. Scofield of the California Division of Fish and Game and forwarded to Dr. Harold Heath, who turned the material over to the California Academy. Three other specimens were dredged with the holotype.

Paratypes: Specimens so designated are the three just mentioned. They have been placed in the California Academy of Sciences (Nos. 8561, 8562), and the private collection of A. G. Smith.

Remarks: There remains a certain amount of doubt in assigning this species to Vitrinellidae because of the relatively small size of the nuclear whorls and the narrowness of the umbilicus. However, the thinness of the shell and the configuration of the columella do not appear to warrant placing it in Turbinidae or in Trochidae. We have seen nothing else like it from the Monterey region or elsewhere.

SYNONYMIC NOTES

Acmaea cassis Eschscholtz, *A. cassis pelta* Eschscholtz, *A. cassis monticola* Dall, *A. cassis nacelloides* Dall, and *A. cassis olympica* Dall, see *A. pelta* Eschscholtz—Grant, 1938.

Acmaea permabilis Dall, see *A. ochracea* (Dall)—Grant, 1938.

Acmaea scutum patina Eschscholtz, *A. scutum pintadina* (Gould), *A. scutum parallela* Dall, and *A. emydia* Dall, see *A. scutum* Eschscholtz—Grant, 1938.

Acmaea spectrum Reeve, see *A. scabra* (Gould)—Dall, Nautilus, vol. 28, (2), p. 14.

Alectrion, Montfort, 1910, see *Nassarius* Duméril, 1805—Grant and Gale, 1931, pp. 670, 672.

Alvania Risso, 1826—For discussion of the classification of the northwest American species under this genus, see Gordon, Nautilus, vol. 53, (1), pp. 29-33.

Antiplanes Dall, 1902 (in part), see *Rectiplanes* Bartsch, 1944, created to include certain dextral turrids formerly included in *Antiplanes.* Type: *Rectiplanes santarosana* (Dall)—Bartsch, 1944b, p. 59.

Antiplanes Dall, 1902 (in part), see *Rhodopetoma* Bartsch, 1944, for *A. amycus* Dall—Bartsch, 1944b, p. 59.

Arca pernoides (Carpenter), see *A. bailyi* (Bartsch)—Reinhart, 1943, pp. 35, 82.

Astraea inaequalis montereyensis Oldroyd, see *A. inaequalis* (Martyn). We are of the opinion that this subspecies has doubtful taxonomic value.

Basiliochiton Berry, 1918—For use as a genus to include *Lepidochitona flectens* (Carpenter), *L. flectens heathii* Pilsbry (= *Mopalia heathii* Pilsbry), and *Basiliochiton lobium* Berry, see Berry, 1925.

Botula diegensis Dall, see *Volsella diegensis* (Dall)—Grant and Gale, 1931, p. 253.

Cardita Bruguière, 1792 (in part), see *Glans* Megerle von Mühlfeldt, 1811—Grant and Gale, 1931, p. 276.

Cardita subquadrata (Carpenter), see *Glans carpenteri* Lamy—Lamy, 1922, p. 264.

Cardiidae—For latest arrangement, see Keen, 1937b.

Cardium corbis (Martyn), see *C. nuttallii* Conrad—Keen, 1936.

Cavolina occidentalis Dall, see *C. tricuspida* (Rivers)—Grant and Gale, 1931, p. 441.

Chemnitzia gracillima Gabb, see *Turbonilla gabbiana* (Cooper)—Cooper, 1870a, p. 66.

Cerithiopsis sassetta Dall, see *Bittium serra* Bartsch—This paper, p. 196.

Chaetopleura Shuttleworth, 1853, see *Dendrochiton* Berry, 1911, for use of this latter genus to include *C. thamnopora* Berry, *C. gothica* Carpenter, and *Dendrochiton semiliratus* Berry—Berry, 1911b.

Chironia Deshayes, 1839—For use of this genus name in place of *Kellia* Turton, 1822, see Grant and Gale, 1931, p. 299.

Chrysodomus Swainson, 1840, see *Neptunea* Bolten, 1798—Grant and Gale, 1931, pp. 652-653.

Clathrodrillia Dall, 1918, see *Ophiodermella* Bartsch, 1944, for *C. halcyonis* (Dall) and *C. incisa ophioderma* (Dall)—Bartsch, 1944b, pp. 61-62.

Columbella Lamarck, 1799 (as used in Dall, Bull. No. 112), see *Mitrella* Risso, 1826—Grant and Gale, 1931, pp. 679, 683, 689-698.

Corbula Bruguière, 1798, see *Aloidis* Megerle von Mühlfeldt, 1811—Winckworth, 1930, p. 15; Keen, 1937a, p. 18; Gardner, Nautilus, vol. 40, (2), p. 43.

Crepidula Lamarck, 1799, see *Crepipatella* Lesson, 1830, for *C. lingulata* Gould and *C. orbiculata* Dall—Woodring, Minutes, Conch. Club of So. Calif., No. 56, p. 17, Jan. 1945.

Cryptoconus von Koenen, 1867, see *Megasurcula* Casey, 1904—Grant and Gale, 1931, pp. 495, 501; Keen, 1937a, p. 40.

Cryptogemma Dall, 1917, see *Carinoturris* Bartsch, 1944, for *C. adrastia* Dall—Grant and Gale, 1931, p. 571; Bartsch, 1944b, p. 60.

Cumingia lamellosa Sowerby, see *C. californica* Conrad—Keen, 1937a, p. 20.

Cuspidaria Nardo, 1840, see *Cardiomya* A. Adams, 1864—Stewart, 1930, p. 308.

Cuspidaria nana Oldroyd, see *Sphenia nana* (Oldroyd)—Based on the type in the Stanford collection (Keen, in correspondence).

Cyanoplax hartwegii nuttallii (Carpenter), see *C. hartwegii* (Carpenter)—Berry, 1933, p. 435.

Cyclostremella californica Bartsch, see *Skenea californica* (Bartsch)— Iredale, Proc. Mal. Soc. London, 1915, vol. 11, p. 292.

Cymbuliopsis vitrea Heath and Spaulding, see *Corolla vitrea* (Heath and Spaulding)—Dall (in Williamson), Proc. U. S. Nat. Mus., vol. 15, (898), p. 194, 1892.

Dentalium hannai Baker, see *D. semipolitum* Broderip and Sowerby—This paper, p. 178.

Diala marmorea Carpenter, see *Barleeia marmorea* (Carpenter)—Dall, Nautilus, vol. 35, (3), p. 84.

Diplodonta Bronn, 1831, see *Taras* Risso, 1826—Grant and Gale, 1931, p. 293.

Epitonium crenimarginatum (Dall), see *E. (Dentiscala) insculptum* (Carpenter)—Willett, Nautilus, vol. 52, (1), p. 10.

Epitonium (Nitidoscala) fallaciosum Dall, see *E. (Nitidiscala) cooperi* Strong— Strong, 1930, pp. 189, 194.

Epitonium subcoronatum (Carpenter), see *E. (Nitidiscala) tinctum* (Carpenter)—Strong, 1930, p. 187.

Epitonium (Opalia) wroblewskyi Mörch, see *Opalia chacei* Strong—Strong, Nautilus, vol. 51, (1) p. 5; also Grant and Gale, 1931, p. 853.

Exilia rectirostris (Carpenter), see *Exilioidea rectirostris* (Carpenter)—Grant and Gale, 1931, p. 665.

Fusinus robustus (Trask), see *F. monksae* Dall—Dall, Nautilus, vol. 29, (5), p. 55.

Gadinea reticulata (Sowerby), see *Trimusculus reticulatus* (Sowerby)—Rehder, 1940, pp. 67-70.

Galiteuthis phyllura Berry, see *G. armata* Joubin—Berry, in correspondence.

Haliotis aulea Bartsch, see *H. assimilis* Dall—Comparison of a series of *H. aulea* obtained by Mr. Andrew Sorensen with shells of *H. assimilis* from various localities lead us to the conclusion that the former species is a variant of the latter that is found toward the northern end of its range.

Halistylus subpupoideus (Tryon), see *H. pupoideus* (Carpenter)—Grant and Gale, 1931. p. 825.

Hemitoma golischae (Dall), see *Fissurella volcano* Reeve—Grant and Gale, 1931, p. 848.

Hemitoma yatesii (Dall), see *H. bella* (Gabb)—Based on a comparison of specimens in the California Academy and other collections with the type of *H. bella* in the University of California collection at Berkeley. See this paper, p. 205.

Hinnites giganteus (Gray), see *H. multirugosus* (Gale)—Gale, 1928, p. 92.

Lacuna porrecta Carpenter, see *L. carinata* Gould—Minutes, Conch. Club of So. Calif., No. 55, p. 13, Dec. 1945.

Leda Schumacher, 1817, see *Nuculana* Link, 1807—Grant and Gale, 1931, p. 118.

Leptochiton Gray, 1847—For use as a genus instead of a section of *Lepidopleurus* Risso, 1826, see Berry, 1919, p. 6.

Leptonidae, see *Erycinidae*—Grant and Gale, 1931, p. 299.

Leptothyra Dall, 1871, see *Homalopoma* Carpenter, 1864—Grant and Gale, 1931, p. 821.

Leucosyrinx amycus Dall, see *Irenosyrinx amycus* (Dall)—Bartsch, in correspondence.

Lora Gistel, 1848 (in part), see *Propebela* Iredale, 1918, for the inclusion of the Monterey species *L. casentina* Dall, *P. diomedea* Bartsch, *L. monterealis* Dall, *L. pitysa* Dall, *P. profundicola* Bartsch, *P. smithi* Bartsch, *L. surana* Dall, and other northwest American species—Bartsch, 1941, pp. 3, 7; also Bartsch, 1944b, pp. 66-68.

Macoma balthica inconspicua (Broderip and Sowerby), see *M. inconspicua* (Broderip and Sowerby)—Keen, 1937a, p. 22.

Macoma inquinata (Deshayes), see *M. irus* (Hanley)—Salisbury, Proc. Mal. Soc. London, vol. 22, (2), p. 85, pl. 12, figs. 7, 8, 1934.

Mangilia Risso, 1826 (emended spelling, of authors), see *Mangelia* Risso, 1826—Grant and Gale, 1931, p. 585.

Mangelia Risso, 1826 (Section *Kurtziella* Dall, 1918), see *Kurtzia* Bartsch, 1944, for *M. arteaga roperi* Dall as reported from Monterey (= *Kurtzia gordoni* Bartsch)—Bartsch, 1944b, p. 64.

Mangelia Risso, 1826 (in part), see *Kurtzina* Bartsch, 1944. Type: *Kurtzina beta* (Dall) = *Mangelia (Kurtziella) beta* Dall—Bartsch, 1944b, p. 64.

Mangelia angulata Carpenter, see *M. barbarensis* Oldroyd—Oldroyd, 1924, p. 82.

Mangelia nitens Carpenter, see *M. variegata* Carpenter—Grant and Gale, 1931, p. 590.

Mangelia pulchrior Dall (= *M. nitens* Carpenter), see *M. variegata* Carpenter—Grant and Gale, 1931, p. 590.

Mangelia (Mitromorpha) crassaspera Grant and Gale, see *Daphnella fuscoligata* Dall—Keen, 1937a, p. 39.

Marcia H. and A. Adams, 1857 (in part), see *Compsomyax* Stewart, 1930, for *Marcia subdiaphana* (Carpenter)—Stewart, 1930, p. 224.

Marcia H. and A. Adams, 1857 (in part), see *Humilaria,* Grant and Gale, 1931, for *Marcia kennerleyi* (Reeve)—Grant and Gale, 1931, pp. 325-326.

Melanella Bowdich, 1822, see *Balcis* Leach, 1847—Winckworth, 1934, pp. 12-13; Keen, Trans. San Diego Soc. Nat. Hist., 1943, vol. 10, (2), pp. 43, 45.

Mitromorpha intermedia Arnold, see *M. gracilior* Tryon—Grant and Gale, 1931, p. 597.

Modiolus Lamarck, see *Volsella* Scopoli, 1777—Grant and Gale, 1931, pp. 248-251.

Murex carpenteri tremperi Dall, see *M. tremperi* Dall—This paper, p. 188.

Nitidella Swainson, 1840, see *Mitrella* Risso, 1826, for *N. gouldii* Carpenter and *N. lutulenta* Dall—Minutes, Conch. Club of So. Calif., No. 51, p. 17, Aug. 1945.

Nitidoscala de Boury, 1909 (emended spelling of Dall and other authors), a subgenus of *Epitonium,* Bolten, 1798, see *Nitidiscala* de Boury, 1909—Grant and Gale, 1931, p. 857.

Ostrea gigas Thunberg, see *O. laperousii* Schrenck—Hanna, 1939, p. 307.

Paphia Bolten, 1798, see *Protothaca* Dall, 1902—Frizzell, 1936.

Pectinidae—For latest classification see Hertlein, 1935.

Pecten (Chlamys) hindsii navarchus Dall, see *P. hindsii* Carpenter—Grant and Gale, 1931, p. 163.

Pecten latiauritus Conrad (emended spelling of authors), see *P. latiauratus* Conrad—Grant and Gale, 1931, p. 203.

Pecten latiauratus delosi Arnold, see *P. latiauratus* Conrad—Grant and Gale, 1931, p. 203.

Pedicularia californica Newcomb, see *Pediculariella californica* (Newcomb)—Thiele, Handbuch der Syst. Weichtierkunde, 1929, part 1, p. 270.

Petricola denticulata Sowerby, see *P. californiensis* Pilsbry and Lowe—Pilsbry and Lowe, 1932, p. 97.

Phacoides Gray, 1847, see *Lucina* Bruguière, 1797—Grant and Gale, 1931, pp. 283-291.

Philbertia Monterosato, 1884, see *Glyphostoma* Gabb, 1873, for *P. canfieldi* (Dall) and *P. hesione* Dall—Bartsch, in correspondence.

Pitaria newcombiana (Gabb), see *Pitar newcombianus* (Gabb)—Grant and Gale, 1931, pp. 344-346.

Platidia hornii (Gabb) and *P. seminula radiata* Dall, see *Morrisia hornii* Gabb—Hertlein and Grant, 1944, p. 110.

Polinices recluziana (Deshayes), emended spelling of authors, see *P. reclusiana* (Deshayes) —Pilsbry, Nautilus, vol. 42, (4), pp. 110-13, pl. 6.

Protocardia centifilosa (Carpenter), see *Nemocardium centifilosum* (Carpenter)—Keen, 1937a, p. 23.

Protothaca staminea orbella (Carpenter), see *P. staminea* (Conrad)—Grant and Gale, 1931, p. 329.

Protothaca staminea petitii (Deshayes), see *P. staminea* (Conrad)—Grant and Gale, 1931, p. 329.

Psammobia californica Conrad, see *Gari californica* (Conrad)—Grant and Gale, 1931, pp. 381-382.

Siliqua patula nuttallii (Conrad), see *S. patula* (Dixon)—Weymouth, McMillan and Holmes, 1925, pp. 202-204.

Simnia Risso, 1826, see *Neosimnia* Fischer, 1884, for all Californian species—F. A. Schilder, 1932.

Simnia variabilis (C. B. Adams), see *Neosimnia inflexa* (Sowerby)—F. A. Schilder, 1932.

Sinum californicum Oldroyd, see *S. scopulosum* (Conrad)—Grant and Gale, 1931, p. 806.

Sphenia globula Dall, see *S. nana* (Oldroyd)—Keen, in correspondence.

Syncera translucens (Carpenter), see *Assiminea translucens* (Carpenter)—Winckworth, Jour. Conch. 1932, vol. 19, (7), p. 223.

Tritonalia Fleming, 1828, see *Ocenebra* Leach, 1818—Winckworth, 1934, p. 14.

Tritonalia michaeli Ford, see *Ocenebra subangulata* (Stearns)—Grant and Gale, 1931, p. 713.

Tritonalia stearnsi (Hemphill), see *Ocenebra gracillima* Stearns—Comparison of the types of *stearnsi* in the California Academy collection with a large series of *gracillima* from various localities indicates the identity of these two species.

Trophon Montfort, 1810, see *Trophonopsis* Bucquoy, Dautzenberg and Dollfus, 1882, for *Trophon lasius* (Dall) and *T. tripherus* (Dall)—Minutes, Conch. Club of So. Calif., No. 51, p. 56, Aug. 1945.

Trophon peregrinus Dall, see *Boreotrophon triangulatus* (Carpenter)—Based on a comparison of specimens of both species in the U. S. National Museum.

Turbonilla (Mormula) ambusta Dall and Bartsch, see *T. (M.) tridentata* Carpenter—Grant and Gale, 1931, p. 871; Willett, 1937, p. 404.

Turbonilla (Pyrgiscus) delmontensis Bartsch, see *T. (P.) delmontana* Bartsch—Bartsch, Nautilus, vol. 50, (3), pp. 100-101.

Turbonilla (Pyrgolampros) berryi Dall and Bartsch, see *T. (P.) chocolata* (Carpenter)—This paper, pp. 192, 193.

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EXPLANATION OF PLATES

PLATE 3

Fig. 1. *Dentalium berryi* Smith and Gordon. Holotype No. 8525 (C.A.S.), about 40 fathoms, Monterey Bay, California. Length, 46.7 mm.; diameter of aperture, 3.7 mm.; diameter of apex, 1.4 mm.; p. 216.

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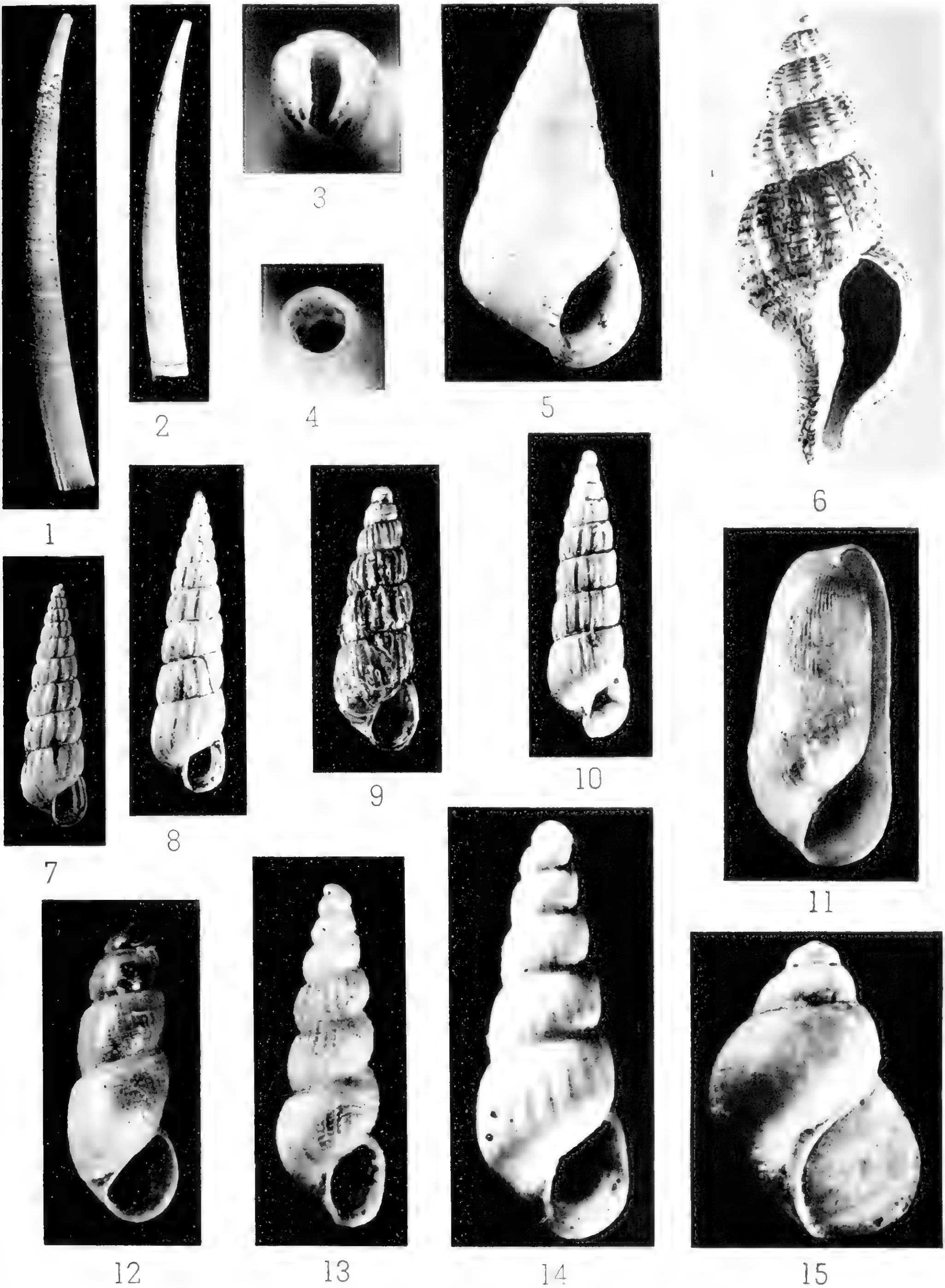
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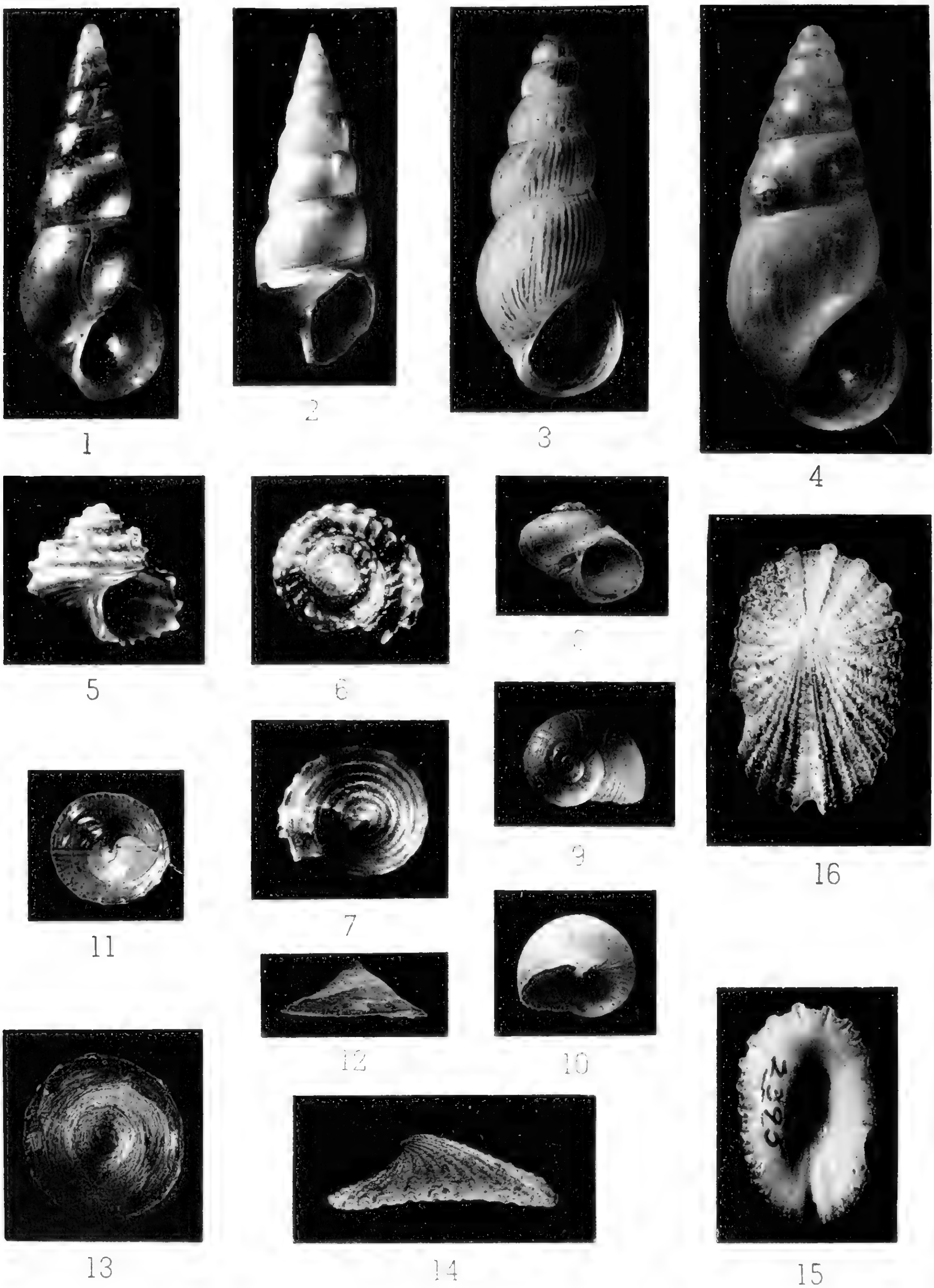
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PLATE 4

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All figures from photographs by F. L. Rogers.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 9, pp. 247-322, pls. 5-10, 4 text figures January 28, 1949

WEST AMERICAN MOLLUSKS OF THE GENUS *CONUS*

BY

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Introduction

The magnificent series of shells belonging to *Conus* and obtained by the two expeditions of the New York Zoological Society to west American tropical waters is one of the most complete ever assembled from the area. Since the bottom work was largely confined to dredging operations in depths less than 100 fathoms, large numbers of some species were obtained which were previously considered to be rare and conversely several of the intertidal species usually common in collections were found in limited numbers or not at all.

Since material from previous collecting expeditions through the area was made available for the study, there was also an abundance of shallow water forms on hand. Therefore, it seems probable that the authors have had a greater assemblage of specimens for comparison than has previously been available at one time from the region.

Excluding the older western collections, consisting more or less of random lots of specimens, the following is a list of the late expeditions which have been sent out for the express purpose of collecting research material:

1. The California Academy of Sciences expedition to the Gulf of California in 1921; Dr. Fred Baker, collector.

2. The California Academy of Sciences expedition to Guadalupe Island and the west coast of Lower California, 1922; G. D. Hanna, collector.

3. The California Academy of Sciences expedition to the Revillagigedo Islands, 1925; G. D. Hanna and E. K. Jordan, collectors.

4. The G. Allan Hancock expedition to the Galapagos Islands and Central America for the California Academy of Sciences in 1931-1932; L. G. Hertlein, collector.

5. The Templeton Crocker expedition to the Galapagos Islands and Central America for the California Academy of Sciences in 1932; Templeton Crocker, collector.

6. Two expeditions down the coast to Panama by H. N. Lowe, primarily for shore collecting, the material having been deposited in the San Diego Society of Natural History.

7. The Templeton Crocker expedition to the Gulf of California for the New York Zoological Society in 1936; William Beebe and Templeton Crocker, collectors.

The Templeton Crocker expedition to Central America for the New York Zoological Society in 1937; William Beebe and Templeton Crocker, collectors.[1]

All of the material obtained by these expeditions has been used in the preparation of the present report. In addition to the above mentioned col-

[1] For data on localities, dates, dredges, etc., see: Beebe, William, *Zoologica*, vol. xxii, pt. 1, no. 2, April 5, 1937, pp. 33-46, and vol. xxiii, pt. 3, no. 14, Sept. 28, 1938, pp. 287-298.

lections, full use has been made of the great series of Galapagos Islands shore-dwelling species obtained in 1905-1906 by the expedition sent out by the California Academy of Sciences, W. H. Ochsner, collector; 18 months were spent in the field.

Furthermore, expeditions sponsored during the past few years by Captain G. Allan Hancock for the University of Southern California have covered much of the area and very large collections of *Conus* have been obtained. This material has been available for consultation and comparison through the kindness of Dr. Irene McCulloch.

A few years ago Mr. George Willett made a trip through a part of the area as a member of an expedition conducted by Mr. J. R. Pemberton. A considerable amount of dredging was done and some very rare species of *Conus* were obtained. These were made available for this report through the courtesy of Dr. Howard Hill of the Los Angeles Museum of Science, History, and Art.

The identification of the species found in the region began in 1921 by the senior author and Dr. Fred Baker at the conclusion of the latter's collecting trip through the Gulf of California. As the work progressed and more material accumulated many difficulties were encountered. Failing health necessitated that Dr. Baker withdraw at an early stage but his keen judgment of obscure points and enthusiasm continued to be an inspiration until just prior to his death.

Without the technical assistance of numerous individuals the completion of the report in acceptable form would not have been possible and the authors take the greatest pleasure in expressing their indebtedness to Dr. L. G. Hertlein, Dr. U. S. Grant IV, Dr. Howard Hill, Dr. Myra Keen, and the late H. N. Lowe.

To Dr. Paul Bartsch all conchologists will be duly grateful for having made available for publication at this time, photographs of several previously unillustrated species, the types of which are in the U. S. National Museum.

We are indebted to Mr. R. Wright Barker, Shell Oil Company, Houston, Texas, for records of species which he collected at Santa Elena, Ecuador. In several cases these mark extensions of range, not previously known and the records have been incorporated in the text.

It was found necessary at the start of the work to compare the collections with original descriptions and figures because many species have been so variously interpreted that subsequent citations must be considered unsafe. Fortunately, west coast libraries are well supplied with literature.

The University of California at Berkeley and at Los Angeles, Stanford University, San Diego Society of Natural History, California Academy of Sciences, U. S. Grant IV, and H. N. Lowe were able to furnish everything needed except the important monograph by Küster and Weinkauff; this was borrowed from the John Crerar Library in Chicago. We wish to thank the librarians in charge of these institutions for their cooperation and especially Miss Veronica Sexton of the Academy Library, who handled most of the correspondence.

West American species appear in all of the important post-Linnaean monographs and some were noted earlier than that. Most of these works appeared in parts and more or less irregularly, so that dates of publication are extremely important. During the heyday of commercial collecting there was a scramble to get names into print and, as a consequence, it sometimes happened that only a few days intervened between the appearance of two names for the same species. Until these works were carefully collated it was impossible to tell which name had priority, and as a consequence some species have gone by later names through the years. Unfortunately, zoologists have no workable machinery for conserving an established nomenclature but prefer to adhere blindly to the rule of priority. This has necessitated several regrettable changes herein.

The dates of publication of the parts of most of these early works have been carefully deciphered by persons connected with the British Museum (Natural History). The published notes are scattered widely, however, and are not accessible to many students. Therefore, it seemed desirable to reproduce the essential information herein as a sort of annotated bibliography.

Some of the publications listed show evidence of haste and carelessness in preparation of text and illustrations; others were obviously prepared with great care. In the last category certainly belongs the work of Dillwyn, and the finest colored pictures of the group as a whole, are those of Kiener, nearly a century ago.

No attempt is here made to subdivide the genus into groups of species. This has been tried sporadically in the past, but with little success. The subdividers[2] differ radically among themselves. If such divisions should ever be made upon a logical basis, it seems that a vast amount of additional information must be accumulated, or the currently accepted system of nomenclature must be abandoned. In contrast with the urge to sectionize genera on one pretext or another, the views of five well known authorities are as follows:

Bergh[3] worked on the anatomy of thirty-three species of *Conus* and found no character of value for the recognition of the subgroups which had already

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[2] See for example:
Montfort, D., Conch. Syst., 1810, pp. 391-410.
Swainson, W., Treat. Malac., 1840, pp. 311-312.
Mörch, O. A. L., Cat. Conch. Yoldi, Fasc. 1, 1852, pp. 64-71.
Woodring, W. P., Carnegie Inst. Washington, Publ. no. 385, 1928, pp. 201-218.
Iredale, T., Mem. Queensland Mus., vol. 10, pt. 1, 1930, pp. 79-80.
Cotton, B. C., Records of the South Australian Museum, vol. 8, no. 2, June 30, 1945, pp. 229-280, 5 pls.

[3] Bergh, R. Beitrage zur Kenntniss der Coniden. Nova Acta Acad. Caesareae Leopoldino—Carolinae Germanicae naturae Curiosorum. Abh. Kais. Leopoldinisch—Carolinischen Deutsch. Akad. d. Naturfor., Bd. 65, Nr. 2, Halle, 1895, pp. 67-214, pls. 1-13.

been established, on shell characters or others which could be based upon the anatomy alone.

Dall[4] recognized the soundness of these investigations, and did not adopt any of the names of subdivisions.

Vredenberg[5], working on the Indian Tertiary stated: "A study of the numerous forms of *Conus* which occur in the Indian Tertiary, clearly reveals the want of sharpness between the various subdivisions of this genus, which all grade into one another so completely that they can only be regarded at most as sections. They never seem sufficiently sharply contrasted to rank as subgenera."

In his excellent monograph of western Atlantic species of *Conus* Clench[5a] recognized the confusion existing in regard to the various divisions of the genus and stated that the entire family would have to be studied as a whole before any stability could be reached and the complex relationships worked out.

Finally, Strong[5b] in preparing a preliminary list of west American species and without a copy of this manuscript available at the time, cited the ranges of the species and gave a key but did not adopt any subdivisions of the genus.

In an excellent article on the radulae of *Conus* Peile[6] has discussed the various groupings which this organ suggests and the groups do not necessarily follow those suggested by shell characters. He figured thirty species and discussed others in groups, yet he did not propose generic or subgeneric names for them. If this had been done it would have necessitated considerable readjustment of the genus-names proposed by Iredale, for instance.

Unfortunately, nuclear whorls are very often eroded or so covered with extraneous growth that the characters cannot be made out. Evidently good specific criteria are present, not only in these earliest whorls, but also in several of those which follow. In many species the shoulder bears a row of closely-placed beads on the early whorls. This is a character which persisted throughout life in most of the western Eocene species but in the living forms it was lost by mid-growth or earlier. This row of beads is not morphologically related to the coronal spines which decorate some of the living forms. Von Linden[7] and later Burnett Smith[8] made attempts to establish the characters of the young stages of several species of *Conus* on a more solid basis but their work has not been followed extensively.

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4 Dall, W. H. Summary of the shells of the genus *Conus* from the Pacific coast of America in the U. S. National Museum. Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 217-228.

5 Vredenberg, E., Records, Geol. Surv. India, vol. 53, pt. 2, 1921, p. 133.

5a Clench, W. J. Johnsonia, no. 6, Dec. 5, 1942, p. 36.

5b Strong, A. M. Minutes, Conch. Club, Southern California, no. 48, May, 1945, pp. 24-27.

6 Peile, A. J., Proc. Mal. Soc. London, vol. 23, pt. 6, Nov. 28, 1939, pp. 348-355, 30 text figs.

7 von Linden, Gräfin Maria. Die Entwicklung der Skulptur und der Zeichnung bei den Gehäuseschnecken des Meeres. Zeitschr. f. Wissenschaftliche Zoologie, vol. 61, Feb. 1896, pp. 261-317, pl. 11.

8 Smith, Burnett. Young stages of *Conus adversarius* Conrad. Proc. Acad. Nat. Sci. Philadelphia, vol. 81, 1929, pp. 659-663, 2 text figs. Some specific criteria in *Conus*. Same serial, vol. 82, 1930, pp. 279-288, 12 text figs.

The photographs reproduced herewith are the result of careful work done by Mr. F. L. Rogers, a member of Works Progress Administrations assigned to the California Academy of Sciences. As black and white reproductions, they leave little to be desired, but of course, full justice to cones can only be done with color.

Most species, when living, are covered with a horn-colored periostracum, which more or less conceals the color pattern on the shell itself. It is customary to remove this coating for illustration. For this purpose, the shells were immersed in a solution of chlorine in sodium hydroxide (a commercial preparation termed "Clorox"). A few minutes to two or three hours is usually sufficient, depending upon the thickness of the covering.

Apparently most species of the genus have a small, slender, non-calcareous operculum with a terminal nucleus. This offers little protection to the retracted animal. Collectors seldom preserve it. Hemphill[9] has given important notes on the habits and external anatomy of *Conus californicus* which are quoted in part under that species.

The northernmost limit of the genus in California is the Farallone Islands where *Conus californicus* has been reported. During the Miocene fossil forms had about the same northern limit as at present but so far as Pliocene records show the genus did not extend beyond Santa Maria Valley, California. During early Tertiary, however, the range was much wider and species are fairly common in the Eocene of Washington. The northernmost west American record is that of Dall who found the genus in material supposed to be Eocene and which was collected by Martin[10] at Point Hey, Alaska.

Conus californicus is all alone as far south as Cedros Island. From there on to Panama, the group forms a conspicuous part of the molluscan fauna[11]. No center of distribution can be indicated and no provinces or sub-provinces seem to exist. There is a mingling of elements from waters near and far, and this leads to speculation on problems of migration. Thus, there are representatives of species, scarcely or not at all distinguishable from collections from the south seas, Indian Ocean, Caribbean Sea, etc. In most cases, when west coast species have analogues elsewhere and have been given local names, we have retained these, although with a certain amount of misgiving in some instances. In order that this relationship may be made obvious, comparative notes have been inserted under the discussions of the species concerned.

Many writers have commented on the centers of distribution from which the west American molluscan fauna was derived. If all such remarks were

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9 Hemphill, H., Zoe, vol. 3, no. 4, 1893, p. 351.

10 See, Martin, G. C. Geology and Mineral resources of the Controller Bay Region, Alaska. U. S. Geol. Surv. Bull. 335, 1908, p. 30.

11 We do not mean to infer, however, that species are as abundant as in some other parts of the tropics. We have recognized only twenty-nine and this seems to be an insignificant number compared, for instance, to the one hundred and sixty-eight recently listed by Faustino from the Philippine Islands. (L. A. Faustino. Summary of Philippine marine and fresh-water mollusks. Monog. 25, Phil. Bur. Sci., 1928, pp. 327-344).

combined and the theory carried to its logical conclusion it would have to be assumed that the time was not very distant, geologically, when this region lacked mollusks altogether. It does not seem to have been accepted as possible that there might have been migration the other way. The genus under review lived as long ago in California as middle Eocene and the derivation of living species in some cases is as likely to have been local as otherwise.

The largest member of the genus in the area here considered is *Conus fergusoni;* a specimen of this is at hand from the ocean shore at Magdalena Bay, Lower California, 150 mm. in length. Other species found elsewhere are larger. A specimen of *Conus litteratus millepunctatus* in the California Academy of Sciences, presented by Mr. T. T. Dranga, is 180 mm. long and 112 mm. in diameter; this came from Waimanalo, Oahu (Hawaii) in 1-2 fms. A shell, probably the same species and collected by the late Eric Jordan in Hawaii, is slightly larger; and a specimen, (Loc. No. 31578 C. A. S.), recently collected by Mr. V. D. P. Spicer on Midway Island is 197 mm. long.

The smallest living west American species is *Conus nux* Broderip, but this is more than twice as large as *Conus micarius* which Hedley[12] stated to be the smallest species of the family, with the possible exception of *Conus parvus* Pease[12a]; there is little information concerning this one. The size of Hedley's species was given as: length, 6 mm.; diameter, 3.5 mm.

In the descriptive notes following, we have given the synonymy of published figures, and such other references as seemed especially important. Records from distributional lists, and other sources, unsupported by taxonomic information, have been omitted usually, because, in this group, it is often impossible to determine the species an author had in hand.

Collecting stations are listed under each species from north to south. Usually, only the shells which have passed through our hands have been so recorded. Original author's localities are cited in the synonymy.

Thus, an attempt has been made to prepare a report which would include sufficient information to permit the identification of any of the described living species of *Conus* of western America. Two fossil species from the Pliocene of Imperial County, California, have been included because of the close relationship shown to living species and to show that the groups to which they belong are not recent migrants to the west American region.

Some species of *Conus* are known to inflict painful and poisonous wounds, which may prove fatal. Although we know of no injuries thus having been received on the west coast of America it is significant to point out that Iredale[13] has recorded a death from the bite of *Conus textile*. The west

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12 Hedley, C., Rec. Austral. Mus., vol. 8, 1912, p. 147, pl. 43, fig. 32. Cape York, Australia.

12a This has been renamed *Lovellona peaseana* by H. J. Finlay, Trans. & Proc. New Zealand Inst., vol. 57, 1927, p. 519.

13 Iredale, T., Nautilus, vol. 49, no. 2, Oct. 1935, p. 41. See also, Journ. Conch., vol. 20, no. 6, Dec. 4, 1935, p. 166.

American representative of this species, *Conus dalli,* is scarcely distinguishable by shell characters and both *lucidus* and *californicus* appear to be distant relatives.

An additional fatality in Australia, recorded by Roughley[14], occurred in June, 1935. In this account it is stated that the proboscis ". . . . . is provided with a number of sharp teeth, each of which has a venom gland at the base." The species illustrated, and presumably the one which inflicted the injury is *Conus striatus* Linnaeus.

Several deaths were recorded recently by Hirotaka Yasiro[15], and for one of these he was able to secure details of the symptoms. The article is written in Japanese and a resumé, based upon a translation by Miss A. Ichiyasu, follows:

> A man, 32 years old, was gathering shells along the southeastern shore of the Bay of Chujo when he was wounded on the right thumb. No ill effects were felt at first but within half an hour intense pain was felt. He collapsed after walking a short distance and a doctor, who was called, noted the following symptoms: Pulse regular but slow. Temperature normal, 36.7° Breathing was very difficult; something similar to Lunstock's disease. Lost consciousness. Feet and hands turned purple. The thumb looked more like it had been bruised than otherwise injured. The man died three hours after having been injured. The species which inflicted the wound was *Conus geographicus,* 135 mmm. long.

That the injury resulting from an attack is not always fatal, however, is evident from an account given by Adams in the Zoology of the Voyage of the *Samarang*[16] of a painful bite received by Sir Edward Belcher. This occurred at Mayo Island, Molucca Group and the species was stated to be *Conus aulicus.*

Peile[17] has given an account of the anatomical features of the poison apparatus and later[17a] illustrated many of the singularly adapted radular teeth used for injecting the poison. Members of the genus are said to feed on annelid worms.

Most of the literature pertaining to this interesting subject up to date has been examined and quoted by Clench[17b]. In his work, which is partly a republication of an earlier paper by him, there is a great deal of valuable information, including four plates of drawings of the anatomy of *Conus striatus* Linnaeus by Yoshio Kondo. This paper should be consulted by those who are further interested in the subject.

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14 Roughley, T. C., Wonders of the Great Barrier Reef, 1937, p. 113, pl. 19, fig. 2.

15 Yasiro, Hirotaka, Venus, vol. 9, nos. 3-4, Oct. 1939, pp. 165-166.

16 Adams, A. and Reeve, L. A., Zool. Voy. H.M.S. Samarang, Moll. 1848, p. 19.

Tryon, G. W., Man. Conch., vol. 6, 1884, p. 5.

17 Peile, A. J., Journ. Conch., vol. 20, 1937, p. 301.

17a Peile, A. J. Radula notes VIII. 34. *Conus.* Proc. Mal. Soc. London, vol. 23, pt. 6, Nov. 28, 1939, pp. 348-355, 30 text figs.

17b Clench, W. J. The Poison cone shell. Occ. Pprs. on Mollusks, Mus. Comp. Zool., vol. 1, no. 7, March 15, 1946, pp.49-80, 5 plates.

There is much scattered information on the general anatomy of various species of *Conus*. In addition to the work of Bergh and Peile, to which reference has already been made, the latter cited several articles of especial importance. In addition he stated that each tooth is "—a rolled up plate, as pointed out by Troschel; the barbs and serrations, when present, are formed by indentations on the sides of the plate, verified by myself recently for teeth of *C. miles* and *C. zonatus*. To prepare for action, one tooth is detached from the bunch, enters the pharynx and is held, projecting, in the end of the proboscis, which then seizes a tooth by the barbed end. The proboscis, when everted would hold the tooth in the required position."

"A hollow, muscular bulb (called by previous authors the poison gland) is connected to the pharynx by a very long, convoluted tube (called previously the poison duct), the highly specialized epithelium of which, in Hermitte's opinion, actually secretes the poison. At the moment of attack, by contraction of the bulb, poison is driven through the proboscis into the tooth, which enters the prey and probably remains there by virtue of its barbs."

Peile further stated that the word "radula" is quite inappropriate as applied to the highly specialized offensive weapon found in other genera of Toxoglossa as well as in *Conus*. We agree, but an applicable term seems not to have been proposed thus far.

Bibliographic Notes

In this study it has been necessary to examine critically some of the more important publications relating to *Conus* and notes thus assembled have proved to be so useful that their publication seems warranted. Numerous other references which are probably equally valuable but are better known, are cited under the various species.

Broderip, W. J., and Sowerby, G. B. In the early volumes of the Proceedings of the Zoological Society of London, these authors described several species of west American cones. The dates of the various parts (1830-1859) with pages included therein, have been published by Sclater[18].

Bruguière, J. G. Encyclopédie Méthodique Hist. Nat. des Vers; Text vol. 1, pt. 1, 1792, pp. 586-597; pt. 2, 1792, pp. 598-757; pls. 315-348, Liv. 64, An. VI, [1798].

This important work was issued rather irregularly and apparently an entirely satisfactory collation is impossible. The best and most complete are those published by Sherborn and Woodward, 1893, 1899, 1904, and 1906[19].

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18 Sclater, P. L., Proc. Zool. Soc. London, 1893, pp. 435-439.

19 Sherborn, C. D., and Woodward, B. B. On the dates of the Encyclopédie Méthodique (Zoology). Proc. Zool. Soc. London, 1893, pp. 582-584; 1899, p. 595.——Cat. Library, British Museum (Nat. Hist.) vol. 2, 1906, pp. 527-528.——On the dates of publication of the natural history portions of the Encyclopédie Méthodique. Ann. Mag. Nat. Hist. ser. 7, vol. 17, 1906, pp. 577-588.

From these, especially the last, it appears that the article on *Conus* was prepared in part by C. H. Hwass[20], and was published in volume 1, part 1 of the "Histoire naturelle des Vers," which appeared in 1792. The same authors (see their footnote 10, 1906 collation) learned from a note published on p. 598 of part 2 of the same volume, that Hwass was responsible for the definition of the genus and its divisions and the Latin diagnoses of the species and varieties. "Deshayes" supplied the general observations, synonymy, and French descriptions. The plates of these forms (315-348) were prepared by Hwass from the specimens, according to Lamarck, 1822[21] and Deshayes, 1845[22]. The latter stated emphatically that Bruguière described the species, using to a large extent, the beautiful collection of Hwass and to whom he referred as a wealthy amateur.

The conflicting statements by Deshayes and the note on page 598 of part 2, volume 1 of the Encyclopédie Méthodique are very confusing. According to the one, Bruguière should be cited as the author and according to the other it should be Hwass. This matter has not been entirely cleared up in the literature.

Further difficulty arises because the plates, which were issued as a part of Liv. 64 "An. VI" [1798], were not supplied with explanations or names for the figures, and in the text there are no references to them. This discrepancy has been supplied to a large extent by later authors, two of whom were in a position to express expert opinion, Deshayes (1845) and Dautzenberg, 1937[23]. The first attributes the species to Bruguière without qualification; the last accredits them to Hwass in headings but cites them in synonymy as "Hwass in Bruguière, Encycl. Méthod." following Sherborn, Index Animalium. Tomlin[24], however, has followed Deshayes and cited Bruguière as author of all of the species.

Reeve[25], who undoubtedly had first hand knowledge stated: "In this species, of which Mr. Cuming has obtained two specimens without any information as to their locality, we may fairly recognize the *C. fulgurans* described in the Encyclopédie Méthodique, in 1792, by Bruguière, from the manuscript of M. Hwass of Copenhagen."

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20 For biographical notes on the life and work of Hwass and also Bruguière, see: Maton, W. G., and Rackett, T. An historical account of Testaceological writers. Trans. Linnaean Soc. London, vol. 7, 1804, pp. 119-224. [This valuable commentary on early writers goes back to Aristotle.]——Gosch, C. A. Christian Hee Hwass, 1731-1803. Journ. of Conchology, vol. 11, 1906, pp. 311-332.——Lamy, Edouard. Les Conchyliologistes Bruguière et Hwass. Journ. de Conchyl., vol. 74, 1930, pp. 42-59.——Iredale, Tom. The truth about the Museum Calonnianum. Festschrift, zum 60 Geburtstage von Prof. Dr. Embrik Strand, vol. 3, 1937, pp. 408-419.——Dodge, Henry. A letter concerning the Cones of Hwass and other collections in Switzerland. Nautilus, vol. 59, no. 3, Jan. 1946, pp. 97-101.

21 Lamarck, J. B., Anim. s. Vert., Tom. 7, 1822, p. 422.

22 Deshayes, C. P., Hist. Nat. Anim. sans Vert., ed. 2, vol. 11, 1845, pp. 2-4.

23 Dautzenberg, Ph., Rés. Sci. Voy. Indies Orientales Néerlandaises. Mem. Mus. Roy. d'Hist. Nat. de Belgique, vol. 2, fasc. 18, 1937.

24 Tomlin, J. R. Le B. Catalogue of recent and fossil cones. Proc. Mal. Soc. London, vol. 22, 1937, pts. 4, 5, and 6.

25 Reeve, L. A., Conch. Icon., Suppl., *Conus*, Feb. 1848, pl. 1, sp. 271.

Clench[25a] in dealing with east American forms used the combination "Hwass [in] Bruguière" and quoted an English translation by Bequaert of Bruguière's remarks upon the authorship.

In view of the difficulty in finding any common ground for agreement or any basis for positive opinion, we have followed the usage of Tomlin in the present report, chiefly because his "Catalogue" will doubtless continue to be used as a checklist for the genus for many years.

In order that the student may have as much information as possible and thereby arrive at an independent conclusion, we have critically examined a copy of the work, which, fortunately, may be found in the Library of the University of California (Biology Branch). The title page is as follows: "Encyclopédie Méthodique/Histoire Naturelle/des Vers./Tome premier/Par M. Bruguière. Paris/ MDCCXCII." Signatures are marked: "Historie Naturelle Tome VI. Vers." (A note opposite the title page indicates that "Tome VI" is an error and that that volume actually pertains to insects.) The first part, pp. 586-597, contains 146 species of cones with common names and short descriptions in French. General considerations occupy pp. 598-602 and the remainder of the chapter, pp. 602-757, contains scientific names, Latin descriptions, resumé of previous literature and synonymy, varieties, descriptions and observations in French, location of specimens, rarity and range of the 146 species. The French text seems to indicate preparation by Bruguière because reference is often made therein, to Hwass. However, the first paragraph of this section contains important information, indicating that the portion in Latin was from the manuscript of Hwass.

Crosse, H. Observations sur le genre Cone et description de trois espèces nouvelles, avec un catalogue alphabétique des Cônes actuellement connus. (Pl. II.) Revue et Magasin de Zoologie pure et appliquée, ser. 2, vol. 10, 1858, pp. 81, 113-127, 150-157, 199-209.

This is the first attempt to make a complete catalog of names which had been applied in the genus and forms a very valuable list. Some of the locality records are not good but they were obviously taken from the literature then available. The increase in number of names is shown by a tabulation as follows:

Linnaeus	35 species	
Bruguière	146 species	
Lamarck	190 species	(9 fossil)
Deshayes	242 species	(14 fossil)
Reeve	268 species	
Kiener	324 species	
Sowerby (Thesaurus)	404 species	

In this enumeration there were listed 455 names of living species, considered valid, 27 doubtful, 62 possible varieties, 76 synonyms (listed twice),

25a Clench, W. J. The genus *Conus* in the western Atlantic. Johnsonia, no. 6, Dec. 5, 1942, p. 3.

88 fossils and 13 names either synonyms or incorrectly referred to the genus. This makes a total of 645 specific names which had been used in the genus up to 1858. By 1937 this figure had so grown that Tomlin required 2719 headings to record the names of living and fossil species he had found. Crosse gave a resumé of various schemes of classification and finally decided that the genus was closer to *Pleurotoma* than to *Strombus*. Nineteen subgenus names had been used up to that time, to which, however, he did not attach much importance. The list is as follows:

Rhombus Montfort	*Coronaxis* Swainson
Stephanoconus Mörch	*Cylindrella* Swainson
Puncticulus Swainson	*Nubecula* Klein
Tuliparia Swainson	*Pionoconus* Mörch
Rollus Montfort	*Phasmoconus* Mörch
Lithoconus Mörch	*Cylinder* Montfort
Rhizoconus Mörch	*Textilia* Swainson
Dendroconus Swainson	*Hermes* Montfort
Leptoconus Swainson	*Theliconus* Swainson
Chelyconus Mörch	

It may be of interest in this connection to record that we have noted incidentally, 48 super-specific names in the family in the preparation of the present report.

In the discussion of the synonymy and relationships, west American species received very little attention.

Dillwyn, J. W. A descriptive catalogue of recent shells, arranged according to the Linnaean method; with particular attention to the synonymy. London, vol. 1, 1817, pp. 1-580; vol. 2, 1817, pp. 581-1092 + 29 pp. of index. For *Conus* see pp. 352-435. This work is extremely valuable when the tracing of names through pre-Linnaean literature is attempted.

Kiener, L. C. Spécies général et inconographie des coquilles vivantes. Famille des enrouleés. Genre *Cône*. 379 pp. 111 plates.

This volume of the Inconographie was prepared entirely by Kiener. A part of the set to which it belongs was finished by P. Fischer. It contains the most exquisite illustrations of *Conus* which have appeared. Sherborn and Woodward[26] have published a collation which shows that the text and plates dealing with cones appeared as follows:

Livraison	Pages	Plates	Date
105-112		111	1846
113-116	1-64		1846
117-123	65-176		1847
124-126	177-224		1848
127-129	225-272		1849
130-137	273-379		1849-50

26 Sherborn, C. D., and Woodward, B. B., Proc. Mal. Soc. London, vol. 4, 1901, pp. 216-219.

The date 1846 assigned to the plates seems very doubtful; they probably appeared along with the text through a period of years.

Küster, H. C., and Weinkauff, H. C., Systematisches Conchylien—Cabinet von Martini und Chemnitz. In Verbindung mit Dr. Philippi, Pfeiffer, Römer, Dunker, Kobelt, H. C. Weinkauf [*sic.*], S. Clessin, Brot und von Martens neu herausgegeben und vervollständigt von Dr. H. C. Küster. Vierten Bandes zweite Abtheilung. Nürnberg, 1875.

Die Familie der Coneae oder Conidae. I. *Conus* Linné angefangen von Dr. Küster, durchgesehen, ergänzt und vollendet von H. C. Weinkauff in Crueznach. Nürnberg, 1875.

Apparently a complete collation of this large monograph has not been published. The text on cones contains 413 pages and there are plates A and 1-71. The first 124 pages and 24 + A plates were prepared by Küster, beginning in 1837, according to Woodward[27]. Pages 125-413 and plates 25-71 are by Weinkauff and were published in 1873-1875. A collation appears as follows in Bib. Zool., vol. 4, 1894, p. 2791:

Band	Abt.	Heft.	Bogen	Pages	Plates	Date
IV	2	10	17-21 [25]	[125-196]	25-29	1873
IV	2	11	26-28	[197-220]	30-35	1873
IV	2	12	29-31	[221-244]	36-41	1873
IV	2	13	32-34	[245-268]	42-47	1874
IV	2	14	35-38	[269-300]	48-53	1874
IV	2	15	39-42	[301-332]	54-59	1875
IV	2	16	43-47	[333-374]	60-65	1875
IV	2	18 [17]	48-50*	[375-413]	66-71	1875

*Plus index and title page for Bd. 4, Abt. 2 Comprising Bogen 51-53.

A critical examination of the only copy of the work available for this study[28] shows that pages 1-124 and plates A+1-23 form a unit printed with similar type and on the same kind of paper. Pages 125-413 and plates 25-71 are likewise a unit, printed with different type and on different paper. Plate 24, while differing in minor details from either of the two groups was drawn by Küster but was probably issued by Weinkauff.

Von Martens[29] reviewed the work and stated that it was resumed in 1873 after having been commenced 33 years before. This would place the beginning of Küster's part in 1840, not 1837 as indicated in the Catalog of the Library of the British Museum. He further stated that Weinkauff issued "parts 66 & 70, pp. 105-124 (old)," presumably meaning the latter part of the material prepared and printed by Küster. This belief is substantiated

27 Woodward, B. B. Catalogue of the Library of the British Museum, p. 1252. A collation, published by C. H. Oostingh (Meded. van de Landbouwhoogeschool te Wageningen (Nederland), Deel 29, Verh. 1, 1925, p. 336), indicates that pages 1-24 and plates 1-6 appeared in 1837, and pages 25-124 with plates A, 7-24 appeared in 1838.

28 This copy was kindly lent to the Library of the California Academy of Sciences by the John Crerar Library.

29 von Martens, E., Zool. Record, 1874, p. 134, 1875, pp. 132, 160.

by the fact that he indicated pp. 125-300 as "new" and that for 1873 plates 19-53 appeared. He noted the completion of the work in the Zool. Record, 1875, (pp. 132-160), when he reviewed the part, pp. 309 [300] - 413, pls. 54-71.

The collation printed by Woodward[30] is very complete so far as entire Abteilung are concerned, but he did not give details of the dates of appearance of the separate parts of Lieferungen, Heften, Bogen, etc. Fortunately the printers numbered the signatures "Bogen," each of which consists of eight pages. To add to the confusion which exists regarding the set, the part on *Conus* was further subdivided into sections, probably for commercial purposes. The following information pertaining thereto was found in the Bib. Zool., vol. 4, 1894, p. 2791:

Sec. II	1873	15 text Bogen	17 pls.
Sec. III	1874	10 text Bogen	18 pls.
Sec. IV	1875	15 text Bogen	18 pls.

If this information be correct Küster did not issue all of the material he had printed and left manuscript which was edited (very considerably) and printed by Weinkauff.

A resumé of the above information, the best obtainable at this time and that which has been cited in the present report is as follows:

Author	Date	Pages	Plates
Küster	1837-1840	1-104	A+1-18
Küster	1873	105-124	19-23
Weinkauff	1873	125-139	24-26
Weinkauff	1873	140-244	25-41
Weinkauff	1874	245-300	42-53
Weinkauff	1875	301-413	54-71

Sherborn used the part published by Küster in the preparation of Index Animalium, 1800-1850, but there was only one new species name to cite, namely: *Conus caerulans,* p. 85, pl. 14, fig. 34. For this he gave the date as 1838 and the part of *Conus* as "(6)." For this reason we have cited the Küster part of the monograph as 1837-1840 rather than accept von Marten's statement regarding the beginning of the work.

The monograph is extremely difficult to use. Citations are often incomplete, misleading, or erroneous. The figures are poorly drawn and greatly over-colored especially in the early part of the copy examined. Nevertheless we have attempted to use it to the extent of our ability in connection with this study of west American *Conus.*

Weinkauff (pp. 174-175) in a footnote explained that the publisher had had difficulty with the draftsman who was responsible for the incorrect figures which appeared up to that time. He added further that Dr. Kobelt had consented to prepare those for the remaining Lieferungen and that in itself

30 Woodward, B. B., Cat. Lib. British Mus., vol. 3, pp. 1252-1253.

was a guarantee of their exactness. This is at the beginning of signature 23. The last plate cited in the old Küster text (pp. 1-124) is no. 24, an odd plate. The highest number cited on any of the Weinkauff text before page 174 is no. 35. Kobelt's name appears only on plates 38-41. These bear a decidedly different style of lettering and incidentally are wrongly labelled [vol.] III [Abt.] 3 instead of "IV 2" which is consistently used elsewhere. In resumé it appears that:

Küster drew plates	A, 24
Another draftsman drew plates	1-23
A third draftsman drew plates , ...	25,26
A fourth draftsman drew plates	26-35
A fifth draftsman drew plates	36,37
Kobelt drew plates	38-41
A seventh draftsman drew plates . . .	42-71

Mermod, G. Catalogue des types et des exemplaires des cônes figurès ou décrits par Hwass, Bruguière, Lamarck, de Lessert, Kiener et Chenu, se trouvant au Musée de Genève. Revue Suisse de Zoologie, tome 54, no. 5, Jan. 1947, pp. 155-217, 4 text figs.

Detailed information is given here on 196 classical species described or figured by the authors named in the title. A large number of the specimens discussed were those actually used for original descriptions and illustrations and therefore they are properly considered to be types. The formal selection of them as neoholotypes or neosyntypes would seem to be in order. Much additional information is given about the early authors, their work and their collections. Also, under each species, there is often valuable taxonomic data.

Only six of the species listed are of special concern to students of west American cones, namely, *tessulatus* Born; *vittatus* "Hwass in Bruguière" (as Mermod consistently cites such species); *monilifer* Broderip; *purpurascens* Broderip; *ebraeus* Linnaeus and *vermiculatus* Lamarck.

Reeve, Lovell Augustus. Conchologia Iconica: Or, Illustrations of the Shells of Molluscous Animals, vol. 1, 1843, 1844, and supplement, 1848, 1849.

This great monograph covering many volumes has a primary title page for the entire work as follows: "Conchologia Iconica: A complete repertory of species. Pictorial. Descriptive." And on this page there is a beautiful figure in colors of *Conus gloria-maris.* Both title pages bear the date 1843. The first 47 plates of the first volume deal with *Conus.* Each plate with its descriptive text was issued separately and the first page of each of the texts is dated with month and year, except for plates 1, 2, and 3, covering species nos. 1-14. [Plate 1 of the copy at the California Academy of Sciences has "Jan. 1843." at the bottom of the first page of text but this has obviously been stamped.] Plate 4 is dated "Jan. 1843," also so it seems safe to assume that 1, 2, and 3 appeared during that year. If this be true then 1843 is the proper year to cite for plates 1-39 inclusive, species 1-216. Plates 40-47, species 217-268, appeared in 1844. The colored figures on these plates are excellent examples of lithography; they are usually signed by Sowerby and Reeve, sometimes by Sowerby alone.

The supplement is not so well known as the general work and copies of the set have been seen in which it is missing. It came out without a title page and was intended to correct some errors which had been detected in his own as well as the work of others and to put some new species on record. The corrections and comments take up seven pages, dated June, 1849. The dates on the explanations of the nine plates are as follows:

1. February, 1848
2. April, 1848
3. April, 1848
4. June, 1849
5. June, 1849
6. June, 1849
7. June, 1849
8. June, 1849
9. June, 1849

There is an unfortunate error in the numbering of the species on the plates and in the explanations, starting with plate 4. The numbers from 237 - 283 should have been 287 - 333. This is noted by Reeve at the end of the work but he printed the last figure as "337" by mistake.

Sowerby, G. B. Jun. The conchological illustrations. This important work appeared in 200 parts between 1832 and 1841. Sherborn and Shaw[31] have published a very valuable history of the work with a collation as complete as was possible. The essential data in connection with *Conus,* follow:

Part	Date	Figures
24	March 29, 1833	1-7
25	April 12, 1833	8-14
28	May 10, 1833	15-21
29	May 17, 1833	22-29
32	May 17-July 12, 1833	30-33
33	May 17-July 12, 1833	34-41
36	July 19, 1833-January, 1834	42-49
37	July 19, 1833-January, 1834	50-58
54	April 15, 1834	59-67
55	April 15, 1834	68-75
56	April 30, 1834	76-91
57	April 30, 1834	
147	December, 1838	92-102
148	December, 1838	
151	December, 1838-April 15, 1839	103-111
152	December, 1838-April 15, 1839	
153	April 15, 1839	112-119
154	April 15, 1839	
155	May 15, 1839	120-127
156	May 15, 1839	
157	June, 1839	128-137
158	June, 1839	

31 Sherborn, C. D., and Shaw, H. O. N., Proc. Mal. Soc. London, vol. 8, 1909, pp. 331-340.

The only text for the above consists of four pages issued in 1841. The copy of the volume in the library of the California Academy of Sciences was bound, presumably, according to the instructions issued to the binder with part 200. The text is assembled in the front, that pertaining to each genus being paged separately, in most cases. The total number of pages is 120 and these have the appearance of the reprinted issue, not the original sheets which accompanied the plates. *Conus* text, however, does not seem to have been reprinted. Plates were numbered as issued, each plate apparently being equivalent to one part. Consequently, when bound consecutively, the material for each genus is scattered through the work.

Sowerby, G. B. Jun. [Completed by G. B. Sowerby III.] Thesaurus Conchyliorum or monographs of genera of shells. vol. 3, 1855-1866. *Conus* occupies the first part of this volume, pages 1-56 and plates [I] 1-24. The plates are numbered consecutively for the genus and also 187-210 for the entire work. Figures are numbered consecutively beginning with 1 and extending to 601. Each plate is accompanied by one page of explanatory text. Supplementary text entitled "Appendix to monograph of the genus *Conus* comprises pages 325-331, plates 25-28 (genus numbers), 286-289 (whole numbers). Figures 602-652 are included on these plates. A "Second supplement to monograph of the genus *Conus*" is found in volume 5. The text includes pages 249-279 and plates 29-36 (genus numbers), 507-512, 512 bis, 512* (whole numbers). Figures 653-761 are included on these plates.

This important work has been collated by Woodward[32], the essential information pertaining to *Conus* being as follows:

Volume	Part	Pages	Plates	Date
3	17	1-24	187-195	1857
3	18	25-56	196-210	1858
3	19			
3	24-25	277-331	266-290	1866
5	44	248-305	507-512*	1887

Tomlin, J. R. le B. Catalogue of recent and fossil cones. Proc. Mal. Soc. London, vol. 22, pt. 4, March 13, 1937, pp. 205-236; pt. 5, July 21, 1937, pp. 237-330; pt. 6, November 15, 1937, p. 333.

This paper is invaluable to any one contemplating a study of this group of mollusks. It is not a bare list of names alphabetically arranged, but has thorough bibliographic references, some notes on synonymy, localities from which the species were described and the disposition of the type specimens when this was known.

Tryon, George W. Jr. Manual of conchology; structural and systematic, [ser. 1], vol. 6, 1883-1884; Conidae, Pleurotomidae. The part of this monograph which deals with *Conus* takes up the first 150 pages and 31 plates of

32 Woodward, B. B., Cat. Library, British Mus. (Nat. Hist.), vol. 5, 1915, p. 1981.

the volume. The title page is dated 1884, but the work was issued in parts at irregular intervals. Vanatta[33] has published a list of all of the parts of the first series of the Manual (17 volumes) giving dates and inclusive pages. The essential data for volume 6 follow:

Part	Pages	Date
21	1-64	December 27, 1883
22	65-150	April 18, 1884
23	151-214	June 10, 1884
24	215-413	October 2, 1884

No information is available to show the allocation of plates to each part. Many of the figures are copied from former works and the complicated system of citing authorities makes it difficult to use as an original source of information. However, once this system is mastered almost every name of living species in the literature up to that time can be found, usually with a reference of some sort. The figures are colored, and in most cases the work is well done.

33 Vanatta, E. G., Nautilus, vol. 40, 1927, pp. 96-99.

CLASS **GASTROPODA**

ORDER **CTENOBRANCHIATA**

SUPERFAMILY **TOXOGLOSSA**

FAMILY **CONIDAE**

Genus **Conus** Linnaeus

Conus LINNAEUS, Syst. Nat., ed. 10, 1758, p. 712.—MONTFORT, Conchyl. Syst., vol. 2, 1810, p. 406. "Espèce servant de type au genre Le Cône flamboyant. *Conus fulgurans*" [Bruguière.] As Iredale[34] pointed out, this is not a valid type designation because *fulgurans* was not in Linnaeus' list of species. However, Montfort included *Conus generalis* Linnaeus as a synonym, and this is in the original list.—CHILDREN, Quart. Journ. Sci. Lit. Arts, vol. 16, 1823, p. 69, Reprint, 1823 p. 107 [143]. Type cited, *Conus marmoreus* Linnaeus, which was in the original list and, therefore, is valid. For good illustrations of the species see: Reeve, Conch. Icon., vol. 1, 1843, pl. 14, sp. 74; or Tryon, Man. Conch., vol. 6, 1883, p. 7, pl. 1, fig. 1.—SWAINSON, Treat Malac., 1840, p. 148. Swainson's type designation is contained in the following: "Nothing additional, in fact, can be added to separate, for instance, the subgenus of *Conus,* whose type is *C. litteratus,* from its representative, *C. marmoratus,* in the genus *Coronaxis*: so perfect are these resemblances, that we do not actually know where the two groups join and unite." On page 312 of the same work, *Conus litteratus* is listed as the second species under *Conus,* not under one of the many subgenera which he established. Iredale[34] considered Swainson's designnation of type species the earliest valid one and he was followed by Cotton.—GRAY, Proc. Zool. Soc. London, 1847, p. 135. Type, "*C. marmoreus*" Linnaeus.

Type (designated by Children): *Conus marmoreus* Linnaeus

The above brief synonymy is only that which has a bearing on the selection of the proper species to serve as the type of the genus. It is obvious that there has been considerable divergence of opinion in this regard and we feel that a final solution may not yet have been suggested. At present we favor following Children in the selection of *Conus marmoreus* as the genotype, a conclusion which was reached independently by Keen[34a], Cox[34b], Stewart[34c], and Kennard, Salisbury and Woodward[34d].

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34 Iredale, T., Mem. Queensland Mus., vol. 10, 1935, p. 79; — Cotton, B. C. Rec. S. Australian Museum, vol. 8, no. 2, June 30, 1945, p. 231.

34a Keen, A. Myra. Min. Conch. Club Southern California, no. 48, May 1945, p. 23.

34b Cox, L. R. Rept. Paleo. Zanzibar Protectorate, Sept. 1927, p. 92.

34c Stewart, R. B. Proc. Acad. Nat. Sci. Philadelphia, vol. 78, 1926, p. 415.

34d Kennard, A. S., Salisbury, A. E., and Woodward, B. B. Smithsonian Misc. Coll., vol. 82, no. 17, 1931, p. 35.

KEY TO WEST AMERICAN SPECIES OF *CONUS*

A. Shoulder ornamented with a row of nodes or blunt spines

- a. Basic color, uniform pink when epidermis is removed
  - b. Marked with longitudinal brown lines or stripes
    - c. Longitudinal markings about 1 mm. broad........ *princeps*
    - cc. Longitudinal markings reduced to hair-lines........ *p.* var. *lineolatus*
  - bb. Without markings, uniform pink........ *p.* var. *apogrammatus*
- aa. Basic color reddish brown to white
  - d. Lower end of body whorl bright purple; white, with brown, zigzag stripes and blotches, very small........ *nux*
  - dd. Basic color darker; shell larger; no purple on tip of body whorl
    - e. Basic color reddish brown or reddish purple
      - f. Reddish brown with white blotches........ *brunneus*
      - ff. Reddish purple with spiral rows of rectangular dots and dashes interspersed with white........ *tiaratus*
    - ee. Basic color chestnut brown or cream
      - g. Basic color chestnut brown
        - h. Coronal spines prominent
          - i. Body whorl without pustules........ *diadema*
          - ii. Body whorl more or less pustulose........ *d.* var. *pemphigus*
        - hh. Coronal spines obscure; body whorl marked with darker brown........ *gladiator*
      - gg. Basic color light cream with blotches and spiral rows of dark brown dots........ *bartschi*

B. Shoulder without nodes

- a. Without color markings
  - b. Shape pyriform, spire low........ *patricius*
  - bb. Shape conical
    - c. Size large, spire low, tinted with orange........ *fergusoni*
    - cc. Size smaller, spire high, slightly dome shaped, not separately colored........ *californicus* (usual phase)
- aa. Color markings present
  - d. Markings form a network of fine lines
    - e. Meshes of network usually triangular........ *dalli*
    - ee. Meshes of network usually rectangular
      - f. Spire straight; heavily reticulate........ *lucidus*
      - ff. Spire domed; reticulation faint........ *californicus* (rare phase)
  - dd. Color markings not forming network
    - g. Markings consist of rectangles of color in spiral rows; not pustulose

h. Markings nearly black and very large, sometimes vermiculate........................*ebraeus*
hh. Markings, smaller and red........................*tessulatus*
gg. Color markings irregular
i. Fine spiral rows of dots predominate
j. Body whorl pustulose or with spiral ridges
k. Shell nearly as broad as high........................*perplexus*
kk. Slender and with high spire........................*tornatus*
jj. Body whorl smooth
l. Very fine spiral lines of dots; a central dark band with white blotches ....*vittatus*
ll. No central dark band
m. With large mahogany red blotches over the fine spiral dotting; interior white........................*mahogani*
mm. Large blotches pale or absent; interior purple........................*ximenes*
ii. Color markings, predominately large, cloud-shaped blotches or longitudinal, flame-shaped masses
n. Spiral grooves over entire body whorl which is short and pinched in below........................*arcuatus*
nn. No spiral grooves except near tip of body whorl
o. Spire low; body whorl disproportionately long................*dispar*
oo. Spire normal or high
p. Purple cloud shaped masses predominate............*purpurascens*
pp. Orange, yellow, brown and red predominate
q. Color markings many, broken longitudinal flames and cloud-shaped masses
r. Spire high; scalariform........................*scalaris*
rr. Spire normal
s. Cloud-shaped masses predominate................*gradatus*
ss. Markings arranged as irregular flammules or spirals
t. Spiral arrangements of markings predominate
u. Only three or four light colored spiral bands ....*archon*
uu. Many spiral bands due to breaking up of flammules ....*regularis*
tt. Flammules predominate; often somewhat zigzag........................*incurvus*
qq. Color markings, few
v. A few longitudinal stains like brush-marks of color ....*virgatus*
vv. Markings consist of a few white blotches in a central band and one near the periphery, predominate color being orange to lemon yellow, entire shell becoming pure white with further growth ....*fergusoni* (immature)

Conus brunneus Wood

Plate 5, Figures 8, 9, 10

Conus brunneus WOOD, Index Test., 1828, Suppl., p. 8, pl. 3, fig. 1. "Habitat unknown." Ed. by Hanley, 1856, p. 207, suppl. pl. 3, fig. 1, *b*. "Panama."—SOWERBY, Conch. Ill., Apr. 15, 1834, p. 3 [119], pl. 54, fig. 63. "Galapagos Isl."; Proc. Zool. Soc. London, 1834, p. 18, "Hab. ad Insulas Gallapagos, ad Puertam Portreram et ad Panamam."—REEVE, Conch. Icon., vol. 1, pl. 14, figs. *72-a*, *72-b*, June, 1843.—KIENER, Icon. Coq. Viv., Genre *Cône*, p. 24, pl. 15, fig. 1, 1-*a*, 1846.—SOWERBY, Thes. Conch., vol. 3, p. 6, pl. 189 [*Conus* pl. 3], 1857, figs. 47-49.—TRYON, Man. Conch., vol. 6, 1883, p. 28, pl. 7, figs. 36, 37.—STEARNS, Proc. U. S. Nat. Mus., vol. 16, 1893, pp. 384-385.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 220; "Cape St. Lucas to the Galapagos and Clipperton Islands, and on the mainland south to Manta, Ecuador."

Type locality: Unknown. Typical specimens have been collected on Albemarle Island, Galapagos Islands.

Range: San Marcos Island, Gulf of California to "Manta, Ecuador" (Dall).

Collecting stations: Mexico: Many of the islands of the Gulf of California and from Magdalena Bay and Cape San Lucas of the Peninsula, south to Guerrero; Costa Rica: Port Parker; Braxilito Bay; Port Culebra; Bat Islands; Galapagos Islands, Indefatigable; Albemarle; Charles; Narborough; Seymour; Cocos Island. This is one of the most common littoral species of *Conus* along west American shores. Its abundance may be demonstrated by the presence of 28 lots in the California Academy of Sciences from points ranging from Magdalena Bay and San Marcos Island, Lower California to Veragua, Panama. It is especially abundant on the Galapagos Islands.

The dirty brown, coralline incrusted shells of this species, found so abundantly in the intertidal zone of the Galapagos Islands present a very different appearance when stripped of their covering. One of these, from Albemarle Island which is considered typical, has been figured herewith because it agrees in all but minute detail with Wood's original illustration. The white ground color on the body whorl is usually reduced to a few median blotches and may be absent. The remainder is a dark reddish brown with many fine spiral lines of a darker shade. Often these are somewhat broken and of uneven width and shade, occasionally taking the form of spiral lines of fine dots. The amount of white is often greater than shown, there being an irregular zone of blotches below the coronal spines as well as around the center. The interior of the shell is leaden gray in fresh specimens, usually white in those which have weathered. Well worn beach specimens are usually purple with a light median band and white spire. Apical characters are not preserved on any available specimen. The spire otherwise is characterized by the many prominent coronal spines and a number of spiral grooves which may vary from none to as many as nine. The number of coronal spines seems to vary only from 10 to 12 on the last whorl.

The name *diadema* Sowerby was given to a uniformly brown specimen from the Galapagos which the author later referred to *brunneus*. However it seems to be specifically distinct.

Dall gave the varietal name *pemphigus* to a small, somewhat pustulate shell from the Tres Marias Islands. With so large a series for study as we have had it seems that this should be allied with *diadema*. Unfortunately, the type of *pemphigus* appears to be an end member of a variable race, rather than an average as represented by our collection.

Conus diadema Sowerby

Plate 5, Figure 6

Conus diadema SOWERBY, Conch. Ill., p. 3 [119], pl. 57, fig. 88, April 30, 1834. [The Calif. Acad. Sci. copy of Conch. Ill. has as explanation of pl. 57, fig. 88: "*C. brunneus*, Wood. (*C. Diadema*, C. I. list).]"—Proc. Zool. Soc. London, June 17, 1834, p. 19. "Hab. ad Insulas Gallapagos."

Conus prytanis MELVILL in Sowerby, Proc. Zool. Soc. London, 1882, p. 117, pl. 5, fig. 1; "Galapagos Islands."—SOWERBY, Thes. Conch., vol. 5, 1887, p. 267, pl. 512 [*Conus* pl. 34], fig. 732.

Type locality: Galapagos Islands.

Range: Known only from Revillagigedo, Tres Marias, and Galapagos Islands.

Collecting stations: Three lots in the California Academy of Sciences came from the stations indicated in the range. It is a littoral form.

Evidently Sowerby was not at all sure of the validity of the species *diadema* and most subsequent authors have placed the name in the synonymy of *brunneus*. However, the plain chestnut brown shell with light buff central stripe (usually present) and the waxen yellow spire seems to deserve specific separation from *brunneus* and *diadema* is the earliest available name. With such very large collections as have been at hand for this study it would seem that intergradation would be indicated if it actually exists. Another good character for separation is the rich purple interior of *diadema*. The inside of the outer lip of *diadema* is very bright purple with a central area of leaden gray. Usually the yellow spire is quite sharply differentiated from the chestnut brown of the body whorl. No trace of light or dark colored blotches has been seen. Specimens from Cocos Island have several rows of small pustules toward the base, a character which reached extreme development in the variety *pemphigus* from the Tres Marias Islands. The largest *diadema* seen came from Hood or Albemarle Islands, Galapagos (No. 23007 C. A. S.) and measures 51 mm. in length. Normally, the shell is only about half that size.

This species, with *brunneus, tiaratus,* and the forms called *miliaris* (=*tiaratus*) constitute a very difficult group but it is believed that the separation shown herein will not lead to confusion. Just as in the case of some other species of *Conus* this west American one has a closely related form in the south seas, *C. lividus* Bruguière. Except for the purple tip usually present in that form the two would be much more difficult to separate.

Conus diadema pemphigus Dall

Plate 5, Figures 7, 11

Conus brunneus pemphigus Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 220. "Tres Marias Islands, west of Mexico."

Type locality: Tres Marias Islands, Mexico.

Range: Espiritu Santo Island, Gulf of California (W. Williams, coll.), to Cocos Island, Costa Rica (W. H. Ochsner, coll.).

Collecting stations: Indicated under Range.

The type specimen of this variety is apparently pustulose all over and represents an end member in this character. All of the available specimens used in this study are only partly covered with these spiral rows of pustules. Many shells of *diadema* from Clarion Island show no trace of the pustules but otherwise they are typical. The light central band is usually sharply differentiated from the chestnut color of the body whorl. This is well shown in the figure of the type specimen which was made available for publication at this time by Dr. Paul Bartsch.

Conus bartschi Hanna & Strong, sp. nov.

Plate 5, Figure 5

Whorls about ten, ornamented around the periphery with 13 regularly spaced nodes; nuclear characters obliterated; spire low, with gently concave sides and a few very faint gently undulating spiral lines; ground color light cream with a large number of spiral rows of fine, brown, somewhat angular dots; in the center and near the canal there are a few large irregular blotches of the same color arranged roughly in two indistinct spiral zones; interior pure white; there are a few small blotches of reddish brown on the periphery of the last two whorls; some of these extend over and upon the spire. Length, 49 mm.; diameter, 30 mm.

Holotype, No. 9296 (Calif. Acad. Sci. Paleo. Type Coll.), dredged off **Cape San Lucas, Lower California,** August 6, 1932, Templeton Crocker in 20-25 fms. Another smaller specimen was obtained at the same time.

The species evidently falls into the group containing *brunneus* and *tiaratus* and is distinguished from them by the peculiar coloration. In some specimens of *brunneus* there are spiral lines of plain unbroken brown but in no case has one been seen in the collections studied which even remotely approaches the fine-speckled condition found in this shell. *C. tiaratus* is a smaller species, and is proportionately broader, has a dome shaped spire and purple blotches inside the aperture. The color pattern of *bartschi* is probably closest to that of the non-coronate *ximenes* of the west American species.

The species is named for Dr. Paul Bartsch of the U. S. National Museum to whom we are indebted in many ways in connection with the preparation of this paper and in others dealing with the molluscan fauna of the same region.

Conus tiaratus Broderip

Plate 7, Figure 12; Plate 8, Figure 18

Conus tiaratus Broderip in Sowerby, Conch. Ill., p. 1 [117], pl. 25, fig. 10, April 12, 1833. "Galapagos Islands."—Proc. Zool. Soc. London, May 24, 1833, p. 52.—Kiener, Icon. Coq. Viv., Genre *Cône,* p. 50, pl. 11, fig. 2.—Sowerby, Thes. Conch., vol. 3, 1857, p. 9, pl. 190 [*Conus* pl. 4], fig. 80.

Conus miliaris Hwass, Tryon, Man. Conch., vol. 6, 1883, p. 21, pl. 5, fig. 85.—Dall, Proc. U. S. Nat Mus., vol. 38, 1910, p. 220. "Clipperton and Galapagos Islands, Ecuador and Peru."—Not *Conus miliaris* Bruguière, Enc. Method. Vers., 1792, pl. 319, fig. 6.

Conus coronatus Dillwyn, Weinkauff, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1873, p. 131. Not *C. coronatus* Gmelin.

Conus minimus Linnaeus, var B, Reeve, Conch. Icon., vol. 1, pl. 26, fig. 143 *b,* September, 1843. "Galapagos Islands."

Conus inconstans Smith, Ann. & Mag. Nat. Hist., Ser. 4, vol. 19, 1877, p. 224.—Sowerby Thes. Conch., vol. 5, 1887, p. 261, pl. 510 [*Conus* pl. 32], fig. 700. "Panama."—Tomlin, Proc. Mal. Soc. London, vol. 22, pt. 5, 1937, p. 261. "Hab.? Types: three in B. M. = *magellanicus* Kstr. not Brug."

Conus roosevelti Bartsch & Rehder, Smithsonian Misc. Coll., vol. 98, no. 10, 1939, p. 3, pl. 1, figs. 4, 7. "Clipperton Island on rocks along the shore south of the landing place." Type, U.S.N.M. no 472854.

Type locality: Galapagos Islands.

Range: Revillagigedo Islands, Tres Marias Islands, south to Galapagos Islands and "Ecuador and Peru" (Dall).

Collecting stations: Mexico: Clarion Island; Socorro Island; Tres Marias Islands; Cape San Lucas (Lowe Coll. labelled *tiaratus*): Galapagos Islands: Indefatigable; Albemarle; Charles; Tower: Costa Rica: Port Culebra; Cocos Island.

Evidently the species is seldom found on the mainland; the Port Culebra record above and a lot labelled *tiaratus* from Cape San Lucas by H. N. Lowe are the only ones which have been seen in connection with the present work.

Although *Conus miliaris* is a highly variable shell, numerous sets of specimens from south sea localities are constantly lighter in color and lack the prominent spiral rows of red and white dots so characteristic of Galapagos shells. That the two species are closely related, there can be no doubt, but the material available for this study does not permit us to unite them as several other authors have done. In view of the confusion which has existed between the names, Dall was perhaps justified in including *tiaratus* under *brunneus* as a variety.

Stearns[35] also included *tiaratus* under *brunneus* as a variety but the species seem to be constantly separable. The interior surface of the outer lip of *tiaratus* bears a large brownish-purple blotch above, and a similar, but smaller one below, the two being separated by a zone of leaden gray. The same area in *brunneus* is a uniform light bluish gray, tinged with yellow toward the canal. Also the spire of *tiaratus* is more dome-shaped and spiral markings predominate. The specimen figured herewith is representative of the large series available, and, using the characters noted, no considerable difficulty has been experienced in placing any of the lots.

Sowerby's colored figure of *C. inconstans* has about the same shape as *tiaratus* but the middle of the body whorl is marked by a sharp band of white with sparse markings. Some specimens from Cocos and the Galapagos Islands are similar, but do not agree exactly. Dall considered the species to be equivalent to *milaris* [=*tiaratus*]. Tomlin, however, questioned the locality record, Panama, and added that the three types in the British Museum are *Conus magellanicus* Küster, not Bruguière.

With over a hundred specimens for study, including a very large series from the Galapagos Islands, the type locality, it becomes possible to indicate some of the wide variation the species undergoes. The background color varies from light brown to dark chocolate brown then through various shades of flesh color to bright pink. *C. roosevelti* falls readily into the series. Shape is not at all constant. The spire in some shells is nearly flat; again it is high and dome shaped with intergrades having concave sides to the spire. The spiral striation may vary from strong to weak on the same shell and there is no constancy to the strength of the small tubercules on these cords. However, the species is usually short and broad and has a pinched in zone toward the canal somewhat after the manner of *C. arcuatus*.

Conus gladiator Broderip

Plate 7, Figure 5

Conus gladiator Broderip, Proc. Zool. Soc. London, May 24, 1833, p. 55. "Hab. ad Panama."—Sowerby, Conch. Ill., p. 2 [118] pl. 33, fig. 34, May 17-July 12, 1833.—Reeve, Conch. Icon., vol. 1, Aug. 1843, pl. 22, fig. 127. "Panama."—Sowerby, Thes. Conch., vol. 3, 1857, p. 6, pl. 189, [*Conus* pl. 3], figs. 59, 60.—Kiener, Icon. Coq. Viv., Genre *Cône*, 1846, p. 25, pl. 15, fig. 4.—Weinkauff, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pl. 2, 1873, p. 196, pl. 30, fig. 10.—Tryon, Man. Conch.,

35 Stearns, R. E. C., Proc. U. S. Nat. Mus., vol. 16, 1893, p. 385.

vol. 6, 1883, p. 28, pl. 8, fig. 38.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 221. "Gulf of California to the Galapagos Islands."—PEILE, Proc. Mal. Soc. London, vol. 23, 1939, p. 354. (Radula).

Conus tribunis CROSSE, Journ. de Conchyl., vol. 13, (ser. 3, vol. 5), no. 3, 1865, p. 312, pl. 10, fig. 2. "Hab. California (Coll. Cuming)." See Tomlin, Proc. Mal. Soc. London, vol. 22, pt. 5, 1937, p. 323.

Type locality: Panama.

Range: San Lazaro Point (Lowe Coll.), Lower California, to Santa Elena Bay, Ecuador, (Lowe Coll.).

Collecting stations: Costa Rica: Piedra Blanca Bay; Port Parker; Gulf of Fonseca and several stations off Panama.

The H. N. Lowe collection in the San Diego Society of Natural History contains specimens from the extremes of range given above. Many other intermediate points and the Galapagos Islands are also represented. The California Academy of Sciences, likewise has it from several stations within that range. Being a shallow water and littoral form, shore collectors often obtain it but dredging expeditions such as those conducted by Messrs. Beebe and Crocker for the New York Zoological Society seldom encounter it.

Many authors have indicated a similarity of this species to *Conus brunneus* of the same general area, but Dall stated that they were in "no way closely related"; he considered *gladiator* to be an analogue of the Atlantic *C. mus,* an opinion which a study of the present collections substantiates. The spire of *gladiator* is lower than in *brunneus,* has straighter sides and the coronal nodes do not show on it to an appreciable extent. In *brunneus* these nodes roughen the spire greatly. Moreover, *brunneus* is normally a much larger shell and much darker in color. This species is believed to be closer to *diadema* than to *brunneus* because of the chestnut-brown ground color and the central, light cream-colored band. The spiral ridges and threads, the dark umber-colored spire with heavy spiral threads are some of the distinguishing characters which separate it from *tiaratus.*

The type of *Conus tribunis* Crosse is in the British Museum and Tomlin stated that it is *gladiator.*

Conus nux Broderip

Plate 7, Figures 6, 7

Conus nux BRODERIP, Proc. Zool. Soc. London, May 24, 1833, p. 54. "ad Insulas Gallapagos."—SOWERBY, Conch. Ill., May 17-July 12, 1833, p. 2 [118], pl. 32, fig. 31.—REEVE, Conch. Icon., vol. 1, August, 1843, pl. 20, fig. 110. Suppl. June 1849, p. 5.—KIENER, Icon. Coq. Viv., Genre *Cône,* 1846, p. 47, pl. 11, fig. 3.—SOWERBY, Thes. Conch., vol. 3, p. 10, 1857, pl. 192 [*Conus* pl. 6], fig. 135.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 224. "Ballenas Lagoon, Lower California, south to Panama and the Galapagos Islands."—SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 10 [13 shells.] "Guaymas, Mexico."

Conus pusillus GOULD, Journ. Boston Soc. Nat. Hist., vol. 6, Oct. 1853, p. 388, pl. 14, fig. 22. "Mazatlan." [Not *Conus pusillus* Lamarck, 1810, a shell reported from west Africa.]

Conus ceylanensis BRUGUIÈRE, TRYON, Man. Conch., vol. 6, 1883, p. 23, pl. 6, fig. 95. [Not *Conus ceylanensis* Bruguière.]

Conus nanus BRODERIP, [SOWERBY], PILSBRY & VANATTA, Proc. Washington Acad. Sci., vol. 4, 1902, p. 555. "Iguana Cove, Albemarle Island."

Type locality: Galapagos Islands.

Range: Magdalena Bay and the Gulf of California south to the Galapagos Islands, Panama and Santa Elena, Ecuador.

Collecting stations: Mexico: San Francisco Island; Espiritu Santo Island; Ventana Bay; Magdalena Bay; Cape San Lucas: Nicaragua: Corinto; San Juan del Sur: Costa Rica: Port Culebra; Piedra Blanca: Panama: Bahia Honda; Isla Parida, Gulf of Chiriqui: Colombia: Gorgona Island: Galapagos Islands: Indefatigable; Albemarle; Chatham; Hood; Duncan. The species has been taken near Cape San Lucas in a depth of 25 fathoms but usually it is found in less than 10 fathoms. It is abundant on the Galapagos Islands.

The species is easily identified by the purple zone at the lower end of the aperture and the arrangement of the central white area or zone into a series of more or less zigzag markings against the chestnut brown above and below. The white spiral band just below or including the periphery is very sharply defined from the brown zone below.

Melvill and Standen[36] recorded *Conus pusillus* Chemnitz from Mazatlan and Cape San Lucas in a list of mollusks of Madras.

Tryon united the species with *Conus ceylanensis,* from the south seas, an extremely variable form or group and it is doubtful if with a large series of specimens from that region it would always be possible to make a separation. In general, however, west American *nux* are somewhat darker and broader in comparison to height.

Tomlin[37], who examined the type specimens reported that *Conus nanus* Sowerby was equivalent to *C. ceylanensis* Bruguière. It seems probable that Pilsbry & Vanatta had *C. nux* when they recorded *C. nanus* from the Galapagos.

Conus princeps Linnaeus

Plate 7, Figures 10, 11

Conus princeps LINNAEUS, Syst. Nat. ed. 10, 1758, p. 713 "Habitat . . ."—WOOD, Index Test., ed. 2, 1828, p. 69, pl. 14, fig. 25. "Asiatic Ocean."—BRODERIP, Proc. Zool. Soc. London, 1833, p. 55. "Hab. ad Sanctam Elenam."—REEVE, Conch. Icon., vol. 1, March, 1843, pl. 7, fig. 36*a*, "Bay of Panama."—SOWERBY, Thes. Conch., vol. 3, 1857, p. 5, pl. 188 [*Conus* pl. 2], fig. 31. "Panama."—WEINKAUFF, Martini &

36 Melvill, J. C., and Standen, R., Journ. Conch., vol. 9, no. 2, 1898, p. 36.
37 Tomlin, J. R. Le B., Proc. Mal. Soc. London, vol. 22, 1937, p. 279.

Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1873, p. 155, pl. 9, fig. 3.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 224. "Cape San Lucas to Panama."—STEINBECK & RICKETTS, Sea of Cortez, (Viking Press, N. Y.), 1941, p. 517, pl. 34, fig. 1. "Pt. Lobos, Espiritu Santo Id.; Port San Carlos, Sonora."—SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 1 [7 shells].

Conus regius CHEMNITZ, Conch. Cab., vol. 10, 1788, p. 138, pl. 138, fig. 1276.—KIENER, Icon. Coq. Viv., Genre *Cône,* 1846, p. 15, pl. 3, fig. 2. "Habite l'océan Pacifique, les côtes du Mexique, la baie de Panama."

Type locality: Unknown. Typical specimens have been collected at San Carlos Bay, Sonora, Mexico.

Range: Cape San Lucas and Gulf of California south to "Punta Carnero, Ecuador," (Barker).

Collecting stations: Mexico: Angeles Bay; Santa Inez Bay; Port Guatulco; Tangola-Tangola Bay; San Carlos Bay; Tepoca Bay; Mulegé; Cape San Lucas; San Jose, Monserrate, San Marcos, Ceralvo, San Diego, Maria Madre and Maria Magdalena Islands: Costa Rica: Uvita; Ballenas Bay; Gulf of Nicoya.

In the typical form of *princeps,* the axial stripes are about a millimeter broad. The two named varieties noted below, *lineolatus* with narrow hair-line stripes and *apogrammatus* without such markings, are usually not so common, at least north of Panama, but all three occupy the same general province. Biologically, the variants are probably of no great importance, but collectors seem to favor recognition of them. In fresh, live specimens, such as Messrs. Beebe and Crocker obtained in Santa Inez Bay, Lower California, the heavy periostracum is so dense that the pink ground color and all markings are obscured; the horn-colored covering then forms a series of sharp nodules, arranged in regular spiral rows.

The species was formerly very rare and because of the unique color it was eagerly sought by collectors. It was mistakenly recorded as having come from China when prices were high.

Peile[38] indicated that radular characters would place *princeps* close to *C. virgo,* perhaps intermediate between that form and *vexillum.*

Mr. Andrew Sorensen collected living specimens at Guaymas, Mexico, in January, 1942 and very kindly brought back two, preserved in alcohol. The animals were deeply retracted but one shell was opened by making a diamond saw cut through about half the circumference just below the shoulder, then by breaking the shell apart with a wedge, the soft parts were removed. After extraction of the animal, the shell was cemented together without greatly marring its value as a specimen. Both of these shells have the characteristic heavy periostracum, nearly completely obliterating the underlying color pattern; the spiral rows of raised tufts are very conspicuous.

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38 Peile, A. J., Proc. Mal. Soc. London, vol. 23, 1939, p. 350.

The animal extracted, a male, showed considerable red color on the foot (July, 1946), with wavy lines of black. The verge is a fluke-shaped organ on the right side of the head and about 5 mm. long. The head tapers outwardly to a blunt cone, evidently being capable of extension a considerable distance in life. Eyes are on or very near the ends of short tentacles and far out toward the end of the head.

The operculum is thick, tongue-shaped, chitinous, with chevron markings on the attachment side. It is about 13 mm. long. A free end projects about 3 mm. beyond the attachment and this is covered with short, blunt and heavy hair-like projections similar to the periostracum. These projections extend downward toward the point of the operculum on the thicker edge, gradually diminishing in size.

This animal had 24 "radular" teeth grouped in two equal bundles in a closed sheath which was attached to the base of the proboscis just forward

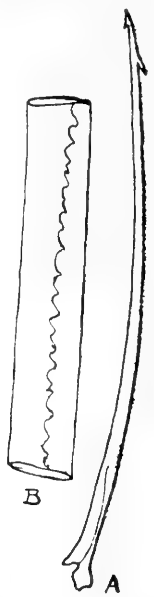

Fig. 1. *Conus princeps* LINNAEUS. A.—Complete tooth, length 2.92 mm. B.—Enlarged section of the shaft showing longitudinal serrations. Hypotype, no. 9344 (Paleo. type coll.), from Loc. 31699 (C.A.S.), San Carlos Bay, Mexico, A. Sorensen, Coll., Jan. 1942.

of the neural ring. Within this sheath there was a small quantity of reddish granular matter, the exact nature of which is unknown. There is no true "radula" as this term is usually applied in Gastropoda.

The "head" is really a sheath through which the very powerful proboscis is protruded. The latter is composed of several layers of muscular tissue, some circular, some longitudinal. The color was still a livid orange after long preservation in alcohol. The extreme tip was acorn-shaped.

Just back of the attachment of the "radular" sheath is the termination of a long and highly convoluted duct, which is generally referred to as the "poison duct." At its distal end it bears a long, highly muscular, tongue-shaped organ which is usually called the "poison gland" in this group. The neural ring surrounds the oesophagus immediately behind the attachment of the poison duct.

The individual teeth are very long and slender (length, 2.92 mm.) with a knob shaped base. All are very weakly attached and appear to be hollow. They end in very sharp points, each tooth having two barbs near the outer end. A single row of fine serrations extends from the base to the base of the outermost barb. It is indeed, a formidable looking weapon.

Conus princeps lineolatus Valenciennes

Plate 7, Figure 8

Conus lineolatus Valenciennes, Zool. Humboldt & Bonpland, Rec. Zool., vol. 2, 1832, p. 336. "Habitat ad Acapulco."—Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 224. "the prevailing form from Panama to Peru."—Fischer-Piette & Beigbeder, Bull. Mus. Nat. d'Hist. Natur. ser. 2, vol. 16, Nov. 1944, p. 461. An individual marked "type" is preserved in the Muséum at Paris.

Conus princeps Linnaeus, Sowerby, Conch. Ill., p. 2 [118], 1833, pl. 32, fig. 30 *a, b*.—Reeve, Conch. Icon., vol. 1, March, 1843, pl. 7, fig. 36 *b*.—Sowerby, Thes. Conch., vol. 3, 1857, p. 5, pl. 188 [*Conus* pl. 2], fig. 33.—Weinkauff, Martini & Chemnitz, Conch. Cab. ed. 2, vol. 4, pt. 2, 1875, p. 302, pl. 54, fig. 13.

Conus regius Chemnitz, Kiener, Icon. Coq. Viv., Genre *Cône*, 1846, p. 15, pl. 11, fig. 4.

Type locality: Acapulco, Mexico.

Range: Acapulco, Mexico, to "Peru" (Dall).

Collecting stations: Costa Rica: Cedro Island; Panama: Bahia Honda.

Few specimens of this variety have appeared in the collections studied. According to Dall it is the prevailing form south of Panama. The brown axial stripes are reduced to hair lines; otherwise it does not differ from typical *princeps*.

Conus princeps apogrammatus Dall

Plate 7, Figures 9, 13

Conus princeps var. *aprogrammatus* Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 224. "Panama."

Conus princeps Linnaeus, Sowerby, Conch. Ill., p. 2, [118], 1833, pl. 32, fig. 30.—Reeve, Conch. Icon. vol. 1, March, 1843, pl. 7, fig. 36 *c*.—Sowerby Thes. Conch., vol. 3, 1857, p. 5, pl. 188 [*Conus* pl. 2], fig. 32.

Type locality: Panama.

Range: Gulf of California to Panama.

Collecting stations: The variety is present in the collection of the California Academy of Sciences (Hemphill, coll.) from the Gulf of California, and from San Juan del Sur, Nicaragua, and Panama, in the San Diego Society of Natural History (H. N. Lowe, coll.).

Axial stripes are entirely missing from this variety; otherwise it does not differ from typical *princeps.*

Conus gradatus Mawe

Plate 6, Figure 1

Conus gradatus Mawe, Linn. Syst. Conch., 1823, p. 90. "California."—Wood, Index Test., Suppl., 1828, p. 8, pl. 3, fig. 6—Reeve, Conch. Icon. vol. 1, Sept. 1843, pl. 25, fig. 140. "Salango, South America (found on the sands); Cuming."—Kiener, Icon. Coq. Viv., Genre *Cône,* p. 140, 1847, pl. 94, fig. 6. "Habite les côtes du Mexique."—Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 221. "Gulf of California."

Conus scalaris Valenciennes, Sowerby, Thes. Conch., vol. 3, 1857, pl. 195 [*Conus* pl. 9], fig. 192.—Tryon, Man. Conch. vol. 6, 1883, p. 35, pl. 10, fig. 83 [?] Not *Conus scalaris* Valenciennes, Humboldt & Bonpland, Reise, 1832, p. 338.

Type locality: Unknown, not "California" as cited by Mawe. Typical specimens have been collected at Cedros Island, Lower California.

Range: Cedros Island to Clipperton Island.

Collecting stations: Mexico; Santa Inez Bay. (Sta. 142, D-1, 30 fms.); Mulegé; Abreojos Point and Cedros Island, Lower California; Clipperton Island.

Usually this species has a moderately high spire as in *scalaris* but when fully grown it is larger and the yellow color is much more extensive. This color is arranged roughly in a series of large blotches, flammules and stripes so that the white ground color forms several variable and indefinite spiral bands. In *scalaris* the white ground color predominates. *C. regularis* is about equal in size to *gradatus* and the two are often hard to separate. The former usually has a lower spire and the color markings are not so dominant. The indefinite white spiral bands are more prominent and numerous and the blotches of color are more nearly rectangular in shape.

The name *gradatus* is the oldest of a group of very variable forms. Whether *regularis, scalaris,* and *dispar* should be considered varieties or separate species or not recognized at all depends upon the viewpoint of the student. They have been segregated here because, in a majority of cases, collections can be satisfactorily placed.

Reeve and Kiener attributed the name *gradatus* to "Gray" and their figures show somewhat differently shaped and marked shells from the original of Mawe. Hanley, however[39], indicated that they are the same.

39 S. Hanley in Wood, Index. Test., Rev. ed. 1856, p. 208, suppl., pl. 3, fig. 6.

Two very fine specimens referred to *gradatus,* were collected by E. H. Quayle in the Pleistocene at Punta Santa Rosalia, west coast of Lower California; these have been placed in the collection of the San Diego Society of Natural History.

Conus recurvus Broderip

Plate 6, Figures 7, 8, 13

Conus recurvus BRODERIP, Proc. Zool. London, vol. 1, no. 4, May 24, 1833, p. 54. "Hab. in Americâ Meridionali, (Monte Christi)."—KIENER, Icon Coq. Viv., Genre *Cône,* p. 132, 1847, pl. 97, figs. 4, 4-a. "Habite les mers des Antilles."

Conus incurvus BRODERIP, in Sowerby, Conch. Ill., June or July, 1833, p. 2 [118], pl. 33, fig. 36. [No locality cited].—SOWERBY, Thes. Conch., vol. 3, 1857, p. 16, pl. 195, [*Conus* pl. 9], fig. 194. "Monte Christo, West Columbia." [This figure may represent *C. regularis*].—(?) DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 222.

Conus arcuatus BRODERIP & SOWERBY, Gray, Zool. Beechy's Voy., 1839, p. 119, pl. 36, fig. 22. [Not *Conus arcuatus* Broderip & Sowerby].

Conus emarginatus REEVE, Conch. Icon. vol. 1, Jan. 1844, pl. 43, fig. 232. "Pacific Ocean." [Copy of Gray's fig. of *C. arcuatus*].—SOWERBY, Thes. Conch., vol. 3, 1857, p. 15, pl. 202, [*Conus* pl. 16], fig. 387. "Pacific Ocean." [Probably not *emarginatus*].—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 222.

Conus zebra LAMARCK, REEVE, Conch. Icon., vol. 1, June, 1843, pl. 16, fig. 87. "Salango, Central America."—SOWERBY, Conch. Ill., March 29, 1833, p. 1 [117], pl. 24, fig. 4. [Not *Conus zebra* Lamarck, Anim. sans Vert., vol. 7, 1822, p. 481. "Habite . . . . . l'Ocean asiatique?"].

Conus scariphus DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 225. "Off Cocos Island, Gulf of Panama, at station 3368, in 66 fathoms, rocky bottom, one specimen with hermit crab, by the U. S. Bureau of Fisheries steamer Albatross." Type No. 123085 (U.S.N.M.)

Conus magdalenensis BARTSCH & REHDER, Smithsonian Misc. Coll., vol. 98, no. 10, 1939, p. 11, pl. 1, figs. 5, 9. "Magdalena Bay, Lower California, in 10-15 fathoms on sandy weedy bottom, at the entrance to the bay between Belcher Point and the anchorage." Type No. 472,521 (U.S.N.M.)

Type locality: "Monte Christi," Ecuador.

Range: Magdalena Bay and Gulf of California, south to Panama and the west coast of Colombia.

Collecting stations: Mexico: Santa Inez Bay, three dredgings; Arena Bank, 11 dredgings; Gorda Bank, two dredgings; Magdalena Bay (Orcutt Coll.); Cape San Lucas; Concepcion Bay; Acapulco; Manzanilla: Costa Rica: Judas Point; Port Parker; Port Culebra; Between Punta Arenas and Bat Islands: Panama: Gulf of Chiriqui; Hannibal Bank: Colombia: Isla Parida.

The species is fairly common along the coast in moderately deep water, 20 to 80 fathoms. Shore collectors seldom find it.

The shells of this group comprise a maze of variations, exceedingly difficult to understand. On the one hand they trend toward the *regularis-gradatus-*

scalaris complex and on the other toward *perplexus.* The involved nomenclature does not simplify the problem. Under the name *recurvus,* however, there have been assembled in the present study those specimens with a moderately elevated spire and the body whorl marked by long flammules of reddish brown. These axial stripes are often broken and discontinuous thus suggesting the *gradatus* group and there is no constancy in the height of the spire.

The earliest name for the species has been used. *Conus recurvus* and *Conus incurvus* appeared almost simultaneously; either one may have been a misprint but there is no published information to suggest which was the original. The part of the Proceedings of the Zoological Society of London in which *recurvus* appeared was distributed on May 24, 1833 according to the collation published in the same journal for 1893, p. 436. Part 33 of the Conchological Illustrations came out between May 17 and July 12, 1833; during that interval, six parts, 29 to 34, appeared so it is highly probable that part 33 was not distributed before late June or early July. This gives precedence to *"recurvus."* These dates are taken from Shaw, 1909[40].

Weinkauff's[41] treatment of the species is highly indefinite. He referred *incurvus* of Kiener (Icon.) and Sowerby (Thes.) to *regularis* and apparently referred *incurvus* Broderip to *cingulatus* Lamarck, an entirely distinct species. This latter is referred to plate 40, fig. 9, but the illustration there is *gabrieli* (Chenu) Kiener, duly accredited on page 243. Apparently he did not figure *cingulatus.*

In addition to the names mentioned above, *lorenzianus*[42] and *flammeus*[43] have been mentioned by Dall in discussing the *recurvus* group. These appear to be otherwise involved, for a discussion of which see under *Conus virgatus.*

Very often the markings on all of the shell, or some restricted portion, assume a roughly zigzag form. There is no constancy in this character, even in lots from the same dredge haul. Again the surface may be all or partly covered with roughly triangular spots of white or cream color. A mixture of these combinations appeared on the specimen to which the name *C. scariphus* Dall was applied. The proportion of colored area to light varies fully 75 percent and *C. magdalenensis* Bartsch & Rehder was applied to a shell in which the two are about equal. The figure of that form shows a slightly rounded shoulder and a central band, across which the color areas do not pass. Sometimes this band is present on one half of the shell absent on the other. Again there may be two, three, or many. The variation and intergradation is such that some justification could be found for giving nearly

40 Shaw, H. O. N. On the dates of issue of Sowerby's "Conchological Illustrations," from the copy preserved in the Radcliffe Library, Oxford. Proc. Mal. Soc. London, vol. 8, no. 6, Oct. 5, 1909, pp. 333-340.

41 Weinkauff, H. C., Conch. Cab., vol. 4, pt. 2, 1873, pp. 262, 263, pl. 40, figs. 9, 10.

42 *Conus lorenzianus* Chemnitz, Neues Syst. Conchylien Cab., vol. 11, 1795, p. 51, pl. 181, figs. 1754-1755.

43 *Conus flammeus* Lamarck, En. Méthod. Vers., liv. 3, 1798, pl. 336, fig. 1—Lamarck, Ann. du Mus., vol. 15, 1810, p. 279.

every specimen a separate name. This, however, would lead to confusion. In some cases our lots of 50 or more specimens from one dredge haul contain shells which will match all the hitherto named forms of this protean species and many more.

Conus regularis Sowerby

Plate 6, Figure 2

Conus regularis SOWERBY, Conch. Ill., p. 2 [118], pl. 29, fig. 29, May 17, 1833, and pl. 36, fig. 45, July 19, 1833.—REEVE, Conch. Icon., vol. 1, Sept., 1843, pl. 26, fig. 146. "Gulf of Nicoya, Panama."—SOWERBY, Thes. Conch. vol. 3, 1857, p. 16, pl. 195 [*Conus* pl. 9], figs. 208-210. [Probably also fig. 195 which is called *dispar.*]—TRYON, Man. Conch., vol. 6, 1884, p. 37, pl. 11, figs. 98, 99.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 221.—TOMLIN, Proc. Mal. Soc. London, vol. 22, pt. 5, July 21, 1937, p. 302.—PEILE, Proc. Mal. Soc. London, vol. 23, 1939, pp. 350, 354, (radula).—SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 4 [9 shells] "Guaymas, Mexico."

Conus angulatus A. ADAMS, Proc. Zool. Soc. London, 1853 [No. 14, 1854], p. 118. "Hab.?" Tomlin, (Proc. Mal. Soc. London, vol. 22, pt. 4, Mar. 13, 1937, p. 212) stated that the type in the British Museum "measures 39x22 mm. and is a rather squat ex. of *regularis* Sow."

Conus monilifer BRODERIP, Proc. Zool. Soc. London, 1833, p. 54, "in Americâ Meridionali. (Salango.)"—SOWERBY, Conch. Ill., May 17-July 12, 1833, p. 2 [118] pl. 33, fig. 37. —REEVE, Conch. Icon., vol. 1, Sept. 1833, pl. 26, fig. 144.—KIENER, Icon. Coq. Viv., Genre *Cône*, p. 141, 1847, pl. 91, fig. 1.—SOWERBY, Thes. Conch., vol. 3, p. 14, 1857, pl. 202 [*Conus* pl. 16], figs. 380-382.—WEINKAUFF, Martini & Chemnitz, Syst. Conch. Cab., ed. 2, *Conus,* vol. 4, pt. 2, 1875, p. 361, pl. 67, figs. 1, 3.—TRYON, Man. Conch. vol. 6, 1883, p. 63, pl. 20, fig. 3; [as *Conus interruptus* Broderip.]—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 222. "Magdalena Bay, Lower California, south to Peru."—TOMLIN, Proc. Mal. Soc. London, vol. 22, pt. 5, July 21, 1937, p. 278. "Types (4) in B. M.=*regularis.*"

Conus syriacus SOWERBY, Conch. Ill., pl. 36, fig. 45, 1833. No locality cited. Tomlin (Proc. Mal. Soc. London, vol. 22, 1937, p. 317), stated that this was "altered to *regularis* in large list." The figure bears the latter name in our copy of the Conchological Illustrations.

Type locality: Unknown. Typical specimens have been collected at San Carlos Bay, Sonora, Mexico.

Range: Magdalena Bay and Gulf of California south to Panama and "Peru" (Dall).

Collecting stations: Mexico: Punta Penasco (Lowe Coll.); San Luis Gonzaga Bay; Pelican Islands; Guaymas; Rocky Point (Gifford Coll.); Angel de la Guardia Island; Tepoca Bay; Gorda Banks; Santa Inez Bay; Santa Cruz Bay; Port Guatulco; Chamela Bay; Tenecatita Bay; Tangola-Tangola Bay; Manzanillo: Costa Rica: Port Culebra.

Shore collectors often find *regularis;* therefore it is common in most collections from west Mexico. Messrs. Crocker and Beebe collected it in abundance by dredging, the greatest depth recorded for it being 55 fathoms.

In the present series, *regularis* is not very distinct and intergrades with *gradatus, scalaris* and *recurvus.* It has a relatively low, non-scalariform, slightly concave spire and the color markings are usually well broken up into spiral rows of square spots, variable in size in different rows. Dall's mention of "longitudinal brown nebulous streaks" does not fit the original figure in the Conchological Illustrations, although it must be admitted that shells with such markings, otherwise referable to *regularis* are not uncommon; these trend in variation toward *recurvus.* Three immature specimens from the Gulf of California, received by the California Academy of Sciences with the Hemphill collection are almost entirely devoid of color markings.

The name *monilifer* has been a source of confusion to most writers on *Conus* and would doubtless have remained so had not Tomlin found the four types in the British Museum and determined that they were *regularis.* It is not at all certain that the references to figures given above in the synonymy correctly pertain to the real *monilifer,* because it would have been logical for anyone to interpret Sowerby's first figure as something akin to *tornatus.*

A specimen collected at Guaymas, Mexico, by Mr. A. Sorensen, has a thin, brown operculum, approximately 4 mm. long and 2 mm. wide. An attempt to find the teeth failed through unfamiliarity with the anatomy. Peile, however, in referring to Bergh's figure remarks upon the fine serrations and the double barb in place of a blade; in this respect it resembles *C. inscriptus* and, in a general way, *C. californicus.*

Conus scalaris Valenciennes

Plate 6, Figures 3, 4, 5, 6

Conus scalaris Valenciennes, Zool. Humboldt & Bonpland, Rec. Zool., vol. 2, 1832, p. 338. "Habitat ad portum Acapulco."—[?] Kiener, Icon. Coq. Viv., Genre *Cône,* p. 158, 1847, pl. 88, fig. 5.—Reeve, Conch. Icon., Suppl. June, 1849, p. 6. [Compared to *C. acutangulus.*]

Type locality: Acapulco, Mexico.

Range: Gulf of California and north along the outer coast of Lower California to Magdalena Bay.

Collecting stations: Mexico: Mejia Island; Espiritu Santo Island; Concepcion Bay; Arena Bank, eight dredgings 40-50 fathoms; Santa Inez Bay, four dredgings, 50-60 fathoms; Gorda Banks, four dredgings, 56-80 fathoms.

The species is rare in most collections because it is not often found on shore or between tides. However, the various dredging expeditions have obtained it in very large numbers, the series collected by Messrs. Beebe and Crocker in Santa Inez Bay being especially good.

Shape is fairly uniform, slender, with a high scalariform, slightly concave spire. Color markings trend to yellows and are usually cloud shaped masses rather than square spots or stripes. It varies imperceptibly into the *gradatus-regularis* complex, however, and some specimens can be placed by arbitrary means only.

Sowerby[44] evidently considered this to be an aberrant form of *Conus gradatus* although he gave a figure and a species heading to it. The figure undoubtedly represents *gradatus* and this was copied by Tryon[45] who further stated (page 122) that Kiener's *scalaris* was equivalent to *arcuatus* Broderip. This seems doubtful although it is not at all certain that Kiener's figure represents the species here considered. It develops that there is no illustration which can be cited to represent what turns out to be a fairly common, high-spired, Gulf of California shell. Valenciennes' description, locality, and the name itself fit this form very well so it seems probable that he had a representative of it.

Conus dispar Sowerby

Plate 6, Figure 11

Conus dispar SOWERBY, Conch. Ill., July 19, 1833, p. 3 [119], pl. 37, fig. 57. [No locality cited].—KIENER, Icon. Coq. Viv., Genre *Cône,* p. 211, 1848, pl. 101, fig. 3. "Habite la mer des Indes."—REEVE, Conch. Icon., Suppl., pl. 4, June 18, 1848, sp. "238" [288]. [No locality cited].—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 222. "Gulf of California."

Type locality: Unknown. Typical specimens have been collected at Cape San Lucas, Lower California.

Range: Gulf of California.

Collecting stations: Mexico: Santa Inez Bay, Lower California (Sta. 142, N. Y. Z. S. D-3, 40 fms.). The species was also dredged by Mr. Crocker in 1932 at a point about 10 miles due east of San Jose del Cabo, Lower California.

Although Sowerby gave no locality for *dispar* and Kiener assigned it to the Indian Ocean, Dall recognized that it was a west American species. It appears to be rare. Tryon[46] was evidently much confused about the species because he placed it in synonymy of *C. regularis* and the figure he assigned to the name is very different from the two cited above. He may have been misled by Sowerby[47] whose later figure of *dispar* certainly represents a member of the *gradatus-regularis* group. The species is very small and slender, smooth and polished except for the usual spiral ridges near the canal and nearly microscopic growth lines. Ground color is white; scattered small yellow blotches and a few spiral rows of fine sparse dots complete the ornament. The blotches extend over the angled shoulder and

44 Sowerby, G. B., Thes. Conch., vol. 3, 1857, p. 14, pl. 195, fig. 192.
45 Tryon, G. W., Man. Conch., vol. 6, 1883, p. 35, pl. 10, fig. 83.
46 Tryon, G. W., Man. Conch., vol. 6, 1883, p. 37, pl. 11, fig. 2.
47 Sowerby, G. B., Thes. Conch., vol. 3, 1857, p. 16, pl. 195, fig. 195.

upon the polished spire. Nuclear whorls two, smooth, white and polished; the first two post-nuclear whorls with quite indistinct beading around the angle; suture channeled. The coloration suggests *scalaris* of the west American fauna more than any other species, but the elongated shape, low nearly straight spire, and slightly channeled suture distinguish it.

Conus archon Broderip

Plate 6, Figure 1

Conus archon Broderip, Proc. Zool. Soc. London, May 24, 1833, p. 54. "Hab. In America Centrali. Bay of Montijo."—Sowerby, Conch. Ill., May 17-July 12, 1833, p. 2 [118], pl. 33, fig. 38.—Reeve, Conch. Icon., vol. 1, March, 1843, pl. 6, fig. 35.—Kiener, Icon. Coq. Viv., Genre *Cône*, p. 146, 1847, [pl. 75, fig. 3?], pl. 104, fig. 4—Sowerby, Thes. Conch., vol. 3, p. 16, 1857, pl. 198, [*Conus* pl. 12], fig. 252.—Tryon, Man. Conch., vol. 6, 1883, p. 27, pl. 7, fig. 26; (not figs. 27-29).—Weinkauff, Martini & Chemnitz, Syst. Conch. Cab., ed. 2, vol. 4, pt. 2, 1875, p. 362, pl. 67, figs. 2, *a*, *b*.—Dall, Proc. U. S. Nat. Mus., vol. 38, June 6, 1910, p. 223.

Conus sanguineus Kiener, Icon. Coq. Viv., Genre *Cône*, p. 356, 1849-50, pl. 111, fig. 2. "Habite."

Type locality: Bahia Montijo, Panama.

Range: Gulf of California to Panama.

Collecting stations: Mexico: 10 miles east of San Jose del Cabo, Lower California, 20-220 fathoms.; Acapulco; Manzanillo. Arena Bank, Lower California, 45 fms.; (Sta. 136, N. Y. Z. S., D-2, 16); Costa Rica: Port Culebra, 14 fms.

Dall stated that the shells figured by Kiener and Reeve are not identical with the one Sowerby published and which, presumably, was authentic. Kiener's pl. 75, fig. 3 may represent a different species; if so, it is unknown to us; specimens in the collections studied resemble his pl. 104, fig. 4. Dall made no suggestion as to where those he thought were not *archon* should be placed.

The species bears a strong resemblance in shape and color to *Conus recurvus* Broderip, but in the latter, when fully adult, there are irregular, white bands among the brown blotches and the suture line on the spire is raised into a sharp carina.

It seems highly probable that *C. sanguineus* Kiener is a synonym of *archon*, as Weinkauff indicated. Kiener himself pointed out the similarity of the two. However, the same author's *C. castaneus*, also from an unknown locality, appears to differ too much in the form of the spire to be included here where Weinkauff put it.

Recent collectors have failed to find many specimens of this robust species; either it is rare or has become localized in distribution.

The spire is usually low, sharply pointed and deeply concave; suture line scarcely impressed. The shoulder of one adult specimen is rather sharp; in another it is much more rounded. Evidence of evenly spaced nodules on the periphery are plainly visible along the suture line on the otherwise nearly smooth spire, up until about half adult size is reached. Twelve whorls are visible on the figured specimen but the nucleus is eroded. The sides are straight with a few very indefinite spiral lines near the canal; growth lines heavy. Periostracum dark brown and thin. Color markings consist of very dark, reddish brown, irregularly shaped dots and blotches on an almost white background, the proportion of dark to light being quite variable. The color is very roughly arranged in bands on one adult specimen but on another these coalesce into two. The interior of the aperture is white. The brown blotches extend over the periphery forming a series of flame-like markings on the spire.

Occasional specimens of *perplexus* Sowerby show a strong resemblance in coloration to this species but in every case noted these bear raised spiral ridges or threads.

Reeve[48] stated that *Conus granarius* Kiener[49] was a "fine *C. archon*" and that the latter approached *C. cedo-nulli* by "easy transition." In spite of the fact that he had examined Kiener's type specimen, it does not seem possible, with our material, to reduce *granarius* to the synonymy of *archon*. It is much more likely that it is a synonym or variety of *cedo-nulli* of the West Indian region, a highly variable form to which *archon* bears some similarity.

Conus ximenes Gray

Plate 8, Figure 17

Conus ximenes Gray, Zool. Beechey's Voy., Moll., 1839, p. 119. "Panama."—Sowerby, Thes. Conch., vol. 3, p. 22, 1857, pl. 199 [*Conus* pl. 13], fig. 285. "Mazatlan, West Columbia." [Printed *"C. ximines"* in exp. of pl.]—Weinkauff, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, 1873, p. 231; [as a synonym of *C. interruptus* Broderip & Sowerby.]—Tryon, Man. Conch., vol. 6, 1883, p. 63, pl. 19, fig. 100; [as a synonym of *C. interruptus* Broderip & Sowerby.]—Dall, Proc. U. S. Nat. Mus., vol. 37, 1909, p. 165.—Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 220. "Gulf of California to Sechura Bay, Peru."

Conus interruptus Broderip & Sowerby, Zool. Journ., vol. 4, 1829, p. 379. "Dredged in the Pacific near Mazatlan."—Gray, Zool. Beechey's Voy., Moll., 1839, p. 119, pl. 33, fig. 2. "Inhab."—Reeve, Conch. Icon., vol. 1, August, 1843, pl. 22, fig. 125. "Pacific Ocean near Mazatlan."—Kiener, Icon. Coq. Viv., Genre *Cône*, p. 152, 1847, pl. 54, fig. 2.—Not *Conus interruptus* Wood, Index Test., Suppl., 1828, p. 8, pl. 3, fig. 2.—Sowerby, Thes. Conch., vol. 3, 1857, p. 7, pl. 189 [*Conus* pl. 3], figs. 43, 44.

Conus tornatus Broderip, Kiener, Icon. Coq. Viv., Genre *Cône*, 1847 p. 153, pl. 59, fig. 5; [not of Broderip].

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48 Reeve, L. A., Conch. Icon., Suppl., p. 4, June 1849.

49 Kiener, L. C., Icon. Coq. Viv., Genre *Cône*, p. 215, pl. 98, fig. 1. [No locality cited.]

[?] *Conus pusillus* Lamarck, Kiener, Icon. Coq. Viv., Genre *Cône,* 1846, pl. 43; according to Reeve, Conch. Icon., Suppl., p. 5, June 1849.

[?] *Conus mahogani* Reeve, Sorensen, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 6 [11 shells.] "Guaymas, Mexico."

Type locality: "Panama" (Gray).

Range: "Gulf of California to Sechura Bay, Peru" (Dall).

Collecting stations: Mexico: Angeles Bay; Punta Penasco; Libertad; Tepoca Bay; San Luis Gonzaga Bay; Cape San Lucas; Santa Inez Bay; Concepcion Bay; Acapulco Bay: Panama: (Hemphill Coll.).

The collections show that it is found from the littoral zone down to 50 fathoms.

It does not seem possible to arrive at an entirely satisfactory conclusion regarding the name *ximenes.* Gray did not indicate in his text that he had illustrated it, but his fig. 2, pl. 33, certainly fits the description as well or better than it does *C. interruptus* Broderip & Sowerby, to which it was referred. Moreover, Sowerby in the explanation of his plate 199 cited references to the literature under each name and for *ximenes* he has *"Gray, Beech. Voy. pl. 33, fig. 2.—C. interruptus* (preoccupied), *Brod. Z. Journ. IV, p. 379."* It seems as if Sowerby should have been in the best position of anyone to determine the characters of Gray's shells because he edited a portion of the manuscript for publication in Beechy's Report. (See Introduction, p. viii and note by Sowerby p. 143.) The purple interior of *ximenes* mentioned by Gray and so well shown in the figure is certainly characteristic of *interruptus* Broderip & Sowerby, not Wood.

Sowerby was the first, apparently, to point out that two species had been named *interruptus;* also that the name *pulchellus* Sowerby[50] was a synonym of *interruptus* Wood, and that this in turn is equivalent to *varius* Linnaeus. This synonymy was adopted by Tryon[51]. Whatever the status may be, that species does not appear to be an inhabitant of west American waters. On the other hand the form Broderip & Sowerby called *interruptus* is a common Gulf of California shell distinguishable from *mahogani* Reeve by its larger size, lighter color, more distinct rows of brown, spiral dots and the interior is pinkish to purplish.

Dall[52] suggested that *C. catenatus* Sowerby, 1878, appeared to be *interruptus* but the figure cannot be distinguished from many *tornatus* seen in the present study.

The shells illustrated by Sorensen from Guaymas, Mexico, are probably all *ximenes;* since the color of the interior is the chief distinguishing feature from *mahogani* it is not possible to determine from the figures alone. The shells came from the area supposedly occupied by *ximenes.*

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50 Sowerby, G. B., Conch. Ill., p. 3 [119], pl. 54, fig. 61, 1834.

51 Tryon, G. W., Man. Conch., vol. 6, 1884, pp. 110, 120.

52 Dall, W. H., Proc. U. S. Nat., Mus. vol. 38, 1910, p. 228.

Mr. Sorensen very kindly supplied us with two of his shells, preserved in alcohol. They were collected at Guaymas in January, 1942. The animal of one of these, a male, was extracted. Except for a few scattered streaks of black on the foot and the tip of the siphon, it was colorless (July, 1946). There was no operculum.

The verge is a large, fluke-shaped organ, apparently highly extensible. The head is narrow and long. The proboscis, although greatly contracted, can probably be extended an inch or more in life. It is highly muscular and terminates outwardly in a rounded tip. The organ, as contracted, is somewhat grub-shaped with the thin body wall attached to the posterior end. The "radular" sheath and "poison duct" are attached to the posterior end

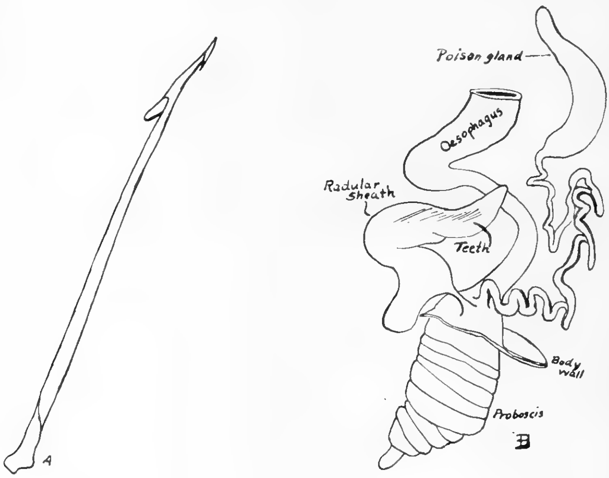

Fig. 2. *Conus ximenes* Gray. A.—Complete tooth. B.—Dorsal view of proboscis and associated organs. Hypotype, no. 9338 (Paleo. type coll.), from Loc. 31699 (C.A.S.), San Carlos Bay, Mexico, A. Sorensen, Coll., Jan. 1942.

just back of the body wall and in front of the neural ring. The teeth are clustered in the tip of the sheath and about half of them pointed one way, the other half the opposite. A small brown mass of granular tissue was associated with them. A side pouch is located near the aperture of the sheath. Attachment to the proboscis is by means of a relatively short duct. The "poison duct" is very long and highly convoluted. Its walls appear to be glandular and, as has been suggested by Hermitte in Peile, the duct itself may be the source of the poison. The so called "poison gland" is a massive, very highly muscular organ and contains no recognizable glandular tissue on gross dissection.

The length of an individual tooth is 1.16 mm. It has no serrations on the shaft but at the tip there is a small barb; just back of this a short distance is a large spade-shaped "blade."

Conus mahogani Reeve

Plate 8, Figure 16

Conus mahogani REEVE, Proc. Zool. Soc. London, 1843, p. 169. "Salango, West Columbia (found in sandy mud); Cuming"—REEVE, Conch. Icon., vol. 1, August, 1843, pl. 22, fig. 126. Suppl. June, 1849, p. 5.—REEVE Ann. Mag. Nat. Hist., N.S., vol. 14, Sept. 1844, p. 206.—KIENER, Icon. Coq. Viv., Genre *Cône,* p. 170, 1847, pl. 74, fig. 3.—SOWERBY, Thes. Conch., vol. 3, p. 22, 1857, pl. 199 [*Conus* pl. 13], figs. 283, 284.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219. "Magdalena Bay, Lower California, to Panama."

Type locality: Salango, Ecuador.

Range: "Magdalena Bay" (Dall), to west Colombia.

Collecting stations: Mexico: Carmen Island; Santa Inez Bay; Acapulco Bay; Port Angeles Light: Nicaragua: Corinto: Costa Rica: Punta Arenas; Port Culebra; Golfito: Panama: Venado Island and Flats; Taboga Island: Galapagos Islands: Albemarle Island.

The range of this species is chiefly from the southern end of the Gulf of California southward to Panama and the Galapagos Islands. No specimens have been seen during the preparation of this report to substantiate either the Magdalena Bay record of Dall or the west Colombia record of Reeve. Only one lot among a large number in the California Academy of Sciences came from the Gulf of California and that from no farther north than Carmen Island (Loc. 23798 C. A. S.).

Dall considered this to be an extreme mutation of the *Conus interruptus* of Broderip and Sowerby and Reeve and used it as the oldest available name for the species, *interruptus* having been previously used by Mawe [Wood] for an entirely different shell. It is a small, slender form with the dark mahogany color frequently covering the entire surface. The interior is usually pure white. The form recorded herein as *ximenes* Gray is the one usually found in the Gulf of California; it is larger, lighter in color and has a purple interior.

C. mahogani and *C. ximenes* are very similar and it probably would be appropriate to call the first a variety of the second as Reeve suggested in his Supplement on *Conus.* We have retained them as distinct species because in most cases they are readily separable.

Conus perplexus Sowerby

Plate 8, Figures 1, 2, 3; Plate 8, Figure 4

Conus perplexus SOWERBY, Thes. Conch., vol. 3, p. 20, 1857, pl. 200 [*Conus* pl. 14], fig. 324. "Gulf of California, West Columbia."—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1873, pp. 150, 230, pl. 38, fig. 2b; [as a var. of *C. puncticulatus.*]

"*Conus puncticulatus* HWASS, and Var. B," REEVE, Conch. Icon., vol. 1, August, 1843, pl. 20, fig. 116. "Salango and St. Elena, West Columbia." [Not *C. puncticulatus* of BRUGUIÈRE, WOOD, KIENER and pre-Linnaean equivalents.]—TRYON, Man. Conch., vol. 6, 1883, p. 62, pl. 19, fig. 91. "Cerros Island."

"*Conus comptus* GOULD," DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219.—Not *C. comptus* GOULD, Journ. Boston Soc. Nat. Hist., vol. 6, Oct. 1853, p. 387, pl. 14, fig. 23.—SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 5 [11 shells.] "Guaymas, Mexico."

Type locality: Gulf of California.

Range: Magdalena Bay and Gulf of California, south to Gorgona Island, Colombia.

Collecting stations: Mexico: Kino Bay; Cape San Lucas; Mazatlan; Acapulco; Chamela Bay; Tenacatita Bay; between Isabel Island and Mazatlan: Guatemala: Seven miles west of Champerico: El Salvador: La Libertad: Costa Rica: Port Parker; Port Culebra: Panama: Taboga Island: Colombia: Gorgona Island.

The greatest depth recorded for any of these localities is 20 fathoms. It is obviously a shallow water form. Tryon's record from "Cerros [=Cedros?] Island" has not been confirmed.

The name *perplexus* seems to have been well chosen for this highly variable form. Normally the surface bears many spiral rows of pustules but even in the same lot there may be every gradation from densely pustulose individuals to those completely lacking such ornament; some specimens are half pustulose, half smooth.

Conus puncticulatus of the older writers is certainly not a west American species and therefore the name cannot be made available in the present case. The true *puncticulatus* probably inhabits West Indian waters. Dall proposed to substitute *C. comptus* Gould for the Pacific species but the original figure of that form is so close to abundant *C. purpurascens* material in the collections studied that this course seems unsound.

The species is short and stout with usually a low straight sided spire. The latter has about 10 whorls, the first two (nuclear) being almost glassy transparent and none of them with beading; the sutures are slightly channelled, spiral striation weak; irregular blotches of reddish brown are scattered over the spire. The ground color is pale cream, the markings being reddish brown; these take the form of spiral rows of square dots over most of the shell but near the shoulder and the center of the body whorl there are irregular shaped patches and flammules of the same color. The inside of the aperture is usually colored purple but specimens are at hand which are pure white.

A very large specimen was collected at San Jose Island, Panama Bay, by W. D. Clark. It is 41.5 mm. in altitude and 22 mm. in diameter. Coloration is nearly identical with specimens in the N. Y. Zoological Society collection from Port Parker, Costa Rica. Brown spots and flammules predominate as in *C. archon* but there are spiral rows of fine brown dots on a nearly white background; spiral threads are well developed but are not nodulous. This specimen was presented to Stanford University and through the courtesy of Dr. A. Myra Keen, it is illustrated herewith.

Conus tornatus Broderip

Plate 8, Figures 4, 5, 6, 7

Conus tornatus Broderip, in Sowerby, Conch. Ill., p. 2 [117], pl. 29, fig. 25, May 17, 1833. "Panama."—Broderip, Proc. Zool. Soc. London, May 24, 1833, p. 53. "in Americâ Meridionali. (Xipixapi)."—Reeve, Conch. Icon., vol. 1, pl. 13, fig. 68, May, 1843.—Sowerby, Thes. Conch., vol. 3, p. 16, 1857, pl. 202 [*Conus* pl. 16], fig. 375, pl. 104 [204] [*Conus* pl. 18], fig. 425, 1858; the last from "West Columbia."—Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219, "Cedros Island, Lower California, to Gulf of California and south to Ecuador."—Not *"Conus tornatus* Broderip," Kiener, Icon. Coq. Viv., Genre *Cône,* p. 153, pl. 59, fig. 5; [=*Conus ximenes* Gray.]

Conus interruptus Broderip & Sowerby, Tryon, Man. Conch., vol. 6, 1883, p. 63, pl. 20, fig. 4; copied from Reeve.

Conus catenatus Sowerby, Proc. Zool. Soc. London, 1878, p. 796, pl. 48, fig. 3. "Hab Panama? (ex coll. Sir E. Belcher)."—Dall. Proc. U. S. Nat. Mus., vol. 38, 1910, p. 228. "Appears to be a variety of *C. interruptus* Broderip."—Tomlin, Proc. Mal. Soc. London, vol. 22, pt. 4, 1937, p. 226. "Type in Coll. Tomlin."—Not *Conus catenatus* Sowerby I, Quart. Journ. Geol. Soc., vol. 6, 1850, p. 45, pl. 9, fig. 2. Tertiary, San Domingo.

Conus concatenatus Sowerby III, Thes. Conch., vol. 5, 1887, p. 249, pl. 507, *(Conus* pl. 29), fig. 654 [As *catenatus* in exp. of pl.].—Not *Conus concatenatus* Kiener, Icon. Coq. Viv., Genre *Cône,* 1849-1850, p. 362, pl. 110, fig. 1.

Conus desmotus Tomlin, Proc. Mal. Soc. London, vol. 22, pt. 4, March 13, 1937, pp. 206, 226.

Type locality: Xipixapi, Ecuador.

Range: "Cedros Island, Lower California, to the Gulf of California, and south to Ecuador" (Dall).

Collecting stations: Mexico: Santa Maria Bay; Santa Inez Bay; Santa Cruz Bay; Acapulco; Port Guatulco; La Paz: Nicaragua: Corinto: Costa Rica: Port Parker: Panama: Bahia Honda; Chagame Island.

The species has been dredged in shallow waters, under 20 fathoms, in large numbers by numerous expeditions; only occasionally is it found on shore or in the intertidal zone.

The spiral rows of regularly spaced, square, rectangular dots of dark reddish brown make it difficult to separate from some young forms of *regularis,* particularly those which formerly would have been called *monilifer.* Part of the difficulty is due to the inability to determine from some of the older illustrations whether the spiral markings are merely color dots or pustules. In the case of the original *tornatus* they are evidently definitely dots because it was Sowerby[53] himself who later pointed out that there are two forms, one smooth and the other "granulose." As a matter of fact there is every conceivable variation between heavily pustulose shells through those partly of that form to those which have no trace of such structure. Some shells are pustulose on one side, smooth on the other. In this respect the species parallels *Conus perplexus,* which it also resembles in color markings but the shape of *tornatus* is decidedly much more slender.

Dall, following a suggestion by Tryon, pointed out that *C. catenatus* Sowerby III was probably *interruptus (=ximenes)* and Sowerby himself indicated the close affinity of the species of this group although the locality was uncertain. The figure is indistinguishable from many specimens of *tornatus.* Tomlin, however, who possesses the type, considered Sowerby's shell distinct and renamed it *"desmotus"* a course which might not have been necessary had large series of specimens been available for comparison. If the species is not *tornatus* it is probably not west American.

Conus arcuatus Broderip & Sowerby

Plate 5, Figures 2, 3, 4

Conus arcuatus BRODERIP & SOWERBY, Zool. Journ., vol. 4, no. 15, Oct. 1828-Jan. 1829, p. 379. "Pacific Ocean, near Mazatlan."—SOWERBY, Conch. Ill., April 12, 1833, p. 1, [117], pl. 25, fig. 9. "Bay of Montija."—REEVE, Conch. Icon., vol. 1, June 1843, pl. 15, fig. 77 *b.* "Mazatlan."—KIENER, Icon. Coq. Viv. Genre *Cône,* p. 157, 1847, pl. 72, fig. 5.—SOWERBY, Thes. Conch. vol. 3, p. 12, 1857, pl. 202, fig. 384.—TRYON, Man. Conch., vol. 6, 1884, p. 75, pl. 24, fig. 98.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 223.

Not *"Conus arcuatus* BROD. & SOW.", GRAY, Zool. Beechey's Voy., Moll., 1839, p. 119, pl. 36, fig. 22; renamed, *Conus emarginatus* REEVE, Conch. Icon., pl. 43, fig. 232, 1844. "Pacific Ocean." [=*Conus recurvus* BRODERIP.]

Conus borneensis ADAMS & REEVE, Zool. Voy. H.M.S. *Samarang,* Moll., 1848, p. 18, pl. 5, figs. 8 *a-d.* "Hab. Northeast coast of Borneo (in ten fathoms, sandy and stony bottom)."

Type locality: Mazatlan, Mexico.

Range: Gulf of California to Panama.

Collecting stations: Mexico: Santa Inez Bay; Arena Bank; Port Guatulco; Acapulco Bay, Oaxaca and between Isabel Island and Mazatlan, Mexico; Costa Rica: Port Barker; Port Culebra; Gulf of Nicoya; Judas Pt.; Panama: Gulf of Chiriqui.

Reeve and others have pointed out the discrepancy in Gray's figure, and, although the former attempted to rectify matters, it appears that his

53 Sowerby, Thes. Conch., vol. 3, 1857, p. 16, pl. 104, [204], fig. 425.

emarginatus is the same shell that was called *recurvus* by Broderip in 1833. The true *Conus arcuatus* has been well figured by several authors; it has strong spiral striations in many specimens and some spirals in all. The nucleus is smooth and polished; four post-nuclear whorls are strongly beaded on the carina and the upper whorls of the spire are nearly always brown. The sharply carinate periphery continues throughout the growth of the shell; the subsutural area is gently curved. Twelve and 13 whorls have been counted. Periostracum, light lemon yellow, very thin, with the scattered brown or yellow spots showing through; these are arranged roughly in three zones but the proportion of the white background covered is highly variable. The spiral grooves are very strong toward the canal but gradually weaken and disappear before the periphery is reached.

The species has been collected in large numbers and is not likely to be confused with any other of the west American fauna. Within its range Mr. Crocker collected it at nine additional stations on previous expeditions, in each case, however, with the dredge or trawl. It evidently does not frequent the littoral often if at all.

Adams and Reeve remarked upon the similarity of their species, *borneensis* to *arcuatus* after a comparison of type specimens and found them scarcely separable. Their excellent illustrations show shells which are practically identical with many in the collections studied from tropical west America. It seems obvious that some error in locality was made in the study of the collections of the *Samarang*. This is further suggested by three other species of *Conus* which were described in the same report immediately adjacent to *borneensis*. These were collected on the voyage of H. M. S. *Sulphur* and have unknown localities. Captain Belcher was on both expeditions and since it was admitted that some of his material became mixed it seems reasonable to suppose that the same happened in this case. No further record of *borneensis* having been found in Borneo has been seen. Two additional species treated in the *Samarang* report appear to be in the same category, *Dosinia dunkerii* Philippi and *Diplodonta sericata* Adams & Reeve.

Conus commodus A. Adams[54] was described without illustration from an unknown locality. Weinkauff, according to Tomlin[55], considered the species to be the one Kiener[56] figured as *Conus ambiguus* Reeve. Neither Kiener nor Reeve had any locality information and, upon comparing the figures it is obvious that the two are not the same species. The reason this concerns us is that Pilsbry & Vanatta[57] recorded *commodus* questionably from Wenman Island, Galapagos, from a much worn specimen taken by Snodgrass and Heller from the stomach of a shark. We have found nothing in any of the

54 Adams, A., Proc. Zool. Soc. London, 1853, [Nov. 14, 1854], p. 117.
55 Tomlin, J. R. le B., Proc. Mal. Soc. London, vol. 22, pt. 4, 1937, p. 230.
56 Kiener, L. C., Icon. Coq. Viv., Genre *Cone*, 1847, p. 150. pl. 70, fig. 3.
57 Pilsbry, H. A., and Vanatta, E. G., Proc. Washington, Acad. Sci., vol. 4, 1902, p. 555.

collections studied, which resembles Kiener's plate 70, figure 3, and if Weinkauff was right in determining this figure as *commodus* it seems doubtful if it is a west American species. Just what form is concerned in the Wenman Island record is equally uncertain. The Kiener figure is a plain olive colored shell with a sharp concave spire and angulated shoulder. The base is slightly pinched in as in *arcuatus.*

Conus fergusoni Sowerby

Plate 7, Figures 1, 2, 3, 4

Conus fergusoni SOWERBY, Proc. Zool. Soc. London, 1873, p. 145, pl. 15, fig. 1. "Panama." —SOWERBY, Thes. Conch., vol. 5, 1887, 2nd Suppl. to *Conus,* p. 256, pl. 508 [*Conus* pl. 30], fig. 675.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 218 - 227.

Conus xanthicus DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 220. "Off Guaymas, Mexico, at station 3011, in 71 fathoms, sand, U. S. Bureau of Fisheries steamer *Albatross.*" [Also reported from Panama Bay in 7 fathoms.]

Type locality: For *fergusoni,* Panama; for *xanthicus,* off Guaymas, Mexico.

Range: Turtle Bay and Magdalena Bay (outer coast), Lower California and Gulf of California, Mexico, south to "Santa Elena, Peninsula, Ecuador," (Barker), and the Galapagos Islands.

Collecting stations: Mexico: Arena Bank, Lower California, (Sta. 136, D-11, 24, 27, 30 to 50 fms.); Santa Inez Bay, Lower California, (Sta. 142, D-4, 40 to 50 fms.; Sta. 147, D-2, 60 fms.); Gorda Banks, Lower California, (Sta. 150, D-13, 16, 25, 56 to 80 fms); off Pyramid Rock, Clarion Island, (Sta. 163, D-4, 50 fms.); Chamela Bay, (Sta. 182, D-4, 16 fms.; Costa Rica: Port Parker, (1 to 90 fms.); 14 miles SxE of Judas Pt., (Sta. 214, D-1, 2, 3, 4, 42 to 61 fms.); Panama: Hannibal Bank, (Sta. 224, 35 to 40 fms.). Above are New York Zoological Society Stations. Additional Calif. Acad. Sci. localities are Turtle Bay, Santa Maria Bay, Magdalena Bay and Cape San Lucas, Lower California; Clarion Island.

It seems remarkable that this huge species, sometimes over five inches long, should have remained undiscovered until 1873 but a search of the literature has failed to disclose a name for either the white adult form or the colored juveniles.

Dall suggested that *C. coelebs* Hinds[58] might be the young of *fergusoni* although both Hinds and Reeve came to believe their shell to be the young of *C. terebellum,* while Tryon[59], after copying Reeve's figure, considered it to

[58] Hinds, R. B., Ann. Mag. Nat. Hist., New ser., vol. 11, no. 70, April 1843, p. 256. "Ambow, Feejee Islands."—Reeve, L. A., Conch. Icon., vol. 1, May 1843, pl. 13, fig. 64. Suppl. June 1849, p. 4.—Hinds, R. B., Zool. Voy. *Sulphur,* Moll. pt. 1, July 1844. p. 7.

[59] Tryon, G. W., Man. Conch., vol. 6, 1884, p. 80.

be *C. terebra.* de Barros e Cunha[60] followed Tryon and cited *terebra* from the Philippines and North Australia. Hinds stated explicitly that *coelebs* was found on a Fiji coral reef and his localities are usually trustworthy.

Conus quercinus Bruguière[61] is very similar to the large *fergusoni;* specimens in the California Academy of Sciences labelled from Mauritius, can hardly be distinguished. *Conus virgo* Gmelin[62] from the same region is also similar but is shaded with purple on the interior of the lower end of the aperture.

A magnificent series of growth stages has enabled us to state with assurance that *C. xanthicus* Dall is the young of *fergusoni.* Without such a series it would not be suspected that the bright yellow or orange small shells could possibly be the same as the huge white ones so familiar to beach collectors at Magdalena Bay and vicinity. For a long time we were puzzled that no small white ones ever turned up in any of the collections. It develops that when *xanthicus* reaches a length of 60 mm., the colored bands become very faint yet upon closer inspection it is found that they still persist in specimens which are unquestionably called *fergusoni* 95 mm. long. Shape, sculpture and number of whorls all point to the identity of the two forms.

We are deeply indebted to Dr. Paul Bartsch of the U. S. National Museum for the photograph of the type specimen of *xanthicus* which is reproduced herewith. Fresh shells are covered with velvety periostracum which is very tenacious and increases in density with age; it almost obscures the color markings and when imperfectly removed leaves the ground color (white bands in this case) a pale yellowish green. These light colored bands are not at all constant; the one near the shoulder may be scarcely visible, and even the middle one may be broken up into a series of cloudy areas. The colored bands vary from light lemon-yellow to orange-yellow with occasionally a trace of brown. The color fades with increasing size so that when fully adult, that is when the length reaches 150 mm. or more, not a trace can be seen, even in living specimens. The largest specimens (alt. 150 mm.) seen came from Magdalena Island, outer coast; the species does not appear to occur in Magdalena Bay at the present time but we have fossils from the Pleistocene deposits just north of the village. Another large specimen, (alt. 128 mm.) is from Tagus Cove, Albemarle Island, Galapagos.

Passing to the fossil forms, *fergusoni* was recorded from the Pliocene, Imperial County, California, by Hanna[63]. *Conus mollis* Brown & Pilsbry[64] from the Miocene, Gatun formation, Panama, is hardly separable. This, in

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60 de Barros e Cunha, J. G. Catalogo descritivo das Conchas exóticas da colecção Antonio Augusto de Carvalho Monteiro, Memórias e Estudos do Museu Zoológico da Universidade de Coimbra sér. 1, no. 71, 1933, p. 183.

61 Bruguière, J. G., Encycl. Méth. Vers, vol. 1, pt. 2, 1792, p. 681. An earlier name for the species seems to be [*Conus*] *cingulum* Martyn, Univ. Conch., vol. 1, 1784, fig. 39. "Friendly Isles."

62 Gmelin, J. F., Linn. Syst. Nat. ed. 13, 1789, p. 3376.

63 Hanna, G. D., Proc. Calif. Acad. Sci., Ser. 4, vol. 14, 1926, p. 446, pl. 21, figs. 6, 7.

64 Brown, A., and Pilsbry, H. A., Proc. Acad. Nat. Sci. Philadelphia, 1911, p. 343, pl. 23, fig. 1.

turn, is very similar to *Conus haytensis* Sowerby[65] from the Miocene of Santo Domingo. The similarity of *Conus hayesi* Arnold[66] from the Temblor Miocene of the San Joaquin Valley, California, to *C. fergusoni* was pointed out by Arnold.

Dall gave the range of the species as from Magdalena Bay to Ecuador and for *xanthicus,* Guaymas to Panama.

Conus vittatus Bruguière

Plate 8, Figures 8, 9; Plate 10, Figures 6-9

Conus vittatus BRUGUIÈRE, Enc. Méthod. Vers., 1798, pl. 335, fig. 3.—LAMARCK, Anim. sans Vert., vol. 7, 1822, p. 470. "Habite l'ocean asiatique."

Conus vittatus BRUGUIÈRE, REEVE, Conch. Icon., vol. 1, June, 1843, pl. 14, figs. 75 *a, b.* "Bays of Panama and Montija, West Columbia."—KIENER, Icon. Coq. Viv., Genre *Cône,* p. 110, 1847, pl. 63, fig. 5. "Habite l'ocean asiatique."—SOWERBY, Thes. Conch., vol. 3, p. 18, 1857, pl. 199, [*Conus* pl. 13], fig. 274; pl. 203 [*Conus* pl. 17], fig. 410, 1858.—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1873, p. 226, pl. 37, figs. 5, 6. "Grosser Ocean an der Küste von Central - America (Carpenter) und Panama (Bernardi)."—TRYON, Man. Conch., vol. 6, 1883, p. 43, pl. 13, figs. 41-44.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 221. "Acapulco to Panama."

Conus orion BRODERIP, Proc. Zool. Soc. London, 1833, p. 55. "In America Centrali. (Real Llejos)."—SOWERBY, Conch. Ill., p. 2 [118], pl. 33, fig. 40, May 17 - July 12, 1833. —SOWERBY, Thes. Conch., vol. 3, p. 19, 1857, pl. 195, fig. 200.—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, 1875, p. 364 pl. 67, fig. 7.—TOMLIN, Journ. Conch., vol. 18, no. 6, 1927, p. 154. "Gorgona Island, Colombia."

"*Conus fumigatus* BRUG. var.," KIENER, Icon. Coq. Viv., Genre *Cône,* pp. 103, 104, 1847, pl. 50, fig. 2 *a.*

[?] *Conus perplexus* SOWERBY, *archon* BRODERIP and *gladiator* BRODERIP, SORENSEN, Nautilus, vol. 57, July, 1943, pl. 1, figs. 7, 8, 9, [9 shells]. Guaymas, Mexico.

[?] *Conus henoquei* BERNARDI, Journ. de Conchyl. vol. 8, Oct. 1860, p. 380, pl. 13, fig. 4; no locality cited.

Type localities: For *vittatus,* "Indian Ocean," [probably an error]; for *orion,* Realejo, near Corinto, Nicaragua.

Range: Santa Inez Bay, Lower California and Guaymas, Mexico, south to Gorgona Island, Colombia.

Collecting stations: Santa Inez Bay, Lower California; Costa Rica; Port Culebra; Panama: Bahia Honda.

In addition to these stations specimens from Mazatlan, Mexico, Port Parker, Costa Rica, and several places in Panama Bay have been studied.

The species is one of the most beautiful of the genus. Ground color is usually white and shows as blotches and spots through the reddish brown to orange color markings. These latter are present in variable amount, sometimes almost obliterating the white base and again they may be broken up

65 Sowerby, G. B., Quart. Jour. Geol. Soc. London, vol. 6, 1850, p. 44.
66 Arnold, R., U. S. Geol. Surv., Bull. 396, 1909, p. 62, pl. 6, fig. 3.

into scattered blotches irregularly shaped and spaced. There is usually a central band, lighter marked with color than the remainder of the shell. The spire is gently rounded, heavily marked with blotches of color and with a sharp apex. Sutures are raised into ridges, usually with spiral lines between. The shoulder is most often somewhat angulated as in Sowerby's figure in the Theasaurus but in older specimens it becomes rounded. The body whorl is marked throughout by equidistant raised spiral threads, sometimes with fine dots of darker color, and minute spiral striation between.

The periostracum is rough, horn colored, and so dense the color markings can barely be seen.

The original figure of *vittatus* is a black and white engraving and the specimen which was probably used for it was photographed by Dr. Mermod who very kindly permitted it to be published herein. From this photograph it seems now to be certain that the species is a west American form and not Asiatic or Indian Ocean as cited by early authors.

In the identification of the collections used for this report those which belong to this species or group of species have caused much trouble. Only a few specimens have been available, all taken in the littoral zone. These either belong to one highly variable form or there are three or more, *vittatus, orion* and one or more unnamed. The course chosen has been the conservative one for several reasons. One is the very great variability of most of the west American species; this appears especially when large numbers of specimens become available. Another is the scarcity of material. Also there is reason to be doubtful if an unnamed littoral species of *Conus* exists in the vicinity of Panama although this is by no means certain. Our treatment of the subject is not satisfactory to ourselves or our colleagues but under the circumstances we feel that it will cause less future confusion than any other action we could take.

We are under obligations to Dr. Howard R. Hill, of the Los Angeles Museum for much assistance with this species and to him and Dr. A. Myra Keen of Stanford University for the privilege of studying the beautiful shells they have received from Panama from Mr. W. D. Clark.

The shells illustrated by Sorensen under the names *perplexus, archon,* and *gladiator* are probably all *orion* or *vittatus;* certainly some of them are. In two cases, shadows cast by the shells make it difficult to determine exactly what the shape and markings may be.

Many authors have placed *C. henoquei* Bernardi[66a] in synonymy of *vittatus* and it seems probable that this is correct. Others have placed *orion* also in synonymy but there has evidently been some hesitation in this respect because of the apparently erroneous locality originally cited for *vittatus*.

66a The holotype of this species is preserved in the Museum National d'Histoire Naturelle, Paris. See Fisher-Piette & Beigbeder in Bulletin of that Museum, ser. 2, vol. 16, no. 6, Nov. 1944, p. 461.

Conus purpurascens Broderip

Plate 8, Figures 19, 20; Plate 9, Figures 1, 2, 3

Conus purpurascens BRODERIP, in SOWERBY, Conch. Ill., April 12, 1833, p. 1, [117], pl. 25, figs. 13, 13*.—BRODERIP, Proc. Zool. Soc. London, May 24, 1833, p. 54. "Hab. ad Panamam."—REEVE, Conch. Icon., vol. 1, July, 1843, pl. 19, fig. 105.—KIENER Icon. Coq. Viv., Genre *Cône*, p. 189, 1848, pl. 39, fig. 2, pl. 61, fig. 3.—SOWERBY, Thes. Conch., vol. 3, p. 28, 1858, pl. 195, [*Conus* pl. 9], fig. 204, pl. 201, [*Conus* pl. 15], fig. 346.—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1873, p. 211, pl. 54, figs. 1, 2.—TRYON, Man. Conch., vol. 6, 1883, p. 64, pl. 20, figs. 15-17, pl. 27, fig. 9.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219. "Magdalena Bay, Lower California to Manta, Peru."—PEILE, Proc. Mal. Soc. London, vol. 23, 1939, p. 349, fig. 5 (radula). "Panama." SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 2 [7 shells]. "Guaymas, Mexico."

Conus luzonicus LAM? SOWERBY, Conch. Ill., April 20, 1834, p. 3, [119], pl. 57, fig. 91.—SOWERBY, Thes. Conch., vol. 3, p. 281, 1858, pl. 201 [*Conus* pl. 15], fig. 344. "Panama."—SOWERBY, Proc. Zool. Soc. London, June 17, 1834, p. 18, "Hab. ad Insulas Gallapagos." Not *Conus luzonicus*, BRUGUIÈRE, LAMARCK and KIENER.

Conus pupurascens var. *rejectus* DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219. "Port Escondido, Gulf of California."

Conus regalitatis SOWERBY, Conch. Ill., April 30, 1834, p. 3, [119], pl. 57, fig. 87.—SOWERBY, Proc. Zool. Soc. London, June 17, 1834, p. 19. "Hab. ad littora Americae Centralis. (Real Llejos)."—REEVE, Conch. Icon., vol. 1, January, 1844, pl. 40, fig. 218.—KIENER, Icon. Coq. Viv., Genre *Cône*, p. 237, 1849, pl. 39, fig. 3.—SOWERBY, Thes. Conch., vol. 3, 1858, p. 28, pl. 201 [*Conus* pl. 15], fig. 345.

Conus purpurascens var. *regalitatis* Sowerby, DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 219. "Cape San Lucas and southward to Peru, the Galapagos and Clipperton Islands."

Conus comptus GOULD, Journ. Boston Soc. Nat. Hist., vol. 6, Oct. 1853, p. 387, pl. 14, fig. 23. "Inhabits Santa Barbara. Col. Jewett." Not *Conus comptus* A. ADAMS, Proc. Zool. Soc. London, 1853 [Nov. 14, 1854], p. 117, from Natal and which Sowerby. (Thes. Conch., vol. 3, index, p. 50, 1858), stated was *Conus castus* Reeve.

[?] *Conus cinctus* VALENCIENNES, Zool. Humboldt & Bonpland, Rec. Zool., vol. 2, 1832, p. 337. "Habitat cum praecedente ad Acapulco."—Not *Conus cinctus* SWAINSON, Zool. Ill., Ser. 1, 1823, p. 110, which Tryon (Man. Conch., vol. 6, 1884, p. 100), placed in the synonymy of *pulchellus* SWAINSON.

Type locality: Panama.

Range: "Magdalena Bay, Lower California to Manta, Peru" (Dall).

Collecting stations: Sets of specimens have been available for this study as follows: Mexico, 14; Nicaragua, 2; Costa Rica, 10; Panama, 1; Colombia. 1; Galapagos Islands, 7.

Thus, from the abundance of material this must be considered to be the most common cone along the west American coast. It normally inhabits rocky shores and tide pools from mid-tide down to a few fathoms.

The typical form of the species is a shell with a low spire and strongly shouldered whorls. From this to the rounded form called *regalitatis* there is endless variation. In addition there are color combinations too numerous to be enumerated. The general predominance of purple, however, shows that the species is well named. The large number of specimens available for this study has convinced us that the named varieties and many others equally distinct have no biological significance. They merely appear to be variants of a somewhat plastic species.

Valenciennes compared his *cinctus* with *hyaena* Bruguière which, with the locality, would indicate that he probably had *purpurascens.* Dall suggested that *cinctus* Valenciennes and *emarginatus* Reeve might be the same but there is not sufficient information published to permit the definite assignment of Valenciennes' name anywhere. Weinkauff (p. 394) stated that *Conus neglectus* A. Adams[67], was the young of *purpurascens* and that the name should be added to the synonymy. However, the description and Sowerby's figure seem to imply a very different shell and this, together with the unknown habitat of *neglectus,* has caused us to omit it.

Conus luzonicus Bruguière[68] is an entirely different species, judging by the original figure, and it is difficult to understand Sowerby's confusion of the shells. Kiener[69] has given a beautiful figure which resembles the one in the Encyclopedia very closely and it may have been made from an original specimen; he gave the locality as "les côtes des îles Philippines."

The variety *rejectus* has not been figured. It was described as having the spire somewhat lower and the shoulder more angular than usual. The color pattern is in small patches, with some pale brown thread-like, articulated spiral lines. There is little in the description to distinguish the form from the original figure of *purpurascens.*

The figure of *comptus* Gould can be matched almost exactly in any large collection of *purpurascens,* in which specimens have been preserved which are not fully grown, the heavy blotches being very distinctive. Carpenter[70] and Cuming, who had studied Gould's type of *comptus* pronounced it to be *purpurascens* and were followed by Sowerby in 1856 and Tryon in 1883. However, Dall in 1910 considered it to be the oldest available name for *Conus puncticulatus* Wood (not Bruguière) [=*perplexus* Sowerby].

Gould[71] stated that *purpurascens* was equivalent to *"Conus achatinus* Menke." Menke[72] merely listed the name from west America and attributed it to Bruguière. It is probably a case of mistaken identification or mixing of collections (as suggested by Carpenter)[73] because *achatinus* Bruguière[74] is a

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67 Adams, A., Proc. Zool. Soc. London, 1853 [November 14, 1854], p. 117; "Hab.?"—Sowerby Thes. Conch., vol. 3, 1858, p. 25, pl. 203 [*Conus* pl. 17], fig. 404; Hab.—?"

68 Bruguière, J. G., Enc. Méthod., 1792, p. 706, pl. 338, fig. 6.

69 Kiener, L. C., Icon. Coq. Viv., Genre *Cone,* 1848, p. 180, pl. 83, fig. 3.

70 Carpenter, P. P., Proc. Zool. Soc. London, 1856, p. 206.

71 Gould, A., Otia Conch., 1862, p. 187.

72 Menke, K. T., Zeit. f. Mal., Jahr. 4, 1847, p. 183.

73 Carpenter, P. P., Rept. Brit. Assoc. Adv. Sci., 1856, [1857], p. 236. [Carpenter added that the species was "= *purpureus* or *regalitatis,*" evidently meaning *purpurascens*].

74 Bruguière, J. G., Enc. Method, 1792, p. 672, pl. 330, fig. 6 [= Hwass of authors].

decidedly different shell, with a predominance of spiral sculpture; it is supposed to be found in Asiatic waters.

Krebs[75] has listed *Conus purpurascens* Broderip from the island of Guadaloupe, West Indies, on the authority of "Bean." It seems reasonable to assume now that this was an error of locality or identification.

Conus patricius Hinds

Plate 6, Figure 12; Plate 9, Figures 6, 7, 8, 9

Conus patricius HINDS, Ann. & Mag. Nat. Hist., N.S., vol. 11, no. 70, April, 1843, p. 256. "Gulf of Nicoya, Central America. Dredged from sandy mud in 7 fathoms."—REEVE, Conch. Icon., vol. 1, May, 1843, pl. 13, fig. 63.—HINDS, Zool. Voyage *Sulphur,* vol. 2, no. 6, July, 1844, p. 7, pl. 1, figs. 1, 2.—KIENER, Icon. Coq. Viv., Genre *Cône,* p. 350, 1849-1850, pl. 88, fig. 4.—SOWERBY, Thes. Conch., vol. 3, p. 12, 1857, pl. 202, [*Conus* pl. 16], fig. 355.

Conus pyriformis REEVE, Conch. Icon., vol. 1, May, 1843, pl. 13, fig. 70. "Bays of Caracas and Montija, West Columbia."—TRYON, Man. Conch., vol. 6, 1883, p. 17, pl. 4, figs. 60, 61.—KIENER, Icon. Coq. Viv., Genre *Cône,* p. 275, 1849-1850, pl. 44, fig. 4.—SOWERBY, Thes. Conch., vol. 3, p. 24, 1857, pl. 197 [*Conus* pl. 11], fig. 238, pl. 201 [*Conus* pl. 15], fig. 354.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 226. "Nicaragua south to Panama and the Galapagos Islands."

Type locality: Gulf of Nicoya, Costa Rica *(patricius);* Caracas, Ecuador, and Montijo Bay, Panama *(pyriformis).*

Range: Nicaragua south to Punta Carnero, Ecuador.

Collecting stations: Costa Rica: Port Culebra.

No specimens have been seen in the collections studied in connection with the present report which confirm Dall's record of the species at the Galapagos Islands although it may reasonably be expected to live in those waters.

Young shells are beautifully coronated with a row of symmetrical beads, but the periphery is gently rounded in adult specimens. Mr. H. N. Lowe collected living shells at San Juan del Sur, Nicaragua, and these are covered with a horn-colored epidermis, the color of the under shell, showing through on the body whorl in the aperture, and on the lower part of the spire. When the epidermis is lost and the shell is weathered, it becomes entirely white. Available material from six localities indicates that this is not only one of the most beautiful of all of the cones but also one of the rarest. However, Mr. R. Wright Barker found it to be one of the most common forms on Santa Elena Peninsula, Ecuador, in 1931 where it lived in tide pools among the rocks. (Letter, March 19, 1940).

The identity of *Conus patricius* and *pyriformis* has been generally recognized since 1883 (Tryon), the first name having been based upon an im-

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75 Krebs, Henry. The West Indian Marine Shells with some remarks, 1864, p. 6. [A copy of this rare document has been consulted in the private library of Dr. L. G. Hertlein. For comments regarding the circumstances of its publication, see letter from Krebs published by Dall, U. S. Nat. Museum, Bull. 37, 1889, p. 20.]

mature specimen. The name *patricius* clearly has priority, having appeared first in April, 1843, while Reeve has the date printed on the explanation of the plate bearing *pyriformis* as May, 1843. Even if there should have been doubt as to the correctness of these printed dates, Reeve included *patricius* on the same plate with *pyriformis,* the first as figure 63, the second as figure 70. There seems to be no good reason for the continued acceptance of the name *pyriformis* for the species.

Usually the shells are characterized by being pyriform, rather thin and uniform pale waxy yellow. However, Mr. W. D. Clark recently collected one on Venado Flats, Panama Bay, which has an extremely heavy, thick shell with a thick horny periostracum. The coating tends to peel off when dry. It is the largest individual of the species which we have seen and measures: Length, 140 mm.; greatest diameter, 89.5 mm. The apex is somewhat worn but shows 13 whorls, the first 8 or 9 being beaded around the periphery. The operculum is thick and horny, spatulate, pitted on the underside at the attachment; length, 22.0 mm.; width, 18.5 mm.; thickness, 3.3 mm. The thin membranous object shown in figure 9 was said to be an egg case of this individual; it consists of 8 leaf-like sacks, now empty. This marvelous specimen was presented to Stanford University (no. 31642) and was made available for this study through the kindness of Dr. A. Myra Keen.

Another giant specimen was collected by Mr. R. Wright Barker several years ago on Santa Elena Peninsula, southwest Ecuador. It measures at least 100 mm. in length and was sent to Mr. J. R. leB. Tomlin.

Conus virgatus Reeve

Plate 6, Figure 10; Plate 9, Figure 5

Conus lorenzianus CHEMNITZ, KIENER, Icon. Coq. Viv., Genre *Cône,* 1847, p. 139, pl. 55, fig. 1. "Habite la Mer du Sud, les côtes d'Acapulco."—Not *Conus lorenzianus* CHEMNITZ, Neues Syst. Conch. Cab., vol. 11, 1795, pl. 181, figs. 1754, 1755. " . . . . ostindischen Meeren."

Conus cumingii REEVE, Conch. Icon., Suppl., pl. 8, figs. 277 *a, b,* June, 1849.—Not *Conus cumingii* REEVE, op. cit. pl. 3, fig. 282, April, 1848.

Conus sanguinolentus REEVE, (?) Conch. Icon., Suppl., pl. 8, fig. 274, June, 1849. [No locality cited.]—SOWERBY, Thes. Conch., vol. 3, 1857, p. 18, pl. 203 [*Conus* pl. 17], fig. 409.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 225. "Guaymas, Mexico to coast of Ecuador."—Not *Conus sanguinolentus* QUOY & GAIMARD, Voy. *Astrolabe,* Zool., vol. 3, 1834, p. 99, pl. 53. fig. 18. "New Guinea."

Conus virgatus REEVE, Conch. Icôn., Suppl., p. 1, June, 1849. Name proposed for pl. 16, fig. 87 (*zebra* from Salango, Central America.)—SOWERBY, Thes. Conch., vol. 3, p. 17, pl. 195 [*Conus* pl. 9], figs. 190, 193, 1857. "Salango, West Columbia."—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, pt. 2, 1875, p. 308, pl. 49, figs. 4, 5. "westküste von Central - und Südamerika."—TOMLIN, Proc. Mal. Soc. London, vol. 22, pt. 5, 1937, p. 328.—SORENSEN, Nautilus, vol. 57, no. 1, July, 1943, pl. 1, fig. 3 [7 shells.] "Guaymas, Mexico."

Conus signae BARTSCH, Nautilus, vol. 51, no. 1, July, 1937, p. 3, pl. 2, fig. 8. Figured specimen from Guaymas, Mexico; also recorded from Cedros Island and from Panama.

Type locality: Salango, Ecuador.

Range: Cedros Island, Lower California, to Ecuador.

Collecting stations: Mexico: Arena Bank, (Sta. 136, D-4, 55 fms.); San Carlos Bay; Guaymas. A living specimen from the last locality, collected by Mr. A. Sorensen, was used for dissection of the radula figured herewith.

Other expeditions, the material from which has been available for this study, shows that the species occurs as far north in the Gulf of California as San Carlos Bay. Apparently the first west American specimen of this group of *Conus* to be noted in the literature was the one figured by Kiener from Acapulco, Mexico. It resembles some of the recent collections very strongly. Kiener referred the shell to Chemnitz's name, *lorenzianus,* the specimens of which came from the East Indies and the name was not validated according to the rules, until Dillwyn[76], 1817. Meanwhile, Lamarck[77] in 1810 had described *Conus flammeus* from "Africa" which, from Kiener's and other figures, is identical. This name, however, had been previously used by Bolten[78] under *Cucullus* for a species figured by Martini[79] as *Conus leoninus.* Tomlin[80], therefore renamed Lamarck's *flammeus, "phlogopus"* but it would seem that *lorenzianus* Dillwyn would be available.

It was necessary to make this somewhat cursory examination of the literature because the species involved in the above complex of names is extremely close to the west American form. In fact the only differences noted (and these may be inconstant) are the heavier coloring of the more numerous stripes which are somewhat broken into spiral rows of spots near the base on the form from the Indies and Africa. It is another case of similarity of the *Conus* fauna from this region to that of very distant areas.

It seems clear that Sowerby, in 1857 attempted to correct the slip made by Reeve in naming two distinct shells for Cuming; he substituted Reeve's earlier name *virgatus* for the west coast species and was followed in this action by Weinkauff, Tryon and Tomlin. Dall made no comment on this procedure, but substituted another of Reeve's earlier names, *sanguinolentus,* for the later *cumingii.* Quoy and Gaimard, however, had previously used *sanguinolentus* for another species of *Conus.* Furthermore Tomlin[81], stated that Reeve's shell of that name was equivalent to *"dacus* Brug." a West Indian species.

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76 Dillwyn, L. W., Desc. Cat. Rec. Shells, vol. 1, 1817, p. 370.

77 Lamarck, J. B., Ann. du Mus. H. N. Paris, vol. 15, 1810, p. 279.

78 Bolten, J. F., Mus. Bolt., 1798, p. 44.

79 Martini, F. H., Conch. Cab., vol. 2, 1771, pl. 55, figs. 606, 607.

80 Tomlin, J. R. le B., Proc. Mal. Soc. London, vol. 22, 1937, p. 206.

81 Tomlin, J. R. le B., Proc. Mal. Soc. London, vol. 22, pt. 5, 1937, p. 305.

The problem finally becomes one of determining if Reeve's pl. 16, fig. 87 is equivalent to his Suppl. pl. 8, fig. 274. From an examination of the figures, Bartsch was evidently unable to reconcile them, a doubt which we shared for a long time, and he renamed the second *cumingii, signae.* However, it seems open to question if there be two very similar species belonging to this group in this region; if so we do not know how to distinguish them at present. Moreover, Sowerby was in an excellent position to know details regarding Reeve's material, and Tomlin's[82] remarks are nearly conclusive where he says regarding the second *cumingii* " ? Types (3) : all much bigger than Reeve's figure. =*virgatus* Rve." Chiefly, for this reason, the name *virgatus* has been chosen for the western shell.

The species is of medium size, rather plainly colored, with dark brown longitudinal stripes on a lighter pinkish ground color. Brown spiral lines are usually present and the exceedingly fine wavy spiral sculpture gives to the shell, a silky texture unlike any other western species.

The collections obtained by the various expeditions to Central American waters of late years, have contained very few specimens of the species so that the range of variation cannot be indicated with any great degree of completeness. However, it will be noted from our figures that this is considerable, the front of one specimen being exceedingly close to the figure of *C. signae* while the reverse side shows pronounced zigzag flammules similar to the original shell Reeve called *zebra* from "Salango" and later renamed *virgatus.* Some specimens are practically without any trace of the brown stripes, thus paralleling, in a way, the condition found in the variety of *princeps* called *apogrammatus.*

The published records, the material noted above and five specimens in the San Diego Society of Natural History (Lowe, coll.) from Carmen Island, Mexico, Socorro Island, Mexico and San Juan del Sur, Nicaragua, show the range to be from Cedros Island to Ecuador. The San Diego Society collection was made available for this study through the kindness of the late Director, Mr. Clinton G. Abbott.

An unusually heavily marked specimen was collected by Mr. W. D. Clark on rocks at Bruja Point, Panama Bay. Through the courtesy of Dr. A. Myra Keen, of Stanford University, to whom the shell was presented, we are able to illustrate it herewith. It measures 33 mm. in altitude, 17.3 mm. in diameter.

One of the animals collected by Mr. Sorensen at Guaymas, Mexico, in January, 1942 was a male and except for black blotches around the margin of the foot and the tip of the siphon, no color was preserved (July, 1946). The head, or snout, is long and slender and evidently capable of great extension. Eyes are near the outer ends of slender tentacles.

The operculum is small (length, 4.5 mm., width, 1.75 mm.), oval in shape, with the apex subcentral. In comparison with other species examined,

82 Tomlin, J. R. le B., Proc. Mal. Soc. London, vol. 22, pt. 4, 1937, p. 236.

the proboscis is not so highly developed as a muscular organ but it is obviously capable of great protrusion. The "poison gland" is massive and pinkish and discharges into the base of the proboscis through an extremely long and greatly convoluted duct, just in front of the neural ring. Immediately in front of this is the attachment of the "radular" sheath, a rather slender pointed tube with a somewhat elongated pouch near the base. There are many teeth

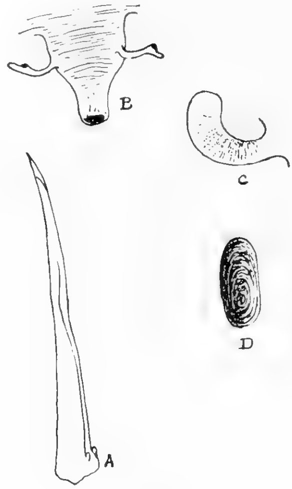

Fig. 3. *Conus virgatus* REEVE. A.—Complete tooth. B.—Dorsal view of head. C.—Verge. D.—Operculum. Hypotype, no. 9343 (Paleo. type coll.), from Loc. 31699 (C.A.S.), San Carlos Bay, Mexico, A. Sorensen, Coll., Jan. 1942.

arranged with the points all toward the aperture of the duct. They are weakly attached to the wall of the duct and each has what appears to be a very fine tube attached to the base. Each tooth is a slender, slightly curved shaft with no well-defined barbs. The base is swollen and a line extending nearly to the tip appears to be the edge of this rolled up plate. The length of an average tooth is .62 mm.

Conus dalli Stearns

Plate 5, Figure 12

Conus dalli STEARNS, Proc. Calif. Acad. Sci., vol. 5, 1873, p. 78, pl. 1, fig. 1. "Gulf of California, from whence specimens are occasionally brought to San Francisco on vessels in the Gulf trade. It is not common."—STEARNS, Proc. U. S. Nat. Mus., vol. 17, 1894, p. 169.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 226—HERTLEIN, Proc. Amer. Phil. Soc., vol. 78, no. 2, 1937, p. 306, pl. 1, fig. 18.—DAUTZENBERG, Mem. Mus., Roy. d'Hist. Nat. Belgique, vol. 2, fasc. 18, 1937, p. 252.

Conus omaria BRUGUIÈRE, Menke, Zeit. f. Mal., Jahr. 8, 1851, p. 23. "Mazatlan."

Type locality: Gulf of California.

Range: Gulf of California to Panama.

Collecting stations: Mexico: Tres Marias Islands; Costa Rica: Port Parker; Cocos Island; Galapagos Islands: Albemarle; Hood.

Most of the specimens (six lots) in the California Academy of Sciences came from the Tres Marias, Galapagos and Cocos Island.

The species is the west American representative of the *Conus textile* group and it is scarcely separable from some members or "varieties" of that great assemblage. Although Stearns stated in 1894 that the differences between immature shells of *dalli* and *textile* were greater than in adult forms, after studying a fairly large series we have been able to indicate no single character which can be relied upon to distinguish the American form in every case. As a general rule specimens of *C. dalli* have the brown blotches of a darker brown and the interior a faint rose pink instead of white, but some finely preserved shells agree in detail to a most remarkable extent with what Reeve[83] called the true *textile.*

Many variations of the *textile* group have been named and Melvill[83a] has given a review of the group; he considered *dalli* to be a variety. Dautzenberg has given very extensive synonymy for *textile* and some of its varieties and discussed their relationship. He considered *dalli* to be a distinct species, partly because of its range and also because the shell is "constamment teinté de rose dans l'intérieur de l'ouverture."

It seems unnecessary here to attempt to unravel the intricacies of the nomenclature. To do so would require the examination of a considerable amount of pre-Linnaean literature because the name was originally founded on several existing figures. It is first necessary to fix upon a definite type form of color pattern for *textile* and from that, work through the various named varieties. It seems probable that when this is done, many names will have to be thrown into synonymy; but until such a study is made we feel that the best course to follow will be to recognize the name *dalli* as applied locally to the west American form. A consideration of the manner in which such representatives of south sea species have been dispersed to American waters, or vice versa, leads to interesting speculation, but there are few facts available to justify positive opinions. However, in the case of *Conus omaria,* a member of the *textile* group, Ostergaard[83b] has observed that the veliger larvae have no free-swimming stage under laboratory conditions. If this be true under natural conditions, and this seems probable, one of the usually cited methods of distribution in the Mollusca is certainly eliminated.

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83 Reeve, L. A., Conch. Icon., vol. 1, Dec. 1843, pl. 38, fig. 209.

83a Melvill, J. C., Journ. Conch., vol. 9, no. 10, 1900, pp. 303-316.

83b Ostergaard, L. M., Bernice P. Bishop Museum, Bull. 131, 1935, p. 24.

The apical whorls are a light purplish-pink, those of the nucleus (about 2) being smooth and the succeeding three or four being each marked by a spiral row of about 30 rounded beads. The remainder of the spire is low, sides nearly straight to gently convex, suture faint, and with a few fine, spiral striations. Specimens of *textile* from Mozambique are practically identical. Depth of color tone varies considerably. The darkest ones seen came from Panama (Stanford University Coll.) and Costa Rica. Fresh living shells from farther north are nearly as dark. The interior of all specimens examined, except beach worn ones, show at least a trace of rose color or purple and some are very dark. Available specimens of *textile* do not show this character in so pronounced a degree and some are definitely white, perhaps due to fading with age.

The extreme similarity of *Conus dalli* to some other members of the group to which it belongs but which now live in far distant places has given rise to the belief that the species is a comparatively recent migrant to American shores. However, the finding of a fossil species in Imperial County, California, with color markings preserved, which obviously belongs to the same group refutes such a supposition and may even suggest to some that migration has been in the opposite direction. (See *Conus durhami* below.)

Conus durhami Hanna & Strong, sp. nov.

Plate 5, Figure 16

Shell broad, spire low with straight sides, suture lightly impressed with a non-striated groove; whorls about eight; shoulder rounded; color markings consisting of a series of network of brown, lines enclosing roughly angular areas of light cream. Length 39.5 mm., diameter 25.5 mm.

Holotype, No. 34200 (Univ. Calif. Mus. Paleo.), from Loc. A 1269 (U. C.), "south side of **Carrizo Mountain, Imperial County, California;** Pliocene; in small canyon about ⅜ mile east of mouth of Alverson Canyon in small draws cut in basal conglomerate in west side of canyon, 100-200 yards from its mouth." (Bramkamp.)

The species is named for Dr. J. W. Durham, paleontologist of the University of California, who made a large collection of fossils in the region in 1934. The specimen is not remarkable solely for the preservation of the color markings but indicates a relationship with the *textile* group of cones. This shows that such forms as *Conus dalli* need not be recent migrants from other seas because in this case as well as others, the group has been here for a comparatively long time. A similar case is presented in connection with *Conus tessulatus* and *bramkampi.*

Conus lucidus Wood

Plate 5, Figure 13

Conus lucidus WOOD, Index Test., Suppl., 1828, p. 8, pl. 3, fig. 4. "M. Cab. South Sea." —WOOD, Index Test., Hanley Ed., 1856, p. 208, Suppl. pl. 3, fig. 4. [The name is followed by "//" which, according to a note on p. 197, indicates that the specimens are from the collection of Mawe and that such names were chiefly manuscript ones of that collector. [In synonymy: "Mawe, Conch. 90 (no desc.)—*C. reticulatus*, Sow. (as of Wood!) C. I. Con. f. 86, S. Seas."]—SOWERBY, Thes. Conch., vol. 3, p. 43, pl. 110 [210] [*Conus* pl. 24], fig. 581, 1858. [Name erroneously attributed to "Mawe, Conch. 90."]—WEINKAUFF, Martini & Chemnitz, Conch. Cab., ed. 2, vol. 4, 1873, p. 238, pl. 39, figs. 9, 10.—TRYON, Man. Conch., vol. 6, 1884, p. 91, pl. 30, fig. 11.—DALL, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 226. [Name attributed to "Mawe, 1828."] "Magdalena Bay, Lower California to the Galapagos Islands."

Conus reticulatus MAWE, Linn. Syst. Conch., 1823, p. 90. "South Seas."—SOWERBY, Conch., Ill., p. 3 [119], pl. 57, fig. 86, April 30, 1834, [As "*Conus reticulatus* WOOD."] —REEVE, Conch. Icon., vol. 1, "June, 1843," pl. 11, fig. 52. [In synonymy: "*Conus lucidus?* Wood (undescribed)."] "Island of La Plata found in coarse sand."— KIENER, Icon. Coq. Viv., Genre *Cône*, 1847, p. 145, pl. 66, fig. 5. [Name attributed to Sowerby.]—Not *Conus reticulatus* BORN, Index, Mus. Caes. Vind., 1778, p. 139.

Type locality: Unknown; not "South Sea" as originally cited. Typical specimens have been collected at Magdalena Bay, Lower California, outer coast.

Range: Magdalena Bay to "Santa Elena Peninsula, Ecuador," (Barker).

Collecting stations: Costa Rica: Port Parker and Port Culebra; Panama: Bahia Honda; Colombia: Gorgona Island (Sta. 232, N. Y. Z. S., D-1, 2 to 8 fms.).

The species is present in the collection of the California Academy of Sciences from Magdalena Bay (outer coast, several lots) and from five localities in the Galapagos Islands.

Although Mawe's name *reticulatus* has clear priority over *lucidus*, as shown in the above synonymy, it is invalidated by earlier usage. Pre-Linnaean writers used *reticulatus* extensively for a variety of *Conus mercator* Linnaeus and it was subsequently validated by Born[84] in 1778. Also the name was presumably applied to another species by Meuschen[85] in 1787. This information was derived from Sherborn, Index Anim., 1758-1800; the original works were not available. However, since Martini[86], 1771, used the name as a species and such post-Linnaean writers as Dillwyn[87], 1817, definitely placed the reference in the synonymy of *Conus mercator*, further tracing of the name seems unnecessary.

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84 Born, I., Index Mus. Caes. Vind., 1778, p. 139.

85 Meuschen, F. C., Mus. Gever., 1787, p. 366.

86 Martini, F. H. W., Neues Syst. Conch. Cab., vol. 2, 1771, pp. 261-262, pl. 56, figs. 619-621.

87 Dillwyn, L. W., Desc. Cat. Recent Shells, vol. 1, 1817, p. 391.

It was necessary to determine these facts, however, because the names *lucidus* and *reticulatus* have been variously substituted in the literature for the west coast species and there seems to be no agreement as to the authorship of either one. We have followed Sherborn, (Index Animalium) in crediting *lucidus* to Wood, 1828, because there is nothing in the original citation to show that it was Mawe's manuscript name; not until the Hanley edition of Wood, in 1856, was there an indication that this might be the case, and even then there is no certainty regarding it.[88]

There is considerable variation in the shape and coloration shown in the various figures, particularly in the height and concavity of the spire. The one published by Kiener agrees very closely with the specimens dredged by the Crocker Expedition of 1932, 13 miles southeast of Cape Tosco, Santa Margarita Island, Lower California, (Loc. 27588 C. A. S.). Reeve's figure fits specimens from the Galapagos Islands more closely than any of the others.

Galapagos beach shells and a set from Magdalena Bay, presumably from shallow water, in the Hemphill collection, are all heavier, shorter and broader than the dredged material. It is possible that some of the differences in the figures may be attributed to the habitat of the shells.

The species has been considered to be one of the rare forms of the west coast, but the collections available for this study have contained numerous specimens.

Conus californicus Hinds

Plate 5, Figures 14, 15

Conus californicus Hinds in Reeve, Conch. Icon., vol. 1, Jan. 1844, pl. 42, fig. 224. "California."—Hinds, Zool. Voy. *Sulphur,* pt. 1, July, 1844, p. 7, pl. 1, figs. 3 - 5. "Bay of Magdalena, California."—Sowerby, Thes. Conch., vol. 3, 1857, p. 31, pl. 200 [*Conus* pl. 14], fig. 332.—Cooper, Geol. Surv. Calif. [Spec. Publ.] Geog. Cat. Moll. W. of the Rocky Mts., 1867, p. 33. "Farallone Islands to San Diego, Lower California."—Tryon, Man. Conch., vol. 6, 1883, p. 17, pl. 4, figs. 62, 63.—Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 220.—Rogers, The Shell Book 1913, p. 116, fig. 1, [opp. p. 118.]—Grant & Gale, Mem. San Diego Soc. Nat. Hist., vol. 1, 1931, p. 472, pl. 24, fig. 21.—Peile, Proc. Mal. Soc. London, vol. 23, 1939, p. 350, fig. 8, (tooth).—Burch, Smith and Keen, Min. Conch. Club Southern California, no. 48, May, 1945, p. 23.

Conus ravus Gould, Jour. Boston Soc. Nat. Hist., vol. 6, Oct. 1853, p. 386, pl. 14, fig. 21. "Santa Barbara."

Conus dealbatus A. Adams, *Proc.* Zool. Soc. London, 1853, p. 117. "Hab?"—Sowerby, Thes. Conch., vol. 3, p. 31, 1857, pl. 191 [*Conus* pl. 5], fig. 103.—Weinkauff, Jahrb. Deutsch. Malak. Gesell., vol. 1, 1874, pp. 248, 291. "Californiens."

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[88] J. Mawe's copy of his System of Conchology, 1823, is in the library of the California Academy of Sciences and is of very considerable interest. It is untrimmed; bound rather cheaply in rough boards, with a cloth backing. Alternate sheets are blank, and upon these Mawe has written a great many notes in a very legible script. Thus, there are additions, corrections, sources of information, and a few original drawings. In no place in this book, however, does the name *lucidus* appear, either printed or in manuscript.

Conus californicus fossils T. S. Oldroyd, Nautilus, vol. 34, no. 4, April, 1921, p. 116, pl. 5, fig. 9. "Lower San Pedro Series, Nob Hill Cut, San Pedro."

Type locality: Magdalena Bay, Lower California.

Range: Farallone Islands, California, south to Cape San Lucas, Lower California.

Collecting stations: This is a common littoral and shallow water species in California. Specimens from south of San Diego from the following localities have been studied in connection with the present report: Guadalupe Island; San Benito Islands; Cedros Island; San Roque Island; San Martin Island; Abreojos Point; San Hipolito Point; Magdalena Bay; Cape San Lucas; San Quentin Bay (Pleistocene).

Long ago, Cooper gave the range of this species as being from the Farralone Islands off San Francisco, to Lower California. It is common from Monterey southward. Immature specimens often show a faint, brown reticulation or spiral striation under the periostracum. This is sometimes retained to the adult stage as shown by specimens in the California Academy of Sciences, one of which is illustrated here. These markings, together with the shape of the shell suggest relationship with *Conus lucidus* and, to a lesser extent with *Conus dalli.*

Few collectors have published notes on the appearance and behavior of the animals of *Conus* in life. The only instance of this having been done for a west American species which has come to our attention is the record made by Hemphill[89] for *Conus californicus.* This is so informatory that it is fully quoted below.

> The body of this mollusk is whitish in color, and profusely dotted over with black specks that frequently coalesce near the margin of the mantle. When the animal is in motion the foot extends about ¼ of an inch beyond the anterior and posterior ends of the shell. It is truncated in front and bluntly pointed behind. The sole is white and sparsely sprinkled with black specks. The motion of the animal is a constant glide. The proboscis is black, and about ½ inch long when fully extended, and seems to be a specialized portion of the animal's mantle, rolled together with the lower edges in contact but not joined. It curves over and above the back of the shell, as the animal moves forward. Two small tentacles, of a dark color, each 5 millimeters long, protrude from the head near the base of the proboscis, bearing two small keen eyes, which are separated about half way between the tips and the base of the tentacles.
>
> The operculum is horn-color and claw shaped, a portion of the lower or sharp end being free from the animal. [See Pl. 5, fig. 14, one of Hemphill's specimens.]
>
> When the animal is in motion this operculum lies transversely across the upper side of the posterior part of the animal's foot.

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89 Hemphill, H., Zoe, vol. 3, no. 4, Jan. 1893, pp. 351-352. Reprinted, Orcutt, Moll. World, vol. 1, (West Amer. Sci., vol. 20), 1915, pp. 200-201.

> The nucleus of the young shell is white and glassy, and after a few turns the spire resembles a bluntly pointed, round peg. After this the upper end of the whorls rapidly enlarge, as also does the length of the whorls from the anterior end of the shell to the shoulder.
>
> In the adult the body of the shell is covered with numerous revolving lines, more prominent near the anterior end of the shell.
>
> On the spire of some specimens there are also strong revolving lines, while on others these lines are entirely obsolete. The shoulder of the last whorl is rather concave and forms a shallow subcanal around the shell at the base of the spire, but this, like all other characters of shells, is very variable and in some individuals it is absent.
>
> The whole shell is covered with a dirty yellowish epidermis that frequently darkens into chestnut color. The shells are quite brittle and very frequently broken, which perhaps is due to the thin, sharp outer lip, and an excessive amount of carbonate of lime in their composition. The bungling manner in which the animal repairs these fractures does not add to the beauty or attractiveness of the shell, which even in its perfect state is not very inspiring, especially when we consider the beauty of many other cones.

The species has been reported from shell heaps left by the Indians, but we have not learned if these people actually used it for food.

A living specimen of this species was collected at low tide at Monterey, California, February 23, 1945 by Mr. H. B. Truett (Cat. No. 32128-*a* C. A. S.). In this the mantle margin was pink, body white with black flecks scattered sparingly over the surface, much denser, nearly black, at the lower 5 mm. of the siphon. The shell is 33.7 mm. long, 18.2 mm. in diameter and deep purple inside of the aperture. The operculum is horn colored, 8.2 mm. long and 2.3 mm. wide. Upon dissection the radula was missed due to un-

Fig. 4. *Conus californicus* Hinds. Complete tooth. Hypotype, no. 9345 (Paleo. type coll.), from Loc. 32128a (C.A.S.), Monterey, Calif., H. B. Truett, Coll., Feb. 23, 1945.

familiarity with the anatomy. Subsequent treatment of the alimentary organs with sodium hydroxide solution, although carried rather too far, detached the radula and it was found among the residual fibers as a mass of clear, needle-like teeth. The exact form of the entire organ was lost. Individual teeth are hollow and have a canal almost the full length, with a terminal aperture near the outer end. This may function in the injection of poison into an attacked animal although there is no known evidence of such action by this species. However, food habits and general behavior have not been observed, or at least not published. The teeth are sharply pointed, even under high magnification. They each bear five or six very sharp, recurved barbs arranged around the circumference. The terminal aperture of the canal is beneath the second or third barb from the outer end. The canal follows a spiral course through the tooth which seems to agree in general with the direction taken by a buttress on the outside. The canal expands into an elongated bulb toward the base, readily outlined by the enclosed air bubble of a dry tooth, but not very easy to see in the mounted specimen. Altogether, one of these individual teeth has the appearance of a wicked weapon.

Two previous illustrations of teeth have appeared, one by Peile[89a] and one by Tom Burch[89b]. Both of these show very close resemblance to our specimen.

T. S. Oldroyd described a large form as *Conus californicus fossilis* from the Pleistocene of San Pedro, California. The height was given as 40 mm. Living specimens in the California Academy of Sciences from San Pedro exceed this dimension and there appear to be no other stable characters for recognition of the fossil form. Many specimens from Morro Bay, San Luis Obispo County, California, are 40 to 42 mm. in altitude.

A larger fossil species, *C. okhotensis,* from the Okhotsk Sea[90] bears some resemblance to *californicus* but the spire is lower and the figure shows no spiral striae.

Conus ebraeus Linnaeus

Plate 8, Figures 12, 13

Conus ebraeus LINNAEUS, Syst. Nat., ed. 10, 1758, p. 715. *"Habitat in India."* Ed. 12, 1767, p. 1169.—GMELIN, ed. 13, vol. 6, 1790, p. 3384.—DILLWYN, Desc. Cat. Recent Shells, vol. 1, 1817, p. 398. [As *Conus ebraeus.* Excellent early synonymy. Seba is cited as authority for the occurrence of the species in America.]—LAMARCK, Anim. sans Vert., vol. 7, 1822, p. 451. "Habite les mers des chauds de l'Asie, de l'Afrique et de l'Amerique." [As *Conus hebraeus.*]—WOOD, Index, Test., 1828, p. 73, pl. 15, fig. 77. [As *Conus ebraeus.*]—REEVE, Conch. Icon., vol. 1, July, 1843, pl. 19, figs. 104 *a, b.* [As *Conus hebraeus.*] [Fig. 104 *a* is referred to *"C. vermi-*

89a Peile, A. J., Proc. Mal. Soc. London, vol. 23, pt. 6, November, 1939, p. 350, fig. 8.

89b Burch, Tom. Minutes Conch. Club, Southern California, no. 42, December, 1944, p. 29, fig. 23.

90 Dall, W. H. A subtropical Miocene fauna in Arctic Siberia. Proc. U. S. Nat. Mus., vol. 16, 1893, p. 47, pl. 56, fig. 4.

culatus Lamarck."]—Kiener, Icon. Coq. Viv., Genre *Cône*, 1846, p. 45. pl. 4, fig. 2, pl. 8, figs. 3, 3-a. [As *Conus hebraeus*.]—Hertlein, Proc. Amer. Phil. Soc., vol. 78, no. 2, 1937, p. 306, pl. 1, figs. 1, 2.—Dautzenberg, Mem. Mus. Roy. d'Hist. Nat. Belgique, Hors Ser., vol. 2, fasc. 18, 1937, pp. 81-88.—Peile, Proc. Mal. Soc. London, Vol. 23, 1939, p. 352, fig. 16 (radula). "Malindi."

Conus vermiculatus Lamarck, Enc. Méth. Vers., livr. 3, 1798, pl. 321, fig. 1.—Lamarck, Ann. du Mus., vol. 15, 1810, p. 34.—Lamarck, Anim. sans Vert., vol. 7, 1822, p. 451. "Habite les mêmes mers que le précédent" [*hebraeus*.]—Dautzenberg, Mem. Mus. Roy. d'Hist. Nat. Belgique, Hors Ser., vol. 2, fasc. 18, 1937, pp. 88-92. [As var. of *ebraeus*.]

Cucullus chaldaeus Bolten, Mus. Bolt., 1798, p. 42.

Type locality: "India," (Linnaeaus).

Range: Generally distributed in the south seas and extending to Clipperton Island and the Galapagos.

Collecting stations: Hood Island, Galapagos Islands (28347 C. A. S.) and Clipperton Island (23000 C. A. S.). Numerous specimens of both typical *ebraeus* and the variety *vermiculatus* [=*chaldaeus* Bolten] were collected by W. H. Ochsner of the 1905-1906 Expedition of the California Academy of Sciences to the Galapagos Islands.

Seba, Dillwyn, Lamarck and Kiener all recorded this species from American seas, yet it does not seem to have been recognized subsequently until recently. This seems remarkable in view of the striking characters of the shells and the fact that it is not as rare as some others.

The names *ebraeus, haebraeus* and *hebraeus* have been used interchangeably through the literature. Linnaeus and Gmelin used the first consistently. Born[91] changed it to *"hebraeus"* and Bory[92] spelled it *"haebraeus"*; both have been followed extensively. No reason has been found for the displacement of the original spelling.

Both color forms, *ebraeus* and *vermiculatus* and intergrading specimens between them, are found together and have been recorded repeatedly in the literature. Some authors prefer to drop the last name, others prefer to call it a variety while others, as Ostergaard[93] for instance, suggest that it be considered a distinct species. Iredale[94] found the two forms living separately at Lord Howe Island and the Kermedecs and pointed out that the oldest available name for the vermiculate one is *Cucullus chaldaeus* Bolten. Our material indicates the identity of the two.

All of Mr. Ochsner's shells were collected on the beach and are somewhat worn; the largest (from Clipperton) is 31.5 mm. in altitude. A specimen in Stanford University collected by E. K. Jordan in Hawaii is 45 mm. in alti-

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91 Born, I., Test. Mus. Caes. Vind. 1780, p. 159.

92 Bory, J. B., Tableau Enc. Meth., Livr. 10, p. 158, pl. 321, fig. 2, 1827.

93 Ostergaard, J. M. Recent and fossil marine Mollusca of Tongatabu. Bernice P. Bishop Museum, Bull. 131, 1935, pp. 21-22.

94 Iredale, Tom, Mem. Queensland Mus., vol. 9, pt. 3, 1929, p. 282.

tude; other specimens in the California Academy of Sciences collected by Dr. C. H. Edmondson, also in Hawaii, are 55.5 mm. in altitude. No available material from other localities exceeds the last figure.

As demonstrated to us by Miss Myra Keen of Stanford University, the symmetry of this species makes it one of the best for top spinning and this feature is used for amusement by the younger generation of natives in some parts of the world.

Dautzenberg has traced the history of *ebraeus* and *vermiculatus* through the literature back to 1684 giving excellent synonymy and a great many collecting stations.

Conus tessulatus Born

Plate 8, Figures 10, 11, 15; Plate 10, Figures 1-4

Conus tessulatus Born, Index Rer. Nat., Pt. 1, Test., 1778 [1780], p. 131.—Born, Test. Mus. Caes. Vind., 1780, p. 151.—[According to Iredale, (Mem. Queensland Mus., vol. 9, pt. 3, June 29, 1929, p. 281), both of Born's publications appeared in 1780.]—Tomlin, Proc. Mal. Soc. London, vol. 22, pt. 5, July 21, 1937, p. 321.—Peile, Proc. Mal. Soc. London, vol. 23, 1939, p. 352, fig. 23 (radula). "Mombasa."

Conus tesselatus Born, Dillwyn, Desc. Cat. Rec. Shells, vol. 1 1817, p. 358.—Sowerby, Conch. Ill., Dec. 1838, p. 120, pl. 148, figs. 27, 28.—Reeve, Conch. Icon., vol. 1, Oct. 1843, pl. 28, fig. 163.—Kiener, Icon. Coq. Viv., Genre *Cône,* 1847, pl. 17, fig. 1.—Sowerby, Thes. Conch., vol. 3, 1857, p. 24, pl. 198 [*Conus* pl. 12], figs. 250, 251; "Ceylon, Mauritius, Philippines."—Tryon, Man. Conch., vol. 6, 1883, p. 11, pl. 2, figs. 26, 27.—Dautzenberg, Res. Scient. Voy. Ind. Orient. Néerlandaises, vol. 2, fasc. 18, 1937, pp. 240-245, pl. 2, fig. 12.

Conus edaphus Dall, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 223. "Off Clarion Island in 31 fathoms, sand."

Type locality: Unknown.

Range: West coast of Mexico, Japan, and Hawaii, through the south seas to Australia and east Africa.

Collecting stations: The species was not obtained by the expeditions of either the Academy or the New York Zoological Society but Mr. George Willett of the Los Angeles Museum collected one specimen at Clarion Island, Revillagigedo Group. Length, 21.3 mm.; diameter, 12.7 mm. 20-40 fms.; March 24, 1938.

This specimen has been illustrated beside a specimen of *tessulatus* of comparable size from Huaheine Island, South Pacific, received from Garrett through the Hemphill collection. Exhaustive search for distinguishing characters for the American form has been without success. Through the kindness of Dr. Paul Bartsch of the U. S. National Museum a photograph of the holotype of *Conus edaphus* Dall is published herewith.

Dautzenberg has lately given an excellent synonymy covering four pages and showed the distribution to be very wide in tropical and subtropical seas.

The nearest records to Clarion Island are Hawaii, Japan, Guam, Loo Choo Islands, etc.

Born originally spelled the species name "*tessulatus*" but subsequent authors have mostly followed Bruguière and Lamarck in writing it "*tesselatus*."

The group to which *tessulatus* belongs inhabited American waters as early as the lower Pliocene, as shown by the following species, and cannot be considered a recent migrant into this area.

Conus bramkampi Hanna & Strong, sp. nov.

Plate 8, Figure 14

Conus regularis SOWERBY, HANNA, Proc. Calif. Acad. Sci., Ser. 4, vol. 14, 1926, no. 18, p. 447, pl. 21, fig. 8.

Spire low, gently concave, suture lightly impressed, without groove, whorls about 10; shoulder rounded; color markings consist of a uniform series of square brown spots in spiral rows, rather distantly spaced. Length 48 mm., diameter 30.5 mm.

Holotype, No. 34199 (Univ. Calif. Mus. Paleo.), from Loc. A-1269 (U. C.), "south side of **Carrizo Mountain, Imperial County, California;** Pliocene; in a small canyon about ⅜ mile east of the mouth of Alverson Canyon in small draws cut in basal conglomerate on west side of canyon, 100-120 yards from its mouth." (Bramkamp).

The species is named for Mr. R. A. Bramkamp, Paleontologist, California Arabian Standard Oil Company, who collected the specimen along with many other forms. The well preserved type specimen shows the color markings better than a previous lot which was identified by one of the present authors as *Conus regularis* when adequate comparative material and literature were not available. The relationship is plainly with *tessulatus* and it indicates that the group is no late migrant into the region, as might be supposed from the rare occurrence of living specimens here.

UNVERIFIED RECORDS

In the preceding pages an attempt has been made to allocate the records found in the literature to the proper species. As usual in such studies this has not always been possible and there remains a residue of references, the taxonomic information pertaining to which, is simply insufficient to enable a reasonable evaluation to be made. In order that the student of the fauna may have these records assembled in one place, they have been collected and are presented herewith. Additional work in the future may permit the finding of those which are purely erroneous as well as those which may, perhaps, pertain to west American species. Annotations have been added in some cases but it must be emphasized that expressions of opinion have very little in way of facts to bear them out.

1. *Conus concinnus* BRODERIP, Proc. Zool. Soc. London, 1833, p. 53. "Gulf of California." Renamed *C. concinnulus* by Crosse, Rev. Mag. Zool., Ser. 2, Vol. 10, 1858, p. 200. According to Dall, (Proc. U. S. Nat. Mus., Vol. 38, 1910, p. 227), this is not a *Conus* but a *Meta* of Columbellidae.

2. *Conus dupontii* KIENER, Icon. Coq. Viv., Genre *Cône,* 1849, p. 273, pl. 61, fig. 2. This species is a common Gulf of California shell and belongs to the Columbellidae.

3. *Conus exquisitus* SOWERBY, Thes. Conch., Vol. 3, 1887, p. 274, pl. 36 [512], fig. 757. "Hab. California." According to Dall, (Proc. U. S. Nat. Mus., Vol. 38, 1910, p. 228), this is almost certainly not west American.

4. *Conus ferrugatus* SOWERBY, Proc. Zool. Soc. London, 1834, p. 19. "Hab. ad Sinum Californiae et apud Insulam Guaymas." Sowerby, (Thes. Conch., Vol. 3, 1857, p. 51) said the shell was unknown to him. Tryon, (Man. Conch., Vol. 6, 1884, p. 106), however, stated that the shell was a var. of *C. cingulatus* Lamarck. Weinkauff made the same suggestion.

5. *Conus fusiformis* MAWE, Linn. Syst. Conch., 1823, p. 87. "California." Tryon, (Man. Conch., Vol. 6, 1884, p. 93), stated that Lamarck's *fusiformis* was indeterminate; Tomlin, (Proc. Mal. Soc. London, Vol. 22, 1937, p. 251), however, renamed it *atractus* because of prior usage. Lamarck gave no locality. If Kiener's figure, (Incon. Coq. Viv., Genre *Cône,* 1848, p. 194, pl. 76, fig. 3), can be relied upon as authentic, and his specimens apparently came from the Lamarck collection, nothing similar has been found in the present study. Kiener gave the locality, questionably as Pacific Ocean. It is not believed to be part of the west American fauna.

6. *Conus hieroglyphus* DUCLOS, Mag. Zool., Ann. 2, pl. 23, 1833. "California." According to Dall, (Proc. U. S. Nat. Mus., Vol. 38, 1910, p. 228), the species is Indo-Pacific.

7. *Conus philippii* KIENER, Icon. Coq. Viv., Genre, *Cône,* 1848, p. 213, pl. 98, fig. 2. "Habite les côtes du Mexique." Tryon, (Man. Conch., Vol. 6, 1884, p. 118), and Tomlin, (Proc. Mal. Soc. London, Vol. 22, 1937 p. 291), placed this species in synonymy of *Conus tornatus* Broderip. We have found no specimens in the collections studied which approach Kiener's figures very closely.

8. *Conus scalptus* REEVE, Conch. Icon., Vol. 1, 1843, pl. 37, sp. 203. "Hab." WEINKAUFF, (Jahresb. d. Deutch. Mal. Ges., Vol. 1, 1874, pp. 247-291), recorded the species from California. It is undoubtedly an error so far as California is concerned and probably was not found in Lower California or the Gulf.

9. *Conus sieboldii* REEVE, Conch. Icon., Suppl. *Conus,* pl. 1, sp. 269, Feb. 1848, "Japan." Dall, (Proc. U. S. Nat. Mus., Vol. 38, 1910, p. 226), listed the species questionably from a fragment dredged near the Galapagos Islands in 300 fathoms.

10. *Conus unicolor* SOWERBY, Conch. Ill., 1834, pt. 54, fig. 59; no locality given; not *C. unicolor* SOWERBY pt. 28, 1833, fig. 20. According to Tomlin, (Proc. Mal. Soc. London, Vol. 22, 1937, p. 325), the 1834 figure was renamed *concolor* in "large list." Dall, (Proc. U. S. Nat. Mus., Vol. 38, 1910, p. 226), stated that Stearns' shell from Acapulco agreed with the original figure.

11. *Conus unifasciatus* KIENER, Icon. Coq. Viv., Genre *Cône,* 1849, p. 361, pl. 110, fig. 4; no locality cited. Tryon, (Man. Conch., Vol. 6, 1883, p. 18), suggested that this may be *Conus californicus.* The figure is dark brown with a lighter colored band around the shoulder. We have seen no specimen of *californicus* which suggests union although the shape is similar.

EXPLANATION OF THE PLATES

PLATE 5

Fig. 1. *Conus archon* BRODERIP. Hypotype, no. 9300 (Paleo. type coll.), from Loc. 27584 (C.A.S.), Lat. 23°03' to 06'N., Long. 109°31'W., off Cape San Lucas, Lower California, 20-220 fathoms. Templeton Crocker Exp., 1932. Length 63 mm., diameter 33.5 mm.; p. 285.

Fig. 2. *Conus arcuatus* BRODERIP. Hypotype, no. 9298 (Paleo. type coll.), from Loc. 27574 (C.A.S.), Lat. 18°33'N., Long. 103°45'W., 47 miles southeast of Manzanillo, Mexico, 52 fathoms. Templeton Crocker Exp., 1932. Length 31 mm., diameter 14.5 mm.; p. 292.

Fig. 3. *Conus arcuatus* BRODERIP. Hypotype, no. 9299 (Paleo. type coll.), from same locality as fig. 2. Length 33.5 mm., diameter 15 mm.; p. 292.

Fig. 4. *Conus arcuatus* BRODERIP. Hypotype, no. 9297 (Paleo. type coll.), from Station 135-D-18 (N.Y.Z.S.), Lat. 23°30'N., Long. 109°25'W., Arena Bank, east coast of Lower California, 40 fathoms. Length 40.5 mm., diameter 20 mm.; p. 292.

Fig. 5. *Conus bartschi* HANNA & STRONG, sp. nov. Holotype, no. 9296 (Paleo. type coll.), from Loc. 27587 (C.A.S.), 20-25 fathoms off Cape San Lucas, Lower California. Templeton Crocker Exp., 1932. Length 49 mm., diameter 30 mm.; p. 271.

Fig. 6. *Conus diadema* SOWERBY. Hypotype, no. 9295 (Paleo. type coll.), from Loc. 23777 (C.A.S.), Clarion Island (Revillagigedo Group), Mexico, between tides. G. D. Hanna and E. K. Jordan, Colls. Length 33.5 mm., diameter 20 mm.; p. 270.

Fig. 7. *Conus diadema pemphigus* DALL. Hypotype, no. 9294 (Paleo. type coll.), from Loc. 23004 (C.A.S.), Cocos Island, Costa Rica, between tides. W. H. Ochsner, Coll. Length 28.5 mm., diameter 14 mm.; p. 271.

Fig. 8. *Conus brunneus* WOOD. Hypotype, no. 9293 (Paleo. type coll.), from Loc. 28187 (C.A.S.), Albemarle Island (Galapagos Group), Ecuador, between tides. W. H. Ochsner, Coll. Length 58.5 mm., diameter 36 mm.; p. 269.

Fig. 9. *Conus brunneus* WOOD. Hypotype, no. 9291 (Paleo. type coll.), from Loc. 23005 (C.A.S.), Hood Island (Galapagos Group), Ecuador, between tides. W. H. Ochsner, Coll. Length 44.5 mm., diameter 26 mm.; p. 269.

Fig. 10. *Conus brunneus* WOOD. Hypotype, no. 9292 (Paleo. type coll.), from same locality as fig. 8. Length 56 mm., diameter 37 mm.; p. 269.

Fig. 11. *Conus "brunneus" [diadema] pemphigus* DALL. Holotype, "Cat. no. 37449*a* (U.S.N.M.), from Tres Marias Islands, west of Mexico." Length 26 mm., diameter 17 mm. Photograph published through the courtesy of Dr. Paul Bartsch; p. 271.

Fig. 12. *Conus dalli* STEARNS. Hypotype, no. 9290 (Paleo. type coll.), from Loc. 24108 (C.A.S.), Maria Magdalena Island (Tres Marias Group), Mexico; beach shell. G. D. Hanna and E. K. Jordan, Colls. Length 50 mm., diameter 26.8 mm.; p. 304.

Fig. 13. *Conus lucidus* WOOD. Hypotype, no. 9303 (Paleo. type coll.), from Loc. 1337 (C.A.S.), Magdalena Bay, Lower California. Henry Hemphill, Coll. Length 50.3 mm., diameter 27 mm.; p. 307.

Fig. 14. *Conus californicus* HINDS. Hypotype, no. 9304 (Paleo. type coll.), from Loc. 13988 (C.A.S.), San Pedro, California, between tides. Henry Hemphill, Coll. Length 40 mm., diameter 20.5 mm., length of operculum 9.5 mm.; p. 308.

Fig. 15. *Conus californicus* HINDS. Hypotype, no. 9305 (Paleo. type coll.), from Loc. 27600 (C.A.S.), dredged in 25 fathoms "above long spit," San Martin Island, west coast of Lower California. Templeton Crocker Exp., 1932. Length 21.2 mm., diameter 13.2 mm.; p. 308.

Fig. 16. *Conus durhami* HANNA & STRONG, sp. nov. Holotype, no. 34200 (Univ. Calif. Mus. Paleo.), from Loc. A1269 (U.C.), south side of Carrizo Mountain, Imperial County, California, Pliocene. Length 39.5 mm., diameter 25.5 mm.; p. 306.

All of the specimens illustrated on this plate, except the ones shown as figures 11 and 16, have been deposited in the type collection of the California Academy of Sciences.

PLATE 6

Fig. 1. *Conus gradatus* MAWE. Hypotype, no. 9306 (Paleo. type coll.), from Loc. 1338 (C.A.S.), Scammon Lagoon, Lower California, Henry Hemphill, Coll. Length 55.5 mm., diameter 27 mm.; p. 279.

Fig. 2. *Conus regularis* SOWERBY. Hypotype, no. 9307 (Paleo. type coll.), from Loc. 28186 (C.A.S.), Kino Bay, Sonora, Mexico, H. N. Lowe, Coll. Length 59 mm., diameter 32 mm.; p. 282.

Fig. 3. *Conus scalaris* VALENCIENNES. Hypotype, no. 9308 (Paleo. type coll.), from Loc. 27587 (C.A.S.), off Cape San Lucas, Lower California, 20-25 fathoms, Templeton Crocker Exp., 1932. Length 37.7 mm., diameter 15.4 mm.; p. 283.

Fig. 4. *Conus scalaris* VALENCIENNES. Hypotype, no. 9309 (Paleo. type coll.), from Sta. 142-D-1 (N.Y.Z.S.), Lat. 27°05′N., Long. 111°56′W., Santa Inez Bay, Lower California, 30-54 fathoms. Length 64.5 mm., diameter 25 mm.; p. 283.

Fig. 5. *Conus scalaris* VALENCIENNES. Hypotype, no. 9310 (Paleo. type coll.), from Sta. 136-D-16 (N.Y.Z.S.), Lat. 23°29′30″N., Long. 109°25′30″W., Arena Bank, east coast of Lower California, 45 fathoms. Length 47 mm., diameter 17 mm., p. 283.

Fig. 6. *Conus scalaris* VALENCIENNES. Hypotype, no. 9311 (Paleo. type coll.), from same locality as fig 4. Length 64.5 mm., diameter 25 mm.; p. 283.

Fig. 7. *Conus recurvus* BRODERIP. Hypotype, no. 9312 (Paleo. type coll.), from Loc. 27584 (C.A.S.), Lat. 23°03′ to 06′N., Long. 109°31′ to 36′W., off Cape San Lucas, Lower California, 20 to 220 fathoms, Templeton Crocker Exp., 1932. Length 50.8 mm., diameter 22.5 mm.; p. 280.

Fig. 8. *Conus recurvus* BRODERIP. Hypotype, no. 9313 (Paleo. type coll.), from Sta. 214-D-1 to 4 (N.Y.Z.S.), Lat. 9°19′32″ to 17′40″N., Long. 84°29′30″ to 27′30″W., 14 miles S x E of Judas Point, Costa Rica, 42 to 61 fathoms. Length 85 mm., diameter 41.8 mm.; p. 280.

Fig. 9. *Conus recurvus* BRODERIP. Holotype of *Conus scariphus* DALL, no. 123085 (U.S. Nat. Mus.), from U.S. Bureau of Fisheries steamer *Albatross* Sta. 3368, 66 fathoms, off Cocos Island, Costa Rica. Length 41 mm., diameter 15 mm. Photograph published through the courtesy of Dr. Paul Bartsch; p. 280.

Fig. 10. *Conus virgatus* REEVE. Hypotype, no. 9314 (Paleo. type coll.), from Loc. 24085 (C.A.S.), San Carlos Bay, Sonora, Mexico, Fred Baker, Coll., 1921, between tides. Length 56.8 mm., diameter 28.7 mm.; p. 301.

Fig. 11. *Conus dispar* SOWERBY. Hypotype, no. 9315 (Paleo. type coll.), from same locality as fig. 7. Length 22.5 mm., diameter 9 mm. The specimen is intermediate between *Conus regularis* and *Conus scalaris;* p. 284.

Fig. 12. *Conus patricius* HINDS. Operculum of specimen illustrated on plate 9, fig. 8. Length 22 mm., width 18.5 mm., thickness 3.3 mm.; p. 300.

Fig. 13. *Conus recurvus* BRODERIP. Copy of photograph of holotype of *Conus magdalenensis* after Bartsch & Rehder, (Smithsonian Misc. Coll., vol. 98, no. 10, 1939, p. 4,

pl. 1, fig. 9). No. 472521 (U.S. Nat. Mus.), from Magdalena Bay, Lower California, 10-15 fathoms, Waldo L. Schmitt, Coll. Length 33.6 mm., diameter 15.3 mm.; p. 280.

All of the specimens illustrated on this plate, except those shown as figures 9, 12, and 13, have been deposited in the type collection of the California Academy of Sciences.

PLATE 7

Fig. 1. *Conus fergusoni* SOWERBY, [*xanthicus* DALL]. Hypotype no. 9318 (Paleo. type coll.), from Station 163-D-2 (N.Y.Z.S.), Lat. 18°19'N., Long. 114°45'W., 55 fathoms, 3 miles off Pyramid Rock, Clarion Island, Mexico. Length 29.2 mm., diameter 14 mm.; p. 294.

Fig. 2. *Conus fergusoni* SOWERBY, [*xanthicus* DALL]. Hypotype, no. 9317 (Paleo. type coll.), from Station 150-D-16 (N.Y.Z.S.), Lat. 23°02'N., Long. 109°30'30"W., 67-75 fathoms, Gorda Banks, Gulf of California, periostracum intact. Length 44.0 mm., diameter 21.3 mm.; p. 294.

Fig. 3. *Conus fergusoni* SOWERBY. Hypotype, no. 9319 (Paleo type coll.), from Loc. 27587 (C.A.S.), 20-25 fathoms off Cape San Lucas, Lower California, Templeton Crocker Exp., 1932. Length 81 mm., diameter 46.4 mm.; p. 294.

Fig. 4. *Conus fergusoni* SOWERBY. Holotype of *Conus xanthicus* DALL, no. 111236 (U.S. Nat. Mus.), from off Guaymas, Mexico, 71 fathoms. Length 42 mm., diameter 22.5 mm. Specimen illustrated through the courtesy of Dr. Paul Bartsch; p. 294.

Fig. 5. *Conus gladiator* BRODERIP. Hypotype, no. 9323 (Paleo. type coll.), from Loc. 27563 (C.A.S.), Gulf of Fonseca, Salvador-Honduras boundary, littoral; Templeton Crocker Exp., 1932. Length 36.7 mm., diameter 22 mm.; p. 273.

Fig. 6. *Conus nux* BRODERIP. Hypotype, no. 9324 (Paleo. type coll.), from Loc. 28346 (C.A.S.), Academy Bay, Albemarle Island, Galapagos; W. H. Ochsner, Coll., 1906. Length 19.5 mm., diameter 12.6 mm.; p. 274.

Fig. 7. *Conus nux* BRODERIP. Hypotype, no. 9325 (Paleo. type coll.), from Loc. 28346 (C.A.S.), Academy Bay, Albemarle Island, Galapagos; W. H. Ochsner, Coll., 1906. Length 21.9 mm., diameter 13.5 mm.; p. 274.

Fig. 8. *Conus princeps* var. *lineolatus* VALENCIENNES. Hypotype, from Las Perlas Islands, Panama Bay, in the collection of Los Angeles Museum of History, Science and Art; W. D. Clark, Coll. Length 57.4 mm., diameter 34.4 mm. Specimen illustrated through the courtesy of Dr. Howard Hill; p. 278.

Fig. 9. *Conus princeps* var. *apogrammatus* DALL. Holotype, no. 37404 (U.S. Nat. Mus.), from Panama. Measurements not recorded, presumably natural size. Specimen illustrated through the courtesy of Dr. Paul Bartsch; p. 278.

Fig. 10. *Conus princeps* LINNAEUS. Hypotype, no. 9326 (Paleo. type coll.), from Santa Inez Bay, Lower California, N. Y. Zool. Soc. 1938 Exp., Coll.; showing periostracum. Length 54.6 mm., diameter 33.5 mm.; p. 275.

Fig. 11. *Conus princeps* LINNAEUS. Hypotype, no. 9331 (Paleo. type coll.), from Loc. 1259 (C.A.S.), Gulf of California; Henry Hemphill, Collector. Length 81.5 mm., diameter 48.8 mm.; p. 275.

Fig. 12. *Conus tiaratus* BRODERIP. Hypotype, no. 9312 (Paleo. type coll.), from Loc. 28348 (C.A.S.), Albemarle Island, Galapagos; W. H. Ochsner, Coll., 1906. Length 30.5 mm., diameter 18.2 mm.; p. 272.

Fig. 13. *Conus princeps* var. *apogrammatus* Dall. Hypotype, in Los Angeles Museum of History, Science and Art, from Venado Island, Panama Bay, W. D. Clark, Coll. Length 44.2 mm., diameter 25.5 mm.; p. 278.

All of the specimens illustrated on this plate, except those shown as figures 4, 8, 9, and 13, have been deposited in the type collection of the California Academy of Sciences.

PLATE 8

Fig. 1. *Conus perplexus* Sowerby. Hypotype, no. 9321 (Paleo. type coll.), from Loc. 27581 (C.A.S.), between Isabel Island and Mazatlan, Mexico; Templeton Crocker Exp., 1932. Length 29.4 mm., diameter 16 mm.; p. 289.

Fig. 2. *Conus perplexus* Sowerby. Hypotype, no. 9320 (Paleo. type coll.), from Loc. 27849 (C.A.S.), Lat. 23°12'N., Long. 106°29'W., Gulf of California, 12 fathoms; Templeton Crocker Exp., 1932. Length 26.2 mm., diameter 15.5 mm.; p. 289.

Fig. 3. *Conus perplexus* Sowerby. Hypotype, no. 9322 (Paleo. type coll.), from Loc. 27226 (C.A.S.), Corinto, Nicaragua, L. G. Hertlein, Coll., 1932. Length 24.9 mm., diameter 18.5 mm.; p. 289.

Fig. 4. *Conus tornatus* Broderip. Hypotype, no. 9329 (Paleo. type coll.), from Loc. 27588 (C.A.S.), Lat. 24°14'-18" N., Long. 111°28'-29"W., about 13 miles southeast of Cape Tosca, Santa Margarita Island, Lower California; Templeton Crocker Exp., 1932. Length 22.3 mm., diameter 10.0 mm.; p. 291.

Fig. 5. *Conus tornatus* Broderip. Hypotype, no. 9330 (Paleo. type coll.), from Loc. 27588 (C.A.S.), Lat. 24°14'-18"N., Long. 111°28'-29"W., about 13 miles southeast of Cape Tosca, Santa Margarita Island, Lower California; Templeton Crocker Exp., 1932. Length 23.4 mm., diameter 9.8 mm.; p. 291.

Fig. 6. *Conus tornatus* Broderip. Hypotype, no. 9328 (Paleo. type coll.), from Loc. 27527 (C.A.S.), Acapulco, Mexico, dredged in Bay; Templeton Crocker Exp., 1932. Length 23 mm., diameter 9.8 mm.; p. 291.

Fig. 7. *Conus tornatus* Broderip. Hypotype, no. 9327 (Paleo. type coll.), from Loc. 27569 (C.A.S.), Gulf of Tehuantepec, Mexico, 28 fathoms; Templeton Crocker Exp., 1932. Length 22.5 mm., diameter 9.7 mm.; p. 291.

Fig. 8. *Conus vittatus* Bruguière. Hypotype, no. 9348 (Paleo. type coll.), from Loc. 20439 (C.A.S.), Mazatlan, Mexico; A. Russell Crowell, Coll., 1920. Length 35.8 mm., diameter 21.9 mm.; p. 296.

Fig. 9. *Conus vittatus* Bruguière. Hypotype from Maria Magdalena Island, Mexico, No. A1207, Los Angeles Museum of History, Science and Art. Length 32.0 mm., diameter 17.5 mm. Specimen illustrated through the courtesy of Dr. Howard Hill; p. 296.

Fig. 10. *Conus tessulatus* Born. Holotype of *Conus edaphus* Dall, no. 130305 (U.S. Nat. Mus.), from Clarion Island, Mexico, 31 fathoms. Length 25 mm., diameter 14 mm.; p. 312.

Fig. 11. *Conus tessulatus* Born. Hypotype from Clarion Island, Mexico, no. A 375, Los Angeles Museum of History, Science and Art; 20 to 40 fathoms, George Willett, Coll. Length 21.3 mm., diameter 12.7 mm. Specimen illustrated through the courtesy of Mr. George Willett and Dr. Howard Hill; p. 312.

Fig. 12. *Conus ebraeus* Linnaeus. Hypotype, no. 7056 (Paleo. type coll.), from Loc. 23000 (C.A.S.), Clipperton Island; W. H. Ochsner, Coll., 1906. Length 31.9 mm., diameter 20.5 mm. After Hertlein, Proc. Amer. Phil. Soc., vol. 78, no. 2, 1937, p. 306, pl. 1, fig. 2; p. 311.

Fig. 13. *Conus ebraeus* Linnaeus (var. *chaldeus* Bolten). Hypotype, no. 7058, (Paleo. type coll.), from Loc. 23001 (C.A.S.), Clipperton Island; W. H. Ochsner, Coll., 1906. Length 24.5 mm., diameter 16.3 mm. After Hertlein, Proc. Amer. Phil. Soc., vol. 78, no. 2, 1937, p. 306, pl. 1, fig. 7; p. 311.

Fig. 14. *Conus bramkampi* Hanna & Strong sp. nov. Holotype, no. 34199 (Univ. of Calif. Mus. Paleo.), from south side of Carrizo Mountain, Imperial County, California; Pliocene., R. A. Bramkamp, Coll. Length 48 mm., diameter 30.5 mm.; p. 313.

Fig. 15. *Conus tessulatus* Born. Hypotype, no. 9332 (Paleo. type coll.), from Loc. 1224 (C.A.S.), Huaheine Island, Garrett, Coll. Length 28 mm., diameter 16 mm.; p. 312.

Fig. 16. *Conus mahogani* Reeve. Hypotype, no. 9333 (Paleo. type coll.), from Loc. 28365 (C.A.S.), Puntarena, Costa Rica; H. N. Lowe, Coll. Length 38.5 mm., diameter 17.5 mm.; p. 289.

Fig. 17. *Conus ximenes* Gray. Hypotype, no. 9337 (Paleo. type coll.), from Loc. 24077 (C.A.S.), Angeles Bay, Lower California; Fred Baker, Coll. Length 43 mm., diameter 21.2 mm.; p. 286.

Fig. 18. *Conus tiaratus* Broderip. Holotype of *Conus roosevelti* Bartsch & Rehder, (Smith. Misc. Coll., vol. 98, no. 10, 1939, p. 3, pl. 1, fig. 7), from Magdalena Bay, Lower California. Length 15.3 mm., diameter 9.6 mm.; p. 272.

Fig. 19. *Conus purpurascens* Broderip. Hypotype, no. 9334 (Paleo. type coll.), from Loc. 27527 (C.A.S.), Acapulco Bay, Mexico; Templeton Crocker Exp., 1932. Length 49.4 mm., diameter 28.4 mm.; p. 298.

Fig. 20. *Conus purpurascens* Broderip. Hypotype, no. 9335 (Paleo. type coll.), from Loc. 27223 (C.A.S.), Mazatlan, Mexico; L. G. Hertlein, Coll., 1931. Length 30.5 mm., diameter 17.7 mm.; p. 298.

All of the specimens illustrated on this plate, except those shown as figures 9, 10, 11, 14, and 18, have been deposited in the type collection of the California Academy of Sciences.

PLATE 9

Fig. 1. *Conus purpurascens* Broderip. Holotype, of var. *rejectus* Dall, no. 34710 (U.S. Nat. Mus.), from Escondido Bay, Lower California. Specimen illustrated through the courtesy of Dr. Paul Bartsch; p. 298.

Fig. 2. *Conus purpurascens* Broderip. Hypotype, no. 9336 (Paleo. type coll.), from Loc. 1306 (C.A.S.), Magdalena Bay, Lower California; Henry Hemphill Collection. Length 54.5 mm., diameter 32.0 mm.; p. 298.

Fig. 3. *Conus purpurascens* Broderip. Hypotype from Venado Island, Panama Bay, W. D. Clark, Coll.; specimen in the collection of Stanford University and illustrated through the courtesy of Dr. A. Myra Keen. This is an immature shell and shows an extreme in coloration. Length 30.9 mm., diameter 16.5 mm.; p. 298.

Fig. 4. *Conus perplexus* Sowerby. Hypotype from San Jose Island, Panama Bay, W. D. Clark, Coll.; specimen in the collection of Stanford University and illustrated through the courtesy of Dr. A. Myra Keen. Length 41.5 mm., diameter 22 mm.; p. 289.

Fig. 5. *Conus virgatus* Reeve. Hypotype from Bruja Point, Panama Bay, W. D. Clark, Coll.; specimen in the collection of Stanford University and illustrated through the courtesy of Dr. A. Myra Keen. Length 36 mm., diameter 17.3 mm.; p. 301.

Fig. 6. *Conus patricius* Hinds. Hypotype, no. 9346 (Paleo. type coll.), from Loc. 27332 (C.A.S.), San Juan Del Sur, Nicaragua, H. N. Lowe, Coll. Length 51 mm., diameter 29.5 mm.; p. 300.

Fig. 7. *Conus patricius* HINDS. Hypotype, no. 9347 (Paleo. type coll.), rom Loc. 27332 (C.A.S.), San Juan Del Sur, Nicaragua, H. N. Lowe, Coll. Length 57 mm., diameter 31 mm.; p. 300.

Fig. 8. *Conus patricius* HINDS. Hypotype from Venado Flats, Panama Bay, W. D. Clark, Coll.; specimen in the collection of Stanford University and illustrated through the courtesy of Dr. A. Myra Keen. Length 140 mm., diameter 89.5 mm.; p. 300.

Fig. 9. *Conus patricius* HINDS. Dried egg capsules from specimen illustrated in fig. 8; p. 300.

The specimens illustrated by figures 2, 6, and 7 have been deposited in the type collection of the California Academy of Sciences.

PLATE 10

Fig. 1. "*Conus tessulatus* HWASS. Type ? 326/7. Length 49.5 mm., diameter 32 mm. Coll. Hwass." Mermod; p. 312.

Fig. 2. "*Conus tessulatus* HWASS. Diameter 31.5 mm.; 11 tours di spire. Coll. Lk." Mermod; p. 312.

Fig. 3. "*Conus tessulatus* HWASS. Coll. Lk." Mermod; p. 312.

Fig. 4. "*Conus tessulatus* HWASS. Coll. Lk." Mermod; p. 312.

Fig. 5. "*Conus tessulatus* HWASS. Coll. Hwass." Mermod; p. 312.

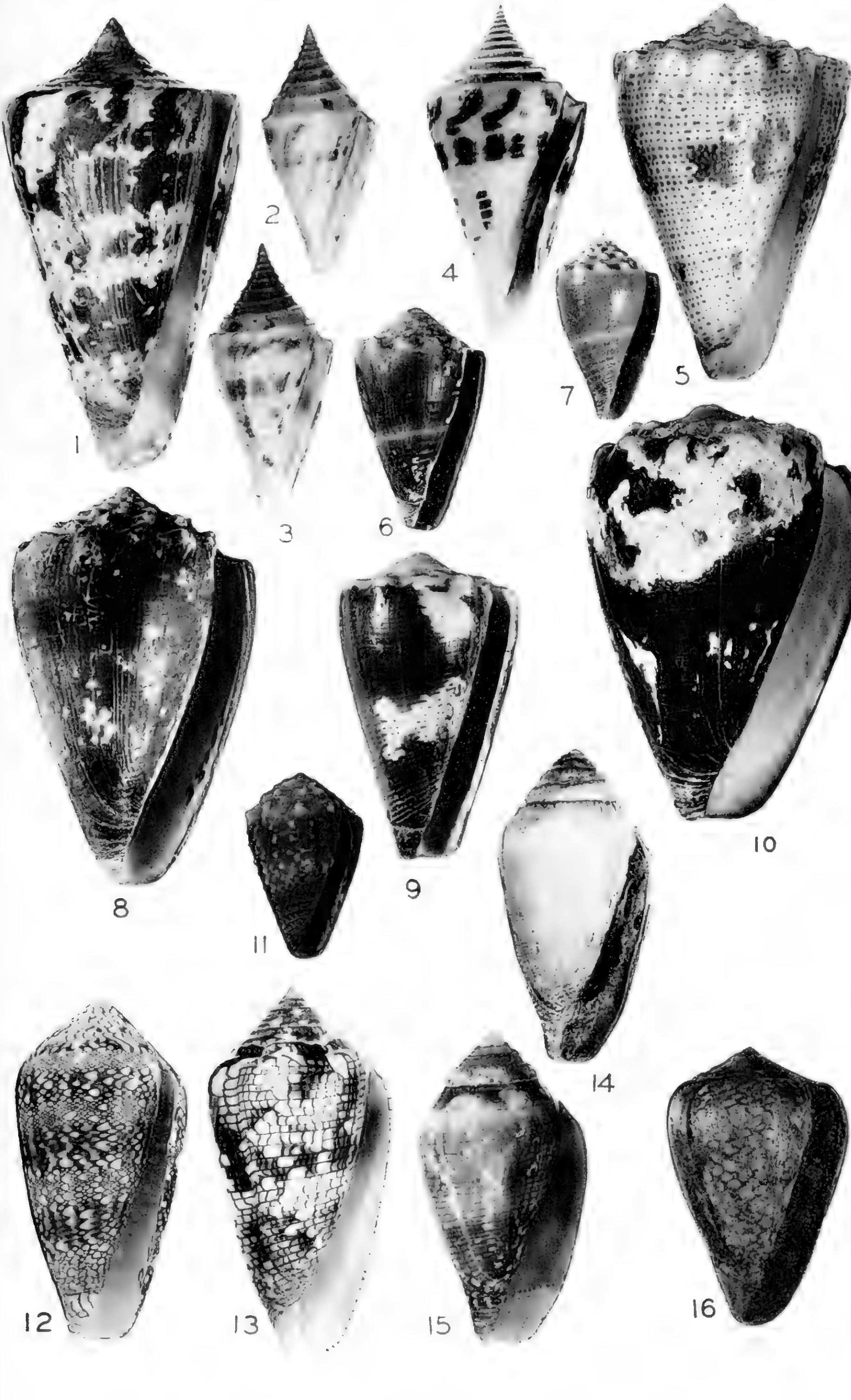
Fig. 6. "*Conus vittatus* HWASS. Type de Hwass?" Mermod; p. 296.

Fig. 7. "*Conus vittatus* HWASS. Coll. Hwass." Mermod; p. 296.

Fig. 8. "*Conus vittatus* HWASS. Coll. Hwass. Delessert. Length 38 mm., diameter 20.5 mm." Mermod; p. 296.

Fig. 9. "*Conus vittatus* HWASS." Same specimen as fig. 8. "Greatest diameter 22-75 mm." Mermod; p. 296.

The specimens illustrated on this plate are from the original collections of Hwass and Lamarck and are now deposited in the Muséum d'Histoire Naturelle, Geneva, Switzerland. The photographs were made available for this report by Dr. G. Mermod of that institution.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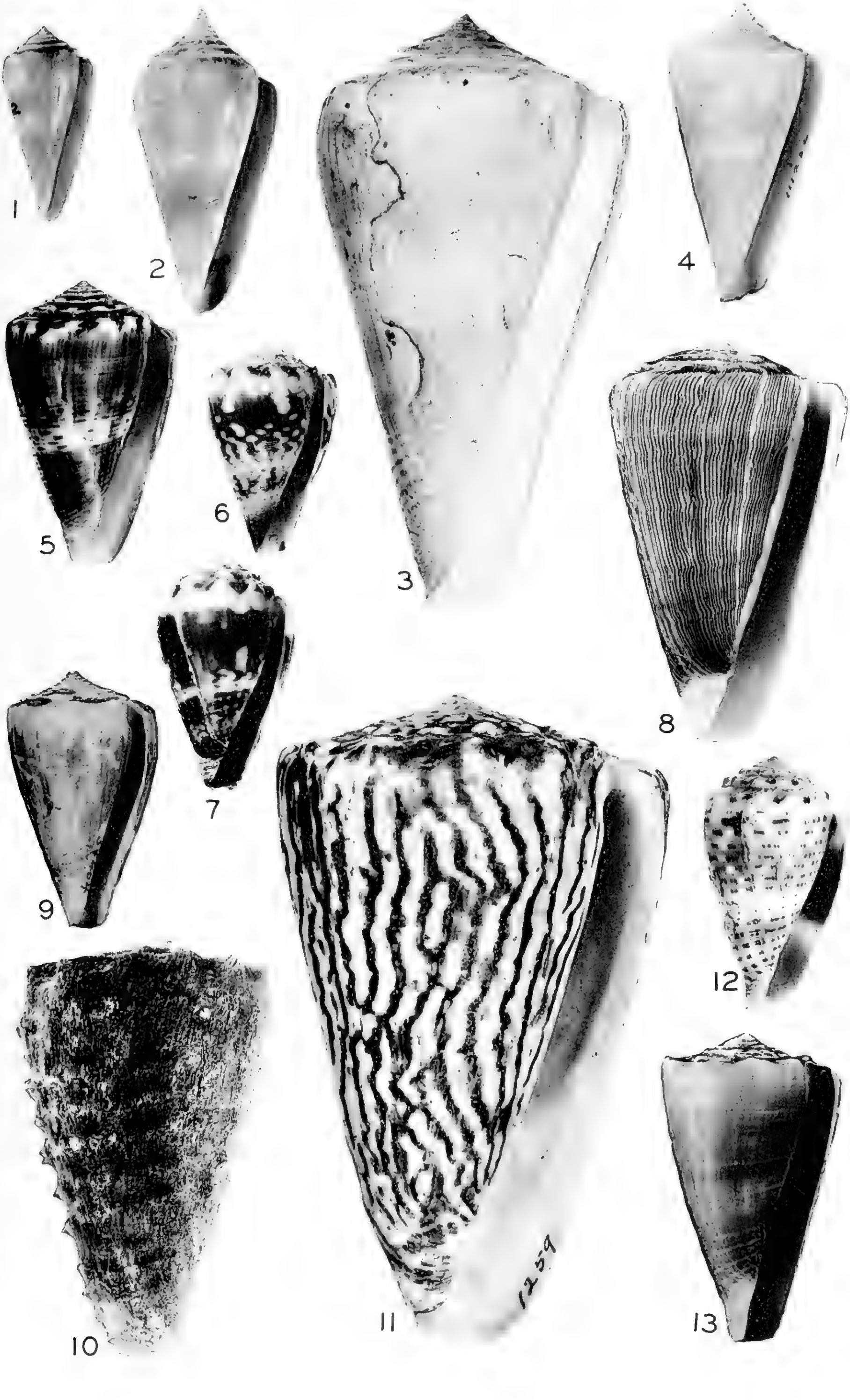
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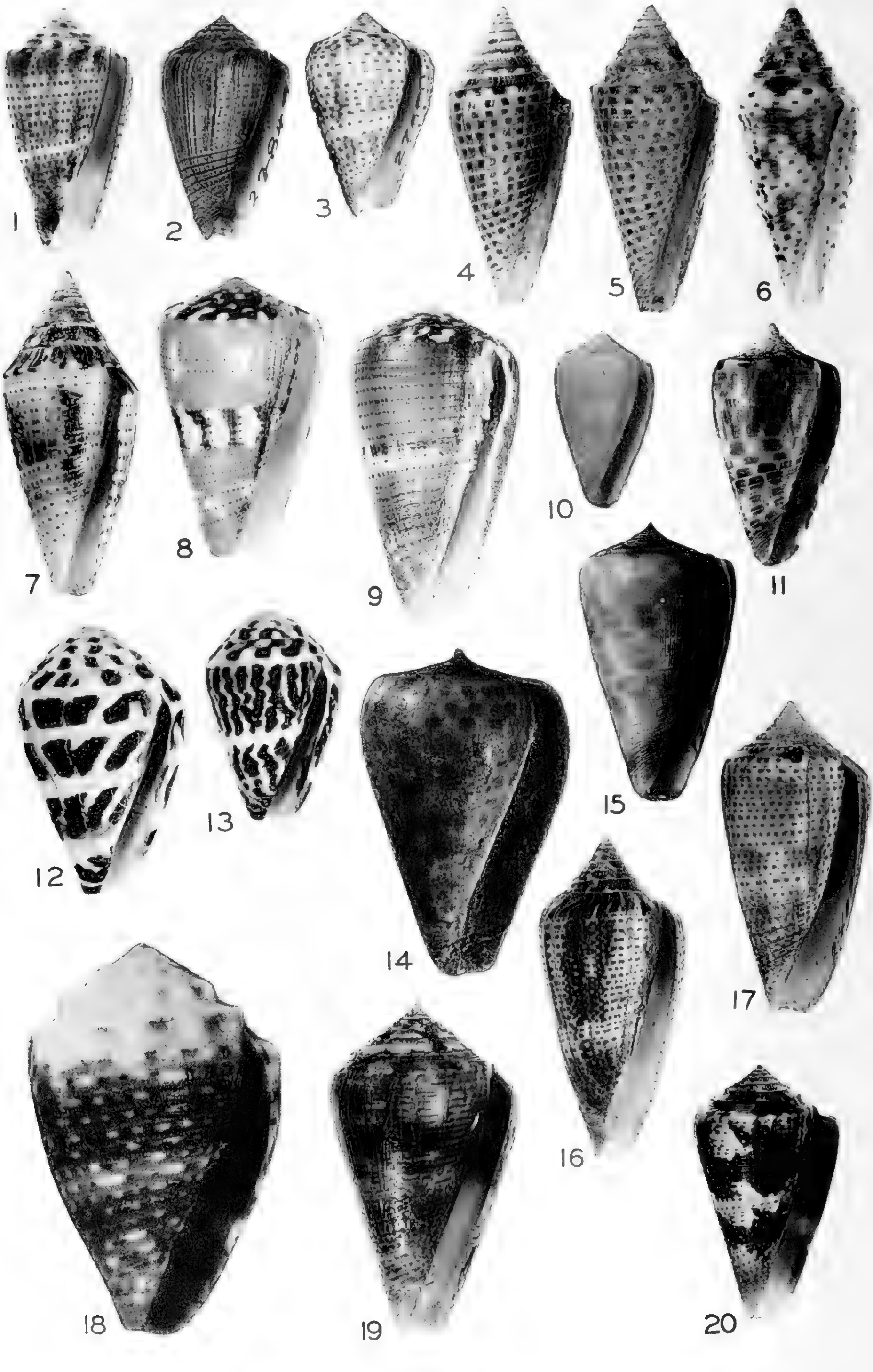
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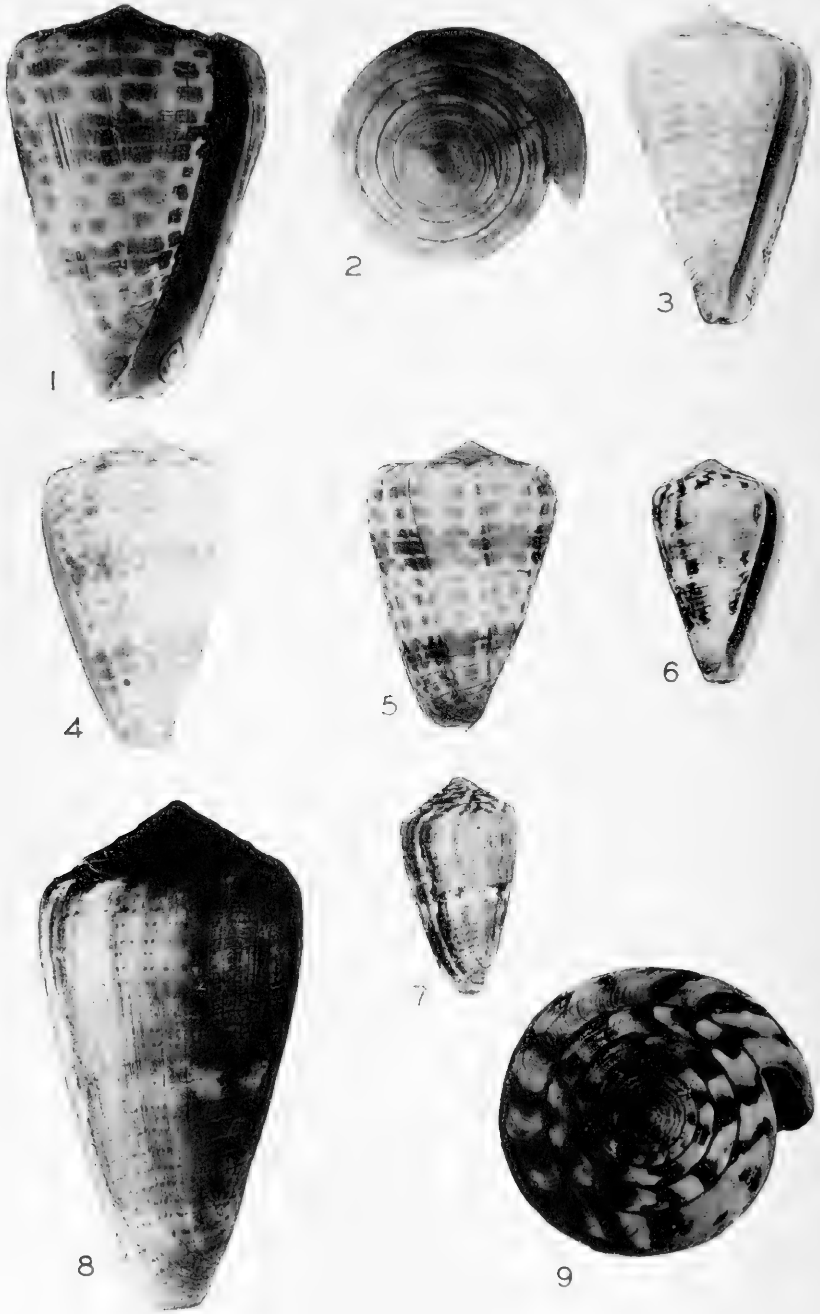
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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 10, pp. 323-351, 8 text figures November 22, 1949

INTERTIDAL PLANT AND ANIMAL ZONATION IN THE VICINITY OF NEAH BAY, WASHINGTON

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Cape Flattery, a rocky headland with cliffs over one hundred feet high, at the southern side of the entrance to Juan de Fuca Strait, is the extreme northwestern point of the continental United States (fig. 1). Three-eighths of a mile off shore is Tatoosh Island, a mass of rock about a quarter of a mile in diameter, partly encircled by reefs but with a sandy beach favorable for landing in a dory. Five miles inside the Cape lies Neah Bay, a small and, until the recent construction of a long breakwater, a rather open harbor, with an Indian village on its southern shore. The northeastern side of the bay is formed by Waadah Island, a narrow strip of land well wooded but with precipitous rocky shores. About two miles eastward from Waadah Island are Seal Rock and Sail Rock (fig. 2), two prominent landmarks of unusual appearance, one-quarter of a mile apart and less than half a mile off shore.

Remote and little visited by scientific workers, the region is characterized by rugged, surf-beaten shores, large tidal range, strong tidal currents, cold water, heavy rainfall, cool air, a low percentage of sunshine, and considerable fog. With the exception of occasional sandy beaches, the shores are rocky and usually steep, and reefs exposed to heavy surf are numerous. In a few places there are wide, wave-cut benches of rock, either well within the littoral zone or awash at high tide. Some of these are so completely covered with large slippery brown algae that the footing is very precarious, and they are commonly strewn with large boulders, some exposed and some awash, so that it is difficult either to wade over the flats or to go among the boulders in a dory. Some of those on Seal Rock, however, are free of boulders and large algae and offer good footing.

As a biological environment the region is exceptionally interesting. A deep and narrow submarine canyon cuts across the continental shelf from the southwest, shoaling gradually in such a way as to bring into the Strait a mass of cold bottom water, rendering the surface temperatures at the entrance definitely colder in summer than those of regions immediately to the north and south along the adjacent coast, and contributing to a rather unusual thermal equability throughout the year. While few temperature records are available from Neah Bay itself, monthly records covering a period of about five years have been obtained from the middle of the Strait, off Pillar Point, about twenty miles to the eastward. These were taken on the scientific cruises of the motorship *Catalyst*. The minimum surface temperature recorded during a five-year period was 5.85°C and the maximum 13.29°C, the latter figure being obtained on an ebb tide in August. During the year 1938 the total range was from a minimum of 7.70°C on February 12 to a maximum of 10.74°C on August 8, constituting a variation of only 3.04°C for the entire year. Conditions at Neah Bay may be expected to be even more stable than those at the point where these temperatures were taken.

Air temperatures, while of course more variable than those of the water, tend likewise to avoid extremes, so that organisms occupying the intertidal zone dwell in a remarkably constant thermal environment.

The heavy rainfall (ranging from 79.75 to 136.16 inches a year, with an average of 109.24 inches for a 17-year period) might be thought of in one sense as a condition of environmental stress. Undoubtedly organisms in the intertidal zone will be subjected to difficulties if exposed to frequent downpours when the tide is out unless they possess some mechanism for adjustment to osmotic changes. For most intertidal forms, however, desiccation in warm sunshine is a greater hazard, so that in general the heavy rainfall over the area may be regarded as a favorable environmental factor in this connection.

Most impressive of all to the student of littoral ecology, the large daily tidal range (exceeding 10 feet on the greatest tides) combines with the unusual features of the shore line to produce conditions favorable to a definite stratification of plant and animal life in the intertidal zone. While it is a commonplace of seashore biology that different communities will be found at different levels between high and low tides, in regions where the tidal range is small or the shores are gently shelving the limits of the vertical distribution

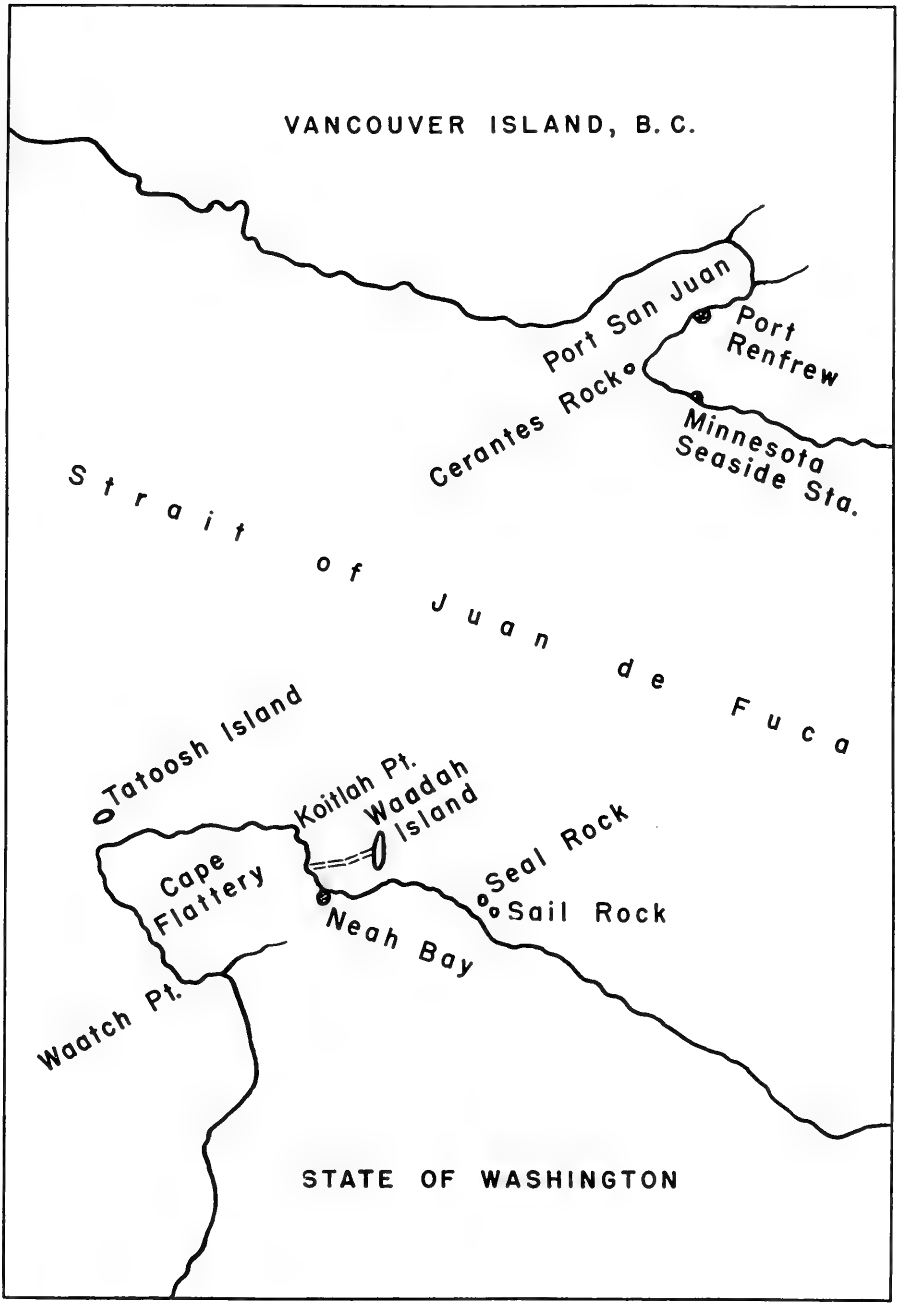

FIG. 1. Map of Neah Bay and vicinity. Dotted line indicates new breakwater.

of a given biome are not easily established. In the vicinity of Neah Bay, each wave-cut bench presents a biological picture characteristic of the level at which it occurs, and on the steep rock walls which are so prevalent the distribution of the dominant organisms takes the form of horizontal bands laid out with almost diagrammatic exactness (figs. 3 and 8).

Localities Investigated

Waadah Island, which is about half a mile long and 220 yards wide, forms the northeastern side of Neah Bay. It bears a coniferous forest with a dense undergrowth of shrubs. The east shore is subject to heavy surf especially in easterly winds and at outgoing tides. The northern end is especially swept by tides and beaten by surf. The east side of the north end, later referred to as Postelsia Point, is subject to heavy waves and surf not only at outgoing tides, which hit it directly, but also at incoming tides which swirl around it. The water at the southwest side of this island is very shallow and numerous large rocks are exposed or awash at low tide. Reefs are numerous. One extends from the southwest corner of the island, and another extends eastward from the central portion of the east side. There is no sandy beach on Waadah Island but landing is readily made on a somewhat rocky beach at the southwest end at slack water in good weather. Frequent landings have also been made at other points when conditions were favorable.

Fig. 2. Seal Rock, with Sail Rock at extreme right, and adjacent mainland.

Seal Rock is about 100 feet high and has vegetation on its upper portion, which is composed of tilted strata of sandstone similar to those of Waadah Island. It lies about 2 miles southeast of Waadah Island and about 660 yards off shore. From certain points the appearance of this rock suggests that of a giant seal (fig. 2). Sail Rock is near Seal Rock. There is no beach on either of these islands, but landing is easily made on the rocks on the south side of Seal Rock at low tide under favorable conditions. Strong tides, both incoming and outgoing, sweep past this rock on both the north side and the south side. The incoming tides beat directly upon the west end of the rock and swirl around the east end, while at outgoing tides the east end gets the beating and the west end gets the swirl.

An interesting feature is the rocky ledge or platform forming the base of Seal Rock. This forms a shelf all around the rock, widest on the east end, approaching the horizontal, then falling off rather steeply at the edges. It is exposed at low tide, and covered at high tide by shallow, churning water.

A dory was landed on this ledge at the north side in calm weather at a 7.6 foot tide and the depth of the water was noted during 20 successive waves. At most of these the depth of the water was about 18 inches and at some of them it was about 30 inches. Between waves there was about 6 inches of water on the ledge.

The occurrence of the two large kelps, *Nereocystis* and *Macrocystis,* was studied by one of us (Rigg) several years ago during two summer visits in 1911 and 1912 and some general observations were made on other algae. During the first of these a trip was made from Neah Bay to Tatoosh Island in a dug-out canoe with an Indian companion. The second trip was made from Seattle to Neah Bay in a 40-foot launch, and permitted examination of much of the American shore of Juan de Fuca Strait. In 1933 a trip was made at low tide in calm weather, in a skiff powered with an outboard motor, along the rocky shore from Neah Bay almost to Cape Flattery, and landings were made at several places.

Most of the detailed study of the region was made during the summers of 1936, 1937, and 1938. These trips were made in the research motorship *Catalyst* from the Oceanographic Laboratories of the University of Washington during the course of the summer work at Friday Harbor. The trips were made in July and on each trip Waadah Island was visited at one early morning low tide and Seal Rock on the following morning. Trips which permitted observations at only one low tide had been made on the *Catalyst* during the summers of 1933 and 1934, but considerable time was spent on these trips in finding the most desirable points for study and the most advantageous places to land from the dories in order to reach them. A trip to Port San Juan and vicinity on Vancouver Island, B. C., was made June 29 to July 1, 1939, and studies were made of the conditions there for comparison with those at Neah Bay. In August, 1948, one of us (Miller) revisited Neah Bay to

FIG. 3. "Postelsia Point" on Waadah Island, showing zonation of algae. 1. Ralfsia-Prasiola. 2. Endocladia-Gigartina. 3. Postelsia. 4. Halosaccion. 5. Alaria. 6. Lessoniopsis. Laminaria and Nereocystis zones are farther seaward and not shown here.

FIG. 4. Detail near upper left of figure 3, showing upper intertidal and splash zones. 1. The dark discoloration is *Ralfsia verrucosa,* the small scattered clumps are *Prasiola meridionalis,* and the white spots scattered *Balanus glandula.* 2. Dense stand of *B. glandula.* 3. *Gigartina* sp., intermingled with *Endocladia muricata.* 4. Dense stand of *Mytilus californianus.* 5. *Postelsia palmaeformis.*

observe what changes might have resulted from construction of the new breakwater erected between Waadah Island and the mainland in 1942-43.

The number of persons taking part in the study on each trip during 1936 to 1938 varied from five to ten, and in the course of the three trips included a considerable number of individuals. The writers wish to express their thanks to all who participated. A complete list would be impossible, but special mention should be made of the assistance of Dora P. Henry, Malcolm Miller, Marian Pettibone, L. D. Phifer, Marjorie Poole, R. H. Tschudy, and R. H. Williams.

The Plants and Their Zonation

The five places studied in most detail are: (1) the steep rocky shore of tilted sandstone strata on the east side of the north end of Waadah Island which in this paper is called for convenience Postelsia Point; (2) the narrow surge-washed channels between the parallel reefs of solid sandstone extending several hundred feet northward from the north end of Waadah Island, which in this paper are called for convenience Reef Channels; (3) the flat shore mainly of solid rock and boulders on the southwest shore of Waadah Island; (4) the steep shore of solid rock and the tide-washed ledge above it at the north side of Seal Rock; and (5) the rocks and tide-washed ledge on the south side of Seal Rock. Observations on Sail Rock were made from a dory. Some attention was also given to the entire eastern shore of Waadah Island and the entire shore of Seal Rock.

Brown, red, and green algae are abundant in the region and there are two seed plants, *Zostera marina* and *Phyllospadix Scouleri*. The list of 88 species of algae with the vertical distribution of each for the points at which it was determined in feet above or below the zero tide datum is given in Table I. The conditions under which field work must be done in this region made exact measurements impossible and the data given must be regarded as approximations. Where blanks occur they mean that the presence of the species was not recorded at that point. It is not to be supposed either that the total list or the occurrence of all the species at all the points is complete, and no doubt future studies will add to the list. A schematic presentation of the vertical distribution of the algae at two of the five points studied is given in figures 5 and 6. Their zonation at each of these points is evident. It seems best to discuss the zones at Postelsia Point in some detail and then to compare the zonation at the other points with this one.

Postelsia Point. Eight zones are here clearly distinguished. These in order from top to bottom are: (1) Ralfsia-Prasiola, (2) Endocladia-Gigartina (3) Postelsia, (4) Halosaccion, (5) Alaria, (6) Lessoniopsis, (7) Laminaria, and (8) Nereocystis.

TABLE I

Vertical Distribution of Algae at Selected Localities in the Neah Bay Region

	Tidal levels between which alga is attached				
	Waadah Island			Seal Rock	
A. BROWN ALGAE	Point	Channels	Flat	North	South
1. *Alaria tenuifolia*	1 to 3	0 to 4	0 to 4	0 to 3	0 to 4
2. *Chordaria abietina*					2 to 3
3. *Colpomenia sinuosa*			3 to 5		
4. *Costaria costata*	—1 to 1			—1 to 1	0 to 2
5. *Cymathere triplicata*					—1 to 1
6. *Desmarestia munda*	—2 to 1				
7. *Egregia Menziesii*	—3 to 4	0 to 5	0 to 4	0 to 2	—2 to 2
8. *Fucus evanescens*		7 to 9			
9. *Fucus furcatus*		7 to 9	7 to 9	8 to 9	5 to 9
10. *Hedophyllum sessile*			0 to 3	0 to 5	—1 to 3
11. *Laminaria Andersonii*	—3 to 2	0 to 3	0 to 6	—3 to 1	—1 to 6
12. *Leathesia difformis*					4 to 6
13. *Lessoniopsis littoralis*	—2 to 2			—3 to 3	—2 to 2
14. *Macrocystis pyrifera*					—2 to 1
15. *Nereocystis Luetkeana*	—10 to 1			—10 to 4	—10 to 0
16. *Pleurophycus Gardneri*	2 to 0			—1 to 0	—1 to 2
17. *Postelsia palmaeformis*	5 to 7				
18. *Pterygophora californica*					—4 to 1
19. *Ralfsia verrucosa*	9 to 13			8 to 10	7 to 9
20. *Soranthera ulvoidea*					2 to 3
B. RED ALGAE					
1. *Agardhiella coulteri*			Drift		
2. *Amphiroa tuberculosa*	1 to 3	0 to 8	0 to 6	—2 to 8	0 to 7
3. *Anatheca furcata*	—1 to 0	—1 to 0			
4. *Bangia fuscopurpurea*	4 to 6				1 to 5
5. *Callithamnion Pikeanum*	—2 to 2				
6. *Callophyllis crenulata*		—1 to 2			
7. *Callophyllis edentata*		—2 to 1			
8. *Callophyllis flabellulata*		—2 to 1			
9. *Callophyllis heanophylla*		—2 to 1			
10. *Ceramium californicum*		0 to 3			
11. *Ceramium pacificum*			2 to 6		
12. *Ceramium washingtoniense*		5			
13. *Constantinea subulifera*		1			2 to 4
14. *Corallina officinalis*	—1 to 6	0 to 2		0 to 5	4 to 6
15. *Cryptopleura Ruprechtiana*		—1 to 1			
16. *Dasyopsis plumosa*	—2 to 1	—1 to 1			
17. *Endocladia muricata*	7 to 9	7 to 9		6 to 8	
18. *Fauchea Fryeana*	—2 to 4	0 to 2	0 to 2	—2 to 2	—2 to 3
19. *Gigartina exasperata*			3		6
20. *Gigartina leptorynchos*	4 to 6	[500 ft. S. of point]			
21. *Gigartina papillata*		4 to 8	5 to 8	6 to 8	5 to 8
22. *Gigartina* sp.	7 to 9				
23. *Gloiopeltis furcata*		9	8 to 9	8 to 9	7 to 9

	Tidal levels between which alga is attached: Waadah Island			Seal Rock	
	Point	Channels	Flat	North	South
24. *Gloiosiphonia californica*		—1 to 1			
25. *Grateloupia Cutleriae*		—1 to 1			
26. *Griffithsia pacifica*			Drift		
27. *Halosaccion glandiforme*	3 to 9	6 to 9	5 to 7	7 to 8	5 to 7
28. *Heteronema boreale*		—2 to 0			
29. *Hildenbrandtia rosea*		0 to 3	0 to 3	0 to 3	0 to 3
30. *Hymenena flabelligera*	—2 to 1	—1 to 1		0 to 3	—1 to 1
31. *Iridophycus flaccidum*	—1 to 1	0 to 2		0 to 3	—1 to 1
32. *Laurencia spectabilis*		0 to 1			
33. *Lithothamnion* sp.	—2 to 5		6	—2 to 3	0 to 4
34. *Membranoptera alata*		—1 to 1			
35. *Microcladia Coulteri*	1 to 3	6	2 to 6	7	2 to 7
36. *Nitophyllum mirabile*		0 to 1		2	1
37. *Odonthalia dentata*		2 to 5			
38. *Odonthalia floccosa*	4 to 6	0 to 2			0 to 5
39. *Opuntiella californica*	—1 to 1			—1 to 1	
40. *Platythamnion pectinatum*		—2 to 1			
41. *Plocamium pacificum*	1 to 3	5		4 to 6	6
42. *Polyneura latissima*		—2 to 1			
43. *Polysiphonia senticulosa*		—2 to 0			
44. *Polysiphonia tenuistriata*			—2 to 1	—1 to 1	1 to 3
45. *Polysiphonia urceolata*				—2 to 1	
46. *Porphyra naiadum*			0 to 3		
47. *Porphyra perforata*			0 to 6	8 to 9	3 to 6
48. *Prionitis Lyallii*		8 to 9	8 to 9	8 to 9	5 to 7
49. *Pterosiphonia dendroidea*			Drift		
50. *Ptilota tenuis*	—2 to 1	4 to 5			
51. *Rhodochorton penicilliforme*		1 to 3			
52. *Rhodomela larix*	4 to 6			7 to 8	3 to 7
53. *Rhodymenia palmata*	—1 to 0				
54. *Turnerella pacifica*		—1 to 1	—1 to 2	—1 to 1	—1 to 2
C. Green Algae					
1. *Chaetomorpha cannabina*		Tide pools			
2. *Cladophora glaucescens*		Tide pools			
3. *Cladophora Stimpsonii*			1 to 3		
4. *Cladophora trichotoma*			7 to 8		4
5. *Codium adherens*		0 to 2	1 to 3		
6. *Codium fragile*			2 to 4		1 to 5
7. *Enteromorpha intestinalis*		Tide pools			
8. *Enteromorpha tubulosa*		Tide pools			
9. *Gomontia polyrhiza*		Tide pools			
10. *Prasiola meridionalis*	10 to 12				10 to 12
11. *Spongomorpha coalita*	1 to 3		1 to 3		1 to 3
12. *Ulva californica*	8 to 9		6	8 to 9	
13. *Ulva lactuca*			—3 to 4		—3 to 0
14. *Ulva linsa*		Tide pools			

The upper zone consisting exclusively of two species, *Ralfsia verrucosa* and *Prasiola meridionalis,* extends from the nine foot level to more than a foot above extreme high tide where it is wetted, so far as sea water is concerned, only by waves and spray. On many days in both summer and winter this entire zone is exposed even at high tide. *Ralfsia,* whose individuals consist merely of an incrustation on the rocks with no evident free portions, seems well fitted for such an existence, while *Prasiola,* often in crevices, and always with its minute individuals so matted together that water is always held within the mat and the surfaces are thus never dry, successfully maintains its existence up to within a foot of the upper limit of its only companion in the zone.

An unidentified species of *Gigartina,* intermingled with *Endocladia muricata,* grows in irregular patches just below the Ralfsia-Prasiola zone.

The Postelsia zone extends through a vertical distance of a little over 2 feet. Its characteristic plant, *Postelsia palmaeformis,* has a striking appearance. Its erect, flexible, hollow stipe, one to two feet tall, bears a dense cluster of narrow, tapering fronds at its top and clings to the rock by a massive holdfast. This Point was observed at a 7.7 foot tide and it was found that the waves were just running over the tops of the plants. The stipe bends as the waves strike it and recovers its erect position as the water recedes, as if made of rubber. Its appearance when exposed at low tide or when hammered by

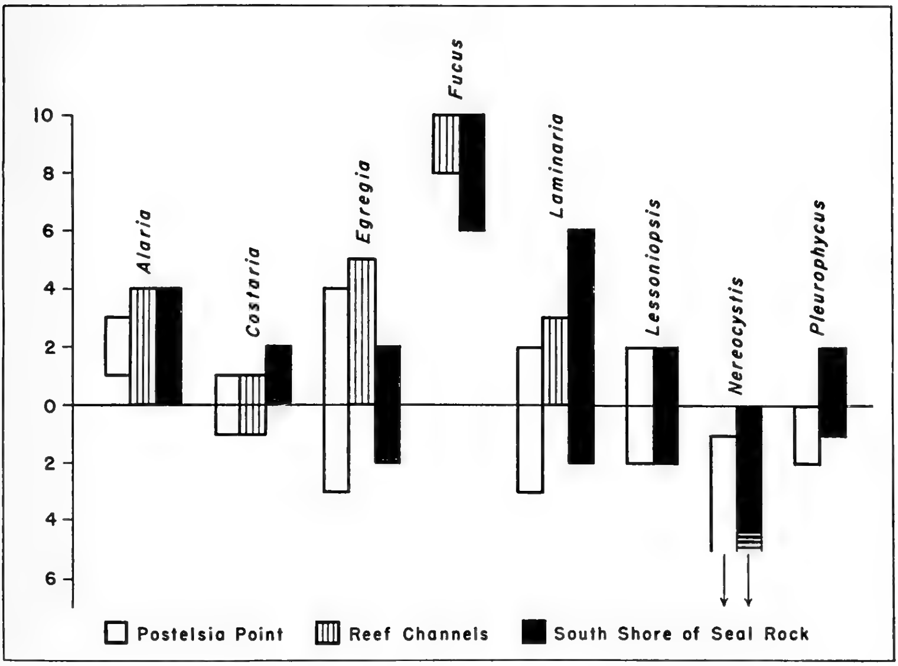

Fig. 5. Chart showing vertical distribution (in feet above or below the zero tide datum) of the principal brown algae at three localities in the vicinity of Neah Bay. *Postelsia,* occurring only at Postelsia Point, is omitted from the chart.

waves well justifies its common name, sea palm. This plant is not found at any of the other four points studied (Table I), but is abundant at the eastern end of the reef extending eastward from the east side of Waadah Island and has also been seen on Cape Flattery and the neighboring rocks and on Tatoosh Island. It occurs also on the exposed rocky shores in the vicinity of Port Renfrew on Vancouver Island, B. C. It is abundant there at the site of the old Minnesota Seaside Station and also on Cerantes Rock. In all these places its vertical distribution seems to be approximately the same as at Postelsia Point. It seems, so far as seen, to flourish in this region only on steep solid rock shores where wave action is violent. On a rock near Cerantes Rock, however, practically all the *Postelsia* found was growing on mussels and barnacles. The rocky surface was so completely covered with the animals that there was no place else for the plants to attach themselves.

Extending into this zone from below are *Odonthalia* and *Rhodomela* whose tough, flexible stipes are bent by waves suddenly and forcibly in every direction from their holdfasts without breaking and whose numerous short matted branches hold water in the mat when exposed and furnish a cushion which softens the violence of contact with rocks when their distal portions are thrown about by the waves. *Halosaccion glandiforme* which extends entirely through the Postelsia zone will be discussed in connection with the next zone below. *Gigartina leptorynchos* does not occur with *Postelsia* but is at the same level on flat rocks a short distance south of Postelsia Point. Its long, narrow, tubular thallus with its numerous short proliferations lies flat upon the rock at low tide. Its anchorage is firm and its adaptation to its habitat is analogous to that of *Odonthalia* and *Rhodomela* and seems even more perfect. It looks like a tough customer which, in the slang of the day, "can take it." The only specimens of *Bangia fuscopurpurea* identified at this point occurred on *Gigartina leptorynchos,* taking advantage of the protection offered by this hardy plant.

The Halosaccion zone, as a distinct zone, is the narrowest of all, extending through a vertical distance of only one and a half feet (3 to 4.5). Its dominant plant, *H. glandiforme,* extends also through the Postelsia zone and nearly to the top of the Endocladia-Gigartina zone, but its dominance at the lower level is clearly evident though the encrusting *Lithothamnion* and the small calcareous *Corallina officinalis* in varying abundance extend entirely through the zone. *Fauchea Fryeana* occurs sparingly in its lower portion and *Odonthalia* and *Rhodomela* extend from above into its upper portion. *Halosaccion glandiforme* is somewhat like a small balloon a few inches long, less than an inch wide, and anchored at one end. Many of the individuals when collected at low tide contain so much water that it can, by slight pressure, be forced out in fine streams in various directions through small pores near the distal end. This internal water seems to take care of the desiccation problem and the dense growth of individuals in this location furnishes mutual protection against mechanical injury by wave action.

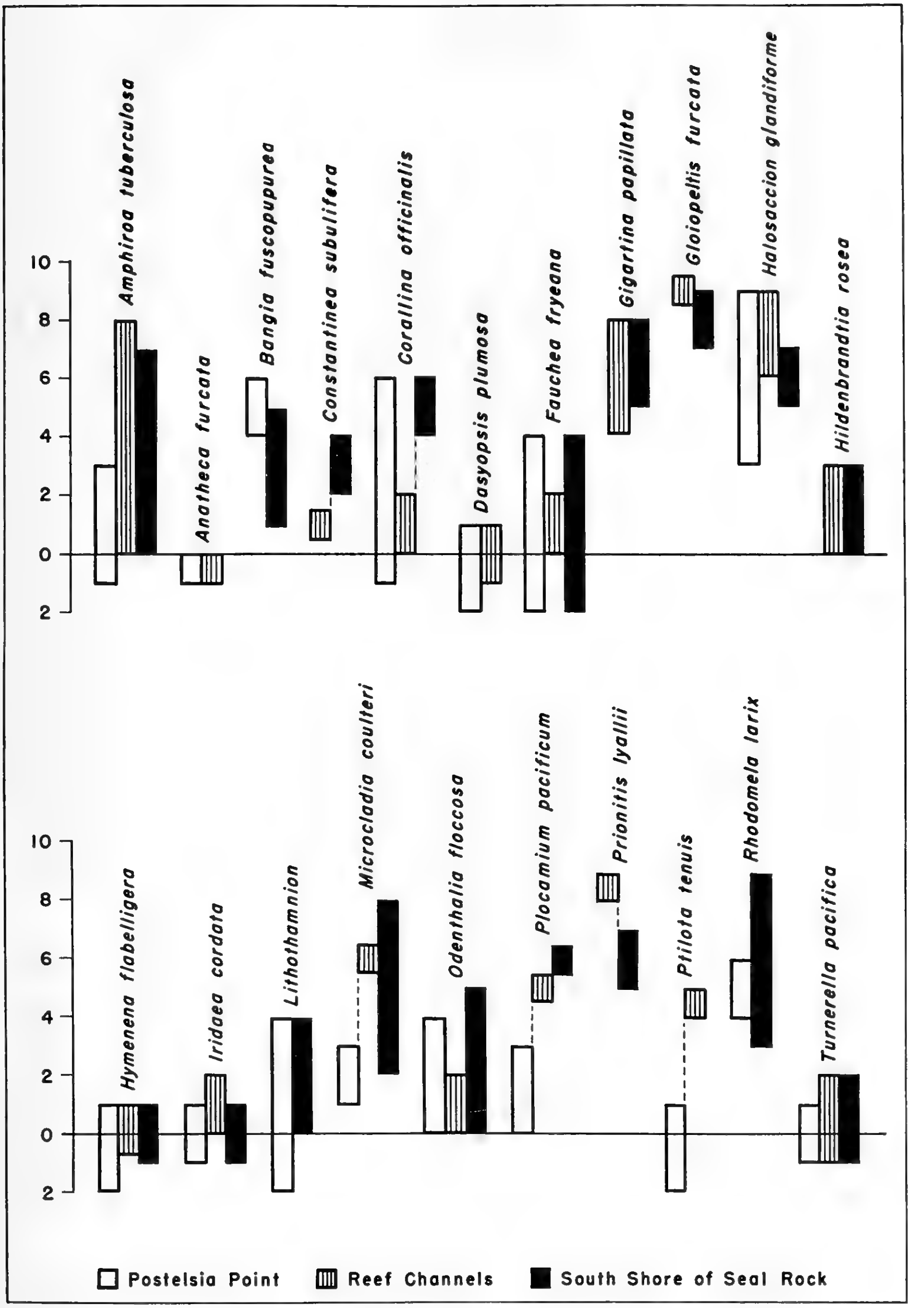

FIG. 6. Chart showing vertical distribution (in feet above or below the zero tide datum) of the principal red algae at three localities in the vicinity of Neah Bay.

The Alaria zone is also narrow, extending in vertical distance only from the one-foot to the three-foot level. It is clearly dominated by *Alaria tenuifolia* which is the only species of large individuals abundant in it. It is limited to this zone as are also the small individuals of *Microcladia, Plocamium,* and *Spongomorpha.* Enormous individuals of *Egregia Menziesii* occur occasionally throughout this zone but this species will be discussed in connection with the next zone below. *Fauchea Fryeana,* which in the region of the San Juan Islands is mostly dredged at 6 to 8 fathoms, here occurs in the littoral zone. *Spongomorpha coalita,* with its filaments held together by small hook-like branches so that they form a dense strand, seems well fitted to withstand mechanical injury and desiccation. The crustaceous *Lithothamnion* and the small stiff calcareous individuals of *Amphiroa* and *Corallina* flourish well in this zone.

The distal portion of the fronds of *Alaria* are worn off by the mechanical effect of wave action and occasionally one finds individuals on which the frond has been entirely destroyed so that only the holdfast, stipe, and sporophylls remain. The production of spores thus seems assured though the vegetative portion may be largely sacrificed. It has been found, however (Frye, 1918), that there are annual rings in the stipe of this species and that the midrib continues to grow in length even when the blade at its margins is destroyed. It thus seems possible that the plants of this species may continue to live in spite of rough treatment.

The Lessoniopsis zone is completely dominated by a dense growth of enormous plants of *Lessoniopsis littoralis.* This is a perennial plant with a stout stipe several inches thick at the base and so hard that a small axe is the best tool for securing specimens. The stipe tapers upward and forks repeatedly bearing a long slender frond at the end of each branch. Zoospores are produced in the sori in these fronds. The great weight of this plant and the flexibility of its stipe cause it to hang down at low tide. A single plant held over the shoulder by its stipe and hanging down the back almost to the ground makes a good load for an able bodied man to carry. This species is on exposed rock shores throughout the region and is seen on Seal Rock, Sail Rock, and along the rocky shore from Koitlah Point to Cape Flattery. It furnishes advantageous anchorage on its stipe for numerous red algae, and large masses of a sponge are numerous on it. Among the red algae growing on its stipe or holdfast are *Dasyopsis* and *Callophyllis. Egregia Menziesii* is common in this zone. No plants were measured here but a plant which was collected at False Bay on San Juan Island in July, 1936, may be taken as characteristic of the species. It had 14 stipes from one holdfast. These stipes varied in length from 8 to 25 feet, five of them approximating the maximum length. It required three men to carry it away. Its holdfast is massive and its stipe is like a long strip of leather. The fronds are borne along the edges of the stipe throughout its whole length and are very small with a small float at the base of each. Zoospores are borne in sporophylls among these fronds.

The Laminaria zone extends from —1½ to —3 and is dominated by *Laminaria Andersonii.* It has an erect dark-colored stipe from the tip of which the digitate frond is pendant at low tide. The stems are flexible and are bent by every wave, but constantly return to an erect position. This species extends upward through the Lessoniopsis zone and into the Alaria zone but is dominant only within the limits stated above. *Pleurophycus Gardneri,* a Laminaria-like kelp with a broad midrib in which the zoospores are borne, extends from above into this zone, as do also such red algae as *Dasyopsis, Fauchea, Hymenena,* and *Rhodymenia,* which in the waters among the San Juan Islands are obtained mostly by dredging at depths of 6 to 8 fathoms. The factors in the occurrence of these red algae at higher levels in the Neah Bay region than in the San Juan Island region are not clear. A possible factor is less intense light due to the prevalence of foggy and cloudy weather and protection from direct sunlight by the dense growth of brown algae.

The Nereocystis zone extends from about 3 feet below datum to an undetermined depth. No soundings were made here but our work in the Puget Sound region and Alaska indicates that *Nereocystis* does not commonly grow in water that is much deeper than 10 fathoms. This plant and its relation to its habitat have been discussed in so many papers that it is unnecessary to give details here. (Crandall, 1915; Frye, 1906, 1915; Hartge, 1928; Hurd, 1916, 1917; MacMillan, 1899, 1901; Muenscher, 1915; Rigg, 1912, 1915, 1915a, 1917; Setchell, 1908, 1912; Setchell and Gardner, 1925.) No doubt red algae

Fig. 7. "Reef Channels," north end of Waadah Island.

grow on the stipe and holdfast of this kelp here as they do elsewhere. The plant seen most abundantly on the distal portion of the stipe of this plant in the Neah Bay region is a filamentous diatom *(Navicula* sp.).

Comparisons of zonation. In general there is considerable similarity between the zonation at Postelsia Point and at the other four places studied, but there are also noticeable differences in both the occurrence of species and their vertical distribution. It seems possible to correlate these differences to a certain extent with environmental factors.

The Reef Channels are not exposed directly to tidal currents and not to direct action of waves except in northerly winds but are subjected to heavy surge of water in and out, giving rise to some surf. There is always water in these channels even at extreme low tide and there are many rocks in them either exposed at low water or awash in the waves. Brown algae are abundant in these channels both on the rocks in the bottom and on the steep sandstone walls which border them. The first impression that one gets of these channels at low tide is of a dense growth of brown algae forming a thick tangled layer on the rocks or pendant from the walls. Mixed with the brown of the tangled mat is the vivid green of *Phyllospadix Scouleri* whose rhizomes cling to the rocks while its long slender leaves are swept about in the surge. Among the bases of the leaves mature pistillate flowers in rows two or three inches long on a spadix and safely enclosed in the boat-shaped spathe were commonly found in July. The vigor of the growth of the branching rhizomes suggests that this plant is largely reproduced here vegetatively rather than by the germination of seeds, but no definite information on this point is at hand.

Red algae are more abundant in these channels than they are on Postelsia Point both as to number of species and number of individuals. The greater number of species is apparent in Table I. *Fucus* is also common here. The absence of *Postelsia* and *Lessoniopsis* constitutes a striking difference between the Channels and Postelsia Point. The absence of heavy waves and surf seems to be a large factor in this. The absence of *Ralfsia* and *Prasiola* is no doubt associated with the lack of surf and spray at high levels.

The southwest shore of Waadah Island is more protected than any of the other four places studied. There is no strong tide through the harbor, and the force of westerly and southerly winds is largely broken by the high land across the bay. The force of such waves as do come in is also broken by the large beds of *Nereocystis,* with some *Macrocystis,* which are immediately to the westward. The island itself prevents easterly winds from affecting this shore. The area was visited at a 7.6 foot tide and it was found that the entire rock shore up to the boulders which lie back of it was awash. This shore has fewer algae than any of the other four places. *Ralfsia, Prasiola, Postelsia,* and *Lessoniopsis* are naturally absent. Red algae are, however, numerous both as to species and individuals.

Seal Rock has quite different conditions from Waadah Island as is indicated by the description given earlier in this paper. The strong tides rush past its north and south shores instead of beating directly upon them as at Postelsia Point, while the east and west ends split the seas that strike them directly, and part of their force carries them along the north and south shores. Then, too, the force of surf and spray at higher levels is lessened by their passage across the ledge. *Ralfsia* occurs here, though not at as high a level as at Postelsia Point, while *Prasiola* maintains about the same level as at the Point. *Fucus* is abundant in places but the individual plants are not large.

A notable plant occurring on the south side of this rock but not at the other four places is *Pterygophora californica.* It is mostly in the sublittoral zone, but extends also into the lower littoral as it does also on the neighboring shore of the mainland. It is a stout, erect perennial kelp with annual rings in its stipe. It bears a new crop of fronds at its top each year. Frye (1918) has investigated the age attained by individuals of this species, by means of both annual rings and leaf traces. Those that he examined were from 5 to 13 years old. MacMillan (1902) reports 24 annual rings in a stalk 5 cm. in diameter. A specimen that drifted up on the rocks at False Bay on San Juan Island in July, 1936, had a stipe 6 feet 9 inches tall and had 15 fronds. The considerable number of large plants that had drifted up on the beach at Neah Bay indicates that the plant flourishes abundantly in the vicinity. It was reported by MacMillan (1901) at Port Renfrew on the coast of Vancouver Island opposite Neah Bay. The fact that it drifts up on the west shore of San Juan Island at the inner end of the Strait of Juan de Fuca indicates its abundance somewhere in the Strait. It seems quite possible that these drift plants come from the Neah Bay region or the south end of Vancouver Island. The known facts thus indicate that this plant is abundant in the Neah Bay region but grows mostly so far below low tide that not even its tops are ever exposed. It is occasionally dredged at 6 to 8 fathoms in Peavine Pass in the San Juan Islands.

Small, round shallow tide pools are common in the sandstone at Postelsia Point and other places on the west shore of Waadah Island and also on Seal Rock. The two most important environmental factors for algae which are different in tide pools from those in other places on these rocky shores are (1) that the plants in them are not subject to desiccation, and (2) that the water becomes warmer. The latter is especially true of those that occur in the upper portion of the littoral zone where they are exposed to the sun's rays for several hours at low tide. The plants found in tide pools at the points studied are *Priontis Lyallii, Codium fragile* (with *Ceramium* sp. epiphytic upon it), *Chaetomorpha cannabina, Cladophora glaucescens, Enteromorpha intestinalis,* and *Ulva linsa.* In addition to the algae, *Phyllospadix Scouleri* also occurs in the tide pools on both Waadah Island and Seal Rock. Muenscher (1915) has studied the tide pools of San Juan Island. He quotes data indicating an extreme difference of 5.6°C between the temperatures of the tide pools and that of the neighboring sea water. He lists 8 species of algae in the San Juan tide pools, only one of which

(Prionitis Lyallii) is in our list for the Neah Bay region. He found *Ulva lactuca* while we found *Ulva linsa.* The tide pools of the west coast of Vancouver Island are numerous and striking in character, especially in the vicinity of the old Minnesota Seaside Station. Their origin and general character have been discussed by Henkel (1906). In 1939 we found *Codium fragile* abundant in a large tide pool on Cerantes Rock. The pool was at about the high tide level and was near the middle of the rock. It was under a ledge of rock which gave shade after about 10 A.M. The occurrence of this species in tide pools at high levels in the Neah Bay region and on the west coast of Vancouver Island is in striking contrast with its position in the San Juan Islands, where it occurs at about the —1.0 foot level.

Unusually large tide pools occur on the south side of Seal Rock. These are irregular depressions in the rocky surface of the shale and are not comparable in origin to the small round tide pools in sandstone discussed above. The vegetation of the two types of tide pools also has little in common. A large one at unusually low level contains a wealth of the brown algae which are characteristic of these shores, and in 1938 two *Nereocystis* plants about 8 feet long were growing in it. *Cymathaere triplicata* is abundant in large tide pools at the site of the old Minnesota Seaside Station on Vancouver Island.

The distribution of *Macrocystis* along the south shore of the Strait of Juan de Fuca has been discussed in a previous paper (Rigg, 1913) and the principal beds of *Nereocystis* in the region have been mapped. (Portfolio accompanying Rept. No. 100, U. S. Dept. Agr.) Both of these kelps reach a considerable length (100 feet or more). The size of these and other kelps has been given by Frye, Rigg, and Crandall (1915). It should be emphasized that reports of enormous lengths of several hundred feet previously reported for these kelps have not been verified. These two kelps form considerable beds or "groves" in the Neah Bay region where depth, anchorage and water movement are suitable. The two species intermingle to only a slight extent. Where the two form beds along the shore, the *Nereocystis* is outside and the *Macrocystis* is closer to the shore (Rigg, 1913). *Nereocystis* commonly disappears in winter in the Puget Sound region and in Alaska and it is to be presumed that it does the same in the Neah Bay region. *Macrocystis,* as is well known, is a perennial species with numerous stipes attached to one large holdfast and its growing region is at the distal end. It has a small float at the base of each of its numerous fronds which are scattered along the slender stipe. The sporophylls occur on special short stipes from the holdfast several fathoms under the surface of the water.

Two species of seed plants, *Zostera marina* and *Phyllospadix Scouleri,* occur in the Neah Bay region, and a third one, *Phyllospadix Torreyi,* is found rolled up in considerable quantities on the sandy ocean beaches southward from Waatch Point, though it was not seen growing. The first is a cosmopolitan species whose range on this coast is Alaska to California (Piper, 1906).

It occurs mostly below low tide and its rhizomes grow in sand or mud. The second has already been discussed. Its range is British Columbia to California (Piper, 1906).

Vertical Distribution and Zonation of the Littoral Invertebrates

For the purpose of an initial survey of the littoral invertebrates of the Neah Bay region with reference to their distribution in or proximal to the intertidal belt, four zones were established on the basis of the most obvious ecological factors:

A. *The splash zone,* extending from mean higher high water to the extreme upper limit of occurrence of barnacles or limpets. Approximate limits, +8.0 feet to +14.0 feet (above mean lower low water). Organisms living in this zone are out of water the greater part of the time and must be prepared to resist both rainfall and desiccation, to withstand a wide range of temperatures, and to subsist on intermittent feeding.

B. *The upper intertidal zone.* Approximate limits, +4.0 to +8.0 feet. Organisms in this zone are out of water more than half the time, but are not subjected to the extreme conditions of environmental stress found in the splash zone. They are to some extent sheltered and aided in their resistance to heat and desiccation by the presence of various algae, especially *Fucus, Halosaccion,* and *Gigartina.*

C. *The lower intertidal zone.* Approximate limits, +1.0 to +4.0 feet. Organisms in this zone are exposed by the tide half the time or less, and grow in the shelter of numerous large algae, most conspicuous of which are *Lessoniopsis, Egregia,* and *Alaria* (see figs. 3 and 8).

D. *The demersal zone.* Approximate limits, + 1.0 to —2.0 feet and beyond. This is the zone that is uncovered only at the lowest tides, and while it affords the seashore biologist his best collecting, most of the animals occurring at these levels are not in the ecological sense intertidal forms at all; they are demersal species which at intervals are briefly exposed by the receding tide, an event to them doubtless as unhappy as it is unexpected. Many of the species collected at the lowest tides can also be dredged at depths of 10 to 20 or more fathoms.

For the purpose of comparison with Shelford's (1935) classification of marine biotic communities in the Puget Sound area, the splash zone corresponds with the Littorina-glandula fasciation and the Littorina-cariosus fasciation of the Balanus-M. californianus association of the Balanus-Littorina biome. The upper intertidal corresponds to the Mitella-Mytilus fasciation and the lower intertidal to the Cribina fasciation of the same association. The demersal zone corresponds to the Strongylocentrotus-Pugettia association of the Strongylocentrotus-Argobuccinum biome. This nomenclature is more complex than is required for the present purpose.

Comparison should also be made with the zones which Ricketts and Calvin (1939) have designated (1) uppermost horizon, (2) high tide horizon, (3) mid-tide horizon, and (4) low tide horizon. The major difference is one of nomenclature, the present writers having regarded mid-tide, not as a zone but as the boundary between the upper and lower intertidal regions. A very little vertical displacement would bring the two sets of concepts into harmony. The present authors, either for adequate reasons or from habit, consider that the terminology herein used provides a better picture of the pattern of distribution on a steep rocky shore.

As a matter of fact, all of these concepts are somewhat arbitrary, and to be thought of primarily as categories for convenience of description. There is no sharp dividing line between lower intertidal and demersal, nor between upper and lower intertidal zones. The splash zone is the best defined; nevertheless, its vertical limits vary greatly with immediate local conditions, such as slope of the rock and exposure to wave action or to sun. On the north and northwest sides of Seal Rock, for example, the splash zone extends on the average at least three feet higher than on the east and south; and in a crevice on the northwest side (most exposed to wave action and least exposed to sun) *Balanus glandula* occurs up to 16 feet and *Acmaea digitalis* up to 19.5 feet above mean low water.

At each locality investigated, zones A, B, C, and D were laid out quickly in terms of measurements based on the height of the tide as ascertained from the tide tables, collecting was done as widely as possible in each zone and the specimens were taken to the laboratory for subsequent identification. Notes were also taken in the field of special conditions, peculiarities of distribution, and general impressions gained by the collector. The notes were subsequently correlated with distributions as determined from identified specimens.

In Table II are given the approximate vertical distributions of some sixty organisms as determined in this way. When an organism occurs in two or three zones but has its maximum distribution in one, the zones of lesser distribution are indicated by parentheses. The time available for collecting was so limited that it is reasonable to assume that all of the organisms found are moderately common in the region.

Certain groups are conspicuous by their absence from the table, notably hydroids, nemerteans, annelids, small crustaceans, and Bryozoa. This does not signify that they were absent in the fauna, but only that they were not taken in the course of rapid general collecting. For most of these groups, special attention and special methods are necessary to collect and identify them.

Only three of the five localities of Table I are included in Table II. Not enough collecting was done in the Reef Channels to justify tabulation. The flat on Waddah Island will be discussed separately on a subsequent page.

TABLE II

Vertical Distribution of Littoral Invertebrates in the Neah Bay Region

A=Splash Zone; B=Upper Intertidal; C=Lower Intertidal; D=Demersal Zone

Organisms	Waadah Island Postelsia Point	Seal Rock North Side	Seal Rock South Side
Acmaea cassis		D	D
Acmaea digitalis	A	A	A
Acmaea instabilis		D	D
Acmaea pelta	D		D
Acmaea scutum	C, D	B, C, D	D
Amphissa columbiana	D	C, D	D
Anisodoris nobilis		C	D
Balanus cariosus	B, C	(A), B, C	(A), B, C, (D)
Balanus crenatus	C, D		C, D
Balanus glandula	A, B, (C)	A, B	A, B, (C)
Balanus nubilis	C		D
Balanophylla elegans	D		D
Bittium eschrichtii			D
Cadlina marginata			D
Calliostoma costatum	D	C, D	D
Cancer oregonensis	D		D
Cancer productus			D
Chthamalus dalli		A	A
Crepidula lingulata		C	D
Crepidula perforans		C, D	D
Cribrina xanthogrammica	C, D	D	D
Cryptochiton stelleri			D
Cucumaria chronjhelmi			D
Cucumaria miniata			D
Dermasterias imbricata	D		D
Diodora aspera	D	C, D	D
Entodesma saxicola			D
Evasterias troschelii	D		D
Haliclona cinerea	D	D	
Hemigrapsus nudus	A, B		
Henricia leviuscula	D	C, D	D
Hinnites multirugosus		D	D
Katharina tunicata	D	D	D
Kellia laperousi		D	D
Lepidochitona lineata		C, D	D
Leptasterias aequalis		C, D	D
Littorina scutulata	B		B
Littorina sitchana	A	A	A
Lygida pallasii	A		
Margarites pupillus			D
Mitella polymerus	B	B, C	
Mopalia muscosa		C, D	D
Mytilus californianus	B	B	B
Ophipolis aculeata		C, D	D
Paphia staminea		C, D	D
Petrolisthes eriomerus			D

Organisms	Waadah Island Postelsia Point	Seal Rock North Side	Seal Rock South Side
Pholadidea penita	D	C, D	
Pisaster ochraceus	C, D	C, D	(B), C, D
Pugettia gracilis		D	D
Pugettia productus		C	
Purpura foliata	D	D	D
Rostanga pulchra		D	
Saxicava arctica			D
Saxicava pholadis			D
Searlesia dira			D
Strongylocentrotus drobachiensis	D	D	D
Strongylocentrotus franciscanus	D	D	D
Strongylocentrotus purpuratus	D	C, D	D
Styela montereyensis		D	
Thais lamellosa			D
Thais lima	D	D	
Thais ostrina	B		
Tritonalia interfossa			D
Tritonalia lurida	D	D	D
Velutina laevigata			D

The greatest number of species was found on the south side of Seal Rock, where the relatively sheltered, shelving shore with numerous boulders and an abundance of tide-pools provides the greatest variety of habitats. The steep, surf-beaten rocks at Postelsia Point and on the north side of Seal Rock obviously constitute a more restricted environment. On the other hand, organisms adapted to this rugged life flourish best where pounded by the surf. *Mitella* is noticeably less numerous on the south than on the north side of Seal Rock and *Mytilus,* while abundant at both places, is definitely smaller in the more sheltered location.

Too much significance should not be attached to the presence of an organism at one locality and its apparent absence at another, as additional collecting would be likely to fill the gaps. It is to be remembered that the workers were always driven away from the rocks by the incoming tide before they were ready to go. The vertical distribution shown in the table, however, may be accepted with a greater degree of confidence, especially when the same organism has been found at the same level at two or more places.

The greatest number of species is to be found in the demersal zone. In several cases species that are characteristic of this zone on the south side of Seal Rock extend also into the lower intertidal on the north side. The explanation may well be that the surf on the north side, combined with the greater shade, enables the organisms to live at a higher vertical level without suffering desiccation. A similar difference in the uppermost level of organisms on the north and south sides of the rock has already been noted (p. 342).

In the upper intertidal and splash zones, the number of species is small, but the number of individuals is often very great. In the areas here studied, the bands of sessile or sedentary organisms characteristic of these levels stand out with actually diagrammatic effect. These bands, which are narrow on a vertical wall, spread out on a sloping rock to a width inversely proportional to the declivity (fig. 8).

On the north and east sides of Seal Rock, the wave-cut platform is almost at the level separating zones A and B. Here we find hundreds of square feet covered with a nearly pure stand of *Balanus glandula,* which is invaded about six feet in from the seaward edge by *Mytilus* and *Mitella. Mytilus* also grows in all depressions in the platform, so that as one surveys the area, the patches of *Mytilus* interspersed among the *Balanus* provide a kind of relief map of the flat.

On this flat also there are a few shallow tide pools, eighteen inches or two feet deep, which contain *Cribrina xanthogrammica, Katharina tunicata, Mopalia muscosa,* and *Strongylocentrotus drobachiensis,* showing that species normally having their distribution in the lower intertidal or demersal zones can subsist at higher levels if the situation is such that they are kept constantly submerged.

A comparable situation obtains on the "flat" on the west side of Waadah Island, which is flat only by contrast with the steepness of much of the island.

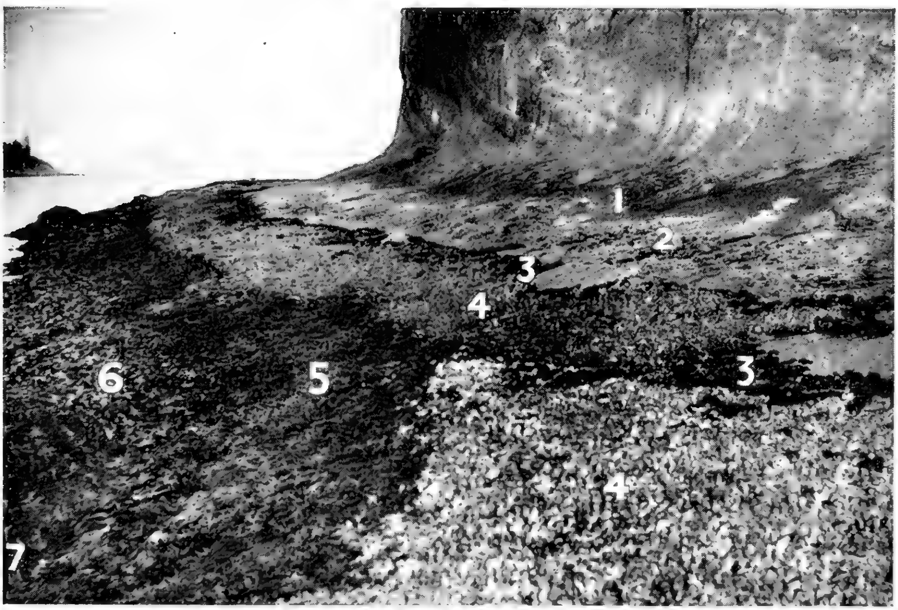

Fig. 8. Base of Seal Rock, south side. At the upper left is a point of the adjacent mainland, with Waadah Island showing faintly in the distance. 1. *Ralfsia verrucosa.* 2. *Balanus glandula,* with some *Gigartina* interspersed. 3. *Gigartina papillata* and *Fucus furcatus.* 4. *Mytilus californianus.* 5. *Halosaccion glandiforme.* 6. *Alaria tenuifolia.* 7. *Lessoniopsis littoralis.* The dominants only are listed. In all cases other species are intermingled.

The area consists of a substrate of horizontal or gently sloping rock overlain with large boulders, the tops of which are awash at high tide. The rough and irregular nature of the terrain, with tide-pools at various levels containing characteristic demersal forms, tends to obscure the vertical stratification of organisms so prominent at the other localities studied.

The relative poverty of marine algae on this side of the island has already been noted (p. 338 and Table I). The invertebrate fauna is likewise rather disappointing when one considers the size of the area exposed at low tide. Thirty-three species were collected here, twenty-eight of which occurred at one or more of the other stations. The five species which in our collecting were found only on the Waadah flat are *Acmaea persona, Crepidula adunca, Crepidula nummeria, Epitonium wroblewskii,* and *Tegula funebralis.* Their presence here is presumably correlated with the relatively sheltered conditions, the surf having its force broken as the incoming waves stream among the boulders.

On August 4, 1948, Waadah Island was revisited by one of us (Miller) to ascertain whether any substantial changes in the biological situation had occurred as a result of the erection of a breakwater (shown as a double dotted line in the map, fig. 1) between Waadah Island and the adjacent mainland south of Koitlah Point. This breakwater, about 2800 yards long, was constructed over a two-year period, 1942-43. It is composed of over one million tons of large rocks somewhat irregularly piled together, forming an extremely rough substrate, over which one can scramble only with considerable difficulty. It shelters the harbor from northerly storms.

The breakwater itself provides material for an interesting biological study. Its outer (northerly) face has rapidly been colonized by *Mytilus californianus, Mitella polymerus,* and other characteristic inhabitants of surf-beaten rocks. No *Postelsia* was observed. The inner, sheltered face of the breakwater has developed the usual complement of sessile organisms found in quiet waters, *Balanus glandula, Mytilus edulis, Pisaster ochraceus* being abundant *(B. glandula* and *P. ochraceus* of course occur on the outer face of the breakwater as well.)

So far as could be determined by a quick survey (the breakwater itself and a mile or more of adjacent rocky shore were traversed at one low tide), the zonation of organisms on the breakwater represents simply an extension of that found generally in the vicinity. An unexpected feature was an extraordinary abundance of the twenty-rayed starfish *(Pycnopodia helianthoides)* in the demersal zone on the inner, sheltered face of the breakwater. It was possible to observe one of these every thirty or forty feet over a distance of more than a mile.

The breakwater had exercised no discernible effect on the organisms at the localities described earlier in this paper. At Postelsia Point, which is on the opposite side of Waadah Island from the breakwater, the stand of *Postelsia palmaeformis* in 1948 was thinner than that observed in earlier years, and the individual plants appeared less vigorous. No reason for this was apparent in the physical environment.

General Considerations

The conditions mentioned in the second paragraph of this paper seem to favor an abundant growth of algae. None of the species mentioned, however, are peculiar to the Neah Bay region. It is their great abundance here both as to species and individuals that is impressive, and the same is true of the Port Renfrew region on Vancouver Island.

While a good deal of attention has been given to the form and structure of the large kelps in relation to the factors that determine their distribution (literature cited above) there seems to have been relatively little consideration of the red and the green algae from this point of view. A review of the known facts about the form and structure of the algae of the Neah Bay region in relation to the environmental factors and a further study of the ecological anatomy is highly desirable.

A study of the algae of this region from the viewpoint of the relation between their methods of reproduction and their local distribution would be an interesting line of investigation. Such questions as whether the species is annual or perennial and whether it is reproduced mainly by vegetative means or by spores would add much to our understanding of the biology of the littoral zone in the Neah Bay region. Studies of the winter condition of algae such as have been made by Hurd (1917) for the Puget Sound region or of the seasonal development of species such as have been made by Rigg for Nereocystis (1917) would be interesting work, full of adventure. Wind and rain are common in the region during the winter months and the days are relatively short in this latitude. There are plenty of low tides in the region in winter but they mostly occur between 5 and 9 P.M. Hardy, sure-footed workers experienced in negotiating treacherous waters and provided with good artificial lights could have an adventurous time working on these shores in winter and could contribute valuable data.

Desiccation does not seem to be as important a factor in the zonation of algae here as it probably is in regions where higher temperatures, greater light intensities, and drier winds prevail on the beaches at low tide (cf. Muenscher, 1915). The exposed rocks in the Neah Bay region are usually cold and damp, and the air is the same. Cloudy or foggy weather is more common than bright sunshine especially on early summer mornings when the low tides occur. Many of the algae (e.g. *Polysiphonia* spp. and *Gigartina leptorynchos)* plaster themselves to the surface of the rocks when the tide recedes and retain water among their densely crowded filaments or their numerous proliferations so that they are in little danger of excessive water loss. The distal portions of the larger brown algae form thick layers on the rocks at low tide and are thus likewise protected from excessive loss of water. The smaller red algae in the littoral zone are commonly so completely covered at low tide by the dense layer of brown algae that they are found only by moving their protectors aside. This is notably the case on the south side of Seal Rock. The red algae are thus protected from the effects of desiccation and intense light.

Evidently all the algal associations of the region are climax vegetation. No evidence of succession was found and this seems to be the natural situation for marine algae. Their "soil" is not the rocks to which they attach themselves, but rather the water which bathes them. Their holdfasts are not comparable to the roots of higher plants except in the one function of anchorage. There does not seem to be any evidence that absorption of either water or salts takes place to a greater extent in the holdfast than in other portions of the plant, and no evidence has been found of the storage of food in the holdfasts. The holdfast is not a region of active growth after the plants attain firm anchorage on the surface of the rocks. The boundaries between zones of algae on these shores are sometimes rather sharp but more frequently are seen to be indefinite when carefully studied. In no case are they to be regarded as real tension lines, but rather as an indication that the plants have established themselves where the conditions are suitable for their form, structure, and methods of reproduction. It does not seem probable that their zonation would show successive changes with the passage of years.

The interrelations between the plants and animals of the upper littoral have been a subject of considerable interest to the writers during the course of this survey, but opportunities for the kind of investigation needed have been extremely limited. The sponge *Haliclonia cinereus* seems to flourish especially on the stalks of large algae, and various species of hydroids and Bryozoa grow on the stalks or stipes. The limpet *Acmaea instabilis* has been found nowhere except on the stalks of *Lessoniopsis*. A good many lower intertidal and demersal animals must obtain from the large algae a great deal of protection from the surf, and from desiccation when the tide is out. Algae and algal detritus undoubtedly provide an important, if not indeed the major, source of food in the littoral economy.

It has been stated by Shelford (1930) that, in areas studied by him, plants are to be classed as sub-dominants in both the intertidal and sub-tidal areas. This probably varies from place to place. In the areas under consideration here, plants are sub-dominant in the upper intertidal (figs. 4 and 8), but it is hard to avoid the belief that they should be classed as dominants in the lower intertidal and in at least the proximal part of the demersal zone (figs. 3 and 8).

In the upper intertidal there appears to be competition between plants and animals for "standing room." On the whole the animals seem to be more successful in occupying the available space. In a situation such as that shown in figure 8, the impression is almost inescapable that the algae have been crowded out to the very borders of the colonies of *Balanus* and *Mytilus.* On the other hand, one finds instances where the algae seem to have gained additional anchorage by pushing their holdfasts in among the barnacles.

Plants and animals struggle endlessly for existence in the rigorous environment of a surf-swept shore. The micro-ecology of these wave-beaten communities presents fascinating possibilities for further study.

Summary and Conclusions

A survey is here reported of the vertical distribution of a number of species of marine algae and marine invertebrates in or adjacent to the intertidal zone at certain localities in the vicinity of Neah Bay in the extreme northwest corner of the continental United States.

Steep rocky shores, considerable surf, a large tidal range, and a moist climate free from extremes of temperature, form an environmental complex favorable to an abundant intertidal flora and fauna. At different vertical levels, different species are dominant, resulting in a zonation of organisms so distinct as to be visible in the form of conspicuous horizontal bands.

For selected localities, tabulations have been made of the vertical range, in feet above or below zero tide datum, of the principal species of brown, red, and green algae, and of the vertical distribution of a number of littoral invertebrates in zones, as follows: (A) splash zone; (B) upper intertidal; (C) lower intertidal; (D) demersal.

At a typical locality ("Postelsia Point" on Waadah Island) eight zones of algae are clearly distinguished. These are in order from top to bottom: (1) Ralfsia-Prasiola, (2) Endocladia-Gigartina, (3) Postelsia, (4) Halosaccion, (5) Alaria, (6) Lessoniopsis, (7) Laminaria, and (8) Nereocystis.

Only above the large algae is the zonation of invertebrates conspicuous. In the upper intertidal belt we find a large stand of *Mytilus californianus* intermingled with *Endocladia, Gigartina,* and—on points most exposed to the surf—dense colonies of *Mitella polymerus.* Above these, but still in the upper intertidal, occurs a nearly pure stand of *Balanus glandula.* Still, above this, in the splash zone, we find a belt of *Littorina sitchana* and *Acmaea digitalis* with scattered *Balanus glandula.*

On a similar rocky shore which slopes more gently (south side of Seal Rock), the width of these bands of organisms increases, in inverse proportion to the steepness of the slope, emphasizing the significance of vertical range. On a wide wave-cut bench at a suitable level (east end of Seal Rock), *Balanus* *glandula* forms a dense growth over an area as large as a city lot, although on a vertical shore the width of the belt in which this organism would be similarly dominant would hardly exceed ten inches.

At levels below the upper intertidal, zonation of animal life is less conspicuous because of the abundance of algae, which the present authors class as dominants in the lower intertidal and at least the proximal part of the demersal zone.

Zonation is regarded as a resultant of two primary factors, which are in fact reciprocals of each other: (A) Organisms of the upper littoral have an optimum vertical range that is determined by a variety of conditions, among which are food supply; illumination; degree of resistance to desiccation when exposed to air and sunshine, and to endosmosis when exposed to rain; and adaptability to survival under the pounding of heavy surf. (B) Organisms characteristic of a given vertical range often can and do survive in limited numbers above or below the level regarded as optimum. It would appear that such organisms could, in the absence of competition, successfully occupy much wider vertical ranges. Their apparent restriction to a narrow belt is due primarily to competition from other organisms better adapted to the vertical ranges immediately adjacent.

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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 11, pp. 355-417, pls. 11-21, 3 text figures April 28, 1950

THE WASPS OF THE GENUS SOLIERELLA IN CALIFORNIA (HYMENOPTERA, SPHECIDAE, LARRINAE)

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Field and laboratory studies on these small, active wasps were begun in 1920 and extended, with many interruptions, up to 1949. About 600 specimens of *Solierella,* chiefly from California, were assembled for study. More than half of this number were of the writer's own collecting. Also available for study was a large, well ordered collection of *Solierella* from Southern California provided by Mr. P. H. Timberlake of the Citrus Experiment Station, University of California at Riverside. Smaller but likewise interesting collections came from Dr. G. E. Bohart and from the California Academy of Sciences. Finally, a number of paratypes and other specimens were loaned by the United States National Museum.

Up to the present writing, there appear to be but three species of *Solierella* correctly reported from the State of California. These are: *S. striatipes* (Ashmead), *S. similis* (Bridwell), and *S. blaisdelli* (Bridwell). However, a critical examination of the material before me reveals twenty-three California species, of which fifteen are here described as new. California, therefore, is rich in species of this genus, and since these wasps are generally small and not too readily collected, additional species are sure to be found. Some species appear to have a rather limited distribution, others are widespread in the state and beyond, and several range at least to the Rocky Mountains. Certain small areas, sometimes but an acre or two in extent, may with close collecting yield a relatively large number of species of *Solierella*. For example, nine species were taken by the writer at Menlo Park, San Mateo County, California, in July, and at Riverside, Riverside County, Mr. P. H. Timberlake collected eleven species during various months. Most of the species include June in their season. Species with the abdomen reddish seem more prevalent in the southern part of California. Naturally enough, not all the species have the same value; some appear rather isolated or set apart, while others form groups of closely related species. Variations in both markings and structure are not infrequent and add to the interest as well as the difficulty of the study.

The following is a list of the twenty-three species of *Solierella* known to occur in California:

1. *S. striatipes* (Ashmead)
2. *S. major* (Rohwer)
3. *S. sonorae* n.sp.
4. *S. lasseni* n.sp.
5. *S. boharti* n.sp.
6. *S. vierecki* (Rohwer)
7. *S. similis* (Bridwell)
8. *S. vandykei* n.sp.
9. *S. corizi* n.sp.
10. *S. nigra* (Ashmead)
11. *S. blaisdelli* (Bridwell)
12. *S. albipes* (Ashmead)
13. *S. bridwelli* n.sp.
14. *S. levis* n.sp.
15. *S. nitens* n.sp.
16. *S. clypeata* n.sp.
17. *S. timberlakei* n.sp.
18. *S. arcuata* n.sp.
19. *S. australis* n.sp.
20. *S. abdominalis* n.sp.
21. *S. bicolor* n.sp.
22. *S. sayi* (Rohwer)
23. *S. californica* n.sp.

Thanks are extended for generous assistance given me: to Drs. C. F. Muesebeck and Karl V. Krombein of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, for the loan of paratypes and other specimens and for comparing specimens with types; to Dr. H. K. Townes, formerly of the above institution and now at North Carolina State College, and to Mr. J. C. Bridwell, both of whom made similar critical comparisons; to Dr. G. E. Bohart of Logan, Utah and Dr. E. S. Ross, Curator of Entomology, California Academy of Sciences, for the loan of specimens; and to Mr. P. H. Timberlake of the Citrus Experiment Station, Riverside, for placing his fine large collection of *Solierella* at my disposal for study, as well as for much helpful criticism of the manuscript. Thanks also are extended to Dr. E. L. Kessel for his painstaking editorial work.

The name *Solierella* (Spinola, 1851, in Gay, Hist. fis. pol. Chile, Zool., vi, p. 349) is here used to include *Silaon* (Piccioli, 1869) and *Niteliopsis* (S. Saunders, 1873). Kohl (Die Gattungen der Sphegiden, Ann. des K. K. naturhist. Hofmus., Bd. XI, Heft 3, 1896, pp. 451-454) analyzes the genus *Solierella*. He unites *Solierella, Niteliopsis*, and *Sylaon* Kohl into one genus, but recognizes these names as convenient for species grouping. He speaks of the variation in venation among these insects and shows that some species have the mandibles well excised on their outer side, others possess mandibles which are rather shallowly excised, and still others have these organs not excised. Kohl's view of this group of wasps is shared by some of the later students, including the writer. For a discussion of the genus *Solierella,* see Pate (Mem. Amer. Ent. Soc., No. 9, 1937, p. 59). Pate considers Herbst's genus *Lautara,* described from Chile (Bol. Mus. Nac. Chile, XI, p. 217, 1919), as in all probability congeneric with the typical species group of *Solierella.*

The type of the genus is *Solierella miscophoides* Spinola ([Gay], Hist. fis. pol. Chile, Zool., VI, p. 352, 1851).

Solierella has been accorded several positions in the classification of the sphecid wasps. The writer has not made an extended study of its relationships with other wasps. To him, *Solierella* seems best placed among the Larrinae.

The wasps of this genus measure from about 2.5 to 11 mm. in length. They are compact in build; the abdomen is sessile, and the ground color is usually black although frequently the abdomen is reddish and even more often creamy white or yellowish markings are present on the thorax and legs. Considerable difference in size may exist among individuals of a single species.

Solierella may be characterized as follows: Eyes entire, converging toward vertex; three perfect ocelli; mandibles entire within, sinuate to emarginate on outer (lower) side; marginal cell more or less truncate and appendiculate apically, three submarginal cells, the second petiolate, receiving one or both recurrent veins, anal lobe of hind wing small; middle tibiae with one apical spur; pygidial area not well defined.

The head is much used in classification. In most species of *Solierella* the mandibles are merely sinuate or very slightly notched on their lower side (2, 25, 76, 182).[1] In relatively few species they may be suddenly narrowed on their lower side somewhat before the middle length so that the basal portion has the upper and lower margins parallel or nearly so, and a tooth or lobe is thereby formed by this narrowing (127, 187). Such mandibles are not, properly speaking, definitely emarginate or excised, as in *Plenoculus* (186), a genus related to *Solierella.* Other *Solierella* have the mandibles intermediate in character. Figures 135 and 142 show moderately excavate mandibles. The malar space—that space between the base of the mandibles and the lower edge of the eye—is very narrow in the female, and very narrow to a length equaling about one-half the width of the mandible at the base, in the male. It is in sections V to VIII in my grouping of the species that the malar space is best developed, these sections being composed of the smallest species. The coloration of the mandibles appears relatively constant for group

1. The numbers in parentheses refer to figures in the plates.

or species. The clypeus, extending from the antennal sockets, is important in marginal outline and profile. Occasionally its anterior margin shows variations (183-185). Often a median carina is present on the clypeus. The disc is more or less tumid and its margin variously shaped. The occipital carina may run boldly into the gular suture, as in *S. corizi*, or it may disappear before reaching this suture, as in the small species. The antennae may be filiform to subclavate. In the male the last segment of the antenna may be normally developed, i.e., but little differentiated and slightly longer than the preceding segment; in many species the last segment is greatly developed so as to equal in length about the sum of the 2 to 6 preceding segments. In dried specimens the last segment may be in a more or less collapsed condition, although it seems always normally round or nearly round in cross section and terminates subconically. The comparative length of the segments is, I believe, sometimes subject to errors of statement due to the frequent telescoping of these segments. Finally, in a small group the males have the last antennal segment reduced, it being subglobular and shorter than the preceding. Particularly in large species the frontal carina may divide U- or V-like and sometimes widens suddenly toward the vertex to form a second but more poorly defined bottomless U (1, 2, 28). The ocelli may form a triangle from about equal to a right angle to one even more acute than an equilateral triangle, a line joining the two posterior ocelli being regarded as the base of the triangle (24, 86, 169). The width of the interocular space is also important in classification.

The legs have several important characters. On the posterior (or upper) inner side of the hind coxae there is a fine carina that is developed basally as a gently rounded lobe, a triangular production, or a thorn (61, 79, 110), according to group. In the male more or less of a stout thorn may be developed on the fore coxa beneath (144), while the fore trochanter is emarginate to a greater or lesser extent basally beneath (59, 85, 165). Also, in males in the groups containing the smaller species, there is a somewhat fusiform thickening of the hind tibiae, as viewed from above (177). Bristles on the outer side of the fore tarsi of the females may be sufficiently long to be regarded as a weak comb (36-39, 178, 181). In the forewing the marginal cell may be fairly parallel-sided, or more or less saccate at the base. The form of the second submarginal cell is of much importance, as also the position of the two recurrent veins, and the relation of the transverse-median and basal veins along the median vein. But variations are not infrequent (7, 9, 35, 84, 101, 103, 104). The dorsal part or disc of the propodeum sometimes has a U- or V-shaped area defined by a raised or carinate line (113, 114); this is a valuable but not altogether constant character. The sculpture of the disc may vary considerably within the species (compare 11 and 12). There is no well-defined pygidial area in *Solierella,* such as occurs in females of typical Larridae and in *Plenoculus*, where there is a bounding carina. In *Solierella,* however, the pygidium is rather obscurely defined by a line of close-set, very short bristles. The form and dentition of the lobes of the aedeagus are useful for specific or for group classification, but the number of teeth may vary considerably, at least in the smaller species.

The practice of mounting specimens of these small wasps with jaws agape is very commendable. Thus the clypeus is exposed for study. Relaxing dried specimens for the arrangement of appendages may result in a chipped or broken clypeus or other injury to the specimen; moreover, the use of potassium hydroxide or even hot water tends to exaggerate carinae, causes antennal segments unduly to protrude from their sockets, produces certain shrinkage of the ocelli, and does other damage (60, 108, 141).

It is hoped that the numerous illustrations accompanying this article will help materially in the identification of species which are too often difficult to describe in words alone. Included among the plates are anatomical details of certain *Solierella* thus far not known to occur in California.

The works of other hymenopterists have been freely consulted. The studies of Mr. S. A. Rohwer, of the United States National Museum, have laid the foundation for systematic work on *Niteliopsis* and *Silaon*, based largely on specimens collected by himself in Colorado (Trans. Am. Ent. Soc., XXXV, pp. 108-116, 1909; Proc. U.S.N.M., 40, pp. 585-587, 1911). More recent workers in this group are Bridwell, Pate, and Krombein. In the Old World, V. Gussakovskij has published on palaearctic *Solierella* (Rev. Russe d'Ent., XXII, pp. 78-84, 1928; t.c. XXIV, pp. 232-235, 1930 [descriptions in Latin]).

A separation of the genus *Solierella* into natural groups may be expressed as follows:[2]

I

Second submarginal or cubital cell relatively longer and flatter, the distal or second transverse-cubital-vein side slightly longer than, or at least equal to the basal or first transverse-cubital-vein side; the cell almost always receives both recurrent veins; transverse-median beyond basal vein; a U- or V-shaped forking of the frontal carina more or less developed; ocelli forming an equilateral triangle, or nearly; posterior coxae with the inner dorsal carina developed basally as a gently rounded lobe; antennal segments of the female relatively long, the third segment equaling or slightly surpassing three times its apical diameter; last segment of male antenna normal, subequal with the preceding one; malar space almost lacking in the female, sometimes slightly developed in the male. This group includes our largest species: *striatipes* (Ashmead), *major* (Rohwer), *foxii* (Viereck), *fossor* (Rohwer), *sonorae* n.sp., *lasseni* n.sp., *boharti* n.sp., *modesta* (Rohwer).

2. This grouping is based mainly on California material and includes only those other species familiar to the writer.

II

Second submarginal cell much as group I, although a little shorter and receiving only the second recurrent vein; transverse-median beyond basal vein; frontal U well developed; antenna of female with length of segment three about twice its apical diameter; last segment of male antenna normal; posterior coxal carina developed basally as a gently rounded lobe. Species of medium size: *vierecki* (Rohwer), (=*parvus?* [Rohwer]).

III

Second submarginal cell much as in I, receiving both recurrent veins; frontal U or V not well developed; antennae and posterior coxal carinae about as in II; malar space very small in both sexes. Of medium size: *plenoculoides* (Fox), *similis* (Bridwell), *vandykei* n.sp.

IV

Second submarginal cell usually relatively shorter, tending to be equilateral, its distal side often shorter than, but sometimes as long as the basal side; the cell sometimes receiving both recurrent veins; transverse-median usually beyond basal; sometimes these two veins are interstitial; a short frontal V, or it is obsolete; ocelli forming a right angle triangle to a triangle somewhat greater than equilateral; posterior coxae with the inner dorsal carina basally developed thornlike; antennae moderately thickened to stout, the last segment in the male being about as long as the three preceding ones; malar space very small in female, sometimes slightly developed in the male. Small to moderately large species: *inerme* (Cresson), *lucida* (Rohwer), probably *iresinides* (Rohwer), *mexicana* (Rohwer), *mirifica* Pate, *corizi* n.sp.

V

First and second submarginal cells each receiving a recurrent vein, the second submarginal cell with the basal almost always longer than the distal side; transverse-median basad of basal vein; more rarely they are interstitial; no U- or V-shaped forking of the frontal carina developed; ocelli forming a triangle slightly greater than equilateral; clypeus produced mesad as a rather narrow lobe which in the male terminates in a spike or short point; last antennal segment of male at least equal to the two and a half preceding ones; malar space small in male, almost lacking in female. Small species: *nigra* (Ashmead), *rohweri* (Bridwell), *blaisdelli* (Bridwell), *kansensis* (Williams), *lagunae* (Williams) (Philippines), *affinis* (Rohwer).

VI

First and second submarginal cells each receiving a recurrent vein; mandibles suddenly or rather suddenly narrowed a little before their middle length (mandibles distinctly emarginate exteriorly); no forking of frontal carina developed; antennae of male as in V; malar space in male about half the width of the mandibles at base. Small species: *albipes* (Ashmead), *bridwelli* n.sp.

VII

Venation as in VI; mandibles weakly to moderately emarginate; frontal carina and male antennae as in VI; clypeus of female broadly rounded out or broadly subtruncate, that of male subconically produced (males of *levis* and *nitens* unknown). Small species: *levis* n.sp., *nitens* n.sp., *clypeata* n.sp., *timberlakei* n.sp., *arcuata* n.sp., *australis* n.sp., *abdominalis* n.sp., *bicolor* n.sp.

VIII

Venation and malar space as in VII; mandibles weakly emarginate; clypeus rather narrowly produced mesad, the process lobed or toothed; ocelli forming approximately an equilateral triangle to one more acute than an equilateral triangle, this triangle placed farther forward than usual in *Solierella* in relation to the hind margin of the compound eyes at the vertex, a line tangential to the hind margin of the eyes being distant from the posterior ocelli by about their diameter. Small species: *sayi* (Rohwer), *californica* n.sp.

KEY TO SPECIES OF CALIFORNIA SOLIERELLA[3]

Females—antennae with 12 segments; abdomen with 6 tergites visible 1
Males—antennae with 13 segments; abdomen with 7 tergites visible 22

1. Second submarginal cell usually longer (10), its distal or second transverse-cubital side longer than the basal or first transverse-cubital side, receiving both recurrent veins (except in *vierecki*); transverse-median usually distad of basal vein; frontal carina forking to form a more or less obvious U or V at its upper end (1), and then usually more widely diverging to form a more or less poorly defined bottomless U in the ocellar region: posterior coxae with the inner dorsal carina developed basally as a gently rounded lobe (4, c) 2

—Second submarginal cell usually relatively shorter (80, 84, 102), the distal side usually shorter than the basal, or the cell may be equilateral; first and second submarginal cells each receiving a recurrent vein (except usually in *corizi*); frontal carina seldom forking to form a well defined U or V (exceptions are *vierecki* and to a lesser degree *corizi* and near allies), usually the frons is simply rounded, brow-like (95-98, 115); posterior coxae with inner dorsal carina sometimes developed basally as a thorn, or triangularly produced (79c, 110) 9

2. Antennae more slender, filiform, length of its third segment 3 times, or a little more, its apical diameter (3, 18, 22, 26, 29); a fore tarsal comb of long bristles usually developed (36-39). Large species 3

—Antennae stouter, length of segment 3 about 2 times its apical diameter (44, 52, 57); fore tarsal bristles short, not forming a comb (58) 7

3. The numbers in parentheses refer to figures in the plates.

3. All black; clypeus pointed somewhat beaklike; frontal U short, not well developed (21); length 6.5 mm. .... **boharti**, new species
—Abdomen reddish 4
4. Usually all tibiae marked with pale yellow; no fore tarsal comb (40); clypeus produced into a rather narrow lobe with a low lateral tooth; a narrow, well-defined frontal U. Length 7-11 mm. .... **striatipes** (Ashmead)
—No pale markings; fore tarsal comb present 5
5. Frontal U short and wide, the carinae low and obscure; at its widest portion the U is somewhat more than half the width between the compound eyes at that point (23); length of fore tarsal bristles a little more than the width of tarsal segments. Length 6-8 mm. .... **lasseni**, new species
—Frontal U longer, its carinae well defined; fore tarsal bristles about 2 times the width of the segments 6
6. Frontal U not narrowed above where it joins the upper U (17); disc of propodeum with a median carina and with strong oblique and then, transverse striae, some of the oblique striae reaching well beyond the middle length of disc, length 9-10 mm. .... **major** (Rohwer)
—Frontal U somewhat narrowed above where it joins the upper U (28); disc of propodeum generally finely reticulate, with a fine median carina and some short radiating basal wrinkles; less often the wrinkles are better developed, thereby partially obscuring the reticulations. Length 7.5-8.25 mm. .... **sonorae**, new species
7. Frontal U well defined (43); first submarginal cell receiving the first recurrent vein; abdomen red, pronotum and legs marked with creamy yellow. Length 5 mm. .... **vierecki** (Rohwer)
—Frontal U poorly defined; second submarginal cell receiving both recurrent veins; abdomen black 8
8. Clypeus steeply depressed just before its margin (67, 68); pronotum black; hind tibiae marked with creamy yellow. Length 6 mm. .... **vandykei**, new species
—Clypeus nearly evenly convex in profile (57 and c); pronotum usually, and hind tibiae rarely and then but slightly, marked with creamy yellow. Length 6-7 mm. .... **similis** (Bridwell)
9. Species 6-8 mm. long; rather coarsely sculptured; posterior coxae with inner dorsal carina developed basally as a stout thorn (79); transverse-median a little distad of basal vein; thorax and legs marked with creamy yellow; radial vein of hind wings continued as a dark streak (80) .... **corizi**, new species
—Smaller species; posterior coxae with process less well developed; transverse-median usually basad of, sometimes interstitial with basal vein; radial vein of hind wing not terminating as a dark streak 10
10. Clypeus produced mesad as a simple, rather narrow rounded lobe (95-97) 11
—Clypeus not produced as a simple, rather narrow shining lobe; it may be broadly, semicircularly produced (116, 118), rather broadly subtruncately produced (121, 122, 124), rather narrowly so produced and usually 3-lobed or with a median tooth (155, 157) 12
11. Usually pronotum, postscutellum, and all the tibiae marked with creamy yellow; disc of propodeum with a U-shaped area defined by a raised line (114) .... **blaisdelli** (Bridwell)
—All black; puncturation and other sculpture generally coarser; area on disc of propodeum defined more often as a truncated V than as a U, the sides being nearly straight (113) .... **nigra** (Ashmead)

12. As seen from the side the mandibles are suddenly narrowed from before their middle length on the lower side, thereby forming a shoulder or notch, the broader basal portion being thus nearly parallel-sided (127, 187); mandibles largely pale yellow; clypeus subtruncately produced (126, 128) .... **albipes** (Ashmead)

—Mandibles not suddenly thus narrowed, moderately emarginate (135, 142), or not emarginate exteriorly (182), the side of the broader basal portion converging.... 13

13. Disc of clypeus broadly depressed from about one-third of its length from the base (between the antennal sockets) to near its margin so that this area, which is smooth and shining, appears concave in profile (122, c, female); mandibles moderately emarginate exteriorly (135); antennae stout; pygidial area strongly and closely punctate; tibiae and tarsi with much creamy yellow; abdomen black .... **bridwelli**, new species

—Disc of clypeus convex in profile (118 c, 119), though it may be upcurved before the margin 14

14. Abdomen largely red 15

—Abdomen black 17

15. Clypeus broadly semicircularly produced, though the rather ample shining margin is very slightly emarginate mesad (119), the disc in profile being rather strongly convex and sloping steeply from about its middle length to the margin; mandibles shallowly and gradually emarginate. Length 3.75 mm. .... **timberlakei**, new species

—Clypeus semicircularly produced (116), though tending to be subconic in outline, the disc in profile moderately convex, the marginal strip very slightly upturned; mandibles moderately emarginate (as in *bridwelli*). Length 4.5 mm. 16

16. Antennae stout, subclavate, the terminal segment hardly or not twice as long as its basal diameter (132); no impressed line extending from anterior ocellus posteriorly .... **bicolor**, new species

—Antennae less stout, the terminal segment about twice as long as basal diameter (133); a distinct smooth impressed line extending from anterior ocellus posteriorly .... **abdominalis**, new species

17. Clypeus rather broadly subsemicircularly or subtruncately produced; ocelli form a triangle slightly greater than equilateral, a line joining the two posterior ocelli being the longest (as in 131); posterior ocelli less than their diameter removed from a line joining the posterior margin of the compound eyes at the vertex 18

—Clypeus rather narrowly subtruncately produced, this production about equaling in width the interspace of the antennal sockets (155, 157, 167); ocelli barely forming an equilateral triangle (169) or the triangle may be more acute; posterior ocelli approximately their diameter removed from a line joining the posterior margin of the compound eyes at vertex 21

18. Longer bristles of fore tarsi about as long as the width of their respective segments (181); clypeus subtruncately produced, the margin rather wide and smooth (121); mandibles shallowly emarginate (142); wide basal portion of mandibles dark brown or blackish; creamy white markings at apex beneath, of the fore and middle femora (though sometimes nearly effaced) and on the hind tibiae. Length 3.8 mm. .... **levis**, new species

—Longer bristles of fore tarsi much shorter than width of respective tarsal segments; clypeus arched subconic or subtruncate; wide basal portion of mandibles pale yellow, rarely a little darker; fore and middle femora and all the tibiae marked with pale yellow. Length 4-4.5 19

19. Clypeus subtruncately produced, the production very slightly lobed mesad (124); disc of propodeum with a U-shaped area marked by a raised line. Shining and finely punctate.......... **nitens**, new species

—Clypeus more perfectly truncate; disc of propodeum without margined U-shaped area. Less shining and finely though more strongly punctate (text fig. 1).......... **clypeata**, new species

—Clypeus arched subconic; disc of propodeum lacking a margined U-shaped area, or it is incompletely defined.......... 20

20. Antennae stout, subclavate, the terminal segment about twice as long as thick (137); propodeal pleura subopaque, with many very fine close parallel striae.......... **australis**, new species

—Antennae less stout, the terminal segment clearly more than twice as long as thick (138); propodeal pleura shining, with about 8-10 well-separated parallel striae.......... **arcuata**, new species

21. Clypeus produced as a simple rather narrow subtruncation, the margin of which is very gently arched (167); longer spines of the fore tarsi fully as long as their respective segments; fore and middle femora and all the tibiae marked with pale amber yellow. Length 4 mm. .... **californica**, new species.

—The clypial subtruncation is produced as a low median tooth (155, 157); fore tarsal spines shorter than their respective segments (180); fore and middle femora with a small creamy yellow mark; tibiae black. Length to 4.5 mm. .... **sayi** (Rohwer)

22. Last segment of antennae as long as or a little longer than the preceding one (6, 31, 51), thus never greatly developed nor very small and subglobular; second submarginal cell receiving both recurrent veins (except in *vierecki*). Generally larger species with the frontal U or V often well defined (2, 31).......... 23

—Last segment of antennae greatly developed, about equaling the preceding 2-6 segments (78, 88, 108; text figure 2); usually the first and second submarginal cells each receive a recurrent vein (102); frontal carina not dividing to form a well defined V (98) except in *corizi*.......... 26

—Last segment of antennae stubby and subglobular, shorter than the preceding one (172); clypeus drawn out into a rather narrow subtruncation with a median tooth (156, 160).......... 34

23. Clypeus truncately produced, the truncation lobed mesad (2, 31, 69); extremity of aedaegus with many fine teeth (15, 30, 74).......... 24

—Clypeus subtruncately produced, its rounded margin obscurely lobed or toothed mesad, or it is broadly triangularly produced (45); extremity of aedaegus with about 5-8 teeth (49, 55, 64).......... 25

24. Frontal U about one and one-half times as long as wide (2); abdomen reddish. Length 5-8 mm. .... **striatipes** (Ashmead)

—Frontal U about as long as wide (69); abdomen black. Length 4-5 mm. .... **lasseni**, new species

25. Frontal U well developed (45); clypeus broadly subtriangularly produced; first submarginal cell receiving first recurrent vein; abdomen reddish.......... **vierecki** (Rohwer) (=**parva**? [Rohwer])

—Frontal U obscure (60); second submarginal cell receiving both recurrent veins (62); clypeus subtruncately produced; abdomen black.......... **similis** (Bridwell)

26. Produced portion of clypeus 3-dentate (78); second submarginal cell usually receiving both recurrent veins; a well developed thorn on posterior coxae basally above (79); first segment of posterior tarsus of about equal thickness throughout; hind

wings with several dark streaks apically. Length 5-6.5 mm. .... **corizi**, new species

—Produced portion of clypeus not 3-dentate; first and second submarginal cells each receiving a recurrent vein; posterior coxae with the carinal process lower and more triangular; first segment of posterior tarsus as viewed dorsally somewhat thickest toward middle length (177). Length 3-4.5 mm. 27

27. Clypeus truncately produced mesad (as in text figure 1); last antennal segment about as long as the two preceding segments combined (text figure 1) **clypeata**, new species

—Clypeus not truncate; last antennal segment relatively longer........ 28

28. Clypeus a median subtriangular lobe usually terminating in a distinct spike (97c, 98, 185), or it may terminate in a slight nipple (183, 184); mandibles usually blackish or reddish brown at base with yellowish or brownish along the middle length or beyond, rarely clear creamy yellow or whitish basally; mandibles shallowly emarginate........ 29

—Clypeus more or less triangularly produced, not spiked or nippled (except in *albipes*, which, however, has the largely creamy yellow mandibles strongly notched); mandibles usually distinctly creamy yellow at or near base, no raised line defining a U-shaped area on disc of propodeum, or this area not clearly developed........ 30

29. Thorax and legs with creamy yellow; often a U-shaped area on disc of propodeum (114)........ **blaisdelli** (Bridwell)

—Usually entirely black and slightly larger; U-shaped propodeal area present or not .... **nigra** (Ashmead)

30. As seen laterally the mandibles are suddenly narrowed before the middle length along their posterior or lower side, thereby forming a shoulder or notch (127) which is evidently a development of the margin into a semitransparent lobe, making the broad basal part nearly parallel sided (mandibles distinctly emarginate)........ 31

—Mandibles not or only moderately emarginate, so that basal portion has converging rather than parallel or nearly parallel sides (135, 182; text figure 2)........ 32

31. Last segment of antenna better developed, as long as the six preceding segments (136); clypeus produced as an arcuate-conic lobe (123) that is tumid in profile and rather steeply depressed anteriorly (122c, ♂)........ **bridwelli**, new species

—Last segment of antenna not exceeding the preceding 3½-4 segments; clypeus gently convex, conically produced or with a small nipple........ **albipes** (Ashmead)

32. Abdomen largely reddish; pale creamy yellow markings on fore coxae beneath, as well as on thorax, femora, tibiae, and tarsi........ **abdominalis**, new species

—Abdomen black, but margin of tergites testaceous and slightly reddish; pale markings present on fore coxae beneath........ **bicolor**, new species[4]

33. Antennae stouter (139); sides of propodeum subopaque, with very fine close striae on reticulate surface........ **australis**, new species

—Antennae less stout (140); sides of propodeum shining, the striae fewer and well separated and on a smoother base........ **arcuata**, new species

34. The produced truncate portion of clypeus with a median spikelike process (171); ocelli forming a triangle slightly more acute than an equilateral one (169); all tarsi with a pale yellowish stripe........ **californica**, new species

—The produced truncate portion of clypeus with a low tooth (156, 160, 162); ocelli forming an equilateral or very slightly more acute triangle; all tarsi usually black .... **sayi** (Rohwer)

4. This may be the male of *bicolor*; the association of the sexes has not been established. See the description.

DESCRIPTION OF SPECIES

1. **Solierella boharti** Williams, new species

(19, 20, 21, 22, 38)

Female, holotype: Length 6.5 mm. Black; head and thorax opaque, abdomen shining, the slender mandibles reddish apically. Head mainly finely granulate; clypeus produced into a wedge with a shoulder interrupting somewhat beyond the middle length, the margin rather broadly polished, carina strong, extending to apex where it is only slightly depressed; frontal carina not strong, dividing above antennae to form a short indistinct U with a median incised line basad; vertex rather narrow, the ocelli forming an equilateral triangle, the lateral ocelli less than their width from the compound eyes; antennae rather slender, segments 3 and 4 subequal. Thorax mainly finely granulate, scutellum with definite punctures; propodeum with a fine median carina and some longitudinal carinae on the sides, the posterior face shining and with transverse carinae and a subtriangular depression. Outer bristles of fore tarsi a little longer than apical width of their respective segments. Second submarginal cell receiving both recurrent veins; transverse-median distad of basal vein. A little silvery pile and some pale mesotibial spines.

Holotype, female (C.A.S. No. 6161) in fresh condition from **Mammoth Lake, Mono County, California**, July 5, 1936 (R. M. and G. E. Bohart).

This fine species is named in honor of Drs. R. M. and G. E. Bohart.

A rather slender and finely sculptured species of the *fossor* group, but with the interocular space at vertex relatively narrow.

2. **Solierella lasseni** Williams, new species

(23, 25, 26, 69-74, 174)

Female, holotype: Length 8 mm. Black; head and thorax generally opaque, abdomen reddish, mandibles reddish apically, fore femora narrowly reddish at base, tarsal joints 2-5 reddish brown. Head and thorax mainly finely granulate-punctate; middle portion of clypeus produced, terminating as a broad wedge, the margin broadly polished, carina sharp and a little downbent at apical portion; frontal carina forming an imperfect U with a median incised line basally; only an indication of the upper U; vertex moderately wide, ocelli in an equilateral triangle, lateral ocelli less than their width from the compound eyes; antennae slender, segment 3 a little longer than 4. Scutellum and postscutellum rather polished, closely punctate; disc of propodeum finely granulate, with a delicate median line and some short basal ones, the pleura more shining, with longitudinal striae, posterior face shining and with strong transverse striae and a median groove opening dorsally into a smooth area. Outer spines of fore tarsi as long as to slightly longer than apical width of their respective segments; second submarginal cell receiving both recurrent veins, transverse-median and basal veins almost interstitial, the transverse-median being slightly distad. A little silvery pile and some pale mesotibial spines; lateral fringe of pygidium of very short dark bristles.

Male, allotype: Length 4 mm. Black; head and thorax opaque, mandibles reddish apically, legs dark brown, tegulae and tarsi brownish, wings infuscate apically, apex of abdominal segments narrowly brownish, posterior tibiae with a yellowish-white stripe dorsally. Middle portion of the clypeus doubly produced (69), carina strong; malar space about $\frac{1}{3}$-$\frac{1}{4}$ as long as width of mandibles at base; frons wide, granulate, the double U fairly strong; vertex granulate to densely punctate; ocelli forming a triangle very slightly greater than equilateral, the posterior ocelli more than their diameter from the compound eyes; a slight depression behind the fore ocellus; antennae fusiform, segments 3 and 4 subequal. Meso- and metanotum closely and strongly punctate; disc of propodeum finely reticulate, median carina present, pleura finely longitudinally striate, posterior face strongly wrinkled and with a shining furrow. Fore trochanters excavate basally (73); carina of posterior coxae developed as a low rounded process, about as in Fig. 61; second submarginal cell receiving the two recurrents near each extremity, about as in Fig. 34; transverse-median slightly distad of basal vein. Apical half of last visible ventral segment narrow. Pile: moderate, silvery.

Holotype, female (C. A. S. No. 6162) with unworn clypeus but rather frayed wings from **Summit Lake**, at about 6700 ft. elevation, on the slopes of **Mt. Lassen, California**, July 21, 1937 (F. X. Williams); *allotype,* male (C.A.S. No. 6163) in fresh condition from Baltimore Park, Marin County, California, July 2, 1920 (F. X. Williams). Paratypes, 1 female with clypeus rather worn but wings in good condition, same data; 2 males, 1 Redwood City, San Mateo County, June 27, 1922, 1 Tahoe, Placer County, 6500 ft., July 1925 (F. X. Williams). Other specimens: all from Mt. Diablo, Contra Costa County, at 2000 ft., viz., 3 females collected on May 21 and June 14, 1949, 6 males on June 14, July 26, August 2, 8, 17, and 26, 1949 (F. X. Williams), at the lower edge of the "chaparral" formation. The 3 females are 6 mm. long and thus considerably smaller than the Mt. Lassen specimens. The males range from 3.5 to 5.2 mm. and some have the apex of the abdominal segments quite dark.

This species, which is related to *S. boharti,* may be considered the far-western representative of *S. fossor* (Rohwer). It differs from *fossor* chiefly in the more poorly defined frontal U (compare 23 with 29). The male *lasseni* is certainly very close to *S. modesta* (Rohwer, 1909) of which I have studied a paratype (No. 13607, U.S.N.M.).

3. **Solierella sonorae** Williams, new species

(24, 27, 28, 39)

Female, holotype: Length 7.5 mm. Black; head and thorax subopaque, mainly finely and closely punctate, though the rather dense silvery pile tends to conceal this; abdomen red, mandibles reddish apically, apex of trochanters narrowly marked with yellow, tarsi reddish brown. Produced portion of clypeus forming a broad-angled wedge, the margin broadly polished, carina sharp though merging at apex into the smooth marginal area; frontal carina dividing above the antennae to form a strongly margined narrow U that expands toward ocellus to form a poorly defined U that lacks the base; vertex narrow, ocelli forming a triangle more acute than equilateral, the lateral ocelli less than their width from the compound eyes; 3rd antennal segment a little longer than the 4th. Propodeal disc finely reticulate, with a delicate median carina and short diverging basal ones; pleura with longitudinal wrinkles, posterior face shining, transversely wrinkled and with a median groove widening dorsad. Outer bristles of fore tarsi fully twice longer than width of their respective tarsal segments. Transverse-median very slightly distad of basal vein. Some short pale meso- and metatibial spines. Lateral fringe of pygidium of pale bristles.

Holotype, female (Citrus Experiment Station, Riverside, California), in fresh condition, from **eight miles south of Indio, Riverside County**, March 28, 1936 (P. H. Timberlake); on ground. Paratypes; 4 females: 1, Palm Springs, May 22, 1917 (E. P. Van Duzee), in collection of the California Academy of Sciences; 1, Quail Springs, Colorado Desert, California, October 5, 1939 (A. J. Basinger); 2, Cathedral City, Riverside County, November 11, 1939, "on ground" (P. H. Timberlake).

In the paratypes the transverse-median and basal veins are interstitial or very nearly so. Sometimes the propodeum shows transverse striations in addition to reticulations. The paratype from Palm Springs is a little over 8 mm. long.

Allied to *S. fossor,* but separated chiefly by its narrower vertex and frontal U. (compare 28 and 29.)

4. **Solierella major** (Rohwer)

(17, 18, 36)

Silaon major Rohwer, 1917, Proc. U. S. Nat. Mus. 53:247-248. Female. North Yakima, Washington. Length 10 mm.

One female, San Diego, California (F. E. Blaisdell) agrees well with Rohwer's description. The outer bristles of the fore tarsi are from twice as long as to a little more than double the width of their respective tarsal segments. It is related to *S. striatipes*, resembling it in the long narrow double U, general outline of the clypeus, which however lacks the well-defined shoulder of *striatipes*, and in the rather coarsely sculptured propodeal disc with its radiating and its parallel wrinkles. It lacks the yellow markings of *striatipes* and has a much longer tarsal comb. The ocellar triangle is more acute than equilateral.

The male seems undescribed.

A female *Solierella* from St. Johns, eastern Arizona, collected by Graham Heid, May 29, 1931 (California Academy of Sciences) much resembles *S. major*, though differing from it in the more arcuate frontal U, the apparently somewhat shorter 3rd antennal segment and in the pale foretarsal bristles.

5. **Solierella striatipes** (Ashmead)

(1-16, 40)

Niteliopsis striatipes Ashmead, 1899, Ent. News, 10:9. Male, not female as stated. "Habitat, California. Carl F. Baker Collection," No. 2375. Type, No. 5065. U. S. N. M.

Females of this species vary from about 7 to 11 mm. long. It is apparently our largest *Solierella*. It was taken in good series chiefly in July 1922, 1925, and 1937, at San Rafael and Mill Valley, Marin County, and at Menlo Park, San Mateo County. Other specimens studied are: 1 male, Bryson, Monterey County, May 19, 1920 (E. P. Van Duzee), and 1 male, Davis Creek, Modoc County (C. L. Fox), both specimens being from the collection of the California Academy of Sciences; 1 male, Riverside, June 12, 1938 (P. H. Timberlake) "Flying over the ground"; 1 female, Buck's, Plumas County, 5070 ft., July 23, 1937 (F. X. Williams). Finally, in the summer of 1949 many of these wasps were collected by the writer on Mt. Diablo, Contra Costa County, at 2000 ft.

The male is from 5 to 8 mm. long and has the clypeus doubly produced (2), and the ocelli forming an equilateral triangle. The dense puncturation is largely concealed by pale brassy and silvery pile. The propodeal area is marked by a delicate median carina and other carinae radiating fan-like, but more or less transversely towards the apex (11), or the apical portion may lack distinct wrinkles, or occasionally may have the wrinkles more or less as concentric ovals (12). The yellowish stripe on the tibiae may vary in extent, sometimes quite disappearing on the 1st and 2nd tibiae. The wings are broadly infuscate apically.

The female appears to be undescribed. It is like the male in most respects. The clypeus is produced into a rounded, smooth-edged lobe with a shoulder on either side; the 3rd antennal segment is a little longer than the 4th; the bristles of the fore-tarsal comb do not exceed the width of their respective segments.

This species was determined for me by the late Miss Grace Sandhouse of the United States National Museum.

6. **Solierella vierecki** (Rohwer)

(43-51)

Niteliopsis vierecki Rohwer, 1909, Trans. Amer. Ent. Soc., 35:112. Male and female. "Habitat, Boulder, Colorado, July 24, 1908 and August 4 and 5, 1908 (S. A. Rohwer)."

One female, Riverside, California, June 11, 1926 (P. H. Timberlake); on *Euphorbia albomarginata.* This specimen is nearly 5 mm. long and agrees very well with a paratype from Colorado kindly loaned me by the United States National Museum. Three females taken by me at Pueblo, Colorado, August 4, 1922, are also typical. The double U is well marked.

A male paratype of *S. parva* (Rohwer) from Boulder, Colorado, has a dull reddish abdomen (as has also the type) and the writer believes that *parva* is a synonym of *vierecki.*

This is a distinct species with a wide frons that seems to me more closely related to *S. plenoculoides* (Fox) than to the *fossor* group (compare 49 with 55).

7. **Solierella similis** (Bridwell)

(57-66, 175, 176)

Silaon similis Bridwell, 1920, Proc. Hawaiian Ent. Soc., 4:402-403. "Described from a single female collected at Berkeley, California, May 12, 1912 (Bridwell)—."

A fair series of both sexes taken by the writer in the following localities in California: Menlo Park and Redwood City, San Mateo County; Lagunitas, San Rafael, and Mt. Tamalpais, Marin County; Bucks, Plumas County, 5070 ft.; Tahoe, Placer County, 6500 ft.; and Danville, and Mt. Diablo, Contra Costa County. The Danville and Mt. Diablo specimens were taken during the summer of 1949.

This is a rather opaque black species up to about 7 mm. long. The double U of the wide frons is obsolescent; there is a shining fovea in the middle of the frons, the pronotum is short in profile (175), the second submarginal cell receives both recurrent veins or the second recurrent and second transverse-cubitus are interstitial or nearly. The pale yellow markings on the pronotum and hind tibiae, as described in the type, may be nearly or quite absent.

The male is much like the female, but the clypeal production has a low median tubercle.

This species is very close to *S. plenoculoides* (Fox) described from New York and Colorado. Rohwer (1909) describes the male of *plenoculoides* and has seen specimens of this sex from Fedor, Texas, and Boulder, Colorado. The writer took a male in Ramsey Canyon, Arizona, June 17, 1920. *S. similis* has rather thicker antennae than *plenoculoides* and the aedeagus has a shorter, fuller crook towards the apex (compare 53 and 63). The ocelli in *similis* form a very slightly greater triangle than equilateral.

A series of 8 males and 1 female from the National Museum and collected at Forest Grove, Oregon (L. P. Rockwood) are all black save for the partly pale pronotal lobes. Structurally they correspond to *similis*, of which they may be considered a dark phase.

8. **Solierella vandykei** Williams, new species

(67, 68)

Female, holotype: Length 6 mm. Black; mandibles reddish apically, a creamy yellow stripe on posterior tibiae above, apex of abdominal segments pale yellowish brown. Clypeus produced into a broad rounded lobe, its median carina strong, extending to near margin which is steeply depressed steplike; frons granulate, subopaque, the median groove in the subobsolete U widely polished; ocelli forming an obtuse triangle slightly less than a right angle triangle, their interspace with some fine longitudinal striae, the posterior ocelli slightly less than their diameter removed from the compound eyes; commencing along the outer side of each posterior ocellus is a rather shining low carina that extends forward beside the eye margin to form the arched sides of the subobsolete upper U. Antennae moderately stout, articles 3 and 4 subequal. Pronotum very slightly notched mesad, meso- and metanotum shining, rather closely and finely punctate, mesopleura finely punctate but with a smooth embossed area below wing bases; disc of propodeum rather opaque, with fine, chiefly oblique wrinkles to the longitudinal carina, the disc rather well rounded and somewhat margined apically, the pleura finely reticulate wrinkled, posterior face reticulate and with a shining subtriangular fovea. In the left forewing the second submarginal cell receives the first recurrent vein very near its base; in the right wing the first recurrent and the first transverse-cubitus are interstitial; transverse-median slightly distad of basal vein. Abdomen shining. Vestiture: moderate silvery pile.

Holotype, female (C. A. S. No. 6164), in fairly fresh condition from **Tahoe, Placer County, California**, 6500 ft., July 1925 (F. X. Williams). Paratype; one female in more worn condition; same data. The paratype has the first recurrent vein of both wings interstitial with the first transverse-cubitus, and the disc of the propodeum rather coarsely reticulate, with a fine median carina and some oblique wrinkles basad.

Superficially like *similis*, but easily separated by the clypeus which is steeply depressed just before the margin.

Named for Dr. E. C. Van Dyke, pioneer entomologist, who has done much to further entomology in California.

9. **Solierella corizi** Williams, new species

(75-87)

Female, holotype: Length 6.5 mm. Black; head and thorax rather shining, abdomen shining, mandibles reddish preapically and with a faint median yellow spot; hind margin of pronotum except narrowly mesad, most of lateral lobes, tegulae and axillary sclerites, postscutellum, a stripe on the tibiae above, the four anterior femora beneath near base to apex, and apex of posterior femora, creamy yellow; tarsi brownish, wings infuscate apically; in addition the hind wings have several dusky streaks to apex, the most clearly marked one being the extension of the radial vein to margin. Clypeus produced into a lobe, rather flat wedgelike apically, where it is smooth and shining, median carina strong, not extending to margin, the disc on either side coarsely punctate; frontal carina dividing V-like, well marked for a short distance; along the eyes above, on each side is a smooth inarched swelling that ends near the posterior ocelli, the latter forming an approximately right-angle triangle; antennae subclavate with segment 3 longer than 4, and 12 longer than 11. Mesonotum with deep, rather irregularly scattered punctures, sulcate mesad and to a lesser degree at either side; disc of propodeum margined, truncate-triangular, with carinulae radiating mainly fanwise from base, the pleura with fine longitudinal striae, posterior face transversely striate and with an oval, very finely reticulate depression. Posterior coxae on their inner side above with a thornlike process toward base (79, c); second submarginal cell receiving both recurrents, the second about the middle; transverse-median distad of basal vein. Intersegmental constrictions of abdomen distinct; pygidium practically bare, shining and with very fine scattered punctures. Vestiture: sericeous pile, often brassy tinged, dense on frons, sides of propodeum, and somewhat bandlike on abdomen.

Male, allotype: Length 6.25 mm. Marked as in the female, but the markings are lemon yellow instead of creamy yellow, with additional markings as follows: antennae with segments 6 and 7 beneath, and 8 and 9 entirely, pale yellow to yellowish brown, 10 chiefly brownish, 11 and 12 brown; mandibles black basally, a yellow spot at median length, apical part reddish to darker. Clypeus drawn out mesad as a tumid tridentate process, the middle carina strong, extending to margin; antennae stout, subclavate, article 8 drawn out beneath, 7 and 8 to a lesser degree, last article tapering cone-like and about as long as the preceding 3½ articles. Fore coxae strongly excavate posteriorly for the reception of the trochanters which themselves are deeply excavate beneath and provided at the outer side of the excavation with a curved bristle; posterior wings with 6 fuscous streaks at the apical portion (80); last visible ventral segment tapering to parallel-sided apical portion; aedeagus sickle-shaped, with fine teeth within.

Holotype, female (C. A. S. No. 6165) in fresh condition, **Menlo Park, San Mateo County, California,** August 8, 1937 (F. X. Williams). *Allotype,* male (C.A.S. No. 6166), in fresh condition, topotypical, July 25, 1937 (F. X. Williams). Paratypes: 1 female, San Rafael, Marin County, July 28, 1922 (F. X. Williams); 1 female, Manor, Marin County, July 28, 1937; 4 females, Menlo Park, San Mateo County, August 1937; 6 males, Menlo Park, July-August, 1937; 4 females, Danville and Mt. Diablo, Contra Costa County, summer of 1949 (F. X. Williams); and 11 specimens all taken by P. H. Timberlake, consisting of 6 females, Riverside, Riverside County, with respective data as follows: September 12, 1947, on *Guticrezia californica,* September 27 and October 19, 1927, on *Hemizonia wrightii,* May 14 and 18, 1925, and May 18, 1928, on *Eriogonum fasciculatum*; 1 female, Strathmore, Tulare County, September 30, 1935, on *Eriogonum angulosum*; 1 female, Lindsay, Tulare County, June 19, 1933, on *Asclepias eriocarpa*; 3 males, Riverside, May 14 and 18, 1925, on *Eriogonum fasciculatum,* and May 8, 1925, on *Euphorbia albomarginata.*

A well-marked species that varies considerably. Some of the more southernly examples have a good deal of yellow on the mandibles. The 3 males and 6 females taken at Riverside by Timberlake have a pair of swellings behind the two posterior ocelli, with which they form a subquadration (87). None of the specimens from central California, which includes the two females from Tulare County, lying north of the Tehachapi Mountains, possesses such swellings. These swellings are more or less characteristic of some of the other species of this group (91). The second submarginal cell usually receives both recurrents, but sometimes the first and the first transverse-cubitus are interstitial, and rarely is it received by the first submarginal cell close to its apex (84). It is chiefly in the males that such variations occur.

Solierella corizi is evidently very close to *S. mirifica* Pate described from Pima County, Arizona. I have not seen *mirifica,* but the differences between the two appear to be chiefly those of markings on the antennae. And in *mirifica* the thorax is described as opaque, whereas in *corizi* it is shining and apparently less densely punctate. *S. corizi* is also related to Rohwer's *iresinides* described from Guatemala. Dr. Karl V. Krombein has kindly compared the two species and furnished the following notes on the unique type of *iresinides,* as differing from a male *corizi*: "median carina of clypeus expanding toward apex to form a narrow platform; portion of occipital carina opposite middle of compound eye expanded to form a short low, rounded lamella, infumated streaks not present in hind wings or only faintly indicated."

10. **Solierella blaisdelli** (Bridwell)

(96, 100, 104, 105, 110, 111, 114, 120, 143, 144, 148, 154, 183-185)

Silaon blaisdelli Bridwell, 1920, Proc. Hawaiian Ent. Soc., 4:401. "Described from a single female collected at San Diego, California, March 29, 1891 (Dr. F. E. Blaisdell). Type in the author's collection."

I have studied a considerable series of both sexes of this species, my determinations having been made from a female specimen from Whittier, California, in the collection of P. H. Timberlake, and which he compared with Bridwell's type. It is characterized by the almost invariably dull reddish brown mandibles, rather narrowly lobed clypeus, ocelli arranged in a triangle slightly greater than equilateral, and the propodeal disc marked U-shaped by a raised line. The transverse-median and basal veins are often interstitial; the pronotum, the lobes and tegulae, postscutellum, the four anterior femora apically beneath, and all the tibiae above are marked with creamy white. Occasionally specimens lack the postscutellar mark, while the leg markings may be reduced. The dorsum is shining and finely punctate. Above the mesopleural pit below the wing bases there is a glabrous shining spot, sometimes absent in the male because of the silvery pile. Length 3.5-4 mm.

The male seems undescribed. It varies considerable, even to the aedeagus, the lobes of which may bear from 4 to 9 teeth. In well-favored specimens the tumid clypeus terminates in a distinct spike, in others this is indicated by more or less of a nipple (183-185). Such variations may occur in specimens taken at the same time and place. The ocelli may equal an equilateral triangle. The last segment of the antenna is often collapsed and is equal to the 3½-4 preceding segments combined. The fore coxae beneath may be armed with a small mucro. The fore trochanters are well excavated at the base. The tarsi are largely creamy white. Figures 120, 144, and 154 show details of a rather aberrant male from the Sierra Nevada.

The following have been studied: 4 specimens labelled "*S. affinis* Rohwer" from the U. S. National Museum consisting of 1 female, Alameda County, July 1907 (W. M. Giffard) and 3 females, Los Angeles, September 1907 (C. H. Hicks); 13 specimens taken by P. H. Timberlake as follows: 1 female, Riverside, California, June 14, 1932, on *Euphorbia albomarginata*; 1 female, Riverside, May 6, 1933, on *Alyssum maritimum*; 9 males and 1 female, Whittier, California, August 11, 1920, the female at fennel (*Foeniculum vulgare*) flower and the males at glands of sunflower, in river bottom; 1 male, Riverside, June 21, 1946, on *Euphorbia albomarginata*; and 43 specimens collected by F. X. Williams as follows: 1 male, Buck's, Plumas County, 5070 feet; 1 female, Point Lobos, San Francisco, June 29, 1920; 1 male, San Rafael, Marin County and 11 males and 11 females, Menlo Park, San Mateo County, all in 1937 and chiefly during the summer; and 1 male, Mt. Diablo and 3 males and 3 females, Danville, Contra Costa County and also 8 males and 3 females, Mill Valley, Marin County, all during the summer of 1949. This species occurs also at Tucson and the Huachuca Mts., Arizona (F. X. Williams, collector).

This insect is very close to *S. affinis* (Rohwer) which was described from Colorado in 1909. According to the description of *affinis* and also in the specimens which I have seen from Colorado, the mandibles are largely yellowish white. *S. blaisdelli* is related to the Hawaiian *rohweri* Bridwell (1920)[5] from which species it differs in being more generally marked with creamy yellow (occasionally all-black *rohweri* occur), in the non-carinate or nearly non-carinate clypeus, the presence of a glabrous mesopleural spot, and a longer propodeum which has a U-shaped rather than a truncate V-shaped enclosure. It is also related to *S. nigra* (Ashmead).

11. **Solierella nigra** (Ashmead)

(97, 106, 107, 113)

Plenoculus niger Ashmead, 1899, Psyche, 8:339. Female. "Habitat, Colorado. Carl F. Baker Collection No. 2170." "Type No. 5068, U. S. N. M."

Niteliopsis niger Rohwer, 1909, Trans. Am. Ent. Soc., 35:115. Male and female. "Habitat, Florissant and Boulder, Colorado."

Specimens were examined from the following localities in California: 3 males and 3 females, Riverside (P. H. Timberlake), with data as follows: 1 male, September 23, 1924, on *Euphorbia albomarginata*; 1 male and 1 female, May 11 and September 15, 1925, on *Euphorbia albomarginata*; 1 female, June 14, 1932, on *Euphorbia albomarginata*; 1 male, October 14, 1924, on flowers of *Gnapthalium*; and 1 female, October 30, 1924, feeding at honeydew. Other specimens studied were 1 female, Antioch, Contra Costa County, October 23, 1938 (J. W. MacSwain); 1 female, Davis, Yolo County, September 15, 1939 (G. E. Bohart); 1 female between Eureka and Weaverville, July 20, 1937 (F. X. Williams); and a series of 27 specimens from Danville and Mt. Diablo, summer of 1949 (F. X. Williams). I have also seen a male paratype (of *Niteliopsis niger* Rohwer) from Boulder, Colorado, August 4, 1908 (S. A. Rohwer), and a female paratype from Florissant, Colorado, June 12, 1908 (S. A. Rohwer), both numbered 13606, in the collection of the U. S. National Museum.

This is a subopaque, all black, or seldom nearly all black, species of rather coarse puncturation. The ocelli are arranged in about a right-angle triangle or a little less. The male clypeus bears a spikelike point, and in the female is produced into a rather narrow rounded lobe, and the clypeal carina is weak

5. Also occurring on the mainland of the United States.

or obsolete. The propodeal disc is short and a subtriangular area, usually marked by a raised line, is present (113). The aedeagus has a few rather large teeth.

Solierella nigra is closely related to *S. rohweri* (Bridwell, 1920) of the Hawaiian Islands; *rohweri*, however, has finer sculpture and the clypeal carina is usually fairly well developed; in addition, *rohweri* commonly has pale yellow markings on thorax and legs.

12. **Solierella nitens** Williams, new species

(124)

Female, holotype: Length 4.75. Shining black; sculpture and punctuation fine; clypeus and mandibles reddish apically; mandibles for basal two-thirds, two wide spots on posterior margin of pronotum, pronotal lobes, tegulae in part, disc of postscutellum, apex of femora 1 and 2 obliquely from beneath, creamy yellowish white. All tibiae with a yellowish stripe exteriorly; tarsi brown, darker apically; apex of abdominal segments testaceous. Clypeus broadly produced, slightly angulate laterad and slightly rounded out lobiform mesad (124), the margin smooth and polished, the disc gently convex, not depressed apically and with a low basal carina; ocelli in slightly less than a right-angle triangle; a weak furrow from anterior ocellus forward; antennae slender, segments 3 and 4 subequal; pronotum slightly depressed mesad posteriorly; a shining glabrous spot below wing base; disc of propodeum with the well-formed U enclosure reticulate, with a median carina and some short ones diverging from base, pleura shining and with fine well-spaced longitudinal striae, the posterior face with transverse wrinkles and a median groove widening above. Abdomen shining, impunctate. Transverse-median a little basad of basal vein. Vestiture: rather sparse silvery pile.

Holotype, female (C. A. S. No. 6167) in good condition from **Menlo Park, California**, July 13, 1937 (F. X. Williams). Paratype 1 female, Menlo Park, July 8, 1937 (F. X. Williams). In the paratype the propodeum is more finely reticulate and the transverse-median and basal veins are interstitial.

A finely polished insect, the dorsulum very finely punctate. Best identified by the clypeus.

13. **Solierella clypeata** Williams, new species

(Text figure 1)

Female, holotype: Length 4 mm. Black; head and thorax only moderately shining, propodeum subopaque, abdomen shining; puncturation fine; clypeus and mandibles reddish apically; basal part of mandibles mostly creamy yellow; two wide spots on posterior part of pronotum, pronotal lobes, tegulae, and axillary sclerites in part, disc of postscutellum, apex of femora 1 and 2 obliquely from beneath, and a stripe on all tibiae, creamy yellowish white. Tarsi dull brownish, femur 3 with a trace of pale markings apically. Clypeus not carinate, nearly squarely truncate for its median portion, in profile convex though slightly and narrowly depressed apically, disc with a some-

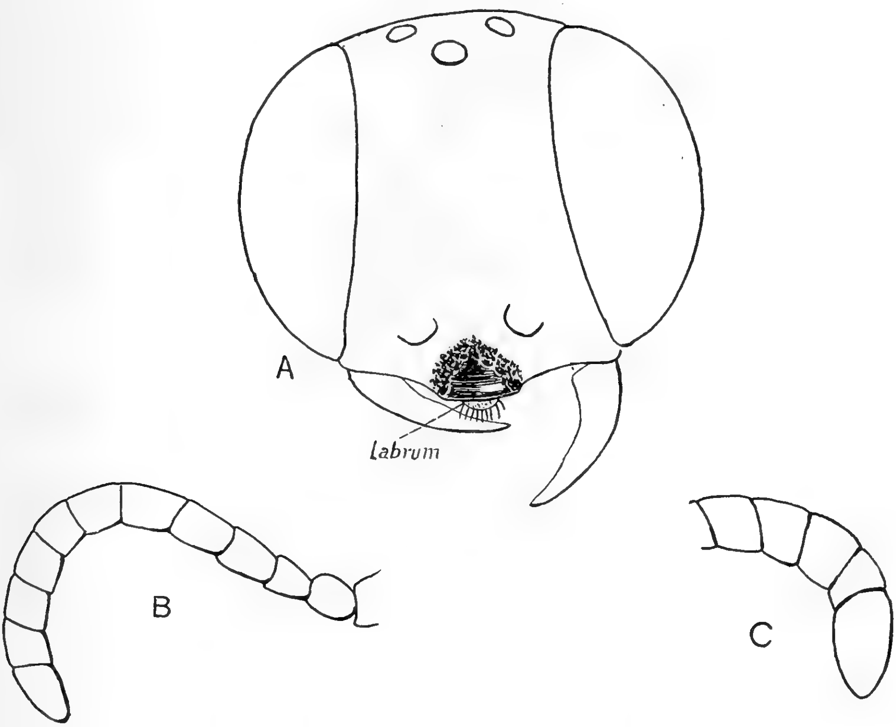


Fig. 1. *Solierella clypeata.* Clypeus and antenna of the holotype, a female from Riverside, California. At right, terminal segments of antenna of a male from Mt. Diablo, California.

what obcuneate, nearly impunctate smooth area; mandibles rather slender, not notched beneath; face only slightly gibbous; ocelli forming slightly more than an equilateral triangle, a depressed line from anterior ocellus forward; antennae moderately stout; frons very finely granulate-punctate, the vertex with fine close puncturation; no bare shining mesopleural spot; disc of propodeum finely granulate and with evidence of fine transverse striae apically, a fine raised median line, no enclosed U-shaped area, pleura shining, finely striate-reticulate, posterior face with some transverse wrinkles, a median cleft and a depression widening above. Anterior tarsi with short spines, no comb; posterior coxae with the inner carina forming an inconspicuous tooth at base.

Transverse-median basad of basal vein; first recurrent from near apex of first submarginal cell. Abdomen very finely and closely punctate. Vestiture: moderate silvery pile.

Holotype, female (Citrus Experiment Station, Riverside) in fine condition, **Riverside, California**, September 15, 1942 (P. H. Timberlake); on *Eremocarpus setigerus* (Euphorbiaceae). Other specimens: 1 female, Mt. Diablo, Contra Costa County, California, June 14, 1949, at 2000 ft., 1 male, same locality, June 23, 1949, and 2 males, same locality, August 23, 1949 (F. X. Williams). The male resembles the female in markings, sculpture and truncate clypeus, the malar space is about one-third the basal diameter of the mandibles, while the terminal segment of the antenna is the shortest for the group having this segment elongate, since in *clypeata* it is about equal in length to segments 11 plus 12 (Text fig. 1).

The Mt. Diablo specimens are not part of the type series.

14. **Solierella arcuata** Williams, new species
(115, 116, 138, 140, 147, 182)

Female, holotype: Length 5 mm. Black; head subopaque, dorsulum shining, propodeum opaque above; mandibles pale yellow at base, clypeus reddish apically; femora largely brownish black; two wide spots on pronotum, the lobes, tegulae and axillary sclerites in part, postscutellum, a widening stripe on the four anterior femora from apical half beneath to apex above, extreme apex of posterior femora, and all the tibiae dorsally, creamy yellow. Tarsi brownish. Clypeus widely arched-subconic, smooth apically, with an imperfect row of strong premarginal punctures and a low and obscure basal carina; mandibles not excised (182); frons finely granulate; ocelli in a little less than a right-angle triangle, the lateral ocelli 1½ times their diameter from the eye margin; antennae rather slender, segments 3 and 4 subequal, the apical segment at least twice as long as its diameter. Dorsulum finely and densely punctate; mesopleural spot beneath wing base finely punctate, or sometimes absent; disc of propodeum dullish, reticulate, mesad somewhat depressed troughlike apically, median carina poorly developed; sides of propodeum shining, with some 8-10 well-spaced longitudinal striae; posterior face shining, with well-spaced cross wrinkles and a narrow median cleft. Transverse-median basad of basal vein, first recurrent vein from apex of first submarginal. Vestiture; rather sparse silvery pile; some pale spines on mid-tibiae.

Male, allotype: Length 3.5 mm. Clypeus produced conelike; last antennal segment a little longer than the 4 preceding combined; ocelli more nearly approaching an equilateral triangle; last visible ventral segment with apical part rather broad, emerging from sloping shoulders; aedeagus with about

10 teeth. In markings, it differs from the female in having all the tarsi creamy yellow with the apices dusky.

Holotype, female (C. A. S. No. 6168) and *allotype* male (C. A. S. No. 6169), both from **Menlo Park, San Mateo County, California**, July 13, 1937 (F. X. Williams). Paratypes: 6 females and 1 male, Menlo Park, July 6, August 1937; 1 female, San Rafael, Marin County, July 28, 1922; 1 female, Manor, Marin County, July 28, 1937; 1 female, Redwood City, San Mateo County, June 27, 1922; 2 females and 2 males, Buck's, Plumas County, July 23, 1937; 1 female, Tahoe, Placer County, July 1925; and 6 females and 5 males, Mt. Diablo and Danville, Contra Costa County, summer of 1949 (F. X. Williams).

Solierella arcuata is one of a small group of closely related species that have the clypeus broadly arched-subconic in the female and conic in the male, and with the propodeum lacking a margined U-shaped area.

15. **Solierella australis** Williams, new species
(101, 103, 130, 137, 139, 149, 150)

Female, holotype: Length 4 mm. Much resembling *arcuata* in its arched clypeus and markings. It differs as follows: generally less shining; antennae stouter (compare 137-140); tibiae of male and tarsi of female brownish; sides of propodeum subopaque, sculptured with *many* fine close parallel striae (instead of 8-10 in *arcuata*), posterior face subopaque, the wrinkles less marked. The pilosity is also denser than in *arcuata,* so that there is no smooth shining mesopleural spot, and the disc of the propodeum may bear rudiments of a U-shaped carina.

Male, allotype: Differs similarly from the male *arcuata,* in being more pilose, duller, antennae shorter, and in the sculpture of the propodeum. The last visible ventral segment as in *arcuata*; aedeagal lobes with about 5-9 teeth. The transverse-median is slightly basad of basal vein.

Holotype, female (Citrus Experiment Station, Riverside) from **Riverside, California,** May 13, 1927, on *Euphorbia albomarginata*; *allotype* male, topotypical, May 25, 1926, at flowers of *Chorizanthe*; paratypes and all other specimens are from Riverside, with the following additional data: 9 female and 11 male paratypes, May 8, 16, 22 and 25, 1925, on *Euphorbia albomarginata*; 2 females, May 18, 1926; 1 female, June 11, 1926, on *Hugelia virgata*; 1 female, June 17, 1930, on *Hugelia virgata*; 1 female, May 18, 1933, on ground; other specimens: 12 males, May 8, 11, 18, 22 and 25, 1925, on *Euphorbia albomarginata*; 1 male, May 31, 1926; 1 male, June 11, 1926; 1 male, May 10, 1927, on *Euphorbia albomarginata*; 1 male, August 28, 1927, on *Gutierrezia californica*; 1 male, May 25, 1926, at flowers of *Chorizanthe*;

1 male, April 5, 1938, flying over ground; 1 male, May 3, 1926, on bare ground; and 1 female, September 14, 1925, on *Gutierrezia californica*; also 1 specimen, Mill Creek, San Bernardino Mts., and 1 female, Lovejoy Buttes, Mojave Desert, California, May 11, 1944, on *Pectocarya penicillata* (Boraginaceae). All specimens collected by P. H. Timberlake.

There is considerable variation in this large series, particularly in the males, and there may be two species involved. The chief variation is in the male clypeus. The fine close striation of the propodeal pleura seems to be a constant character, as nearly always, the lack of a propodeal enclosure. From *blaisdelli*, doubtful specimens may be separated chiefly by the whitish instead of the reddish mandibles.

16. **Solierella timberlakei** Williams, new species

(119)

Female, holotype: Length 3.75 mm. Black, moderately shining, clypeus largely reddish, antennae dull brownish beneath for about basal half, apex of segment 1 with yellowish brown, mandibles creamy white, becoming reddish apically; two wide spots on pronotum, portion of lobes, tegulae, axillary sclerites, and costal border of wing in part, postscutellum, the four anterior femora from apical half beneath obliquely to apex above, the very apex of hind femora, a stripe on all tibiae, and the first segment of the middle and posterior tarsi above, creamy white; rest of tarsi brownish; tibiae reddish brown beneath. Clypeus with the disc gibbous, not carinate, shining, with a few large punctures except on the steep, somewhat flattened apical slope, broadly rounded-subtruncate, very slightly emarginate mesad along the wide marginal strip; mandibles not notched beneath, hardly emarginate; antennae moderately stout, the segments thick, the apical one about twice as long as wide at base; ocelli forming a slightly greater than equilateral triangle; frons rather protruding, finely granulate, vertex finely and closely punctate except for a shining area on outer side of posterior ocelli. Pronotum slightly notched mesad; scutum and scutellum deeply and closely punctate; no shining glabrous spot above pit on mesepimeron; metapleura smooth and shining, with a few fine striae; disc of propodeum subopaque, finely reticulate, with short diverging basal striae, traces of transverse striae apically and a weak longitudinal carina, the pleura shining, finely and rather closely striate, the posterior face with an oval depression and some transverse wrinkles. Middle femora with a few short pale bristles. First recurrent entering first submarginal cell near apex, second recurrent entering second submarginal cell somewhat beyond middle; transverse-median basad of basal vein. Pygidial area polished, with fine shallow, well-separated punctures. Vestiture: rather dense silvery pubescence.

Holotype, female (Citrus Experiment Station, Riverside) in fresh condition, the clypeus being quite unworn. **Six miles south of Palm Springs, Colorado Desert, California,** June 8, 1930 (P. H. Timberlake), on *Eriogonum trichopodum*.

Named for P. H. Timberlake whose careful collecting has brought to light many new species of insects.

A distinct species.

17. **Solierella abdominalis** Williams, new species
(117, 118, 131, 133, 134, 152)

Female, holotype: Length 4.5 mm. Black; head and thorax subopaque, mandibles creamy yellow, becoming reddish apically, clypeus more or less reddish; two wide spots on pronotum, the tegulae, axillary sclerites in part, postscutellum, the four anterior femora with an oblique stripe for more than apical half beneath to apex above, extreme apex of hind femora, all tibiae above, creamy yellow. Tibiae beneath in part and the tarsi reddish brown, apical tarsal segment darker, abdomen red with a basal dark spot on tergite 2, the 3 apical tergites and sternite 3 in part, dark brown; wing veins pale at base. Mandibles somewhat emarginate beneath (about as in 142); clypeus broadly arched-subconic, as in *arcuata*, not carinate, shining, with a few large punctures beyond base, the marginal area smooth and fairly wide; antennae rather stout, last segment about twice as long as thick; ocelli forming a triangle slightly less than right angled; frons and vertex finely granulate-punctate. Scutum and scutellum finely and closely punctate; no shining mesopleural spot; disc of propodeum finely reticulate, without a bounding U-shaped carinate line, the delicate median carina in a shallow trough, some basal radiating striae, the pleura subopaque with fine separate parallel striae, the posterior face with an inverted tear-shaped depression and some meshlike transverse wrinkles. A few pale bristles on midtibiae. Venation as in *timberlakei*. Abdomen with the segments hardly depressed apically; pygidial area finely punctate, densely so at sides. Vestiture: moderate silvery pile.

Male, allotype: Length 3.75 mm. Marked like the female, but the last antennal segment dull reddish brown, fore coxae beneath chiefly yellow, apex of abdomen blackish above. Clypeus as in *arcuata* and *australis*, the apical portion not punctate; last antennal segment about as long as the 5 preceding together; ocelli in an obtuse though more nearly equilateral triangle; no line from anterior ocellus posteriorly. Aedeagus with 7-8 teeth.

Holotype female (Citrus Experiment Station, Riverside) in fresh condition; from **Palm Springs, California**, May 11, 1935 (P. H. Timberlake), on

Euphorbia polycarpa. *Allotype* male, topotypical, March 26, 1932, on *Malva pusilla*. A third specimen is from Kyle Canyon, Nevada (P. H. Timberlake).

Differs from *timberlakei* in the finer and denser puncturation of the head, the more rounded clypeus with its narrower margin, and in the somewhat emarginate mandibles, while the ocelli of *abdominalis* and of the following closely related species (*S. bicolor*) are arranged in an approximately right-angle triangle and slightly more obtuse than in *timberlakei*.

18. **Solierella bicolor** Williams, new species

(132, and text figure 2)

Female, holotype: Length 4.75 mm. Black; head and thorax subopaque; the creamy yellow markings, mandibular and clypeal colors are as in *abdominalis*; tergites 1, 2, and 3, except the dark middle portion, reddish, segments 4 and 5 brownish black, pygidium dark reddish brown, sternites mainly reddish, the 3rd with a dusky suffusion; apical margin of segments testaceous; legs except for the pale markings largely reddish brown. The only differences

Fig. 2. *Solierella bicolor* ? Mandible of male as seen from the outer side. Specimen from Palm Springs, California.

I find between *bicolor* and *abdominalis* are: *bicolor* has the abdomen more solidly dark reddish brown to brownish black; there is no definite though finely impressed line from anterior ocellus posteriad, as in the *abdominalis* female; the clypeus in *bicolor* has the disc more strongly punctate, the close punctures extending closer to the margin, thus leaving a smaller median and lateral impunctate area (as in *S. arcuata* and *australis*); in *bicolor* the antennae are definitely stouter and shorter, the last segment being slightly less than twice its thickness.

Holotype female (Citrus Experiment Station, Riverside) from **Riverside, California**, April 25, 1929, "flying low over the ground" (P. H. Timberlake). Paratypes: 4 females in good condition, 2 from Riverside, April 21, 1938, and April 15, 1939, "flying over ground"; 1, Riverside, April 16, 1928, "on ground"; 1, one and one-half miles west of Perris, Riverside County, on *Salvia columbariae*, April 27, 1938 (P. H. Timberlake). Also 3 females, The Gavilan, near Riverside (P. H. Timberlake).

What may be the male of this species is represented by a single specimen taken in fresh condition by Mr. Timberlake, at Palm Springs, May 6, 1946, on *Euphorbia polycarpa*. The description follows: Length 3.6 mm. Black; head, thorax, and abdomen not very shining; mandibles creamy yellow becoming reddish apically; fore coxae in part beneath, two wide pronotal marks, lobes in part, tegulae and axillary sclerites, the four anterior femora beneath from apex to near basal third, posterior femora apically, all tibiae except a dark stripe beneath, the tarsi except the reddish brown apical segment, and the postscutellum, creamy yellow; apex of tergites more or less widely testaceous. Head and thorax very finely punctate and granulate, the abdomen very finely reticulate. Mandibles somewhat excavate beneath (text figure 2), malar space ½ to ⅓ basal diameter; clypeus produced about as in *abdominalis*, slightly upturned at apex, the apical portion with some large punctures; ocelli forming very slightly more than an equilateral triangle, an ill-defined impressed line from anterior ocellus posteriad; antennae subclavate, the last segment approximately equalling the preceding five. No shining mesopleural spot. Disc of propodeum not enclosed by a raised line, reticulate and with a delicate median carina, the pleura shining, with well spaced parallel carinulae, posterior face transversely carinulate and with an inverted tear-shaped depression.

19. **Solierella levis** Williams, new species
(121, 142, 178)

Female, holotype: Length 3.8 mm. Black; head, thorax, and abdomen shining; puncturation fine; mandibles yellowish brown near the middle, clypeus largely dark reddish; two wide spots on posterior part of pronotum, the lobes narrowly, postscutellum, four anterior femora apically to postero-ventrad, a stripe on the posterior tibiae above, creamy white; tarsi brown; apical margin of abdominal segments testaceous. Mandibles slightly notched beneath toward base (142), clypeus not carinate, broadly subtruncately produced, depressed toward margin to form a rather wide smooth rim, the disc shining, with a few strong punctures; antennae rather slender, slightly clavate, segments 3 and 4 subequal; ocelli forming a triangle slightly greater than an equilateral triangle; a furrow forward from anterior ocellus; front and vertex very finely reticulate (close shallow punctures). Scutum and scutellum finely and closely punctate, a rather shining though punctate spot on mesopleura; disc of propodeum without bounding enclosure, reticulate, with a rather weak median carina, the sides of posterior face shining, with transverse wrinkles, those of the posterior face few and widely spaced, the posterior depression subtriangular. Outer spines of fore tarsi equalling to surpassing the diameter of their respective segments. Transverse-median basad of basal vein. Abdominal segments very slightly depressed apically; pygidium with some fine scattered punctures, subaciculate above the marginal pilose boundary.

Holotype female (C. A. S. No. 6170) from **Emeryville, Alameda County, California,** October 26, 1938 (J. W. MacSwain). Four female paratypes and same data. Two of the paratypes have a well-marked U-shaped enclosure on the disc of the propodeum. Additional speciments: one female from Cathedral City, California, October 8, 1945 (P. H. Timberlake), "entering hole in sand." This specimen is peculiar in that it has but two submarginal cells, the distal side of the second submarginal being absent.

A smooth shining species with sparse vestiture and somewhat resembling *S. nitens,* but differentiated by the shape of the clypeus and the brownish ground color of the mandibles, and by the gently notched or excavate mandibles.

20. **Solierella bridwelli** Williams, new species
(122, 123, 135, 136, 145, 153)

Female, holotype: Length 3.5 mm. Black; mandibles creamy white at wide basal portion, thence yellowish and then brown apically, legs deep brown to black. Pale markings as follows: two wide pronotal spots, the lobes, tegulae, axillary sclerites in part, postscutellum, stripe on four anterior femora beneath for more than apical half to apex above, apex of hind femora beneath, all the tibiae above and the first segment of all tarsi, creamy white; other tarsal segments becoming darker, costa and subcosta at base creamy to pale brown; apical margin of abdominal segments testaceous, venter particularly at base largely obscure brownish. Mandibles rather slender and more emarginate than usual (135); clypeus broadly rounded out, with a wide smooth margin very slightly depressed and emarginate mesad, the disc itself broadly depressed in a procurve before the middle length, smooth and shining, excavate in profile, with a very few large punctures; antennae short and stout, the last segment a good deal longer than the preceding one; frons subopaque, very finely granulate, vertex shining and very finely and closely punctate; ocelli forming a triangle only slightly greater than equilateral. Pronotum slightly notched mesad; dorsulum shining, very finely and closely punctate; no smooth shining mesopleural spot, the area all covered with sericeous pile; disc of propodeum opaque and finely reticulate, no U-shaped bounding line, some fine oblique wrinkles and a median carina in a shallow trough; pleura very finely reticulate-striate, the posterior face with some transverse wrinkles and a shallow triangular depression. First and second submarginal cell each receiving a recurrent vein, the second recurrent entering near apex of cell; transverse-median well basad of basal vein. Disc of pygidium finely and closely punctate. Some pale bristles on meso- and metatibiae. Vestiture: rather dense silvery pile.

Male, allotype: Length 3.5 mm. Marked as in female, but the sculpture is coarser, the clypeus more convex and shining for a shorter portion, and arcuate subconic mesad (123); the mandibles are more strongly excavate; antennae mainly brownish, the last segment being equal to about the preceding 5½; malar space about as long as ½ the width of the mandibles at base (practically no malar space in the female). Disc of propodeum with a faint median carina, some basal fanning-out wrinkles and some transverse ones; posterior face with transverse wrinkles and a strong triangular depression. Carinal tooth on posterior coxae at base obtuse, blunter than in *S. blaisdelli* (110). Lobes of aedeagus rather high, with 5 teeth each.

Holotype female (Citrus Experiment Station, Riverside) in fresh condition from **10 miles south of Adelante, Mojave Desert, California**, May 28, 1932, on *Chorizanthe thurberi*. *Allotype* male from 5 miles south of Palm Springs, Colorado Desert, June 8, 1930, "in shade of *Dicoria*." Paratypes: 1 female, Riverside, July 5, 1929, on *Eriogonum gracile*; 1 female, Yermo, Mojave Desert, June 19, 1939, on *Eriogonum reniforme*. All collected by P. H. Timberlake.

A thickset species, particularly the female. The mandibles in both sexes are more emarginate than usual, except in *S. albipes* (Ashmead). One of the paratypes being quite freshly developed still shows a good deal of brownish ventrad.

Named for J. C. Bridwell, who has described several species of *Solierella* and has done excellent work among the Hymenoptera.

21. **Solierella albipes** (Ashmead)

(125-129, 146, 151, 179, 187)

Plenoculus albipes, Ashmead, 1899, Psyche 8:338-339. Male. Rifle, Colorado.

Solierella albipes (Ashmead) Krombein, 1938, An. Ent. Soc. Amer., 31:469.

A small series of *Solierella* from San Mateo County and the Sierra Nevada, and a larger series from southern California seem to belong here. A female collected by the writer in Pueblo, Colorado, August 4, 1922, is probably the undescribed female of *albipes*. The males from central California have the clypeus more or less acutely produced (125); those taken by Timberlake in southern California have the clypeus terminating in an inconspicuous nipple (129). In addition, the two males from central California have a mucro on the fore femora beneath (as in some males of *blaisdelli*). Timberlake's specimens are the most strongly marked with creamy yellow and to that extent better conform to Ashmead's description. Comparison of Californian specimens with those at the U. S. National Museum indicate their probable identity with this apparently variable species.

The following is a description of this species from southern California: Female: Length 3.75 mm. Black; mandibles creamy white at base, clypeus in part reddish brown; two wide pronotal spots, pronotal lobes, tegulae and axillary sclerites in part, and postscutellum, creamy white; legs largely dark brown with the anterior femora for more or less of the apical half beneath to apex above, the middle femora apically beneath, and all the tibiae above, creamy white. Clypeus broadly rounded subtruncate with a rather wide smooth margin, the convex disc shining for more than its apical half and with large sparse punctures; mandibles emarginate beneath (127); antennae moderately slender, subclavate, the last segment about twice as long as thick and one-third longer than penultimate segment; ocelli in somewhat less than a right-angle triangle; frons subopaque, very finely granulate, vertex shining and with fine close punctures. Scutum and scutellum shining, with fine close punctures; a shining mesopleural spot; disc of propodeum subopaque, without a well-margined enclosure, and with a fine incomplete carina and basal and transverse carinulae, sides subshining with fine well-separated wrinkles, posterior face with the usual wrinkles and median depression. A few pale bristles on middle and posterior tibiae. Abdomen shining; pygidium with fine separate punctures. Moderate silvery pile.

Male: Length 2.9-3.6 mm. Marked like the female, with the addition that the first four segments of all tarsi are creamy yellow, the fifth segment becoming dusky. The clypeus is subconic in outline with an apical nipple. The terminal segment of the antennae is about equal to the sum of the four preceding ones. There is usually a shining mesopleural spot. The disc of the propodeum is rather coarsely reticulate and has a median carina.

Three females and 1 male, Riverside, September 9, 1924, May 4, 1925, June 16, 1925, and September 23, 1934; all on *Euphorbia albomarginata*; 1 female and 4 males, Whittier, August 1920, in river bottom, at glands of *Helianthus*. Additional specimens: 1 female, Camp Pendleton, April 23, 1946, flying over ground, and 1 male, Palm Springs, May 6, 1946, on *Euphorbia polycarpa* (P. H. Timberlake).

22. **Solierella sayi** (Rohwer)

(56, 155-166, 168, 169, 173, 177, 180)

Niteliopsis sayi Rohwer, 1909, Trans. Amer. Ent. Soc., 35:114-115. Male and female. "Habitat, Florissant, Colorado, June 19, 1908 (S. A. Rohwer). Caught while flying over sandy soil in a dry creek bed, and under bushes of a wild gooseberry (*Ribes vallicola*).

"A very distinct species, easily recognized by the short submedian cell, and the testaceous mandibles. Dedicated to the pioneer entomologist Thomas Say."

The large series of Californian specimens taken by me chiefly on Lone Mountain, San Francisco, and in Marin, Contra Costa, and San Mateo Counties, as well as a few in the Sierra Nevada, together with a number taken by P. H. Timberlake in southern California, while presenting some slight variations in markings and form of clypeus, agree with the type specimens in the United States National Museum.

Solierella sayi, length 3.5-4.7 mm., is a finely and closely punctate species with the head and thorax opaque. Proceeding from base to apex, the mandibles are black, creamy yellow and reddish brown; the femora of the fore and middle legs apically beneath and the pronotal lobes are creamy while, although in specimens from the Sierra Nevada the femoral marks may be nearly obsolete. The antennae are rather slender with segment 3 distinctly shorter than 4 in both sexes and segment 13 very short. This and the following species are the only ones known to me that have the clypeus rather narrowly produced mesad, the subtruncate portion usually more or less three-lobed and the sides commonly angulate. The posterior ocelli are rather more distant than usual from a line joining the posterior margin of the compound eyes at the vertex. The propodeum has no bounding carina and the pygidium is broad and finely reticulate.

The specimens collected by Timberlake bear the following data: two males and 1 female, Yerba Linda, August 14 and 15, 1920, on *Euphorbia albomarginata*; 3 males and 3 females, Riverside, as follows: 1 female, July 1, on *Euphorbia albomarginata*; 1 female, September 15, 1925, on *Eriogonum gracile*; 1 male, August 2, 1929, on *Eriogonum gracile*; 1 male, September 23, 1929, on *Euphorbia albomarginata*; 1 female, April 16, 1936, "excavating nest"; 1 male, April 20, 1937, "flying over ground"; 1 male, Whittier, August 11, 1920, at glands of *Helianthus*. Six additional specimens, Riverside, June and September, 1946, were also collected by Timberlake.

23. **Solierella californica** Williams, new species
(167, 170-172, 181)

Female, holotype: Length 4 mm. Black; subopaque, abdomen shining; mandibles blackish at very base, then pale yellow, and finally reddish brown apically; pronotal lobes, four anterior femora apically beneath and posterior femora at extreme apex and a stripe on all tibiae above, whitish yellow; tarsi brown. Clypeus rather narrowly truncately produced, the angles sharp, the margin gently arched and polished well back on its relatively flat disc, antennae slender, segment 3 a little shorter than 4; frons finely punctate; ocelli forming a triangle slightly more acute than equilateral, placed well forward in relation to posterior margin of compound eyes. Mesonotum and metanotum finely and closely punctate, the mesopleura without a polished spot; disc of propodeum finely reticulate, fan-wrinkled basally in the non-carinate median trough; pleura very finely reticulate, the posterior face with some transverse wrinkles and a shining inverted tear-shaped fovea; fore tarsus with the posterior or external bristles about as long as the width of their respective tarsal segments (18); first and second submarginal cells each receiving a recurrent vein. Pygidium rather broad, finely reticulate. Vestiture, of moderate silvery pile.

Male, allotype: Length 3.5 mm. Marked like the female. The rather narrow produced part of the clypeus bears a spinelike process; the upper frons and the vertex are narrower than in the female, and the relatively forward ocelli form a slightly more acute angle than in the female; the last antennal segment is much shorter than the preceding one. The fore trochanters as in *sayi,* are only gently excavate.

Holotype female (C. A. S. No. 6171); *allotype* male (C. A. S. No. 6172) and 2 female and 15 male paratypes, all from **Los Angeles** sand dunes, **California,** May 23, 1920 (F. X. Williams); 1 male and 1 female paratype, Whittier, August 11, 1920 (P. H. Timberlake), at glands of *Helianthus.* An easily recognized little species.

NOTES ON THE HABITS OF SOLIERELLA

These wasps favor warm dry regions where there is enough vegetation to furnish nectar for themselves, and other insects as provender for their young. Montane species of *Solierella* usually occur in stony areas where there is not too much undergrowth, while those living close to the seashore are often found among sand dunes.

The flowers which these wasps visit are very commonly species belonging to the families Polygonaceae and Euphorbiaceae; among the former are *Eriogonum* spp., *Polygonum* (knotweeds, etc.), and *Chorizanthe,* while in the latter family, *Euphorbia albomarginata* appears to be the most favored among the *Solierella* in southern California. Other favored plants are stork's bill (*Erodium* sp., Geraniaceae), *Gutierrezia californica* and tarweed (*Hemizonia wrightii*), the last two belonging to the Compositae. The glandular stems of the sunflower (*Helianthus* sp.) also attracts these wasps. It is fitting to state here that it is due mainly to the meticulous care of Mr. P. H. Timberlake in recording the flower hosts of *Solierella,* and of other hymenopterans, as indicated in his labeling, that I have been able to secure these data.

Our knowledge of the prey of *Solierella* is very scanty, but the available data agree at least in a rough measure with the natural groupings of these wasps. Thus, the largest species belonging to group I, those of group III, and perhaps group II prey on short-horned grasshoppers; groups IV-VII store hemipterans (bugs), while in group VIII, *Solierella sayi* preys upon psocids (book-louse relatives).

These wasps show very little construction ability. They seem usually not to excavate their nest-holes, but choose for example, a deserted spider burrow, a beetle boring, or the old nest of a solitary bee in some bramble.[6] Their paralyzed prey is stored in this nest amid the various debris brought in, and the entrance to the nest is crammed with this material.

In the United States, *Solierella peckhami* (Ashmead) (=*Plenoculus peckhami*) was observed by the Peckhams in Wisconsin nesting in stems of raspberry bushes and storing them with immature bugs of the genus *Pamera* (Lygaeidae) (*Wasps, Social* and *Solitary,* 1905, on pp. 95-96. Boston and New York). In *Wasp Studies Afield,* by Phil and Nellie Rau, 1918, on pp. 134-135 (Princeton University Press), and in Field Studies in the Behavior of the Non-social Wasps, by Phil Rau (Trans. Acad. Sci. St. Louis, XXV, 1908, on pp. 375-378) there is considerable information on the biology of *Solierella nigra* (=*Silaon niger*) in Missouri.

In Europe, S. Saunders (Trans. Ent. Soc. London, 1873, on pp. 410-411) describes the genus *Niteliopsis,* at best a subgenus of *Solierella,* for *N. pisonoides* Saunders, and he describes its pupal case found in brambles and refers to its also being found (teste Giraud) nesting in trunks and branches of decayed trees. In Bul. Soc. Ent. France, 1896, on pp. 79-80, Captain Xambeu describes the early stages of *Sylaon xambeui* Andre nesting in old longicorn beetle burrows, in southern France. In Bonifacio, Corsica, Ferton found *S. compeditus* Picc., a species closely related to *S. xambeui* nesting in the ground. Both of these species prey upon immature hemipterans; in the case of *S. compeditus,* on bugs of the family Lygaeidae. Ferton found *S. xambeui* paratized by *Eupelmus geeri* Dalman and by an anthrax fly. (Bul. Ent. Soc. France, 1896:80, and An. Soc. Ent. France, LXX, 1901: 101-102).

Solierella striatipes (Ashmead)

(Text figure 3)

This is our largest species, measuring up to 11 mm. Biological data on it were obtained in the vicinity of Stanford University during the summer of 1937, and are as follows:

Menlo Park, July 7, at about 3:00 p.m., I noticed a *striatipes* searching for her prey among dry grass and particularly in little patches of bindweed (*Convolvulus arvensis*). She would creep among the bases of the plants or, flying about the green stems, would poise in air a moment as if to dart at her prey, and then would continue her search in the adjoining weed patch. She searched to perhaps a distance of 30 feet on both sides of her nest-hole which, after a fruitless hunt she would occasionally visit. Finally, at about 15

6. Those species with well-developed tarsal combs may perhaps dig their own burrows.

feet from her nest-hole she issued from a weedy area, dragging by the antennae and venter up, her relatively enormous prey, a short-horned grasshopper twice her length and several times her weight. Her progress nestwards was tedious. Straddling her victim, the third pair of legs on the sides of the grasshopper's thorax, she pulled herself along, with now and then a hop, with her first, and to a lesser extent her second pair of legs. Once,

Fig. 3. *Solierella striatipes.* Female. Taken with her prey, *Melanoplus ligneolus,* at Menlo Park, California. The grasshopper is 22 mm. long.

apparently where the grasshopper had been overcome and again, where it had been dragged to about 6 feet from her burrow, she left her prey and went to reconnoiter about her burrow. Resuming her journey she rushed headfirst with her prey into the tunnel. In less than five minutes she reappeared and briskly set to work filling up the tunnel. This was of very ample bore and in rather dry and cracked soil. It sloped steeply, although, as later revealed, was scarcely double the length of the contained grasshopper, which was 22 mm.

The wasp selected her filling material with some care. This appeared to consist chiefly of the brittle-dry leaflets of an ornamental leguminous shrub which she procured at times from a distance of several feet. Later on, small lumps of soil were also used. All this material was carried forward in the wasp's mandibles and thus inserted into the tunnel. When the latter seemed nearly filled I captured the wasp and opened the nest-hole. The grasshopper that lay at the bottom had been so paralyzed by stinging that it could little more than move its antennae. Evidently the wasp's egg had been brushed off its body through my clumsy digging. The orthopteran proved to be a mature brachypterous female of *Melanoplus ligneolus* Scudder.

A second observation on *Solierella striatipes* was made on August 2, at Searsville Lake, back of Stanford University. By an oak tree on a dry hillside exposed to the noonday sun, one of these wasps was filling up her nest-hole. She would fly rapidly back and forth a few inches, while on the wing would drop a bit of material in the entrance, but occasionally descend with her load to enter. This hole, a smooth-walled earthen tube separable from the surrounding soil and a little more than a half inch in diameter was evidently an old trap-door spider or tarantula burrow. Two nearly immobilized melanopline grasshoppers had been stored, seemingly in a single chamber, at a depth of about two inches. They were supported on a loose core of debris that consisted of bits of oak leaves, twigs, gravel, etc., and were covered by a similar mass of material. The larger grasshopper, a fully-winged specimen was 19.6 mm. long; the smaller one, in the penultimate stage was 14.3 mm. Both were perfect specimens. The pale creamy *Solierella* egg was firmly cemented at one end, in the crotch formed by the inner base of the hind leg and the body, on the right side in one victim, and on the left in the other. It protruded upwards to bend somewhat over the venter of the first abdominal segment of the grasshopper.

In both cases the nest-holes of this wasp were quite loosely filled, affording plenty of ventilation and access, it would seem, to ants.

A little fly of the genus *Taxigramma* (Metopiidae) was captured as it hung about one of the nests, and was probably parasitic in the stored prey.

The related *Solierella fossor* (Rohwer) was taken by Rohwer in Colorado, with an immature oedipode grasshopper.

Solierella similis (Bridwell)

This species which was described from Berkeley, California, is nearly all black and measures up to about 6.5 mm. long. It also preys upon acridiid grasshoppers, selecting very small individuals about its own size, or smaller.

My first observation was made July 13, 1925, at Lagunitas, Marin County. Shortly after noon, *S. similis* was noted flying for a distance of about two feet between the ground and a broken stem some 9 inches tall, of an umbelliferous plant growing in a dry creek bed. She was evidently plugging up a cell in this comparatively large stem, disappearing out of sight in it with a grain of soil in her mandibles, and turnng around therein when ready to fly off. On cutting open this stem the following day, it was found to be filled for nearly 3 inches with bits of soil, bark, wood, etc. At the bottom was a full-fed *S. similis* larva, with prominent lateral thoracic tubercles. In the midst of the debris were three or four tiny grasshopper nymphs, one of which bore a wasp larva on its breast. Several other nymphs were found in this more or less disturbed nest, at the recently filled extremity of which was a single nymph with a *Solierella* egg glued to the base of the abdomen and just back of the stub of the hind leg and therefore in about the same situation as that of *S. striatipes*. From this nest a single male *S. similis* was reared.

Near Lake Tahoe in the Sierra Nevada, in late July 1925, I observed this wasp and *S. vandykei,* which resembles it. One of these two species was found to have habits as recounted above. The tunnel in this case was a beetle boring in the bark of a giant dead conifer that lay along the ground. The wasp had stuffed the tunnel with debris, among which lay its paralyzed victims—three very young short-horned grasshoppers, one of which bore the delicate wasp egg glued near the base of one hind leg and extending obliquely across the breast.

At Menlo Park, San Mateo County, during late July 1937, several *Solierella similis* were observed hunting in an almost bare and somewhat burnt-over field. They made brisk, short-distance flights, to alight and run a little, and to examine and hover about plant stems. Prey was scarce. I caught two of these wasps and enclosed them in a glass tube with a very young short-horned grasshopper. One of these wasps quickly pounced upon the orthopteran and, curving her abdomen under her prey soon stung it to passivity. Shortly thereafter she grasped the base of the grasshopper's antennae in her jaws and carrying her prey venter up hopped about the tube.

Solierella corizi Williams

This seems to be the largest of our bug-catching *Solierella,* females attaining a length of 8 mm. It is prettily adorned with creamy white or yellowish markings and fine silky vestiture. The scene of its observed activities lay chiefly in a small area of hard, sun-baked soil in the yard of my sister's residence at Menlo Park, and I am thankful that here as elsewhere, waste places are to be found on properties favorable to wasp life. In this little piece of land, so conveniently situated, I made many observations not only on the genus

Solierella, but on *Diploplectron* and *Astata.* During late July and early August 1937, several female *S. corizi* were seen flying in an erratic manner hardly an inch above the ground, winding among the sparse dwarf weeds and grass, now stopping to feed at the pink *Erodium* flowers or those of a mat knotweed (*Polygonum* sp.), else alighting to rest or to sun themselves, or again, to examine one or several holes. It appeared that the wasp uses—sometimes more than once—burrows made by other creatures. On leaving a burrow the wasp hovers about it in gentle curves—the so-called "locality study." And in filling or opening the tunnel, soil or other debris is seized in the mandibles—with the possible aid of the forefeet—and carried to or from the hole on the wing, the wasp seeming always to face the hole, this operation recalling that of *Belomicrus franciscanus* Pate, a little oxybeline wasp studied by the writer in San Francisco (Pan-Pacific Entomologist, XII, 1936, on pp. 3-6). Provender appeared to be scarce. On July 31, during the heat of the day, a wasp was observed storing her nest-hole with young bugs. Carrying her prey venter up beneath her she squeezed into the entrance with hardly a pause. But a bug that was too large to be thus hurried inside had to be carried somewhat behind the wasp, with a second pull to draw it wholly inside the tunnel.

The first stored tunnel examined was between 2½ and 3½ inches long. It was quite steep and contained 3 cells with contents as follows: in the first or uppermost were four immature *Corizus hyalinus* (Fabr.)[7] bugs, of which at least two were still able to twitch the tarsi. Transversely across the throat of one of these bugs and not quite reaching the fore coxae and crossed above by the bug's beak was the rather stout curved glassy white wasp egg. The second cell, separated from the first by the usual debris, contained two immature and one mature *Corizus hyalinus,* one of the former bearing the egg; in addition this cell contained a broad immature pentatomid bug, probably *Perilabus abbreviatus* (Uhl), apparently in the antepenultimate stage. The third cell contained four, apparently penultimate stage *Corizus hyalinus,* one bearing the wasp's egg.

A second nest-hole contained two cells separated by debris. The top cell revealed a wasp grub in the act of forming its cocoon cask, there being a wet ring of earth about itself. Somewhere below was a crushed young *Corizus* bug, and one hatched *Solierella* cocoon.

7. The bugs were determined by E. P. Van Duzee, then Curator of Entomology at the California Academy of Sciences.

At Manor, Marin Co., July 28, 1937, a *Solierella corizi* was observed filling her tunnel, gathering small particles from a bare area some 5-6 ft. away. These trips were made in flight. At first she disappeared well down her tunnel; eventually, however, as it filled up she often dropped small particles in or at the entrance. I tried digging out the smooth vertical tunnel, which I suspect had belonged to a spider, but without success.

While in Kansas in 1912, the writer was able to study a little of the nesting habits of *Solierella inerme* Cresson, or of a species closely related to it. This wasp, which belongs to the same section as *S. corizi*, stored her tunnel, apparently an abandoned spider domicile, with immature green capsid bugs.

Solierella nigra (Ashmead) and **Solierella blaisdelli** (Bridwell)

In the middle of July 1937, these two species were not uncommon at Menlo Park, where they often occurred intermixed. A note of July 18 is as follows: In an area about 5 feet square both of these little wasps were observed preying on *Nysius ericae minutus* Uhler, a small bug that as both young and adults almost seethed with abundance among the low battened down and largely dry vegetation. So quickly did the wasps move about, seize their prey, and take off that they were difficult to bottle. However, I succeeded in catching several of these wasps with their prey, in all cases immature. I concluded at the time that these *Solierella* nested in the ground.

Rau has made observations on *S. nigra* in Missouri (*Wasp Studies Afield*, pp. 134-135, 1918. Princeton Univ. Press; and "Field Studies in the Behavior of the Non-Social Wasps," Trans. Acad. Sci. St. Louis, XXV, No. 9, on pp. 375-378, 1928). He found that it nested in hollow woody stems and had little architectural ability, to wit: "*S. niger* does not make either partitions or cells in this burrow, but merely fills up the tunnel from bottom to top with bits of any material that she finds convenient, with her eggs and provisions scattered along at intervals in the mass." Rau says further: "The parasites *Cleptes* sp. (S. A. Rohwer), *Ellampus* sp. (S. A. Rohwer), and *Chrysis* sp. emerged from the nests of *S. niger*."

Solierella rohweri was described by Bridwell (Proc. Hawaiian Ent. Soc., IV, pp. 398-399, 1920) from the Hawaiian Islands. He found it nesting in dead twigs of a species of *Euphorbia* and using *Nysius* bugs as provender. In VI, 1926, of the same Proceedings, I gave further details of the biology of this species. This wasp which is widely distributed in the lowlands of the

Hawaiian Islands may often be observed at the flowers of *Euphorbia* weeds, such as *E. hirta* L., or seeking its prey, as also does the wasp *Astata immigrans* Williams, on purslane (*Portulaca oleracea* L.) that harbors the desired *Nysius* bugs.

Solierella nitens Williams

I have seen but two examples of this small shining black wasp. Both are from Menlo Park. One of these specimens was observed in 1937 filling its nest-hole in the ground with fine particles of debris, the wasp dropping this material while in flight.

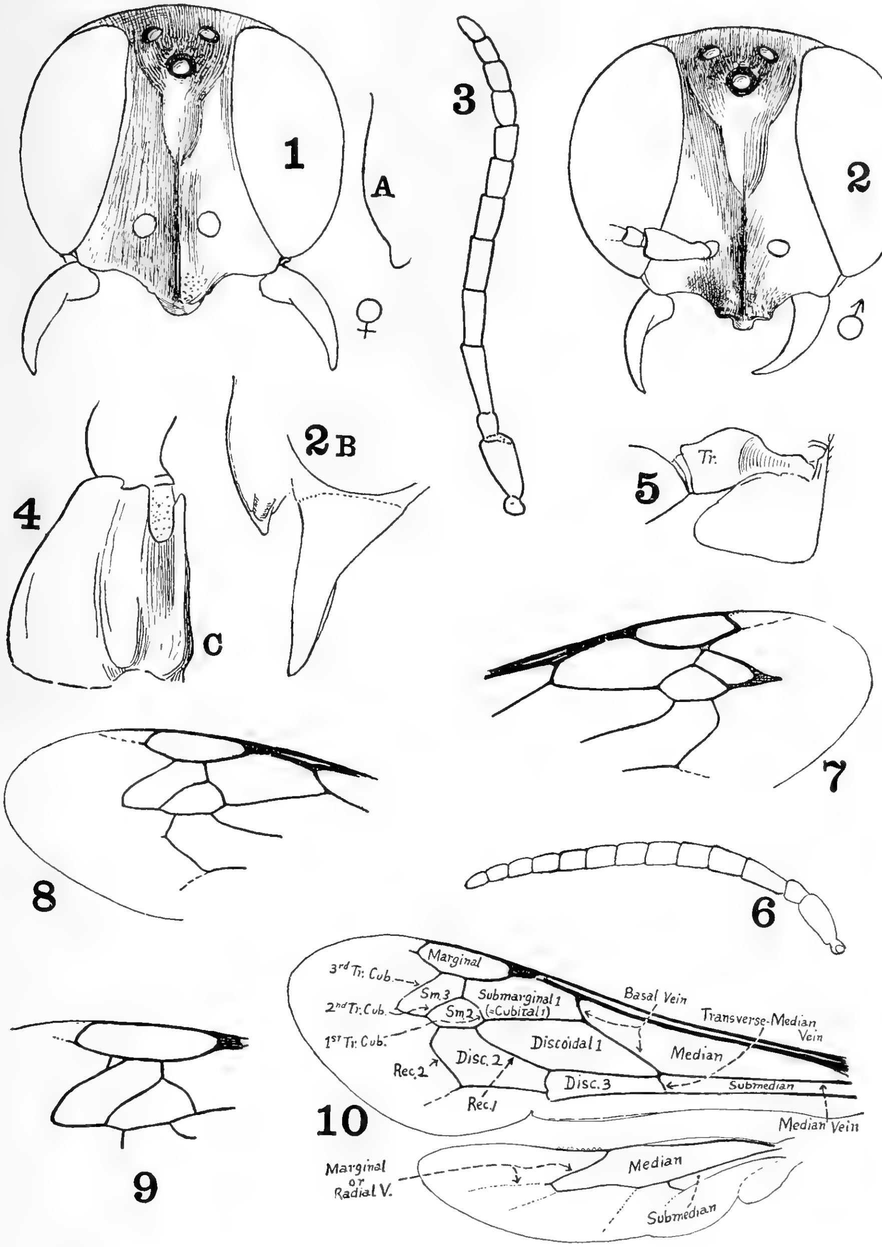
Solierella sayi (Rohwer)

This little wasp was described from Colorado. It is common in San Francisco, where my scant observations on it were confined chiefly to Lone Mountain, a sandy hillock, once the writer's favorite collecting ground. On the southern exposure of this hill, *S. sayi* was often seen basking in the sunshine or, in nervous haste, examining dead twigs near the ground, fine debris, crannies, and other likely places for its prey which consists of psocids.

On June 21, 1922, two of these wasps were observed carrying well under their bodies a species of winged, fat-bodied psocid. This prey seemed to be carried by the antennae, the burdened wasps hopping along and making short sailing flights nestwards. Similarly in 1925, and again in 1930, a wasp was seen carrying the same species of psocid, which was determined by Mr. Nathan Banks as *Psocus californicus* Banks. In 1925, one of these wasps was observed plunging into her nest-hole in the sand. The tunnel measured three inches long and was stored with small psocids which Mr. Banks regards as probably the male of *Lepidilla kelloggi* Ribago. In this case the wasp's eggs were fastened transversely between the first and second pairs of legs of the prey. The eggs were curved, with the free end extending beyond the thorax of the psocid.

PLATE 11

Fig. 1. *Solierella striatipes.* Female. Head. A, clypeal profile.
Fig. 2. Same. Male. Head. B, clypeus and mandible in profile.
Fig. 3. Same. Female. Antenna.
Fig. 4. Same. Male. Posterior coxa from side. C, carinal crest.
Fig. 5. Same. Male. Fore coxa and trochanter from side.
Fig. 6. Same. Male. Antenna.
Fig. 7. Same. Male. Aberrant venation.
Fig. 8. Same. Male. Aberrant venation.
Fig. 9. Same. Female. Aberrant venation.
Fig. 10. Same. Male. Wings, showing normal venation.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Sm.3
Submarginal 1
(=Cubital 1)
2nd Tr. Cub.
Sm.2
1st Tr. Cub.
Basal Vein
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Vein
Discoidal 1
Median
Disc.2
Rec.2
Disc.3
Submedian
Rec.1
Median Vein
Marginal
or
Radial V.
Median
Submedian

PLATE 12

Fig. 11. *Solierella striatipes.* Male. Propodeum, showing the more usual sculpture as seen from above.

Fig. 12. Same. Male. Propodeum, showing occasional sculpture as seen from above.

Fig. 13. Same. Female. Ocelli.

Fig. 14. Same. Male. Aedeagus and lateral lobes.

Fig. 15. Same. Male. Aedeagal lobe from above, more enlarged.

Fig. 16. Same. Male. Last visible ventral segment.

Fig. 17. *Solierella major.* Female. C, clypeal profile. From San Diego, California.

Fig. 18. Same. Female. Antennal segments 3 and 4.

Fig. 19. *Solierella boharti.* Female. Disc of propodeum.

Fig. 20. Same. Female. Ocelli.

Fig. 21. Same. Female. Head. C, clypeal profile.

Fig. 22. Same. Female. Antennal segments 1-4.

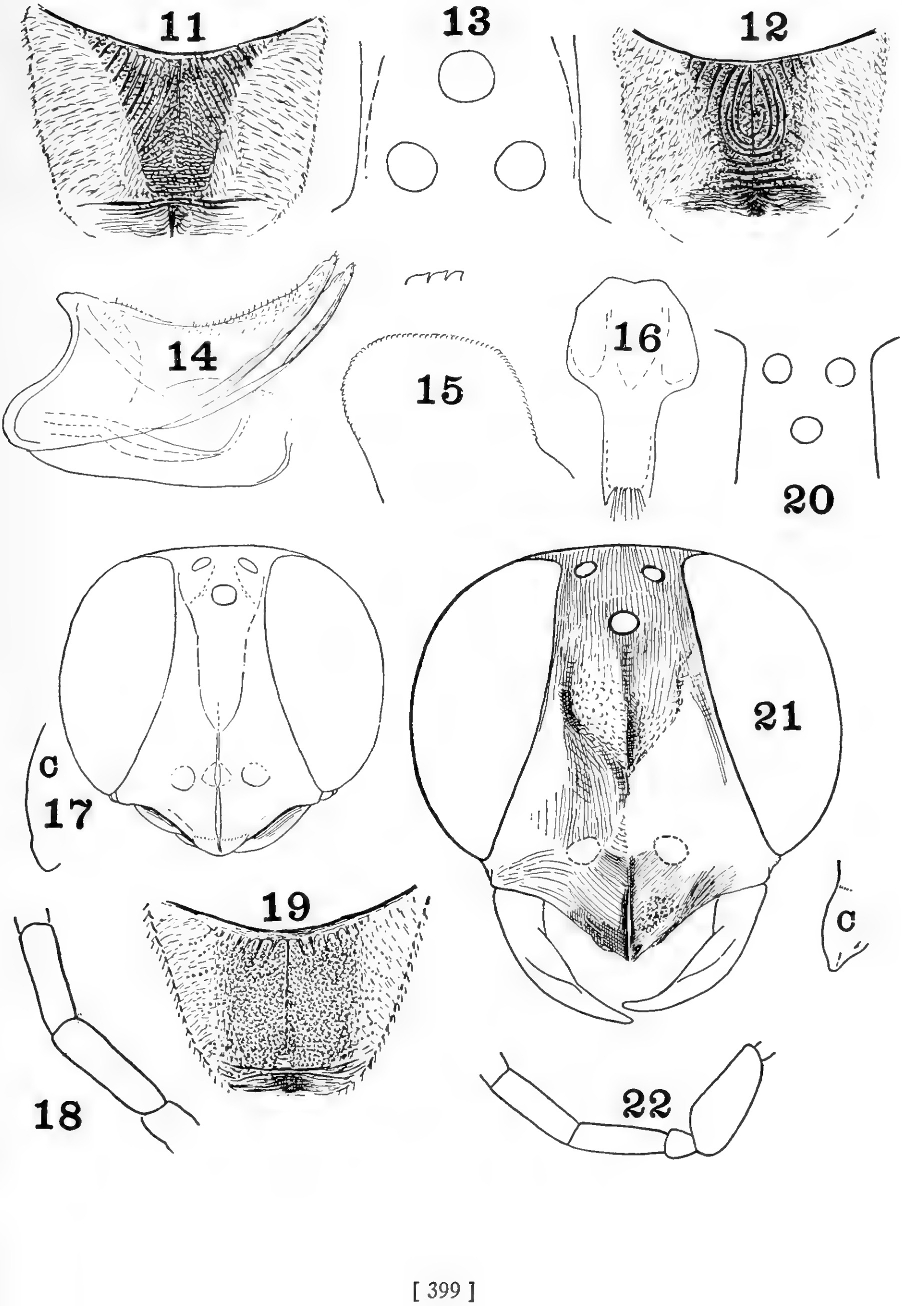
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PLATE 13

Fig. 23. *Solierella lasseni*. Female. C, clypeal outline of type.
Fig. 24. *Solierella sonorae*. Female. Ocelli.
Fig. 25. *Solierella lasseni*. Female. Mandible, from side.
Fig. 26. Same. Female antenna.
Fig. 27. *Solierella sonorae*. Female. Posterior coxa. C, carinal crest.
Fig. 28. Same. Female. Head.
Fig. 29. *Solierella fossor*. Female paratype. From Boulder, Colorado.
Fig. 30. Same. Male paratype. Aedeagal lobe. From Rifle, Colorado.
Fig. 31. Same. Male paratype. Head and portion of antenna.
Fig. 32. Same. Male paratype. Last visible ventral segment.
Fig. 33. Same. Male paratype. Aedeagus and lateral lobes.
Fig. 34. Same. Male paratype. Portion of right wing.
Fig. 35. Same. Male paratype. Portion of left wing.
Fig. 36. *Solierella major*. Female. Fore tarsus, showing long bristles on outer side.
Fig. 37. *Solierella fossor*. Female. Fore tarsus, showing long bristles on outer side.
Fig. 38. *Solierella boharti*. Female. Fore tarsus, showing long bristles on outer side.
Fig. 39. *Solierella sonorae*. Female. Fore tarsus, showing long bristles on outer side.
Fig. 40. *Solierella striatipes*. Female. Fore tarsus, showing long bristles on outer side. In this species they are relatively short.
Fig. 41. *Solierella fossor*. Female. Ocelli.
Fig. 42. Same. Male. Ocelli.

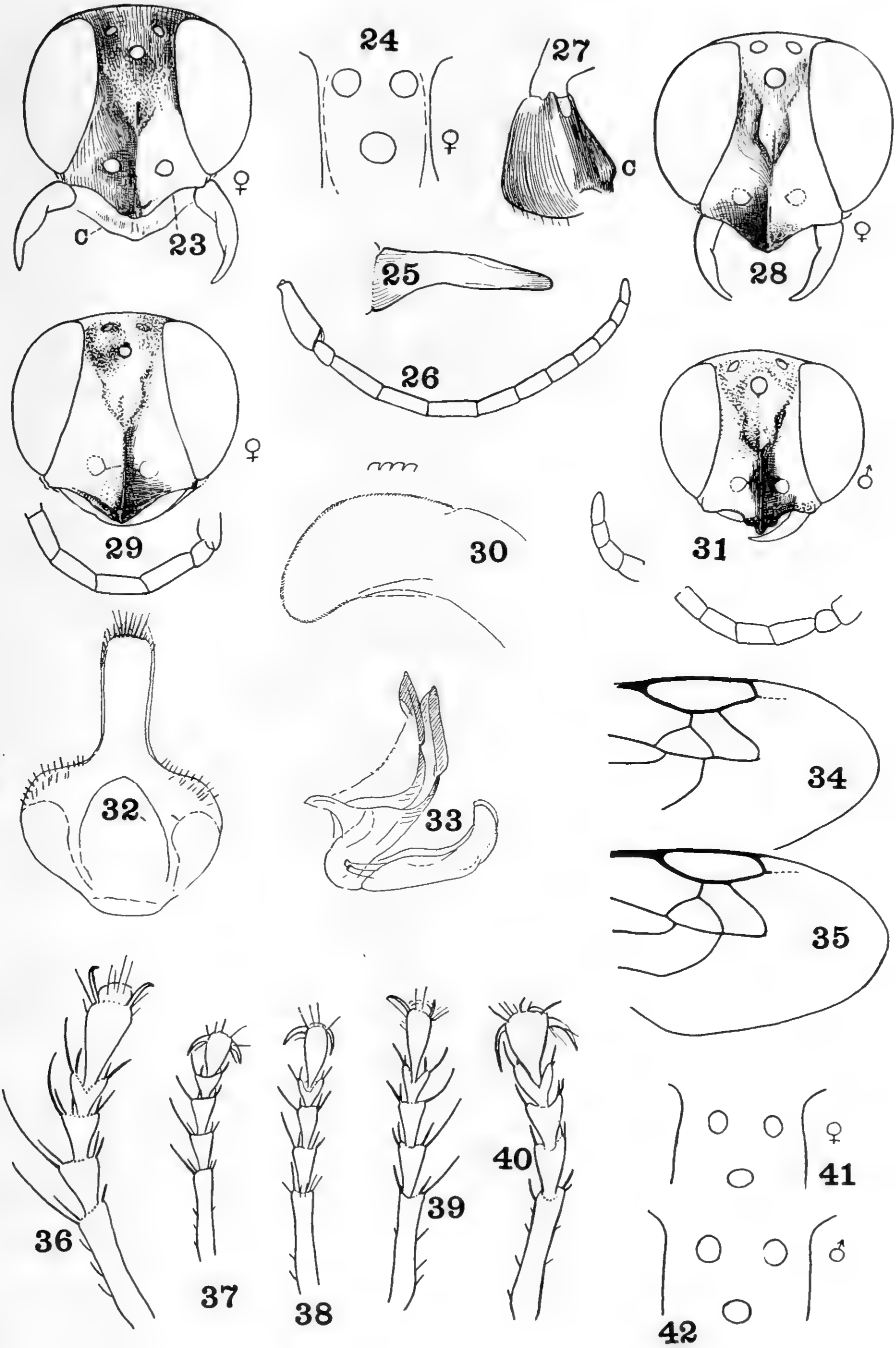
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PLATE 14

Fig. 43. *Solierella viereckі.* Female. Head. From Riverside, California.

Fig. 44. Same. Female. Antenna.

Fig. 45. *Solierella "parva."* Male paratype. Head. C, clypeal profile. This is probably a synonym of *viereckі.* From Boulder, Colorado.

Fig. 46. *Solierella viereckі.* Female. Ocelli.

Fig. 47. *Solierella "parva."* Male. Last visible ventral segment. From specimen of Fig. 45.

Fig. 48. Same. Male. Aedeagus and lateral lobe. From specimen of Fig. 45.

Fig. 49. Same. Male. Aedeagal lobe. From specimen of Fig. 45.

Fig. 50. *Solierella viereckі.* Female. Wing.

Fig. 51. *Solierella "parva."* Male. From Boulder, Colorado. Specimen of Fig. 45

Fig. 52. *Solierella plenoculoides.* Male. From Boulder, Colorado.

Fig. 53. Same. Male. Lateral lobe and aedeagus. From Boulder, Colorado.

Fig. 54. Same. Male. Last visible ventral segment.

Fig. 55. Same. Male. Aedeagal lobe.

Fig. 56. *Solierella sayi.* From Lone Mountain, San Francisco, California.

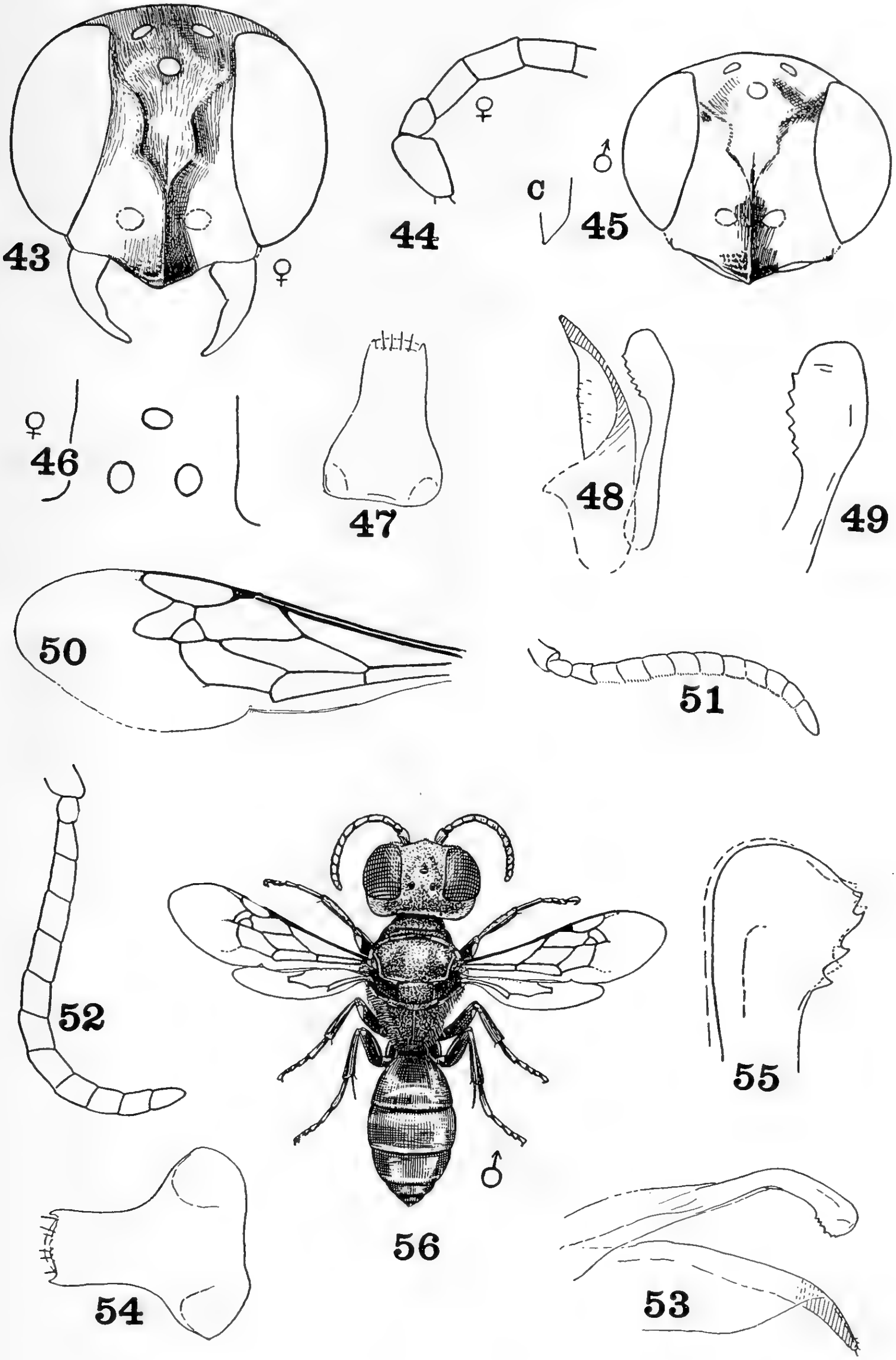
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PLATE 15

Fig. 57. *Solierella similis.* Female. Head, antenna, and clypeal profile.
Fig. 58. Same. Female. Fore tarsus.
Fig. 59. Same. Male. Fore coxa and trochanter from in front.
Fig. 60. Same. Male. Head and antenna.
Fig. 61. Same. Female. Posterior coxa, to show carina.
Fig. 62. Same. Male. Wing.
Fig. 63. Same. Male. Lateral lobes and aedeagus.
Fig. 64. Same. Male. Aedeagal lobe.
Fig. 65. Same. Male. Last visible ventral segment.
Fig. 66. Same. Female. Ocelli.
Fig. 67. *Solierella vandykei.* Female. Head.
Fig. 68. Same. Female. Frontal and clypeal profile.
Fig. 69. *Solierella lasseni.* Male. Head and antenna.
Fig. 70. Same. Male. Frontal view and clypeal profile.
Fig. 71. Same. Male. Lateral lobes and aedeagus.
Fig. 72. Same. Male. Last visible ventral segment.
Fig. 73. Same. Male. Fore trochanter, from in front.
Fig. 74. Same. Male. Lobes of aedeagus.

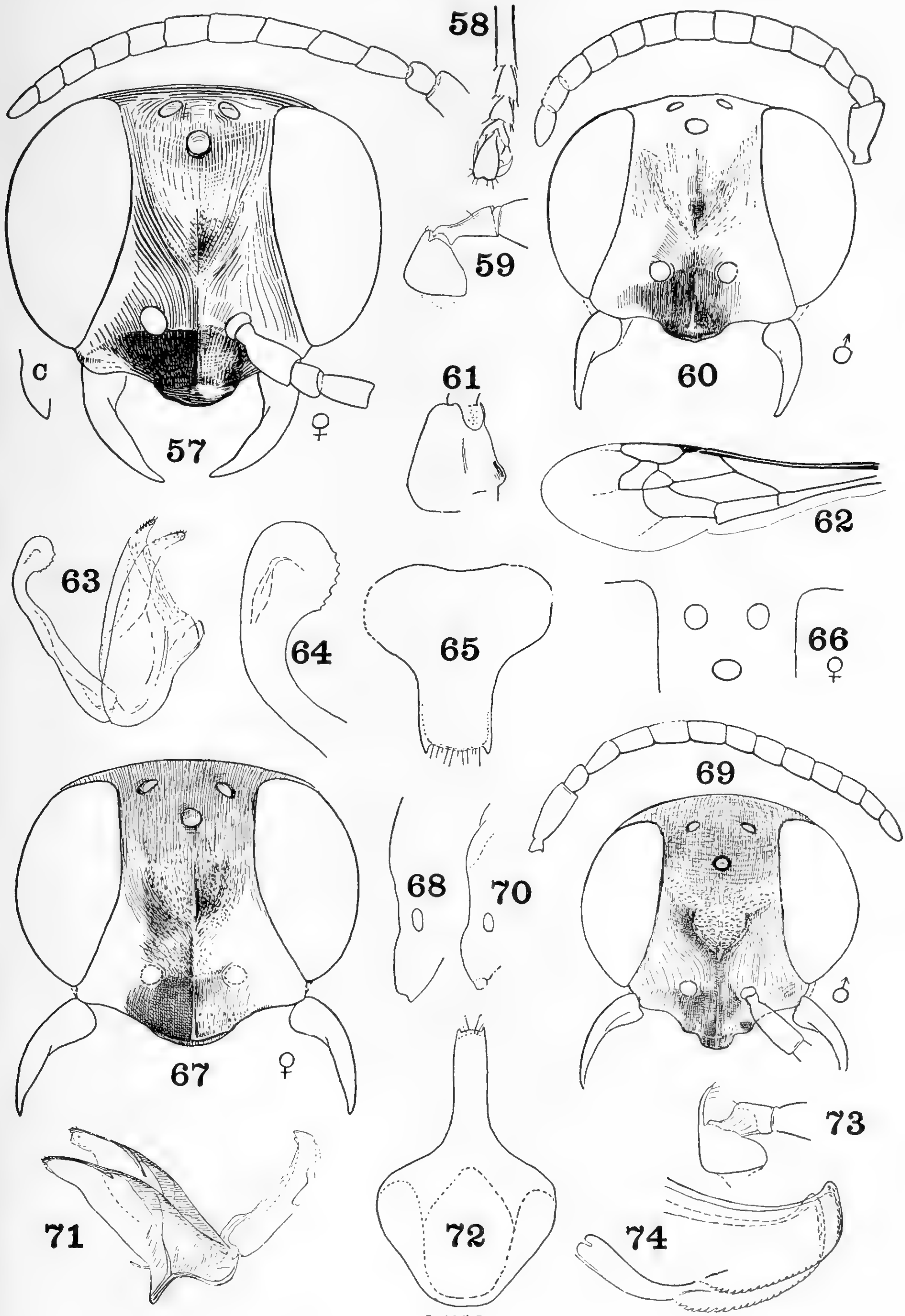
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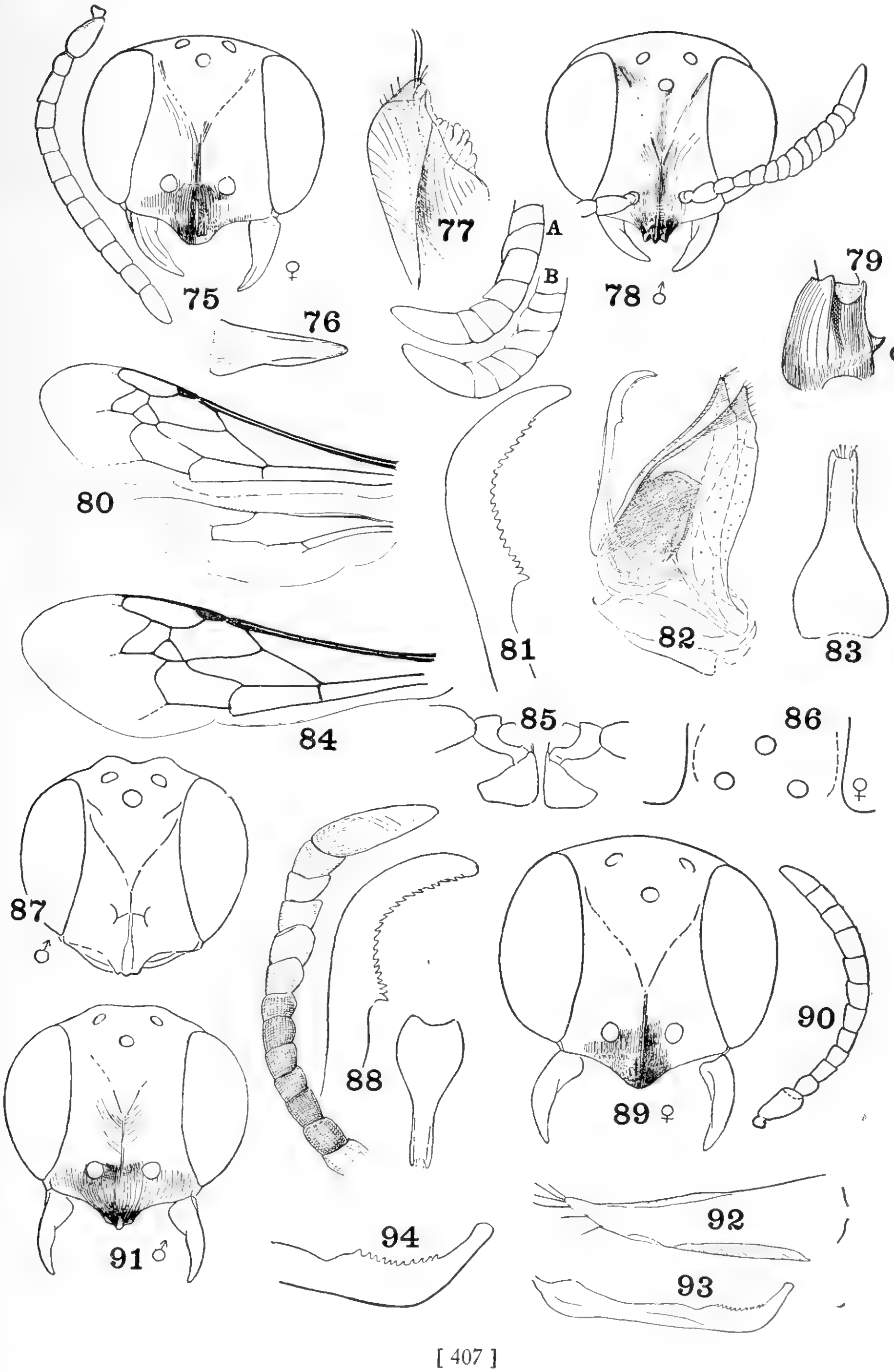
PLATE 16

Fig. 75. *Solierella corizi.* Female. Head and antenna.
Fig. 76. Same. Female. Mandible, from side.
Fig. 77. Same. Male. Extremity of outer lobe or clasper.
Fig. 78. Same. Male. Head and apical portion of antenna. A, outer side. B, inner side.
Fig. 79. Same. Female. Posterior coxa, showing thorn at C.
Fig. 80. Same. Male. Wing.
Fig. 81. Same. Male. Aedeagal lobe.
Fig. 82. Same. Male. Aedeagus and lateral lobes.
Fig. 83. Same. Male. Last visible ventral segment.
Fig. 84. Same. Male. To show first recurrent vein entering first cubital cell.
Fig. 85. Same. Male. Fore coxae and trochanters, from in front.
Fig. 86. Same. Female. Ocelli.
Fig. 87. Same. Male. To show tubercles of vertex developed. From Riverside, California.
Fig. 88. *Solierella inerme,* or relative. Male. Antenna, lobe of aedeagus, and last visible ventral segment. From Kansas.
Fig. 89. Same. Female. From Kansas.
Fig. 90. Same. Female. From Kansas.
Fig. 91. Same. Male. With indication of tubercle on vertex. From Kansas.
Fig. 92. *Solierella lucida.* Male. Lateral lobe. From Boulder, Colorado.
Fig. 93. Same. Male. Aedeagus. From Boulder, Colorado.
Fig. 94. Same. Male. Aedeagal lobe. From Boulder, Colorado.


75
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89 ♀
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91 ♂
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PLATE 17

Fig. 95. *Solierella rohweri.* Female. From Hawaii.

Fig. 96. *Solierella blaisdelli.* Female. C, clypeus more enlarged.

Fig. 97. *Solierella nigra.* Female. C, clypeus of male. Both from central California.

Fig. 98. *Solierella rohweri.* Male. C, clypeal profile. From Hawaii.

Fig. 99. Same. Female. Clypeal profile. From Hawaii.

Fig. 100. *Solierella blaisdelli.* Female and male. Clypeal profiles.

Fig. 101. *Solierella australis.* Male. Forewing with only two cubital cells.

Fig. 102. *Solierella rohweri.* Wing. From Hawaii.

Fig. 103. *Solierella australis.* Male. Right wing with two, left wing with three cubital cells.

Fig. 104. *Solierella blaisdelli.* Female. Wing with second cubital cell incomplete.

Fig. 105. Same. Male. Lobe of aedeagus. In this specimen each lobe has 8 teeth.

Fig. 106. *Solierella nigra.* Male. Paratype. Last visible ventral segment. From Boulder, Colorado.

Fig. 107. Same. Male. Paratype. Aedeagal lobe. In this specimen each lobe has 5 teeth.

Fig. 108. *Solierella rohweri.* Male. Antenna and aedeagal lobes of two specimens. A, aedeagal lobe of specimen having 4 teeth on one lobe and 4½ on the other. B, aedeagal lobe of specimen having 3 teeth on each lobe. All from Hawaii.

Fig. 109. *Solierella nigra* (probably). Male. Aedeagal lobe of specimen having 6 teeth on the other lobe.

Fig. 110. *Solierella blaisdelli.* Female. Posterior coxa, showing carinal process in profile.

Fig. 111. Same. Female. Ocelli.

Fig. 112. *Solierella rohweri.* Fore coxae and trochanters, from in front. From Hawaii.

Fig. 113. *Solierella nigra.* Female. Disc of propodeum, general structure. From Riverside, California.

Fig. 114. *Solierella blaisdelli.* Female. Disc of propodeum, general structure. From Riverside, California.

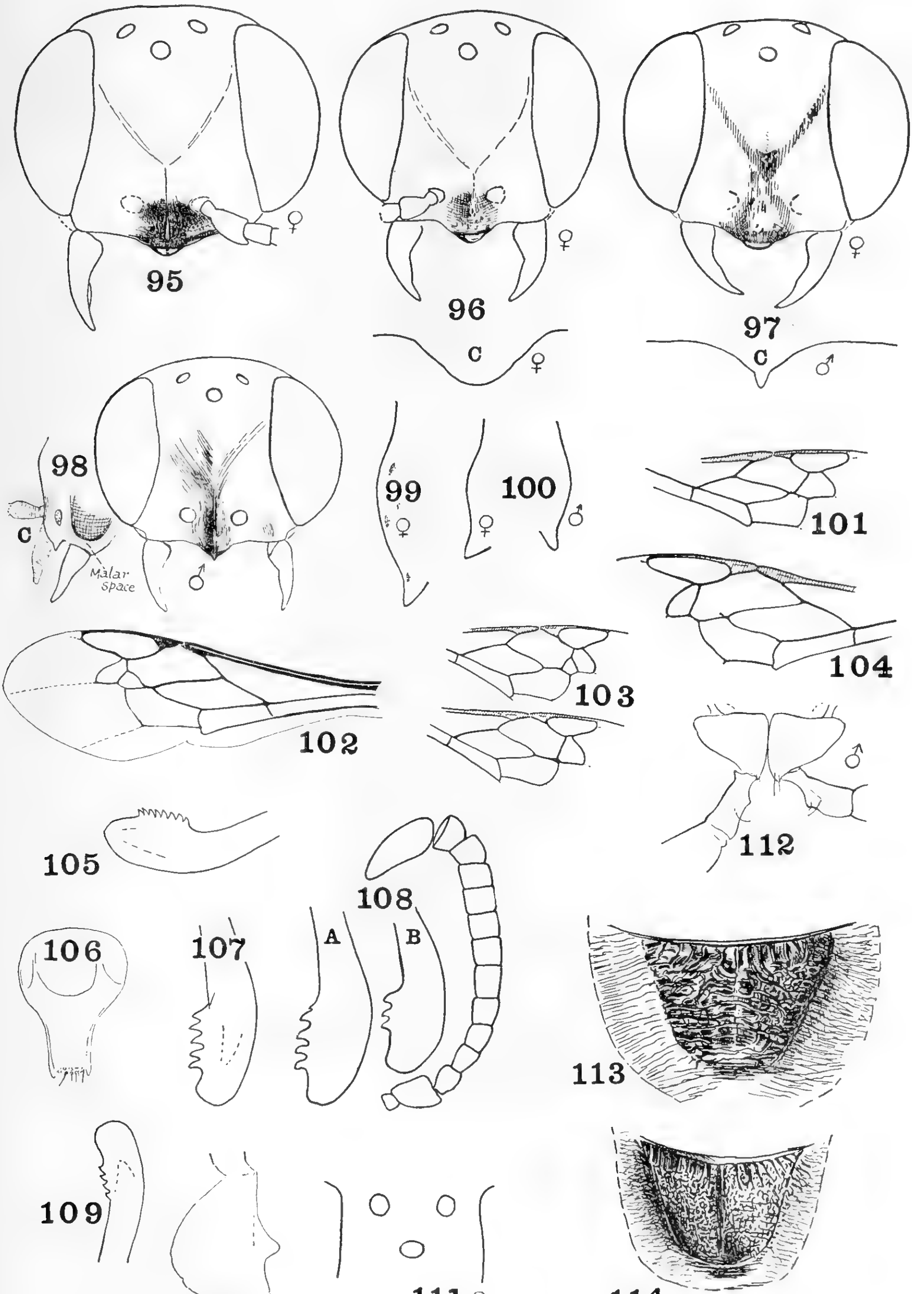
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PLATE 18

Fig. 115. *Solierella arcuata.* Male. From Menlo Park, California.
Fig. 116. Same. Female. From Menlo Park, California.
Fig. 117. *Solierella abdominalis.* Male. From Palm Springs, California.
Fig. 118. Same. Female. C, clypeal profile.
Fig. 119. *Solierella timberlakei.* Female. Clypeus and its profile.
Fig. 120. *Solierella blaisdelli.* Male. From Plumas County, California.
Fig. 121. *Solierella levis.* Female. Head and clypeal profile.
Fig. 122. *Solierella bridwelli.* Female. At C, clypeal profiles of male and female.
Fig. 123. Same. Male. Clypeal outline.
Fig. 124. *Solierella nitens.* Female. Head.
Fig. 125. *Solierella albipes.* Male. From Redwood City, California.
Fig. 126. Same. Female. Lower part of head.
Fig. 127. Same. Male. Mandible, from outer side.
Fig. 128. Same. Female. Clypeus.
Fig. 129. Same. Male. Clypeus. From southern California.
Fig. 130. *Solierella australis* var. Male. Clypeus. From Riverside, California.

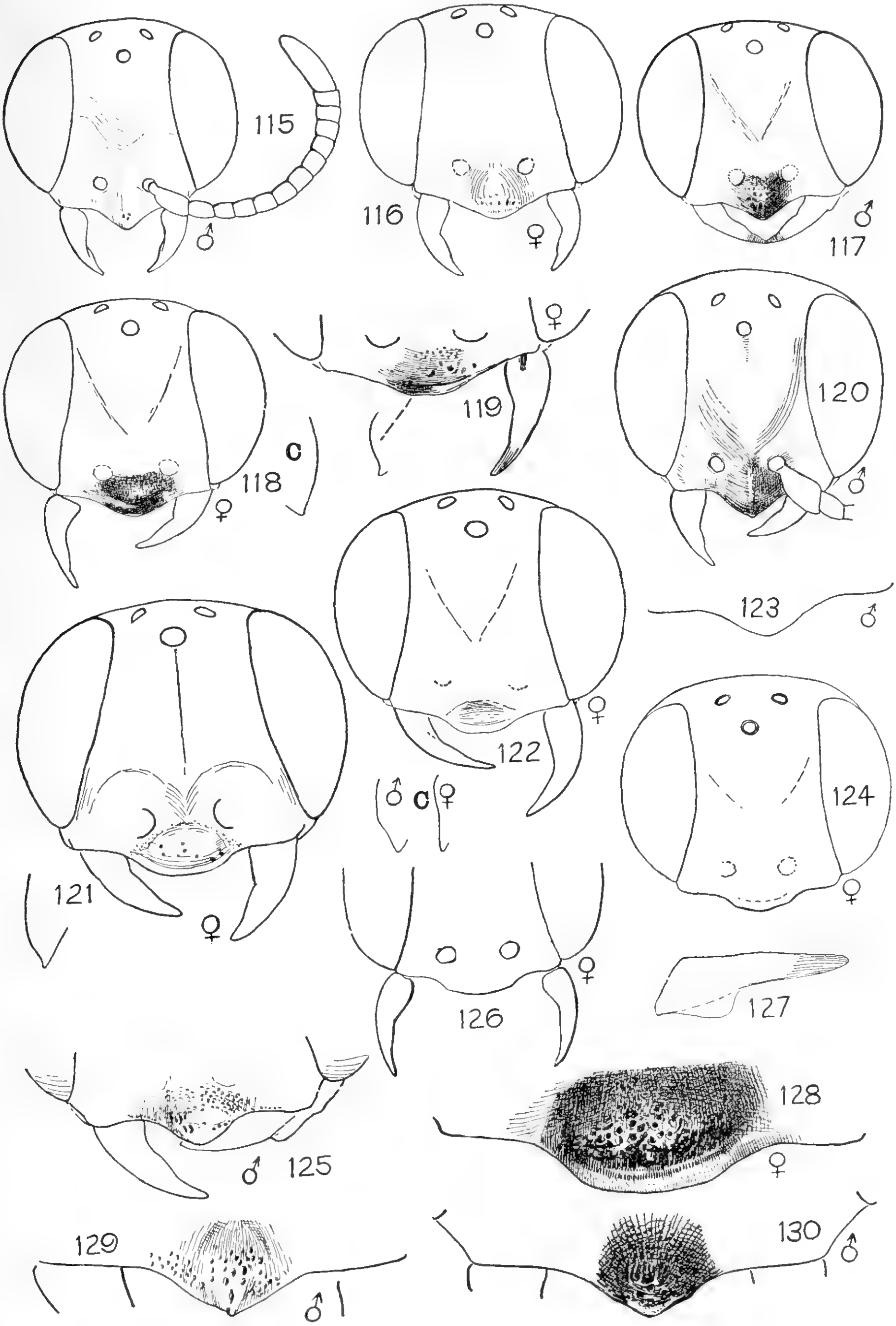
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PLATE 19

Fig. 131. *Solierella abdominalis.* Female. Ocelli.
Fig. 132. *Solierella bicolor.* Female. Apical portion of antenna, from side.
Fig. 133. *Solierella abdominalis.* Female. Apical portion of antenna, from side.
Fig. 134. Same. Male. Apical portion of antenna, from side.
Fig. 135. *Solierella bridwelli.* Female. Mandible and antenna, from side.
Fig. 136. Same. Male. Antenna, from side.
Fig. 137. *Solierella australis.* Female. Apical portion of antenna, from side.
Fig. 138. *Solierella arcuata.* Female. Apical portion of antenna, from side.
Fig. 139. *Solierella australis.* Male. Apical portion of antenna, from side.
Fig. 140. *Solierella arcuata.* Male. Apical portion of antenna, from side.
Fig. 141. *Solierella albipes.* Male. Antenna. From central California.
Fig. 142. *Solierella levis.* Female. Mandible, from outer side.
Fig. 143. *Solierella blaisdelli.* Male. Antenna.
Fig. 144. Same. Male. Fore coxa in two positions, to show mucro.
Fig. 145. *Solierella bridwelli.* Male. Aedeagus and lateral lobes.
Fig. 146. *Solierella albipes.* Female. Antenna. From central California.
Fig. 147. *Solierella arcuata.* Male. Aedeagal lobe.
Fig. 148. *Solierella blaisdelli.* Male. Last visible ventral segment.
Fig. 149. *Solierella australis.* Male. Aedeagus.
Fig. 150. Same. Male. Aedeagus.
Fig. 151. *Solierella albipes.* Male. Aedeagal lobe. From Whittier, California.
Fig. 152. *Solierella abdominalis.* Male. Aedeagal lobe.
Fig. 153. *Solierella bridwelli.* Male. Aedeagal lobe.
Fig. 154. *Solierella blaisdelli.* Male. Aedeagus.

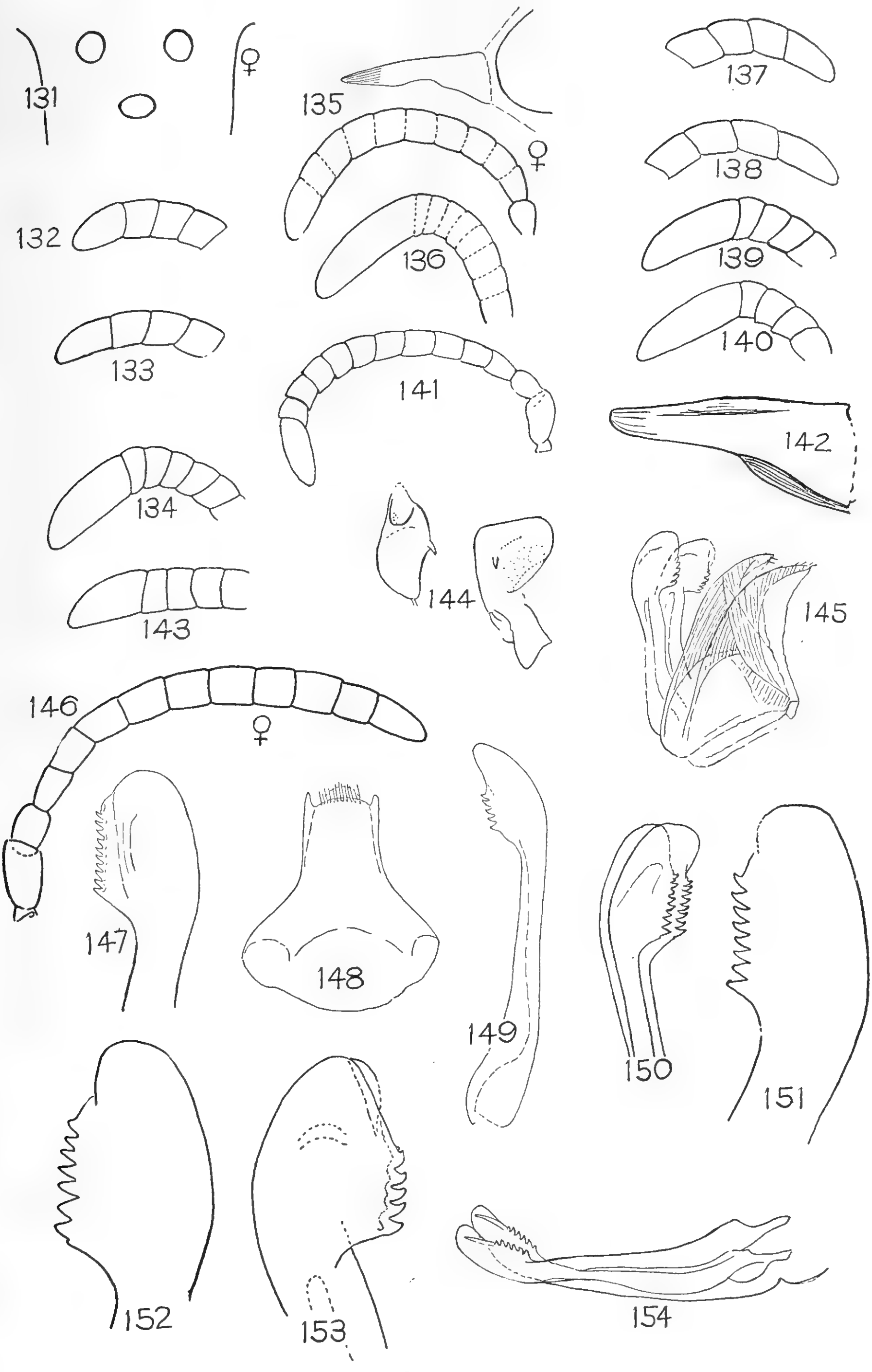
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PLATE 20

Fig. 155. *Solierella sayi.* Female. From San Francisco, California.

Fig. 156. Same. Male. Head and extremity of antenna. From San Francisco, California.

Fig. 157. Same. Female. From Tahoe, California, 6500 ft.

Fig. 158. Same. Male. Aedeagal lobe. From San Francisco, California.

Fig. 159. Same. Male. Aedeagal lobe. From Riverside, California.

Fig. 160. Same. Male. Clypeus. Paratype (U.S.N.M.). From Florissant, Colorado.

Fig. 161. Same. Male. Aedeagal lobe. Paratype (U.S.N.M.). From Florissant, Colorado.

Fig. 162. Same. Female. Clypeus. From Tahoe, California, 6500 ft.

Fig. 163. Same. Male. The pair of aedeagal lobes.

Fig. 164. Same. Male. Last visible ventral segment. From San Francisco, California.

Fig. 165. Same. Male. Fore coxa and trochanter, from in front.

Fig. 166. Same. Male. Paratype. Last visible ventral segment.

Fig. 167. *Solierella californica.* Female. Head. From Los Angeles, California.

Fig. 168. *Solierella sayi.* Female. Pygidial area. From San Francisco, California.

Fig. 169. Same. Male and female. Ocelli.

Fig. 170. *Solierella californica.* Male. Aedeagal lobe of specimen having 3 teeth on one lobe and 4 on the other. From Los Angeles, California.

Fig. 171. Same. Male. From Los Angeles, California.

Fig. 172. Same. Male and female. Antennae. From Los Angeles, California.

Fig. 173. *Solierella sayi.* Wing. From San Francisco.

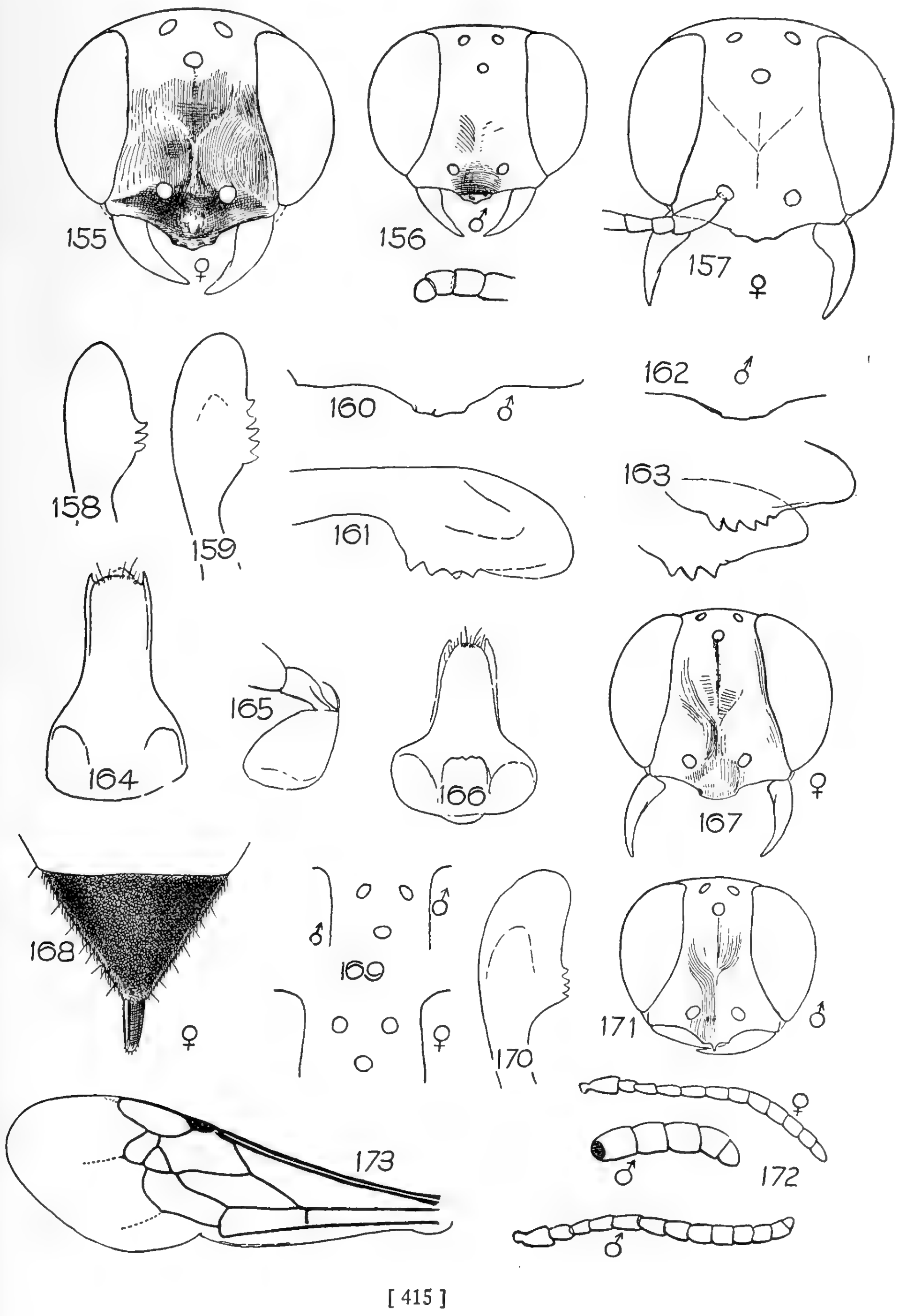
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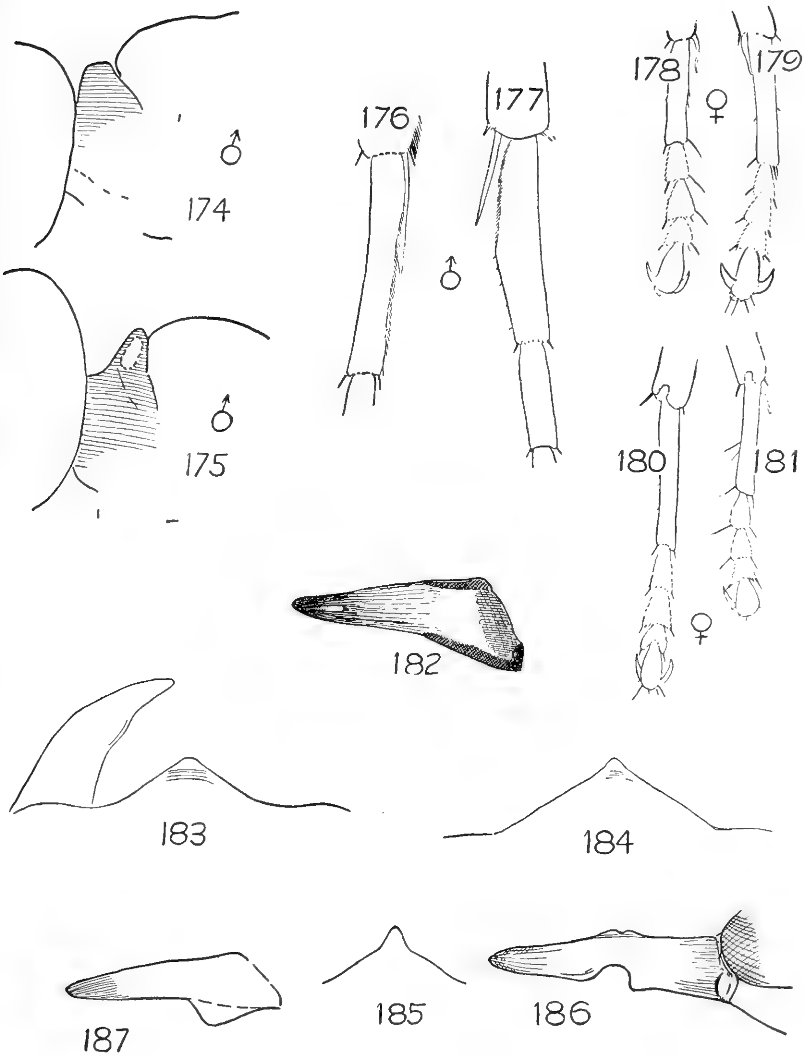
PLATE 21

Fig. 174. *Solierella lasseni.* Male. Shaded area is pronotum in profile.
Fig. 175. *Solierella similis.* Male. Shaded area is pronotum in profile.
Fig. 176. Same. Male. Metatarsus, dorsal view.
Fig. 177. *Solierella sayi.* Male. Metatarsus, dorsal view.
Fig. 178. *Solierella levis.* Female. Fore tarsus.
Fig. 179. *Solierella albipes.* Female. Fore tarsus.
Fig. 180. *Solierella sayi.* Female. Fore tarsus.
Fig. 181. *Solierella californica.* Female. Fore tarsus.
Fig. 182. *Solierella arcuata.* Male. Mandible, outer broadside view. From Sierra Nevada, California.
Fig. 183. *Solierella blaisdelli.* Male. Clypeus. From Whittier, California, August 11, 1920 (No. 1234).
Fig. 184. Same. Male. Clypeus. From Whittier, California, August 11, 1920 (No. 1238).
Fig. 185. Same. Male. Clypeus. From Whittier, California, August 11, 1920 (No. 1239).
Fig. 186. *Plenoculus* sp. Female. Mandible, outer broadside view. From Riverside, California.
Fig. 187. *Solierella albipes.* Male. Mandible, outer broadside view.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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 12, pp. 419-466, 10 text figures April 28, 1950

SNAKES OF THE KIUKIANG-LUSHAN AREA, KIANGSI, CHINA

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Large collections of any group of animals from a circumscribed area are of particular interest from a taxonomic and ecological point of view because they provide precise evidence of the animals' choice of habitat and they fairly adequately indicate the fauna of the area.

The present paper is a description of such a collection consisting of 403 snakes taken in the vicinity of Lushan, a small mountain range ten miles south of Kiukiang, Kiangsi, China, in the course of my stay there in 1935 and 1936. The importance of this collection lies in the fact that, though it is from an area with a herpetological history dating from 1871, it is the first comprehensive collection made there. Furthermore, it represents the fauna of a region with diverse habitats, including such widely different ecological situations as hot humid plains and mountains high enough to support purely montane species.

Lushan is a range of mountains rising as a promontory from the South Yangste Hills (Cressey, 1934, p. 323). This range extends north and east along the western side of Poyang Lake, ending abruptly ten miles south of the Yangste River near Kiukiang, Kiangsi. It is isolated on three sides from other mountain areas, but on the south low hills connect it with the South Yangste Hills. The promontory, arising abruptly from the alluvial plains, is approximately fifteen miles wide and forty miles long. It averages between 3,500 and 4,000 feet in altitude, but certain points are as high as 5,000 feet. These altitudes are the highest of any in the lower Yangste River Basin. There are numerous temples and pagodas situated in the mountains, usually surrounded by areas not molested by woodcutters. Except for such isolated forested tracts and deep inaccessible ravines, the mountains are denuded of timber. Comparatively recent acquisitions of estates by foreign residents and the even more recent interest of the Chinese government in reforestation have added several more forested areas to Lushan. These, from a herpetological standpoint, are invaluable as collecting sites for certain species. The larger valleys in the foothills of Lushan are given over to the growing of rice. Most of the smaller valleys and gorges are so precipitous or so subject to violent torrents following rains as to make them unsuitable for agricultural use.

The climate of this area is typical of central China in that extremes of temperature are great. In Kiukiang, the average mean yearly temperature is 17.4° C. The lowest mean temperature, 4.7° C., is in January; the highest, 29.8° C., is in July. The mean temperatures in the mountains, for which figures are not at present available, are lower by possibly three or four degrees. Often, in winter storms, the trees and brush in the mountains become heavily encrusted with ice.

Figures for rainfall in Lushan also are not available at present. In Kiukiang the average yearly total is 1,465.7 mm. The heaviest rains are in June (242.7 mm.), and the lightest precipitation occurs in December (43.3 mm.). Although these figures are high, they give no indication of the exceedingly heavy precipitation on the mountains. The low but hilly regions east of Poyang Lake average over 2,000 mm. of precipitation per year. Probably the rainfall on the summits of Lushan is even greater. The average number of rainy days per year in Kiukiang is 123.5. Rain falls at any season of the year; droughts of six weeks or longer are unusual.

From a physiographic point of view the area may be divided into three simple divisions, the plains, the mountains, and a transitional zone between them, the foothills. The plains include the floors of the larger valleys, up to elevations of 100 or 200 feet; these are extensively used for the cultivation of rice and also include the slightly elevated areas away from the hills which are surrounded by irrigated lands. The foothills include the outlying, more highly elevated areas and the valleys and ridges at the base of the mountains up to approximately the 1500-foot level. The mountains comprise those regions above this level, or more particularly the steeper slopes, the summit ridges and the high valleys. A crude indication of the relative frequency of species in the various zones is indicated by the numbers of asterisks in the appropriate column of table 1. Also included in the table are the earliest local records of the species, with the name combination under which the form was recorded. Of the 29 species known to inhabit the region, *Natrix percar-*

inata, Dinodon flavozonatum, Elaphe porphyracea nigrofasciata, and *Trimeresurus mucrosquamatus* are here recorded with certainty for the first time.

TABLE 1.

Distribution of the Snakes of the Kiukiang-Lushan Region

	Plains	Foot-hills	Moun-tains	First record from the area			
Species				David, 1873	Guenther, 1888, also in Pratt, 1892	Stanley, 1914, 1915-1920	Chang, 1936
Sibynophis chinensis			*				S. collaris chinensis
Natrix annularis	**	*			Tropidonotus annularis		
N. percarinata		**	*				
N. tigrina lateralis	*	*		Amphiesma tigrinum Tropidonotus lateralis			
Pseudoxenodon nothus		*	**			Pseudoxenodon macrops	
Plagiopholis styani			*			Trirhinopholis styani	
Achalinus spinalis		*	**	"elapoid"			
Lycodon ruhstrati			*		Ophites septentrionalis		
Dinodon flavozonatum			*				
D. rufozonatum	*	*	*	Lycodon rufozonatus			
Zaocys dhumnades dhumnades	**	*			Zaocys dhumnades		
Ptyas korros	not rep. in collection				Ptyas korros		
Elaphe bimaculata		*			Elaphis dione		
E. carinata		*			Elaphis sauromates		
E. mandarinus			*	Elaphis conspicillatus			
E. porphyracea nigrofasciata			*				
E. rufodorsata	***	*			Coluber rufo-dorsatus		
E. taeniurus	*	*	*	Elaphis virgatus			
Opheodrys major	*	***	**		Cyclophis major		
Oligodon chinensis					Simotes chinensis		
Calamaria septentrionalis		**	*?	1872 description			
Bungarus m. multicinctus	not rep. in collection			Bungarus semifasciatus			

Species	Plains	Foot-hills	Moun-tains	First record from the area: David, 1873	Guenther, 1888, also in Pratt, 1892	Stanley, 1914, 1915-1920	Chang, 1936
Calliophis macclellandi		*	***		Callophis annularis		
Naja naja atra	*?	not rep. in collection		Naja tripudians			
Pareas chinensis	not rep. in collection		*?			Amblycephalus sp.	Amblycephalus chinensis
P. boulengeri			*				A. boulengeri
Agkistrodon halys	**	**	*	Trigonocephalus blomhoffii			
Trimeresurus mucrosquamatus		*				Trimeresurus sp.	Trimeresurus gramineus stejnegeri
T. s. stejnegeri		*	*				

It will be seen from this list that most of the mountain and plains forms extend into the intermediate zone, the foothills. Only three species are at present known to occur only in the foothills; these are *Elaphe bimaculata, E. carinata,* and *Trimeresurus mucrosquamatus.* Further collecting will probably demonstrate that the first two also occur on the plains.

This division of the area into altitudinal zones does not take into account the ecological variables concerned in the restriction of the various species. Clues as to the controlling factors in certain of the species appear when the habitat choice of the same species in different areas is considered. Certain mountain inhabiting species of southern and western China when present in central China are found to inhabit the foothills and plains, or at least to occur at very much lower altitudes. This trend is still more marked when the same species are considered in northern and eastern China where they exhibit a still greater restriction to lower levels. The following species fall into this category: *Achalinus spinalis, Zaocys dhumnades, Elaphe carinata, Opheodrys major, Oligodon chinensis, Calamaria septentrionalis,* and *Trimeresurus stejnegeri.* In connection with this altitudinal distribution as correlated with latitudinal distribution it should be pointed out that collecting records indicate that *Natrix tigrina lateralis* is definitely a snake of the foothills and plains in the Lushan region, yet it ascends to considerable altitudes in both northern and southern China. Pope (1935, p. 292) states that in central China *Oligodon chinensis* occurs on open plains and plateaus; but both the specimens included in this collection were captured in the foothills. In southern China *Trimeresurus stejnegeri* appears to be a mountain species, but altitude apparently is of little significance in Lushan, for the snake is found distributed generally throughout the hilly regions. Its distribution is more directly correlated with the presence of bushes and low trees.

Certain species, namely *Sibynophis chinensis, Plagiopholis styani, Achali-*

nus spinalis, Lycodon ruhstrati, Dinodon flavozonatum, Elaphe mandarinus, Elaphe porphyracea nigrofasciata, and *Calliophis macclellandi* are typically montane throughout the greater part of their ranges. *Sibynophis chinensis* and *Achalinus spinalis* do occur at low altitudes in eastern China; the latter also descends into the lower slopes of Lushan and for this reason has also been considered with those snakes whose altitudinal distribution is correlated with latitude. *Calliophis macclellandi* also is found at fairly low elevations. Pope (1935, p. 343) states that Mell has informed him that this species occurs in open level country about Pingsiang, Kiangsi. He accounts for this habitat choice on the grounds of the northern position of the station, yet in Lushan, 150 miles to the northwest, it is quite obviously a mountain form. In all the foregoing species, then, mean temperature as a controlling factor in their distribution is relatively unimportant in that north or south they occur at similar altitudes. This, *per se,* indicates that they possess a wider degree of temperature tolerance with a lower threshold than other snakes inhabiting the same geographic areas. With the exception of *P. styani, A. spinalis,* and *C. macclellandi* these species are relatively rare and their habits little known. It is then impossible to say what environmental factor is dominant in controlling their distribution. *Plagiopholis styani* and *A. spinalis* are known to feed on earthworms and both inhabit damp hardwood forests with their accompanying deep humus floors. *Calliophis macclellandi* is found in the same situations but it is ophiophagous. Both *C. macclellandi* and *P. styani* are fossorial snakes whereas *A. spinalis* apparently is not. The latter, however, is extremely delicate and especially subject to desiccation. It is quite likely that its range of tolerance for humidity is unusually narrow. While there is no direct evidence as yet that *C. macclellandi* feeds on these two small species, nor on the small *Sibynophis chinensis* and *Calamaria septentrionalis* which are found in the same habitat, the presence of these five species together suggests that they form part of a distinct hardwood forest community. *Calliophis macclellandi* plays the part of vertebrate predator; its prey may differ in different localities, but its status in the community remains the same.

The only species which may be described as being typically snakes of the plains are *Natrix annularis* and *Elaphe rufodorsata.* Both species are water snakes and occur in great abundance in paddy fields and irrigation ditches all around the mountain. *Natrix annularis* ascends into cultivated valleys in the foothills but is always associated with still or slow moving water. It shares this habitat with *Natrix tigrina lateralis* which, however, is frequently found some distance from water, although clearly associated with it.

The two other common water snakes of the region are typically found in pools or cascading streams. These species, *Natrix percarinata* and *Pseudoxenodon nothus,* show little altitudinal preference. The former is found in similar situations in southern and western China. In areas other than Lushan nothing is known of the habits of *P. nothus.*

Of the remaining species known to occur in the region but not mentioned above, *Dinodon rufozonatum, Elaphe taeniurus, Pareas boulengeri,* and *Agkistrodon halys* are apparently eurytopic both in Lushan and elsewhere. All of them with the exception of the amblycephalid are quite common. The latter seems to be restricted to forests but its rarity makes such a classification hardly warrantable. *Ptyas korros, Bungarus m. multicinctus, Naja naja atra,* and *Pareas chinensis* are not represented in the collection and no precise data regarding their habitats in the region is available, but from indirect evidence it appears that *Naja naja atra* is a snake of the plains.

More specific details concerning the habits and habitats of the species and the morphological variations exhibited by them are included in the following annotated list. When possible the observations of other workers have been verified. Variations have been discussed at some length with the hope that these observations may be integrated with those of others and make for a clearer understanding of the geographic variations in behavior and morphology of the Chinese snakes represented in this region.

METHODS AND MEASUREMENTS

Unless otherwise stated, all measurements of length are in millimeters. The ventral scale count is made from the first median unpaired scale on the throat to and including the scale immediately preceding the anal plate or plates. If any ventrals are partly divided, paired, or incompletely traverse the ventrum, they are counted as a single ventral. Subcaudal counts are begun on the first pair of scales in contact with each other posterior to the vent; or, when the subcaudals are single, the first median subcaudal posterior to the vent. The terminal scale is included in the subcaudal counts regardless of whether the subcaudals are single or paired. The first number of the scale row formula represents the number of rows at that point on the neck where the circumference of the neck is smallest; in the event that the head is not distinct from the neck, the count is made one head-length posterior to the head. The last number in a scale row formula represents the number of rows one head-length anterior to the vent. The remaining numbers in the formula represent the number of scale rows found at as many points as numbers are given, these points dividing the intervening body into equal lengths. When numeric formulae of oculars, labials, and temporals are given, the left-hand number represents the number of plates on the left side of the animal; the right-hand number, that of the right side. When measurements of identical structures are given in the text for two or more animals, the order in which they are given corresponds to the order of the catalog numbers initiated at the head of that species account. All subsequent comparative measurements are given in the same order. In various places the following abbreviations have been used: v, ventrals; sc, subcaudals; jv, juveniles. Descriptions and drawings of hemipenes are based on hemipenes that have been dissected free of the tail, opened longitudinally opposite the sulcus spermaticus and stretched out flat. All the figures of the dorsal and lateral views of the heads of snakes are tracings of photographs of alcoholic specimens. Unless otherwise indicated, catalog numbers refer to specimens in the Museum of Vertebrate Zoology, University of California.

In addition to the specimens in this collection the small collections of the Kuling Library and the Kuling American School were examined.

ANNOTATED LIST OF SPECIES

Achalinus spinalis Peters

This series consists of five specimens, Nos. *22167–22169*, Kuling American School Collection No. 28, and Kuling Library Collection No. 4. No. *22167* is a female; the other four are males.

TABLE 2.

Summary of Counts and Measurements of *Achalinus spinalis*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	4	150–153	151.7	1.6	Maslin
	♀	1	162			Maslin
		5	156–164			Chang, 1936, p. 328
		2	152,175			Chang, 1936, p. 328, types of *Ophiclaps braconnieri* Sauvage, 1877.
Subcaudals	♂	4	61,60,59,60	60		Maslin
	♀	1	49			Maslin
		5	45–57	49.6		Chang, *loc. cit.*
		2	59,52			Chang, *loc. cit.*
Tail ratio	♂	4	.22,.20,.20,.20			Maslin
	♀	1	.15			Maslin
		5	.16–.21	.178		Chang, *loc. cit.*
		2	.20,.16			Chang, *loc. cit.*

Inasmuch as the hemipenis of this species has not been adequately described, I here include a description and figure of the organ: Hemipenis thin-walled, slender, extending to 16th subcaudal; sulcus deep, extending to tips of organ, forked just proximal to hemipenial fork; lips of sulcus massive in basal half of unforked region, these lips and adjacent regions covered with minute folds; lips in distal portion of unforked region less massive, still secondarily folded; arising from sulcus lips distal to fork, high, thin folds extend diagonally around organ, meeting

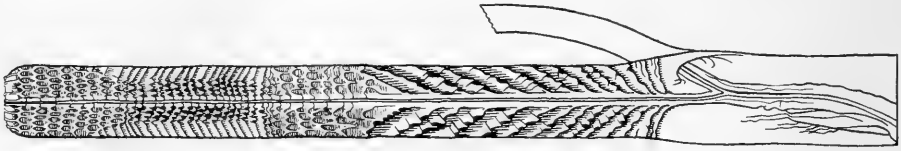

Fig. 1. *Achalinus spinalis,* left hemipenis of No. 22169, x 4½.

on wall opposite sulcus; these folds slightly flounced, edges sharply but minutely serrate; more distally, low longitudinal connecting folds appear, thus forming typical calyces; one-half distance toward tip of fork, calyces become smaller and shallower, with thicker septa; tip of organ with deeper calyces, edges of septa weakly papillated, almost smooth; just proximal to tip of organ sulcus lips raised into two basally directed pocket-like flaps; sulcus lips elsewhere ornamented as adjacent regions.

A compilation of the records of the relatively few specimens that have been sexed seems to indicate that the ventral counts show considerable variations, as Pope (1935, p. 184) has noted. But in each locality there is a definite sexual difference, the females having on the average ten more ventrals than males. The subcaudal counts are even more definitely segregated. In the species as a whole the males have from 50 to 61 subcaudals, the females 39 to 54. In any specific locality, however, there is a distinct difference with no overlapping (Pope's 1935 Chungan Hsien series offers the only exception to date). There is a difference in tail per cent between males and females; my single female has a tail .15 of the total body length; the males average .20. These figures agree with other records. The above differences have been noted by Pope (1935, p. 184) and others; but no mention has been made of the differences in the anal regions. In males, the scales of this region are slightly knobbed and very much reduced in length, so that the general pattern of long slender scales is suddenly broken by these pebble-like scales about the vent.

Habits and habitat: The animals which I caught alive, three in all, were captured at night on the roads of Kuling at an altitude of 3500 feet. They were close to streams and damp humus soil. I have observed others, badly crushed, lying on the ground as though they had been stepped on inadvertently, not deliberately killed. These dead snakes were curiously desiccated, which corroborates Pope's (1929) observation that after death they quickly dry up without putrefying. Alive, the snakes are extremely docile, soft and delicate to the touch. The scales are highly iridescent, and over the rich brown of the body this iridescence is beautifully accentuated. The female, caught on the 28th of June, 1936, contained six eggs, the largest being 15 x 6 mm. The natives of this region say they do not see this snake on the plains, but often find its crushed remains on the mountain paths.

Remarks: The variations in the stripe on the back may have some taxonomic significance. The Lushan form has an unusually wide stripe (three entire median scale rows), whereas Chang and Fang's (1931, p. 264) Nanking specimen has a stripe inclusive of but one median row. Pope (1929, p. 435) found that the majority of his Fukien snakes were similar to the Nanking form, but that two had a stripe twice as wide. Stejneger (1907, p. 297) found that the Japanese variety was of this latter type. Chang's (1936, p. 327) specimens from the same locality as the present series also have three scale rows involved in the stripe, while Boulenger (1893, p. 309) found no stripe at all on certain Ichang forms (*"Achalinus bracconieri"*). As yet there are not enough records concerning this point to warrant conclusive geographic correlation.

Sibynophis chinensis (Guenther)

Two specimens, females, numbered 21927 and 21928, from Lushan, Kiangsi, China.

TABLE 3.

Summary of Counts and Measurements of *Sibynophis chinensis*

No. and sex	Ventrals	Anals	Subcaudals	Source
2 ♀	180–179	1	101+–108	Maslin
2 ♀	170–175		74+–81+	Chang, 1928, p. 321

Habits and habitat: Both specimens were found in Kuling at an altitude of 4000 feet, in tall grass and brush adjacent to forested areas. The stomachs have been examined; one contained a few reptilian scales (*Takydromus*), the other was empty. Pope (1929, p. 390) also found that his specimens had eaten lizards.

Remarks: These two specimens possess the diagnostic characters which Pope (1935, p. 85) used to separate this species from *S. collaris*. There are two anterior temporals on each side, and 9-9 supralabials, the lower anterior temporal thrusting itself between the seventh and eighth labial but not reaching the lip. The dark bands on the head are most indistinct; the band crossing the posterior third of the parietals as described by Pope (*loc. cit.*) is, in these specimens, completely confluent with the nuchal or occipital band. The subcaudal counts are high in these specimens; in No. 21927 a few terminal scales are missing but the number of subcaudals is still within the range for *chinensis*. The color pattern of the head, especially the labial and nuchal pattern, is

Fig. 2. *Sibynophis chinensis*, No. 21928 ♀, dorsal and lateral view of the head, x 2.

strikingly like that of *S. grahami*, in that the nuchal white collar is not crescentic as it is in *chinensis*, and in that the white labial band is broken up anterior to the eye into posteriorly pointing V-shaped marks; but, as Pope (1929, p. 390) has pointed out, the color pattern in this species is extremely variable.

Natrix annularis (Hallowell)

A series of 110 specimens, numbered 21929 to 22038 inclusive; the series consists of 6 male and 12 female juveniles plus 51 male and 41 female adults. No. 21929 was obtained in October, 1935; all the others were collected between the dates of May 7 and June 7, 1936, in the foothills and plains about Lushan.

TABLE 4.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Natrix annularis*

	Sex	No.	Extremes	Mean	Standard Dev.	Remarks
Ventrals	♂	57	150–165	155.1	2.3	
	♀	53	143–159	149.0	2.7	
Subcaudals	♂	38	63–72	68.2	1.87	
	♀	33	59–69	63.3	2.2	
Tail ratio	♂	33	.21–.23	.221	.006	
	♀	23	.18–.24	.213	.012	
Maximum total lengths	♂	3	584,589,599			
	♀	3	835,867,696			Last specimen to vent only.
Body bands	♂	57	35–45	40.0	2.2	
	♀	42	31–43	38.1	2.97	

Sexual dimorphism is marked in this species. Pope (1935, p. 97) has pointed out the difference in ventral and subcaudal counts, the greater size of the females, and the greater number of bands, especially on the tail, in males. These characters are expressed numerically in Table 2. Pope also mentions the tuberosities on the labials and chin shields in males. These tuberosities are lacking on snakes measuring less than 325 mm. in length, but are invariably present on adults.

Habits and habitat: Pope (1929, p. 394) reports that these snakes are "vicious and wild." I found them rather the contrary in this locality. When caught, they made efforts to escape, and when cornered, assumed a hostile stance, but they seldom struck. None of the females had eggs. This was to be expected, as Pope (1935, p. 99) has shown that females of this species give birth to their young in September. Specimen No. 21929, caught in October in a wide stream in the foothills, regurgitated a large loach soon after capture. The other individuals of this species were caught in habitats similar to that described for No. 21929, some in flooded rice fields. This snake does not occur in the mountains themselves.

Growth: Study of this large series has brought out several points regarding growth rates in this species. In the accompanying graph (fig. 3), the series is arranged according to length measured from snout to vent to the nearest 5 mm. Pope (1929) reports seeing a large female give birth to nine offspring, and gives the measurements of the two largest. Assuming the tail to be 20 per cent of the body, I have calculated the length to the vent of these snakes recorded by Pope and have included them in the graph. Stejneger (1907, Formosa), and Chang and Fang (1931) also record young, giving their measurements. These are likewise included. My juveniles, judging from these, must have been born the preceding fall, their present size representing probably only a month's growth or less. A large gap occurs in length, the next group being about 100 mm. longer. The first few snakes between 300 and 335 mm. have very nearly the same color pattern as the smaller snakes and the males of this length have smooth chins. It is assumed that snakes in the 300–435 mm. group are one year older than those in the 150–210 mm. group. In the males it is possible to judge the second year's growth as represented by the group about the 460 mm. lengths. The females do not show this as well, and after the third year there are no size differences which have any significance whatsoever. It is significant that the females grow much faster and become much larger than do the males. There are 22 females longer than the longest male among the 92 adults.

Remarks: There has been some confusion in the written accounts of the similar color patterns of the two closely allied species *N. annularis* and *N.*

percarinata. But a close examination of the snakes discloses considerable difference, particularly obvious in young snakes. One of the best characters for distinguishing the two forms is that in *N. annularis* the bars extend to mid-belly on the neck region, while in *N. percarinata* they do not (Pope, 1929, p. 394). Another obvious character is the shape of the bars on the dorsum. In *N. percarinata* these bars form a sub-diamond shaped loop on the back,

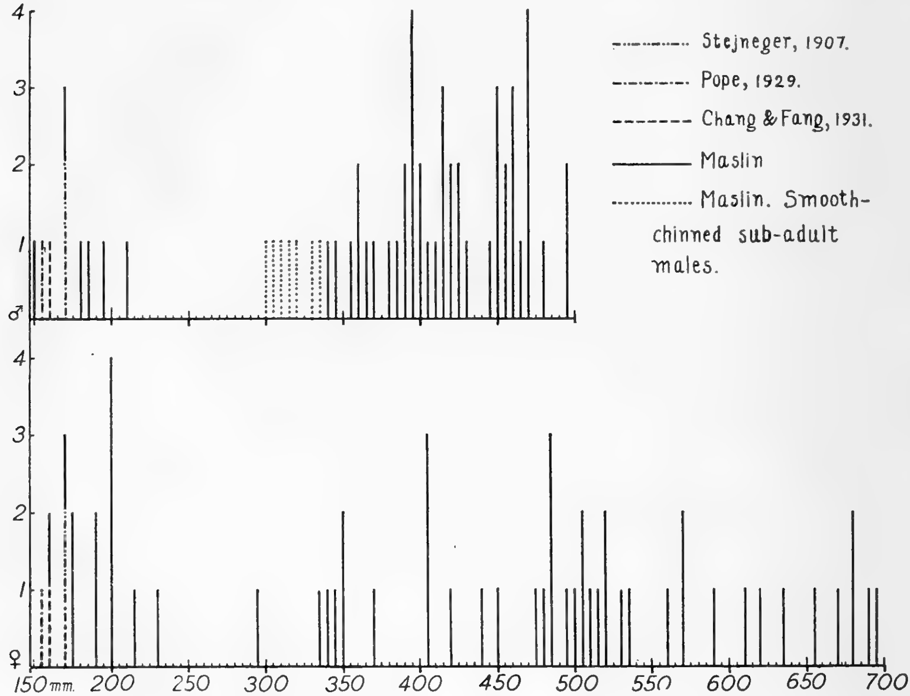

Fig. 3. *Natrix annularis,* lengths from snout to vent. Juveniles recorded by Stejneger 1907, Pope 1929, and Chang and Fang 1931, are included in both groups.

the centers being somewhat lighter than the ground color; this looping is hardly apparent in *annularis.* A good character for distinguishing specimens over 450 mm. is the color of the ventrum in life; *N. annularis* has a rich coral red ventrum, whereas that of *N. percarinata* is pale white. This characteristic, however, is nearly useless for preserved or young specimens.

In both species the black ventral bars fade considerably with age, and even disappear in some old females. But since they tend to fade from the center first, it is possible to determine their outlines even when they are almost gone. *Natrix percarinata* displays a peculiar ontogenetic color change. The ventrum of the young is a rich orange color which extends up the sides between the black bars as a deeper red orange. In this juvenile color phase it closely resembles *N. annularis,* although the abdomen of the latter is a coral red. As *N. percarinata* becomes older, this color fades from the ventrum, and by the time the animal is a year old the ventrum is white. The lateral reddish markings persist considerably longer; one female measuring 672 mm. still had traces of this color on her sides.

Further differences between *N. annularis* and *N. percarinata* may be summarized as follows:

Rings on the tail: In *N. annularis* the tail rings are distinct and countable on even the largest snake. In *N. percarinata* after the first year the subcaudal regions become so mottled that it is almost impossible to distinguish the rings. This obliteration of the pattern is most pronounced distally but with increasing age becomes more general. In large specimens no subcaudal rings can be made out at all.

Tail ratio: Snakes with tails less than .24 of the total length are *N. annularis,* and those having tails greater than .24 are *N. percarinata,* regardless of sex.

Ventrals: *N. annularis* has a higher ventral count: ♂ 150–165, ♀ 143–159; with averages of 155.06 and 149.02, respectively. For *N. percarinata* counts are ♂ 136–142, ♀ 135–142; averages 139.55 and 138.78, respectively.

Subcaudals: *N. annularis* has a slightly lower subcaudal count: ♂ 63–72, ♀ 59–69; averages 68.2 and 63.3, respectively. *N. percarinata* has ♂ 72–74, ♀ 68–76; averages 73.00 and 71.22, respectively.

Labials entering the eye: *N. annularis* has only the fifth labial entering the eye, while *N. percarinata* has the fourth and fifth entering. This is a good character in this collection; exceptions are rare.

Labial sutures: The sutures are dark or black in *N. annularis* and are undifferentiated from the rest of the labials in *N. percarinata.*

Width of eye: The eye in *N. annularis* is as wide as the diameter of the frontal at its center. The eye is wider in *N. percarinata* when measured in the same way (Boulenger, 1899, p. 163).

Boulenger (1893, p. 233) in his catalog has given the counts of the specimens collected by Pratt. These are as follows: specimen nos. a-d (Brit. Mus.); 3♀ (v. 148, 147, 145; sc. 54, ?, ?); 1 juv. (v. 153; sc. 69). The above measurements increase the range of subcaudals in females from 59–69 to 54–69.

Natrix percarinata (Boulenger)

This series consists of 32 specimens (nos. 22039–22070); 29 adults, 16 males and 13 females; 3 juveniles, 2 males, and 1 female. With the exception of the three specimens they were caught between May 7 and June 6, 1936. All specimens were collected in the foothills and mountains of Lushan.

TABLE 5.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Natrix percarinata*

	Sex	No.	Extremes	Mean	Standard Dev.	Remarks
Ventrals	♂	18	136–142	139.6	1.5	
	♀	14	135–142	138.8	2.0	
Subcaudals	♂	9	72–74	73.1	1.0	
	♀	9	68–76	71.2	2.1	
Tail ratio	♂	11	.24–.28	.265	.010	
	♀	7	.25–.29	.264	.014	
Body bands	♂	16	36–43	40.0	2.0	Bands indistinguishable in
	♀	9	35–42	39.0	2.3	the larger specimens.
Juv. tail bands	♂	2	30,33			
	♀	1	20			
Maximum lengths	♂	2	608,638 mm.			
	♀	2	887,1040 mm.			

Sexual dimorphism is not so pronounced in *Natrix percarinata* as in *N. annularis* as far as body measurements are concerned, except that females are larger. But the rugosity of the anterior lower labials and chin plates is more pronounced in males of this species than in *N. annularis*. Such rugosity is found also on the upper labials, nasals, and adjacent scales of many individuals.

Habits and habitat: N. percarinata is more active and vigorous than *annularis* and will strike when teased. It is fond of shaded streams in the mountains but is more commonly found in the streams in the foothills. At these lower altitudes it is found with *N. annularis*. Both species, when alarmed, dive beneath the surface of the water and secrete themselves under rocks or in tangles of submerged roots.

Remarks: This series is too small to allow an adequate study of growth but it does represent a complete age sequence. The three juveniles measure 194, 264, and 266 mm., respectively, in total length, the first two being males.

Natrix tigrina lateralis (Berthold)

Of the 71 specimens in this series, 68 are numbered 22071 to 22138; the remaining 3 are in the Kuling American School collection. In all there are 24 males and 47 females.

TABLE 6.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Natrix t. lateralis*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	22	143–155	149.5	2.7	Maslin
	♀	49	144–159	152.4	2.66	Maslin
		1	151			Boettger, 1894, p. 139
	♀	1	152			Boulenger, 1893, p. 250
Subcaudals	♂	20	61–71	65.2	2.9	Maslin
	♀	37	52–64	57.6	2.7	Maslin
		1	56			Boettger, *loc. cit.*
Tail ratio	♂	20	.20–.29	.225	.012	Maslin
	♀	37	.16–.23	.191	.013	Maslin

The average ventral counts of both sexes are nearly the same. The average subcaudal counts, however, differ considerably when series are considered, but overlapping is extensive. The most obvious sexual difference with high diagnostic reliability is the sudden reduction of girth at the vent in females; in males, the body tapers imperceptibly into the tail. As Pope (1935, p. 438) has mentioned, the scales in the anal region of males are more strongly keeled than elsewhere on the body. This pronounced development is even more noticeable to the touch than to the eye. If the fingers are rubbed over this area in postero-anterior direction the scales seem rough and catch on the fingers. Another difference, variable in its distinctness, is the presence of small tubercules on the heads of males. In most specimens they occur on the upper and lateral parts of the head, with the exception of the frontal and medial parts of the parietals, but are absent from the ventral head surface. In this respect these snakes differ from others of this genus.

Habits and habitat: In agreement with Pope (1935, p. 137), I find that this snake varies in its choice of habitat. Usually it is found near streams, irrigation ditches, and paddy fields. I have taken it also several hundred yards from water on hill slopes at the base of Lushan. Sowerby (1926) states that in North China it is found at altitudes between 2000 and 4000 feet. In the Lushan area, however, it is distinctly a snake of the foothills and plains. The actions of a snake which I kept for several days in a glass box were similar to those observed by Kreyenberg (1907) and Pope (Schmidt, 1927, p. 512). Pope's description follows: "It flattened the whole body, especially the neck, and the sides of the neck were drawn down until the angle below was a right angle, or less, and the skin above was tightly stretched over the vertebrae. Just behind the head the neck was strongly arched, to such a degree as to make a fold of loose skin appear under the head where head and neck meet. The head, held in this position, was raised from one to four inches from the ground. The body was thrown into varying but gracefully regular coils. This snake could not be induced to bite or strike, but when its body was pinched at any point it would turn and 'butt' with its nose, but not with any particular violence. Sometimes the head and arched neck would be thrown well back, and then its attitude was much like that of a cobra." In the snake I observed the head was held higher, five to six inches above the ground, and, significantly, the back of the neck was always kept facing towards me. If I circled about the snake, it carefully maintained this orientation. I say "significantly" because of Nakamura's (1935) discovery of integumental poison glands in the nuchal region of this species. He finds these glands function by rupture, their excretions being offensive in odor and irritating to mucous membranes in general. The action of the snake seems correlated with the possession of what I have termed Nakamura's glands; and the exposure of the vivid red and black pattern on the neck may serve as a warning, anticipating and discouraging attack on the part of an experienced aggressor. Smith (1938) has found similar glands in a number of other species.

Remarks: The series here reported on does not differ from those described by Schmidt (1927), Pope (1929), or Chang and Fang (1931) in any significant way. The ventral counts most closely resemble series from Anhwei, whereas the subcaudal counts are more similar to the northern and extreme southern types. The longest males in this series measure 754 and 668 mm.; the longest females, 778, 764, and 749 mm. These are not large compared with the measurements made by Chang (1932) and others, who have records of 1031 and 1090 mm. for total length.

Pseudoxenodon nothus H. M. Smith

Of 17 specimens, 15 are numbered 22139–22153; one, No. 18, is in the Kuling American School collection; and one, No. 2, is in the Kuling Library collection. All specimens were collected in Lushan.

Description: Head broad, distinct from body; body cylindrical, skin of neck loose, dilatable; tail moderate (see table 5); scales keeled, weakly on neck (five or six scale rows smooth in this region); posteriorly all rows keeled; scales arranged in 19–17–15 rows, reduction to 17 rows occurring between 61st and 74th ventral, reduction from 17 to 15 invariably occurring within ten ventrals posterior to the first reduction; anal plates large; subcaudals paired; occasionally ventrals immediately anterior to vent are divided.

TABLE 7.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Pseudoxenodon nothus*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	12	138–145	142.7	1.8	Maslin
	♀	5	145–150	146.4	2.3	Maslin
		5	141–150?	(4) 143.5		Chang, 1936, p. 324
Subcaudals	♂	10	60–66	62.7	2.0	Maslin
	♀	3	57,58,59			Maslin
		5	43?–63	(4) 59.8		Chang, *loc. cit.*
Tail ratio	♂	10	.19–.21	.203	.007	Maslin
	♀	3	.18,.19,.20			Maslin

Rostral almost twice as broad as high, clearly visible from above; internasals slightly shorter than prefrontals, as wide as inter-prefrontal suture; frontal as long as distance from it to rostral; broad anteriorly, greatest breadth equalling length of lateral edge; parietals large, longer than frontal; supraorbitals twice as long as wide. Nostril large, touches internasals; posterior nasal broadly in contact with prefrontal, this suture twice as long as posterior nasal-internasal suture; loreal quad-

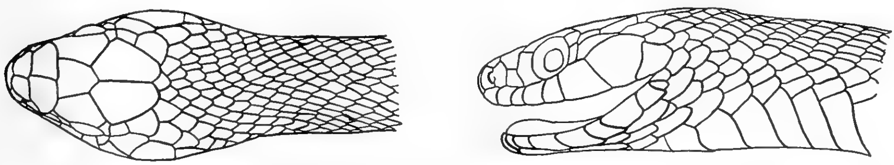

Fig. 4. *Pseudoxenodon nothus*, No. 22145 ♀, dorsal and lateral view of the head, x 1.

rangular, much longer than high; preoculars 1–1, 1–2 in one female; postoculars varying from 2–2 to 4–3, normally 3–3, upper largest, in contact with parietals; temporals 2+2, occasionally a third posterior temporal is present. Supralabials 8–8, occasionally six or seven on either side, fourth and fifth entering eye, seventh largest; infralabials 9–9, variations from 8–8 to 11–10 in eight specimens; four or five labials in contact with anterior chinshields; posterior chinshields equal to or larger than anterior, widely divergent posteriorly.

Ground color of head tan-gray; an indistinct interorbital bar of darker gray markings lies across posterior edges of prefrontals; frontal marked by several dots of a similar dark gray; starting from posterior tip of frontal a parabolic mark of gray reaches to sides of neck; this mark has a clearly defined anterior edge, posterior edge fades to a reddish gray; a dark gray chevron is superimposed on this reddish portion, its arms extending to tenth ventral; posteriorly, edge of chevron bordered with a narrow, but conspicuous, light gray stripe similar in color to centers of dorsal spots (see below); postorbital streak extends from eye to corner of mouth; posterior edges of first five supralabials edged with black, this color not touching lips; scales of dorsum rich gray, with intervening irregular cutaneous pattern of black and light gray, this pattern usually embracing basal edges of scales; a row of 21 black-bordered light gray marks of irregular shape extends down back; anteriorly these are diagonal bars about four scale widths long and one scale width wide, posteriorly bars become shorter, wider, more irregular; from one tail length or less anterior to vent a black-bordered stripe similar in color to dorsal spots extends to tip of tail; scales of neck not entering into chevron mark are red or yellow basally with gray tips, this color extending posteriorly down sides, disappearing at mid-body; ventrum anteriorly spotted with large, diffuse black smudges; beginning sparsely about two head lengths down body, bases of ventrals become speckled with black, these speckled areas extending laterally to posterior edge of each ventral, thus forming a distinct but mottled line extending to tip of tail; anals and ventral anterior to them conspicuously lighter than adjacent scales.

Maxillary teeth number 24 to 26, arranged in two groups; anterior group consists of strong, slender conical teeth, anterior few smallest, remainder subequal; posterior group consists of two large teeth preceded by a short gap, these teeth twice as long as teeth of first group. Lateral processes of maxillary small, subequal; dorsal surface of bone undulated.

Hemipenis forked, extends to seventeenth subcaudal; sulcus shallow, proximally paralleled by minute folds without spines; this region followed by an area in which sulcus is deeper, with spinous lips, paralleled on each side by a large fold covered with small soft spines; sulcus forks

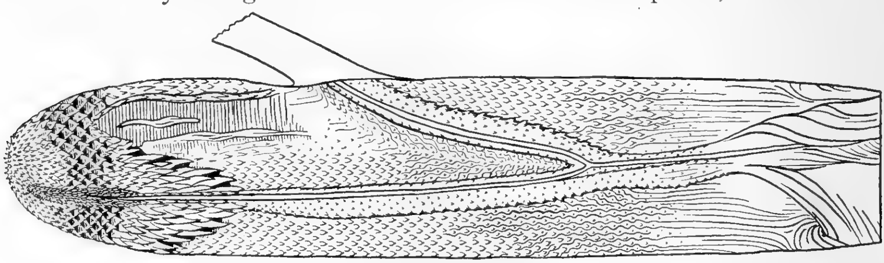

Fig. 5. *Pseudoxenodon nothus*, right hemipenis of No. 22142, x 4.

at sixth subcaudal; hemipenis forks at the twelfth; immediately distal to this fork in each branch large folds of main canal give way to dense masses of large, hard spines, and a similar mass lies on opposite side of sulcus; these masses gradually diminish in size, giving way at tip to minute calyculations; edges of distal calyces deeply serrated, appearing like densely crowded, soft spines; sulcus ends in raised fold near tip of organ; calyculate area and immediately proximal spines extend completely about hemipenial wall; more proximal spiny areas lie in two masses on either side of sulcus, as mentioned above.

In common with *P. striaticaudatus*, the largest snakes are males, the two largest measuring, respectively, 736 and 731 mm. The largest females are 645, and 584 mm., respectively. Of the 12 males examined, 10 have knobbed scales in the cloacal region; the other two are young snakes measuring, respectively, 405 and 531 mm. There is a correlation between body length and the size of the knobs, the largest snakes having these knobs better developed. The males have slightly fewer ventrals and more subcaudals than do the females. There is also sexual chromatic dimorphism; the females have reddish neck areas, and the males yellow with no trace of red.

Habits and habitat: These snakes are mountain-stream dwellers, foraging in the streams or on the banks close by. Some of the specimens were caught near streams in the foothills. The altitudinal range of these snakes varies from 500 to 4000 feet. When cornered, they invariably coil and dilate the skin of the neck region, exposing the vivid red or yellow pattern. When caught, they strike or writhe about with great energy. Their hibernation period apparently extends from late October to the latter part of April. None of the 5 females examined was gravid.

Remarks: Pseudoxenodon nothus has been named by Hobart M. Smith (1942). This species is obviously closely allied to *P. striaticaudatus* in that it has the lineate tail which separates it from the other mainland forms. This series differs from typical *P. nothus* in having a higher ventral count and in having 17 scale rows for only a short distance, about ten ventrals, at the midbody. In coloration, however, it is remarkably similar to typical *P. nothus*. It differs from *P. striaticaudatus* in having 19 scale rows anteriorly and in having a red or yellow coloration about the neck regions.

Another point of difference between this species and *P. striaticaudatus* is the shape of the dorsal spots. These are large and diamond-shaped in *P. striaticaudatus*, and oblique rhombic bars in *P. nothus*. Still another point of difference is the distance the caudal stripe extends onto the body. In *P. striaticaudatus* this distance is usually from one to two tail lengths, whereas in *P. nothus* it is never longer than one tail length and may be as short as one-half a head length. There is overlapping in this character. Only seven specimens, or one-half of this series, have 4–4 labials in contact with the anterior chinshields, four have 5–5, three 5–4, and one has 4–5. Pope (1929, p. 406) points out that in *striaticaudatus* 4–4 labials are regularly in contact with the anterior shields. Chang (1936, p. 324) shows that there is a correlation between this character and the number of lower labials: when ten of the latter are present five are in contact with the anterior chinshields. This correlation is not found in the present series. The lower labials number 9–9 in *P. striaticaudatus,* with occasionally 10 on one side.

Chang (1936, p. 321) has described five specimens from this locality. His descriptions do not differ essentially from the foregoing, but his ventral and subcaudal counts increase the range as here outlined. He has synonymized *P. striaticaudatus* and *P. nothus,* but for the reasons already established I feel that *striaticaudatus* is a perfectly valid form.

Plagiopholis styani Boulenger

Fourteen specimens, ten males and four females, caught in Kuling at an altitude of 4000 feet, Nos. 22154–22166, and one specimen in the Kuling American School collection.

TABLE 8.

Summary of Counts and Measurements of *Plagiopholis styani*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	10	111–117	114.1	1.74	Maslin
	♀	4	119–122	120.7	1.25	Maslin
		5	112–121	117.0		Chang, 1936, p. 326
Subcaudals	♂	10	28–34	31.1	1.92	Maslin
	♀	3	26,29,30			Maslin
		5	25–30	27.6		Chang, *loc. cit.*
Tail ratio	♂	10	.12–.15	.14	.007	Maslin
	♀	3	.11,.13,.14			Maslin

There is a distinct difference between males and females in the number of ventrals. In this rather small series there is even a distinct gap between the extremes; but this would certainly be filled if more specimens were available. Pope (1935, p. 179) and Stejneger (1925, p. 77) give counts for series from Fukien and Szechwan. Here also there are sexual differences in the counts, but the Szechwan females have practically the same range as the Fukien males. The inference is that locally there is strong sexual dimorphism but in the species as a whole extensive overlapping occurs. There is also a tendency for the males to have a greater number of subcaudals. Pope (1935, p. 179) mentions that the males have keeled scales in the anal region. I find that the keeling is also present in all but one of the females in this series, but is much fainter than in the males. In some males these keels show a tendency to develop knobs. Females show a slight but sudden reduction of girth posterior to the vent.

Habits and habitat: This snake is quite common in Kuling but for the greater part of the year is rarely seen. During the months of May and June it can easily be found in the mornings along the roads and paths about the resort. Friends on a stroll before breakfast have reported seeing as many as seven or eight of these snakes. Usually this species is associated with damp forests having brush or grassy floors. The snake is harmless, never attempting to bite or strike, but when held it may press its tail against the hand, giving a pricking sensation. Its tail and neck are unusually strong; by flexing the latter between the fingers it can exert sufficient pressure to wedge itself through. Its body form and actions in general suggest burrowing habits. An examination of the stomachs of seven specimens revealed an earthworm in one and black grit in two others; the rest were empty. One specimen had a parasitic nematode in its intestine. Two of the females had six and eight eggs, respectively. The largest eggs measured 18 x 9 mm., and appeared to contain very young embryos. The eggs were enclosed in extremely thin membranes. One female was caught in May, 1935, the other on June 7, 1936.

Remarks: The longest female of this series measured 396 mm. in total length and 352 mm. from snout to vent. The two longest males measured, respectively, 374 and 349 mm. in total length and 320 and 307 mm. from snout to vent. Chang (1936, p. 326) records one specimen from this region measuring 435 mm. in total length or 384 mm. from snout to vent. This is truly a large snake for this species, the usual adult length being about 350 mm.

Lycodon ruhstrati (Fischer)

One male, No. 22170, of this comparatively rare snake was collected at an elevation of 3500 feet in Kuling.

TABLE 9.

SUMMARY OF COUNTS OF *Lycodon ruhstrati*

Sex	No.	Ventrals	Subcaudals	Source
♂	1	210	89	Maslin
Jv.	1	211	88	Boulenger, 1893, p. 363

Habits and habitat: This specimen was taken at the west end of Kuling at an altitude of 3500 feet, some hundreds of yards from the nearest stream. It was in a clearing on a westerly facing slope where lizards abounded and may have been hunting them when caught. The time of capture was approximately 2:00 p.m. The undigested tail of a lizard (*Takydromus* sp.) was found in the stomach. Pope (1935, p. 195) suggested that the snake was nocturnal in habits and a frequenter of streams. However, he found the remains of a small skink in one, and a species of *Takydromus* in another. So it is likely that this snake is active both day and night.

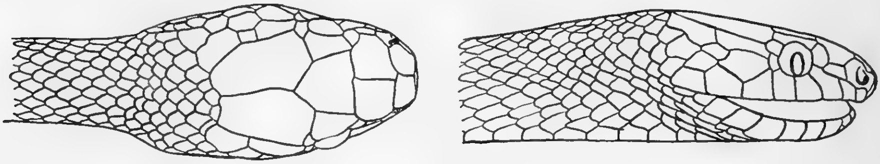

Fig. 6. *Lycodon ruhstrati*, No. 23758 ♀, dorsal and lateral view of the head, x 1½.

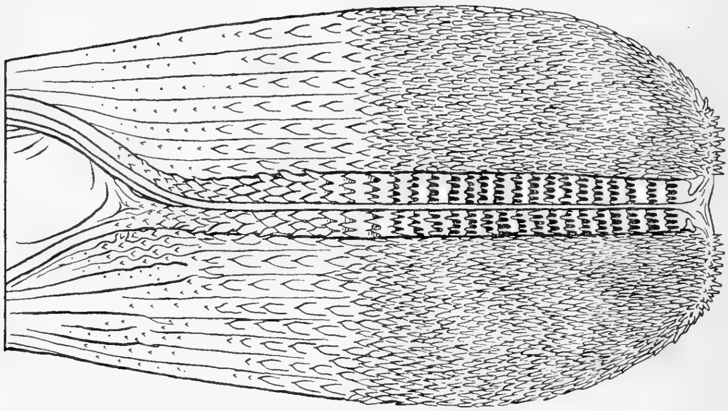

Fig. 7. *Lycodon ruhstrati*, left hemipenis of No. 22170, x 6.

Remarks: While this snake is not exceptionally long, 551 mm. from snout to vent, it shows no trace of the white juvenile band across its head. Another point concerning color pattern deserves comment: at no place do the white rings, measured middorsally, become wider than the intervening black rings. Laterally, however, they are wider from a point one-third the total length from the head to a point shortly posterior to the vent, where the white stripes again become widely separated by black.

Dinodon flavozonatum Pope

One male and one female, numbers 22171 and 22172, were taken at Kuling, Lushan.

Description: Head broad, blunt, distinct from body; eyes set back from swollen lips, considerable part of lips visible from above; body compact, ventrals laterally angulate; tail of male .19 of total length, tail of female incomplete; scales glossy, all rows smooth on neck, posteriorly median rows weakly keeled, at vent all but first row keeled; scale formula 17–17–15; ventrals 212 in male, 105 in female; anal single; subcaudals 80 in male (almost complete), 43 in female.

Remarks: In contrasting the hemipenis of *D. flavozonatum* with that of *D. rufozonatum,* Pope (1935, p. 200) describes the tip of the organ in *flavozonatum* as being almost perfectly smooth. In my Lushan specimen this is not the case, although the papillae are much sparser and less developed than in *rufozonatum.* Furthermore, the bases of the minute spines in both species are not essentially different. The lips of the sulcus in *rufozonatum* are poorly developed at the center of the organ and pronounced distally and proximally. In *flavozonatum,* on the other hand, the lips are much better developed throughout the central and proximal portion of the organ, and nearly equal in size. Some further differences not mentioned by Pope are:

1. The proximal folds near the mouth of the organ are more numerous and more conspicuous in *flavozonatum.*

2. The hemipenis extends to the 12th or 13th subcaudal in *flavozonatum* and only to the 10th or 11th in *rufozonatum.*

3. The calycular region is absent in *flavozonatum.*

4. Distally the sulcus lips break up into numerous longitudinal folds in *flavozonatum.* In *rufozonatum* these folds are entirely wanting.

5. Opposite the sulcus near the tip of the organ there are longitudinal folds in *flavozonatum;* these are wanting in *rufozonatum.*

6. In *flavozonatum* the minute distal spines do not completely encircle the organ because of the nature of the folds mentioned above. In *rufozonatum,* however, these spines do encircle the organ.

That *D. flavozonatum* is a valid species is clearly apparent from the hemipenial differences listed above. Werner (1929, p. 59) and Chang (1932, p. 55) refuse to recognize the species, basing their opinions on external characters alone, which, except for color, are rather poor for differential diagnoses.

Pope (1935, p. 201) gives seven differences supporting the distinctness of his species. A careful comparison of the two forms confirms his conclusions in part at least. His points of difference are:

1. The hemipenes of the snakes differ.

2. Dorsal bands yellow in *flavozonatum,* red in *rufozonatum.*

3. Loreal separated from eye constantly in *flavozonatum,* usually enters eye in *rufozonatum.*

4. *D. flavozonatum* has 6 to 9 keeled scale rows at mid-body, *rufozonatum* is essentially smooth.

5. *D. flavozonatum* has a slightly higher maxillary count than *rufozonatum.*

6. *D. flavozonatum* is more slender than *rufozonatum.*

7. *D. flavozonatum* inhabits high mountain forests, *rufozonatum* is eurytopic.

The fifth and sixth points do not hold for this small series. The seventh point will need further corroboration, although both my snakes were taken in the mountains around Kuling. There are, however, a number of other differences not mentioned by Pope.

Pope (1935, p. 200) describes the dorsal transverse bands as being "about half as wide as a scale is long" in *D. flavozonatum.* Wall (1903, p. 89) describes the bands of *D. rufozonatum* as being one scale length in width. I have found this difference to hold in my series as well. The cross bands in *D. flavozonatum* are narrow, only half as wide as those of *D. rufozonatum.*

The median dorsal scale rows are composed of relatively long narrow scales. Three to four headlengths posterior to the head these scales are three-fourths as wide as they are long in *D. flavozonatum.* In *D. rufozonatum,* however, similarly located scales are equal in length and breadth, appearing broad and short.

Other differences less easily demonstrated and more variable are:

1. In males of *flavozonatum* the chin is very weakly and minutely tuberculate. This tuberculation is absent in *rufozonatum* (feebly present in one young specimen).

2. The eye of *flavozonatum* is larger than the eye of *rufozonatum.*

3. The lower postocular is relatively larger in *flavozonatum.*

4. The fifth labial is well separated from the anterior lower temporal in *flavozonatum;* these plates touch or nearly touch in *rufozonatum.*

5. The fifth labial does not extend so high behind the eye in *flavozonatum.*

Dinodon rufozonatum (Cantor)

Nine specimens, Nos. 22175–22180, five males and three females; and No. 24, unsexed, in the Kuling American School collection. Specimens collected in Lushan and plains near Kiukiang.

TABLE 10.

Summary of Counts and Measurements of *Dinodon rufozonatum*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	5	197–211	203.3	5.3	Maslin
	♀	4	197–207	203.3	4.1	Maslin
	♀	1	203			Boulenger, 1893, p. 362
	Jv.	1	203			Boulenger, 1893, p. 362
Subcaudals	♂	2	76,76			Maslin
	♀	4	68–75	71.3	3.0	Maslin
	♀	1	72			Boulenger, *loc. cit.*
	Jv.	1	67			
Tail ratio	Jv. ♂	2	.21–.24			Maslin
	♀	3	.16,.17,.18			Maslin
Body bands	♂	5	63–86	74.0	8.8	Maslin
	♀	3	63,70,78			Maslin
Tail bands	♂	2	23,25			Maslin
	♀	3	20,22,27			Maslin
Longest specimens (snout to vent)						
	♂	2	795,708 mm.			Maslin
	♀	2	635,540 mm.			Maslin

In this series the males exceed the females in size. As in *D. flavozonatum* females can usually be distinguished from males by the sudden reduction in girth at the vent. The scale counts in the two sexes differ but slightly.

Habits and habitat: Pope (1935, pp. 205–207) has given an excellent summary of the known habits of this snake. My observations accord with his in every respect. His remarks on the temperament of the snake are most apt. Usually the snake is docile and easily handled, as reported by Wall (1903, p. 89) of individuals from Shanghai, but as Pope (1935, p. 207) states, ". . . a small percentage of individuals are treacherous—instead of striking, these more aggressive individuals simply open the mouth and quietly bury the teeth in the flesh that happens to be nearest to their jaws."

The juveniles seem rather tolerant of cold weather. They are the first snakes to appear in the spring and the last to disappear in the fall. I captured one active specimen in Kuling on November 18, 1935, at an altitude of 3,500 feet. Cold weather had already set in; nevertheless, the snake seemed healthy, though its stomach later proved to be empty. On November 26, 1935 another specimen at the same locality was dug up from boulder-filled soil by workmen digging a foundation. This snake contained the remains of a relatively large *Eumeces* almost completely digested. On February 21, 1936, Chinese collectors brought a juvenile caught among the foothills near Lien Wha Tung;

its stomach was empty. The adults were caught in May and June; their stomachs also were empty.

Remarks: This snake has been known from China for a long time and is one of the first snakes described from this country (Cantor, 1842). Subsequent notes are numerous. Schmidt (1927, p. 523) is surprised that Kiukiang specimens in the British Museum do not agree with his series from Changsha. The present series, however, does agree a little better, primarily in the number of dorsal and caudal bands. Hallowell (1856, p. 152) described this snake as having a pointed tail. None of the snakes in this series has such a tail. Usually the last scale is blunt or rounded. In juveniles the terminal scale is much elongated and slightly bulbous at the tip. This scale in most adults suggests an injury at some early growth stage. This is further suggested by the higher subcaudal counts of juveniles which have complete tails. A discussion of the differences between this snake and *flavozonatum* is included in the account of the latter species.

Zaocys dhumnades dhumnades (Cantor)

This series consists of 32 snakes, Nos. 22182–22213, 22 males and 10 females. They were taken from Lushan and its vicinity.

TABLE 11.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Zaocys dhumnades dhumnades*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	25	188–196	192.5	2.6	Maslin
	♀	10	187–197	192.3	3.0	Maslin
	♂	3	194,189,194			Boulenger, 1893, p. 376
		1	196			Boettger, 1894, p. 139
Subcaudals	♂	13	115–126	119.6	3.45	Maslin
	♀	7	112–125	118.1	4.0	Maslin
	♂	3	115,116,115			Boulenger, *loc. cit.*
		1	123			Boettger, *loc. cit.*
Tail ratio	♂	10	.27–.32	.288	.014	Maslin
	♀	7	.27–.30	.284	.010	Maslin

Pope (1929, pp. 414–415) makes an excellent comparison of this snake with *Z. d. nigromarginata.* The comparisons are based on young specimens in which the pattern is vivid and complete. In life, juveniles of *dhumnades* are extremely beautiful. The head is an orange fawn color, the upper labials a rich yellow, the ventral surface of the neck slightly lighter.

Anteriorly the dorsal scales have light yellow-green centers, at mid-body pale gray-green, and on the tail the light centers are again a light yellow-green. The ventral surface of the tail is a rich yellow. It is hard to identify such a specimen with its sombre adult color phase.

Chang and Fang (1931, p. 266) found that females had on the average slightly fewer subcaudals. These figures were based on 12 females and 6 males. In this series I, too, find that females have fewer subcaudals, but here also the series is small and overlapping is extensive. In males the tail is slightly thicker posterior to the vent. The largest males measure from snout to vent 1386 and 1398 mm.; the largest females, 944 and 986 mm.

Habits and habitat: This snake is often found about low overhanging banks near ponds, or in low brush and grass close to water. I have found several coiled up in small pockets beneath overhanging turf in banks surrounding weed- and brush-choked ponds. The skin is usually dirty with mud or dried scum. When surprised, these snakes make off with great speed, secreting themselves in dense brush, but if cornered, they form loose coils and, by inflating the body with air and slowly expelling it, make a loud hissing noise. This is repeated several times. Teasing will cause them to raise their heads and strike, hissing at the same time. As in a good many water snakes, the anal glands are well developed, and handling will often cause them to emit an offensive discharge which the animal distributes over its body and on the hands of its captor by violent writhing.

Remarks: Stejneger (1925, p. 87) and Pope (1935, p. 208) have worked out the distribution of this species. To their lists of localities may be added a point 50 miles south of Nanchang, Kiangsi (No. 22181). The snake taken here, a male, has 193 ventrals and 120 subcaudals.

Ptyas korros (Schlegel)

The only specimen of this species known from this region was collected by Pratt in 1887. Boulenger (1893, p. 384) gives the following counts for the specimen, a male: V. 166, sc. 122.

Elaphe bimaculata Schmidt

This series consists of one male, No. 22225, and three females, Nos. 22223–22224 and 22228, from Lien Wha Tung in the foothills of Lushan.

TABLE 12.

Summary of Counts and Measurements of *Elaphe bimaculata*

	Sex	No.	Measurements	Source
Ventrals	♂	1	191	Maslin
	♀	3	197,198,199	Maslin
	♀	1	202	Boulenger, 1894, p. 45
	Jv.	1	187	Boulenger, *loc. cit.*
Subcaudals	♂	1	78	Maslin
	♀	2	70,75	Maslin
	♀	1	68	Boulenger, *loc. cit.*
	Jv.	1	76	Boulenger, *loc. cit.*
Tail ratio	♂	1	.22	Maslin
	♀	2	.18,.19	Maslin

Comparison of the hemipenis of No. 22225 with Pope's (1935, p. 242) list of differences between *bimaculata* and *dione* brings out the following points in these Lushan specimens:

1. The organ extends beyond the 11th and 13th subcaudal plates as in typical *bimaculata.*

2. The calyces distally form papilla-like structures as in typical *bimaculata.* This is indistinct on the hemipenial walls but two such structures are well developed on the larger sulcus lip.

3. The scallops are horny and distinctly stiff and spinelike, rather than soft and fleshy, as in *dione.*

Other differences are so relative that without actual specimens of *dione* comparisons are impossible.

Pope (1935, p. 438) notes that sexual dimorphism occurs in the ventral and subcaudal counts, the females having more ventrals and fewer subcaudals than the males. In addition to these differences in the counts the tail of the females is clearly marked off from the rest of the body by a sudden reduction in girth. This change of body girth is gradual in males. Furthermore, in males the scales are faintly keeled about the vent. In females keeled scales are not found below the regular keeled scales rows.

Remarks: Schmidt (1927, p. 531) and Chang and Fang (1931, p. 274) found that anteriorly the dorsal scales are smooth. In these three snakes the keeling, although weak, begins on the neck. The cranial chevron mark in these snakes does not extend as far posteriorly as on the specimen figured by Schmidt (1927, fig. 17) but the posterior extensions do not expand into blotches, as reported of *dione.* Aside from these differences these snakes agree well with Schmidt's amplified description.

Elaphe carinata (Guenther)

Nine specimens, Nos. 22214-22222, including six males and three females All are adults taken from the foothills of Lushan.

TABLE 13.

Summary of Counts and Measurements of *Elaphe carinata*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	8	214–222	217.4	3.4	Maslin, Boulenger
	♀	3	213,214,215	214.0		Maslin
	♂	2	213,215			Boulenger, 1894, p. 55
	♀	1	215			Boulenger, *loc. cit.*
	Jv.	1	210			Boulenger, *loc. cit.*
		1	220			Chang, 1936, p. 330
Subcaudals	♂	7	88–95	90.9	2.9	Maslin, Boulenger
	♀	2	85,95			Maslin
	♂	2	93,87			Boulenger, *loc. cit.*
	♀	1	83			Boulenger, *loc. cit.*
	Jv.	1	86			Boulenger, *loc. cit.*
		1	92			Chang, *loc. cit.*

The hemipenes of these Lushan forms differ from Pope's description in that there are two longitudinal areas with reduced calyces and the sulcus is minutely forked at its extreme tip. Otherwise they are essentially the same. Pope (1935, p. 235) states that a Lushan specimen he examined had three folds paralleling the sulcus; only two folds were present in the specimens examined from this collection.

Sexual dimorphism is apparently absent in this species. The number of females in this series is too few to show any significant dimorphism as far as scale counts are concerned.

Habits and habitat: This snake is not found in the mountains proper but in the foothills about the mountains it is relatively common. Chang and Fang (1931, p. 275) mention that in life the snake is black and yellow. I found this to be so of all the snakes I obtained; on these the yellow is brilliant and of the same color value on all parts of the body not marked with black. Pope (1929, p. 438) remarks that specimens from Ch'ungan Hsien, Futsing, and Hok'ou are docile and easily handled. This is most surprising, for the snakes of the Kiukiang-Lushan region are exceptionally vicious. When cornered, the snake loops its neck in a tight S-shaped coil and strikes ferociously without any visible body movements prior to the strike. The mouth is held open, the head thrown back, and a slight hiss is heard as the head nears its target. Snakes kept in a glass-sided cage would repeatedly strike at anyone passing with such violence as to necessitate moving them to cages without glass. All the snakes obtained were heavily parasitized in the connective tissue of the abdominal skin and visceral mesenteries with pseudophyllidean tapeworm larvae (*Sparganum mansoni*).

Remarks: The nomenclatorial history of this snake is complicated, primarily as a result of the great difference in color pattern of the young and adult. A description of the juvenile color pattern is here included. "General color fawn brown; a dorso-lateral line on each side of the neck, reaching and passing the first dorsal crossbar, and indicated on subsequent crossbars; a longitudinal row of narrow black spots below this; middle third of the body with somewhat irregular narrow dorsal black crossbars from ventral to ventral, mostly elongate between the 4th and 5th row to indicate a lateral line, which becomes continuous on the posterior third of the body, between the 3rd and 4th scale rows; a row of dorsolateral spots on the 7th and 8th scale rows in this part of body also tends to form a line, and continue as very distinct lines on the tail, which is otherwise uniform; most of the anterior and middle ventrals with black dots near their outer tips; venter posteriorly uniform; a few small black spots on parietals and labials.

"This specimen measures 404 mm., of which the tail occupies .18." This description is of the type of Schmidt's (1927, p. 535) *Elaphe osborni* now synonymized with *E. carinata.* In older snakes the stripes break up or are obliterated by the gradual darkening of the individual scales around their edges. In adults the lateral stripes of the neck region can sometimes be traced, but with difficulty.

Elaphe mandarinus (Cantor)

One specimen (No. 22226), a juvenile male measuring 238 + 52 mm.

TABLE 14.

Summary of Counts and Measurements of *Elaphe mandarinus*

	Sex	No.	Extremes	Source
Ventrals	♂	1	214	Maslin
		1	217	Chang, 1936, p. 331
Subcaudals	♂	1	73	Maslin
		1	63	Chang, *loc. cit.*

Remarks: Although this snake is widely distributed, collections contain but few specimens from a locality. Variations in scale counts, number of maxillary teeth, temporals, and details of color pattern are extensive; but the color pattern in general and the body form of the snake are so distinctive that the species is readily recognized. Werner (1903, p. 356), nevertheless, has apparently confused it with *E. conspiculata,* a Japanese species, the juveniles of which closely resemble *mandarinus.* No. 22226 agrees well with the specimen recorded by Chang, (1936, p. 131) from Lushan. Cantor (1843, p. 483), in his original description of the type, describes the snake as "bright scarlet above, with numerous yellow lozenges, surrounded with broad, black brims, relieved with white edges; on either side a number of small irregular black marks edged with white; the abdominal surface pearl-colored, checkered with black."

Elaphe porphyracea nigrofasciata (Cantor)

One male, No. 22227, from Kuling, Lushan, 3500 feet.

Description: Head broad, rounded, barely distinct from neck; body slightly flattened dorsally; ventrals 197, obtusely angulate laterally; anal divided; sc. 65, paired, 10th–13th sc. undivided; scales smooth in 19–19–15 rows.

Habits and habitat: This snake was taken in the afternoon at an altitude of 3500 feet, in the vicinity of inhabited buildings in Kuling. The finding of it here is in line with the experience of most observers, who describe it as a mountain form.

Remarks: The hemipenis differs from the one described by Pope (1935, pp. 257–258) in that the organ extends to but the ninth subcaudal rather than the eleventh. The maxillary teeth are apparently variable in number. Pope

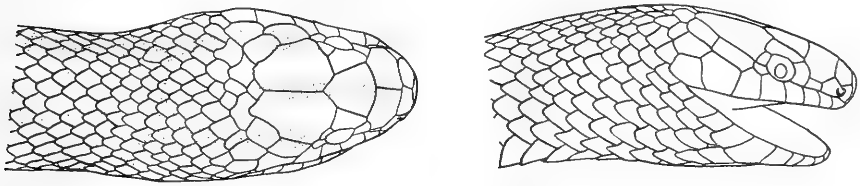

Fig. 8. *Elaphe porphyracea nigrofasciata,* No. 22227 ♂, dorsal and lateral view of the head, x 1¼.

(1935, p. 445) finds 22–24 and 21–20 in two specimens. In my specimen there is an ill-defined depression just posterior to the last tooth. If this be considered as a tooth socket the count is 20 (left side only). The color variation in this species deserves careful attention. Cantor (1839, p. 51) describes his type of *porphyracea* from Assam as bright porphyry red, and his type of *nigrofasciata* (1839, p. 53) from Eastern China, a juvenile, as "a light reddish yellow." Since most subsequent descriptions have been based on preserved material, it is impossible to know what the color was in life. Red and yellow pigments are quickly leached out by alcohols, and transformed by formalin to brown or black. In spite of these changes brought about by preservation techniques, the descriptions of the ground color of many specimens from various localities, particularly in China, strongly suggest that the original color was not a bright porphyry red. Venning (1910, p. 337) describes the ground color of specimens of *porphyracea* from the Chin hills of northwestern Burma as a "rich red." Major Wall describes them as a "raw beef color." From this same locality, however, an adult was taken which was yellowish rather than red. Southeast of this locality in the southern Shan States, Wall (1901, p. 661) describes "all the adult specimens" of *porphyracea* as being "a pale brownish lilac color." This color description fits the Kiangsi *nigrofasciata* herein described. Sauvage (1877, p. 107) describes his type from "China" of *Simotes vaillanti* (*Elaphe p. porphracea,* synonymized by Pope 1935, p. 255) as a "brown-olive." This description suggests the porphyritic color of life. Anderson's (1879, p. 812) specimens from Momein, western Yunnan, are also an "olive-brown above." Gray (1853, p. 390) describes specimens of *porphyracea* from Khassia as a pale brown. Boulenger (1894, p. 34) describes *Coluber porphyracea* (*E. p. porphyracea* and *E. p. nigrofasciata* are included in this description and considered as a single species), including both of Cantor's types, as being a pale reddish brown. Chang's (1932, p. 60) description of a Szechwan *porphyracea,* preserved in formalin, as "pale grayish" suggests the lighter phase. In general, it appears from these accounts that toward the south and west of its range the ground color of *E. p. porphyracea* is reddish, and toward the north and east the color is yellowish or fawn. In *E. p. nigrofasciata,* however, the Fukien and Hainan snakes (Pope, 1929, p. 442; Schmidt, 1927, p. 528) are reddish, whereas the Kwangsi (Fan, 1931, p. 86) and north Kiangsi snakes are a buff or fawn. When both subspecies are considered together it is seen that the lighter-colored snakes occur in a fairly coherent area between two regions occupied by the red phase. This area consists of Kiangsi, Kwangsi, eastern Yunnan, Szechwan, and the southern Shan States. The young of both subspecies are apparently yellowish, with solid dark cross-bars, as described by Roux (1919, p. 63), Schmidt (1927, p. 529), and Wall (1901, p. 611); and, as pointed out by Wall (1901, p. 611) and Sauvage (1877, p. 107), they may or may not have the longitudinal dorsal lines.

The snake herein described measures 938 mm., of which .17 is tail. It is, therefore, an exceptionally large snake. Chang (1932, p. 60) records a specimen from Szechwan measuring 892 mm.

Elaphe rufodorsata (Cantor)

Seven males, Nos. *22234, 22237–22239, 22241–22243*, and eight females, Nos. *22229–22233, 22235, 22236, 22240*, all collected in the plains and foothills about Lushan.

TABLE 15.

Summary of Counts and Measurements of *Elaphe rufodorsata*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	7	159–165	162.1	2.2	Maslin
	♀	8	169–178	174.9	2.8	Maslin
	♂	1	165			Boulenger, 1894, p. 44
	♀	1	170			Boulenger, *loc. cit.*
		1	176			Boettger, 1894, p. 140
Subcaudals	♂	5	56–63	61.0	2.8	Maslin
	♀	8	51–56	54.0	1.7	Maslin
	♂	1	58			Boulenger, *loc. cit.*
	♀	1	47			Boulenger, *loc. cit.*
		1	56			Boettger, *loc. cit.*
Tail ratio	♂	5	.19–.21	.202	.007	Maslin
	♀	8	.15–.20	.165	.016	Maslin

Sexual dimorphism is pronounced in the species. The females are much larger; the three largest females measure from snout to vent 661, 580, and 516 mm., respectively; the three largest males, 412, 446, and 387 mm. The females average a higher ventral and lower subcaudal count (see table). The average ratio of tail to total length differs in the two sexes, but overlapping is extensive. The scale rows of females are smooth or show only a trace of keeling dorsal to the vent, whereas these same scale rows are distinctly though weakly keeled in males. The sudden decrease in girth posterior to the vent is pronounced in females.

Habits and habitat: The snake inhabits rice fields and water lily swamps, and swims rapidly out among the plants when startled. Four females collected on June 7, 1936, contain 10–16 eggs, the largest measuring 16 x 7 mm.; no embryos could be detected. The stomachs of two females contain frog remains. Most of the snakes are parasitized by nematodes, which are found free or partly embedded in the walls of the stomach.

Remarks: The dorsolateral dark stripes in this series show, on the whole, but a slight tendency to break up into spots. I found only two females with the typical link-like spots described by Boettger (1886, p. 519, Shanghai), Chang and Fang (1931, p. 269, Nanking), Guenther (1864, p. 89, Chekiang), and Dumeril and Bibron (1854, p. 324, China). The ventral and subcaudal counts of this series average somewhat lower than those from other localities.

Elaphe taeniurus Cope

Twelve males and eight females, Nos. 22244–22260, Kuling American School collection No. 12, Kuling Library collection No. 3, collection of Mr. Berkin of Kuling, one specimen. These snakes were collected in the mountains and foothills of Lushan at elevations up to 4000 feet.

TABLE 16.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Elaphe taeniurus*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	12	230–247	239.4	4.3	Maslin
	♀	8	238–248	243.4	3.2	Maslin
		2	286[1]–242			Chang, 1936, p. 332
Subcaudals	♂	9	96–108	103.8	3.5	Maslin
	♀	8	94–104	100.6	3.0	Maslin
		2	96–100			Chang, *loc. cit.*
Tail ratio	♂	7	.18–.22	.206	.012	Maslin
	♀	8	.18–.20	.193	.008	Maslin

Sexual dimorphism is but slightly expressed in this species. The two largest males measure respectively 1930 and 1905+ mm., females 1886 and 1610 mm. There are slight ventral and subcaudal differences in this series with extensive overlapping. The most obvious difference is the sudden reduction of body girth in females just posterior to the vent.

Habits and habitat: Most of the specimens of this series were caught in the daytime (collector's reports). I myself collected several at night. At this time they were timid and moved rapidly in attempts to escape. I have captured them also in the daytime in grass and brush and took one out of a low tangled tree about five feet above the ground. Pope (1929, p. 445) also reports their arboreal habit. All the snakes captured by me were near human habitations, but not definitely associated with water. This is in agreement with Chang and Fang's (1931, p. 371) findings. Wall (1903, p. 92, Shanghai), however, writes of an individual that submerged itself in water, among weeds, in an attempt to hide. Individuals kept in captivity can be irritated to the point of striking and hissing. The head is held high and usually at a slight angle. The strike is slow and clumsy, being in the nature of a butt. Further irritation causes the snake to coil tightly in a tangled ball, which can be freely handled. In this posture the head and tail are near the center. This defense mechanism has been described for other species. Normally the snake is docile and, as Pope (1935, p. 275) reports, quickly becomes accustomed to handling. One specimen contained the remains of a rat. Similar records of diet have been made by Pope (*loc. cit.*) and Chang and Fang (*loc. cit.*).

[1]Undoubtedly a typographical error, possibly meant to be 236 ventrals.

Remarks: To Stejneger's (1907, p. 321) list of scutellation abnormalities and variations may be added the tendency of the parietals to break up into small plates and the extreme variations in size and shape of the rest of the dorsal plates on the head. Mocquard (1905, p. 319) reports that certain subcaudals are single in one of his specimens. Stejneger (*loc. cit.*) found that 40 per cent of the snakes he examined had 23 scale rows at mid-body. Schmidt (1927, p. 533) found that 66 per cent of the Yunnan snakes and 73 per cent of the Anhwei snakes described by him had 23 scale rows. In the twenty-two snakes from Lushan, two recorded by Chang (1936, p. 332), only 23 per cent have 23 scale rows. The eye in adults is normally not as large as Mocquard (1905, p. 319) reports, eyes relatively as large being found only in juveniles.

Opheodrys major (Guenther)

Thirteen specimens: eight males, four females, Nos. 22261–22272; and one of undetermined sex, Kuling American School Collection No. 48.

TABLE 17.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Opheodrys major*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	8	165–174	168.4	3.1	Maslin
	♀	5	168–176	172.6	3.4	Maslin, Boulenger
	♀	1	170			Boulenger, 1894, p. 279
	Jv.	1	166			Boulenger, *loc. cit.*
		3	166,173,177			Boettger, 1894, p. 140
	Jv.	1	170			Chang, 1936, p. 333
Subcaudals	♂	7	83–91	86.9	3.4	Maslin
	♀	1	80			Maslin
	♀	1	87			Boulenger, *loc. cit.*
	Jv.	1	82			Boulenger, *loc. cit.*
		3	82, ?, 83			Boettger, *loc. cit.*
	Jv.	1	82			Chang, *loc. cit.*
Tail ratio	♂	7	.24–.28	.260	.014	Maslin
	♀	1	.24			Maslin

Chang (1932, p. 67) reports of Szechwan specimens that the scales are "all smooth except the sixth, eighth, and tenth [dorsal scale rows] which are weakly keeled." I also find a tendency in this series for scale rows to be irregularly keeled. The keeled rows in this case are differently arranged. Just anterior to the vent the median row may be weakly keeled or entirely smooth, one or two adjacent rows on either side being keeled instead. If the median and adjacent rows are keeled, the median row is the more weakly keeled. At mid-body, the keeling, if present, is on one, three, or five dorsal rows, the median row being as strongly keeled as those adjacent to it. None of these rows is keeled anteriorly. There is much variation in the keeling but the females tend to have fewer rows keeled than do the males. Three males are smooth throughout; only one of the females is keeled at all and here it is just at the vent on the median row. The keeling, furthermore, does not extend to the tip of each scale but ends rather abruptly one-quarter scale length anterior to the tip. A weak ridge may continue to the tip but it is inconspicuous.

Sexual dimorphism is apparently lacking in this species. Too many of the females in this relatively small series have damaged tails to give significant figures as to length. The longest males measure 868, 857, and 918+ mm. respectively; the largest females, 795, 807+, 830+, and 850+ mm.

Remarks: This snake is confused by the natives with the poisonous green pitviper, which it superficially resembles in being of a green color. For this reason it is often found badly mutilated on the mountain roads. It is found in Kuling itself, 4000 feet, and among the foothills, usually in damp forests. The stomachs of three snakes examined contained grit and segments of earthworms. This agrees with Pope's (1935, p. 286) findings. One female caught on June 6, 1936, had ten white immature eggs.

Oligodon chinensis (Guenther)

Two females, Nos. 22273, 22274, one a juvenile measuring 318 mm., and the other an adult measuring 674 mm. These topotypes along with Guenther's type (1888, p. 169) are the only three specimens collected from this locality.

TABLE 18.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Oligodon chinensis*

	Sex	No.	Extremes	Source
Ventrals	Jv. ♀	1	190	Maslin
	♀	1	188	Maslin
	♀[1]	1	191	Boulenger, 1894, p. 228, pl. IX, fig. I.
Subcaudals	Jv. ♀	1	55	Maslin
	♀	1	57	Maslin
	♀	1	55[2]	Boulenger, *loc. cit.*
Tail ratio	Jv. ♀	1	.13	Maslin
	♀	1	.15	Maslin

Habitat: These snakes were brought in with other snakes by native collectors from the foothills (Lien Wha Tung) of Lushan. Under what circum-

[1]Sex recorded by Pope, 1935, Rept. China, p. 292.
[2]Guenther (1888, p. 169) records 63 subcaudals; this is probably an error.

stances they were found could not be ascertained, as they were confused in the collectors' minds with *Elaphe bimaculata*.

Remarks: These specimens differ in no way from Guenther's type as far as he described it. He gives the subcaudal count as 63, but Boulenger (1894, p. 229) gives the count of the same specimen as 55. This latter count is probably correct, as subcaudals of the topotypes number 55 and 57. Schmidt

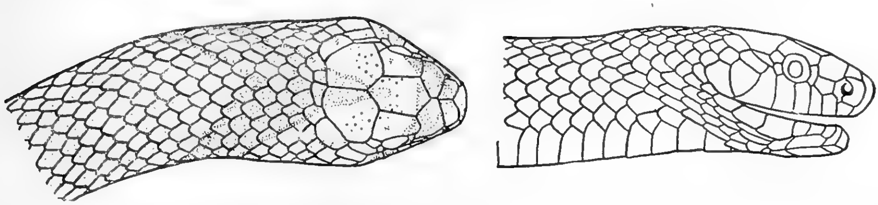

Fig. 9. *Oligodon chinensis,* No. 22274♀ dorsal and lateral view of the head, x 1½.

(1927, p. 537) describes a light median stripe and irregular black crossbands between the distinct dorsal saddles of a Yunnan specimen, and on this account suggests that there may be two varieties of *chinensis*. Guenther failed to describe these relatively inconspicuous characters, even though his type was a juvenile, where, normally, these marks are most distinct. Both the present specimens have these marks, which are particularly distinct in the juvenile. Fang (1931, p. 95) found these marks on specimens from Yoashan, Kwangsi, as did Chang and Fang (1931, p. 262) on Nanking specimens. Boulenger (1903, p. 351) mentions the crossbands, but not the median stripe, on Tonkin specimens. Schmidt's suggestion seems warranted. The type without a median stripe and extra crossbands appears to be confined to an area including Kwangtung, Fukien, Chekiang, and a part of Anhwei.

Calamaria septentrionalis Boulenger

Four males, Nos. 22275–22278, taken in the foothills of Lushan in the vicinity of Lien Wha Tung from May 26 to June 12, 1936.

TABLE 19.

Summary of Counts and Measurements of *Calamaria septentrionalis*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	7	157–162	158.0	4.3	Maslin, Boulenger
	♂	3	161,159,148	156.0		Boulenger, 1894, p. 349
	♀	3	171,172,176	172.7		Boulenger, *loc. cit.*
Subcaudals	♂	7	15–18	17.0	1.1	Maslin, Boulenger
	♂	3	17,16,15	16.0		Boulenger, *loc. cit.*
	♀	3	9,10,9,	10.7		Boulenger, *loc. cit.*
Tail ratio	♂	4	.07,.08,.08,.08			Maslin

Habits and habitat: These snakes were taken in the foothills about Lushan and on the road up the mountain from Lien Wha Tung. But from descriptions of a "two-headed" snake by natives on the mountains it seems likely that it occurs at these higher altitudes as well. It is much feared locally, but I found it most docile. While it was being handled it made constant efforts to escape, using its head in the manner of burrowing snakes to pry my fingers apart. Fang (1931, p. 107), however, remarks that when annoyed the snake attempts to bite but can do no damage. Pope (1935, p. 307) concludes from reviewing available observations that the snake "is secretive and spends much of its time beneath the surface" of the ground. He also observed (Schmidt, 1927, p. 538) that on provocation it will feign death, and under special circumstances use its tail as a head, prodding restraining fingers with it.

Remarks: Guenther (1888, p. 169) described *four* specimens collected by Pratt from Lushan as *Calamaria quadrimaculata*. Boulenger (1890, p. 34), however, showed that these and a juvenile from Honkong differed from *C. quadrimaculata* and proposed the name *septentrionalis* for them. In 1894 (p. 349) he gave an amplified description of the species, with the scale counts of *six* specimens from Lushan, apparently Pratt's; he also figures the snake. My topotypes differ in no respect from his description and figures. But the hemipenis in these specimens differs noticeably from that described by Pope (1935, p. 307) in that the sulcus distally splits up, fanlike, into a number of secondary grooves, the folds between being papillated. Furthermore, there is a well developed lobate flap on the outer lip of the sulcus just distal to its point of forking which is very conspicuous. Apparently this structure is absent in Loshiang specimens.

Bungarus multicinctus multicinctus Blyth

Both David and Pratt record this species from this region; none, however, has been taken since Pratt made his collections. The published counts of a known Kiukiang-Lushan specimen, a male, are as follows: V. 214, Sc. 46 (Boulenger, 1894, p. 369).

Calliophis macclellandi (Reinhardt)

Seven specimens, four females and three males, from Kuling, Lushan, and the surrounding foothills; Nos. 22279–22283, Kuling American School collection No. 21, and Kuling Library collection No. 1.

TABLE 20.

Summary of Counts and Measurements of *Calliophis macclellandi*

	Sex	No.	Extremes	Mean	Source
Ventrals	♂	4	205,205,206,206	205.5	Maslin
	♀	3	213,220,221	218.0	Maslin
		1	215		Boulenger, 1896, p. 399
Subcaudals	♂	4	32,38,38,38	36.5	Maslin
	♀	3	28,30,31	29.6	Maslin
		1	26		Boulenger, *loc. cit.*
Tail ratio	♂	4	.10,.10,.10,.12	.105	Maslin
	♀	3	.10,.11,.11	.107	Maslin
Body bands	♂	4	31,35,37,38	35.3	Maslin
	♀	3	34,35,36	34.0	Maslin
Tail bands	♂	3	5,6,8	6.3	Maslin
	♀	3	4,5,5	4.6	Maslin
Max. lengths	♂	2	533,542 mm.		Maslin
	♀	2	485,579 mm.		Maslin

In this small series dimorphism in scale counts is distinct, but small series from other localities show considerable overlapping, with extensive variation in both sexes. The tendency exists for males to have fewer ventrals and more subcaudals than do females. Other than this the sexes are indistinguishable.

Habits and habitats: All the specimens in this collection, with the exception of one (No. 22281), were collected at elevations above 3000 feet. The exception, a male, was collected in the foothills at Lien Wha Tung. Most of the specimens were unearthed during excavations of one sort or another about the resort of Kuling; others were found secreted behind stones or stumps in damp forested regions. Apparently the snake is nocturnal. Pope (Schmidt, 1927, p. 451) evidently concurs in this belief. Wall (1925, p. 805) described a snake which when caught by the tail at night turned to bite. In an earlier paper (1918, p. 628) he described it as apathetic. Pope (1929, p. 466) remarks that the snake acts in a stupefied manner and cannot be made to bite or strike. I have found it to act in the same way. Never having encountered it at night, I can make no comment on whether its activity is increased at that time. The stomachs of all the adults in this collection were empty.

Remarks: Of the seven specimens examined, four show no dorsal markings other than the dark rings characteristic of this species. Of the remaining three, No. 22282 has a narrow black median streak on the neck. A median stripe is indicated from mid-body posteriorly by faint black streaks down the centers of the median scales lying between the transverse stripes. Lying on the second row lateral to the median row, and exactly between the succeeding rings on each side, there are faint black spots. These spots are clearest on the neck, lacking at mid-body, but present again posteriorly. Nos. 22280 and 22283, both juveniles, have these same lateral spots but lack the median stripe on the body; but No. 22283 does have a black median streak on the neck. Except for these inconspicuous marks, all the specimens agree with Wall's (1918, pl. XXV) beautiful colored plate of this species. The variations in color pattern in this series are the same as described by Pope (1929, p. 465) for three snakes from Chungan Hsien, Fukien. If the species is separated into subspecies, the Lushan forms should be included with those from Fukien.

Naja naja atra Cantor

The only records of this species from the Kiukiang-Lushan area are by David and Boulenger. The fact that both Pratt and I have failed to take it would indicate that it is relatively rare. This is to be expected, as Kiukiang is the most northerly record station for the species. However, several students of the Kuling American School reported seeing a dead specimen hanging in a tree in the outskirts of the town of Nan Kang to the east of Lushan. Boulenger's (1896, p. 383) record from Kiukiang, a female, has 25–21 scale rows, 166 ventrals, and 48 subcaudals (collected by J. Walley, Esq.).

Pareas boulengeri (Angel)

One male, No. 22284, captured in Kuling, Lushan.

TABLE 21.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Pareas boulengeri*

	Sex	No.	Extremes	Source
Ventrals	♂	1	183	Maslin
		2	179,181	Chang, 1936, p. 337
Subcaudals	♂	1	70	Maslin
		2	64,66	Chang, *loc. cit.*
Tail ratio	♂	1	.21	Maslin
		2	.19,.19	Chang, *loc. cit.*

Habits and habitat: This species is apparently a mountain inhabitant. Pope (1935, p. 369) records a specimen from Szechwan taken at 3000 feet. No. 22284 was captured in Kuling at an altitude of 3,500 feet. Apparently the specimens recorded by Chang (1936, p. 335) also came from Kuling. The stomach of my specimen was empty.

Remarks: Pope (1935, p. 368) mentions three characters of *boulengeri* which he feels warrant further study. These are:

1. The imbricate condition of the anterior lower labials.
2. The relatively large size of the sixth or seventh lower labial.
3. The number of lower labials in contact with the anterior chinshields.

In this specimen all the scales of the head are imbricated, not merely the anterior lower labials. This condition is supposedly characteristic of this species. The sixth lower labial is twice as high as the fifth in this specimen, its

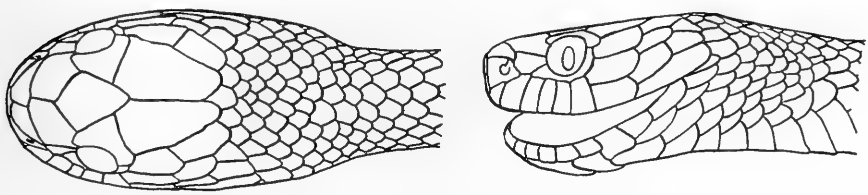

Fig. 10. *Pareas boulengeri*, No. 22284 ♂, dorsal and lateral view of the head, x 2.

length along the lip, however, is equal to that of the fifth labial. Chang (1936, p. 369) has examined Angel's (1920, p. 113) types and reports that the infralabials are 8–8 in all three specimens; furthermore, 4–4 labials are in contact with the anterior chinshields. Pope (1929, p. 459) considered a count of 9–10 infralabials, with 4–5 in contact with the anterior chinshields, on a Szechwan snake as characteristic enough to separate that specimen as a member of the species *boulengeri* from all other forms. The normal number of infralabials, however, appears to be eight. The specimen in the collection under consideration and the two reported by Chang (1936, p. 335) from the same locality all have 8–8 infralabials, with 4–4 in contact with the anterior chinshields. The first pair of labials in No. 22284 do not meet posterior to the mental.

Pareas chinensis (Barbour)

This species is reported from Lushan by Chang (1936, p. 333).

Agkistrodon halys (Pallas)

Thirty-nine specimens in all, 14 males and 25 females, Nos. 22285–22323; specimens numbered 22286, 22303, 22321 are juveniles measuring in total length 229, 223, 197 mm., respectively; specimens collected in region between Kiukiang and Lushan.

TABLE 22.

Summary of Counts and Measurements of *Agkistrodon halys*

	Sex	No.	Extremes	Mean	Standard Dev.	Source
Ventrals	♂	14	134–144	138.6	2.9	Maslin
	♀	25	137–147	142.3	2.9	Maslin
	♀	3	142,138,138			Boulenger, 1896, p. 526
	Jv.	1	143			Boulenger, *loc. cit.*
Subcaudals	♂	13	37–46	40.5	2.3	Maslin
	♀	25	31–42	35.4	3.0	Maslin
	♀	3	32,29,32			Boulenger, *loc. cit.*
	Jv.	1	31			Boulenger, *loc. cit.*
Tail ratio	♂	13	.12–.15	.133	.008	Maslin
	♀	23	.10–.13	.111	.008	Maslin

Sexual dimorphism is poorly expressed in this species and is of no diagnostic value in identifying individuals. The males average a lower ventral count and a higher subcaudal count and have a slightly longer tail. Females have exceptionally large post-anal glands, their secretions so swelling the glands as to make them obvious from the exterior; but the hemipenes of males swell the basal parts of the tail in the same way, so that superficially these regions resemble each other in the two sexes.

Habits and habitat: The snake is abundant on the plains about Lushan, occurring much less commonly in the mountains, all specimens examined for stomach contents were heavily parasitized by nematodes. Normally these parasites (in preserved condition) are free in the stomach. One snake contained the remains of a frog.

When annoyed, the snake assumes an alert attitude, facing its aggressor; but no amount of teasing can induce it to strike. On several occasions I have surprised these snakes beside roads on the plains. When startled they often vibrate the tip of the tail. Instead of being held in an erect position, the tail is allowed to vibrate extended on the substratum. On dry leaves this makes a low-pitch buzzing sound not unlike that produced by rattlesnakes, but not nearly as loud or steady. Wall (1903, p. 99) and Sowerby (1930, p. 23) have also noticed this reaction. I have seen these snakes also flatten the entire body, keeping themselves as close to the ground as possible, as described by Wall (1906, p. 3). One female caught June 10, 1936, contained six eggs without embryos; the largest egg measured 23 x 12 mm.

Remarks: Stejneger (1907, pp. 449–456), Thompson (1916, pp. 61–76), and Pope (1935, pp. 390–398) have extensively discussed this widespread and extremely variable species. Thompson's (*loc. cit.*) discussion of variation in the species has convinced me as well as others that this species should be considered a single variable unit rather than divided into a number of subspecies. Pope (1935, p. 396–397) has listed in tabular form arguments for dividing or uniting the species and subspecies, and suggests that only a field study can settle the problem. I agree with him in this suggestion. Thompson (1916, p. 68) states that *Thamnophis ordinoides* of North America presents an equally variable complex. Fitch (1940) has shown that the latter species may be divided into a number of subspecies, some of which actually inhabit the same terrain but remain distinct, owing to the different niches they occupy. Possibly the same is true of *A. halys,* but field observations required to establish this are lacking.

Trimeresurus mucrosquamatus (Cantor)

Two specimens, Nos. 22324 and 22325, one male and one female, both collected in the foothills of Lushan.

Description: Head unusually large and long; crown covered with small scales; neck slender; body slightly depressed laterally, tail moderate, .19 of total length in male, .16 in female; scales posteriorly pointed, strongly keeled, outer row smooth; scale formula 29–25–19; ventrals-anals-subcaudals, 201–1–87, 212–1–78, for male and female respectively; subcaudals paired; dorsal scales dull, ventral scales and first scale row glossy.

Habits and habitat: Pope (1935, p. 418) has various records showing that the snake is often found associated with human habitations. Chang (1932, p. 71) also records specimens taken from a peasant's house in the country. Although the bite of these snakes has been known to be fatal (Maxwell, 1912, p. 244), the snake is normally reluctant to strike or bite. No amount of teasing caused the individuals now in this collection to show any signs of hostility. Pope (1929, p. 477) also found them apathetic. No. 22324, a female, contained a large, recently devoured rat. The size of this animal was prodigious, distinctly hampering the snake in its movements.

Remarks: No. 22325 has twenty-nine scale rows on the neck; this is an unusual number. Pope (1935, p. 416) states that twenty-five is normal, with occasional counts of twenty-seven. Schmidt (1927, p. 545), however, reports finding twenty-nine rows on the neck of a male from Yenping, Fukien. The specimens dealt with here are large, the male and female, respectively measuring 1057 and 1096 mm. in total length, but they do not approach Chang's (1932, p. 71) unusual record of an unsexed individual measuring 1,226 mm. The dark reticulations of the dorsal head pattern described by Stejneger (1907, p. 470) and Chang (*loc. cit.*) are lacking in these specimens. The nasals have been described as consisting of an anterior and posterior nasal on each side. This appears to be the case in these specimens, also; but careful examination proves the nasals to be fused into a single one. Just within the nostril, on the posteroventral wall, there is a fairly conspicuous pore. I (1942) have discussed the taxonomic significance of this pore in an earlier paper.

The hemipenis of this Lushan form differs notably from that of Pope's

(1935, p. 416) specimen from Yenping, Fukien, in that the organ extends only to the tenth instead of to the fifteenth subcaudal, and is forked opposite the fifth instead of the seventh.

Trimeresurus stejnegeri stejnegeri Schmidt

Five specimens, Nos. 22326–22328, females; Kuling Library collection No. 6, male; Kuling American School collection No. 31, head only. All specimens collected in Lushan and its foothills.

TABLE 23.

SUMMARY OF COUNTS AND MEASUREMENTS OF *Trimeresurus s. stejnegeri*

	Sex	No.	Extremes	Source
Ventrals	♂	1	161	Maslin
	♀	3	158,159,166	Maslin
		3	168,168,161	Chang, 1936, p. 339 and 343
Subcaudals	♂	1	73	Maslin
	♀	3	63,62,64	Maslin
		3	73,66,63	Chang, *loc. cit.*
Tail ratio	♂	1	.21	Maslin
	♀	3	.18,.16,.17	Maslin
		3	.17,.16,.16	Chang, *loc. cit.*

Sexual dimorphism, according to Pope (1935, p. 419), is evident primarily in color pattern. He pointed out (1929, pp. 480–481) that the white part of the lateral stripe of males extends to the eye or nearly to the eye, whereas in females this stripe does not extend beyond the neck; furthermore, the lateral stripe in males is usually white and red, whereas that of females is white only. As Pope himself indicated, these characters are not invariable. No. 22328, a female, has a red and white lateral line. Pope (1935, p. 419) finds little secondary sexual difference in this species as to subcaudal counts. He suggests (*op. cit.* p. 423) that owing to the arboreal habits of the snake a shortening of the tail in males would be disadvantageous. Slight differences, however, do exist.

Habits and habitat: This snake is normally arboreal. I have seen it in bushes and trees at heights of up to fifteen feet. A student at the Kuling American School, while picking azaleas, was bitten by one on the thumb. Although he wound an elastic band about the thumb until he was treated, the hand and arm became swollen. Natives from the foothills have asked my advice concerning bites by this snake. In each case the bite had been inflicted several days previously; the victims eventually recovered. Pope (1929, p. 482) reports that he has taken *stejnegeri* from streams only, which they apparently frequent at night in search of frogs. The stomachs of several specimens examined by him contained remains of frog, rat, and shrew. The stomachs of the series from Lushan were empty. Nos. 22326 and 22328 contained seven and four eggs, respectively. The largest eggs measured 21 x 10 mm. (No. 22328, collected March 31, 1936).

Remarks: Stejneger (1927), in his review of the green pit vipers in China, correctly differentiated the Chinese forms. However, he considered them subspecies of *T. gramineus,* (=*T. popeorum*) a Malayan species, listing the three Chinese forms as *T. g. gramineus, T. g. stejnegeri,* and *T. g. yunnanensis.* Since then Pope (1933) has shown that *T. popeorum* does not extend north of Burma, and that the Chinese forms are separate species. Stejneger's *T. g. gramineus* Pope considers as one species, and the remaining two as subspecies of a second species. The only available name for the former is *T. albolabris* Gray (type locality, China), and for the latter, *T. stejnegeri stejnegeri* and *T. stejnegeri yunnanensis.*

Trimeresurus was recorded from Lushan by Stanley in 1914, but because his identification is not accompanied by a description and because I have not examined his material or been able to learn more about it than he has published, its specific status cannot be determined. Chang (1936) records *T. g. gramineus* (= *T. popeorum:* not *T. albolabris* as defined by Pope, 1933) and *T. g. stejnegeri* from the same locality. In neither case did he establish the sex of his specimens, but from his descriptions, scale count, and figures, it is likely that his *T. g. gramineus* is in reality a male *T. s. stejnegeri.* This seems particularly probable in view of the fact that *popeorum* is not known to occur north of Burma. His specimens of *T. g. stejnegeri* are correctly identified and probably are females.

The nasal pore described under *T. mucrosquamatus* is present in this species as well. Here the nostril is relatively much smaller, with an accompanying reduction of the pore. Again, it is found on the posteroventral wall of the nostril and under a lens is clearly visible when one looks directly towards the snout.

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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 13, pp. 467-481, pls. 22-26. April 28, 1950

NOTES ON CALIFORNIA ISOPODS OF THE GENUS ARMADILLONISCUS, WITH THE DESCRIPTION OF ARMADILLONISCUS CORONACAPITALIS N.SP.

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The California species of *Armadilloniscus* which have been examined agree in every detail with the description of the genus given by Verhoeff, 1916, pp. 162–163. Verhoeff lists four segments to the flagellum of the second antennae. Van Name (1936, p. 101), on the other hand, writes "flagellum of second antennae described as having four articles, but apparently with also a rudimentary fifth article." Harger (see Van Name 1936, p. 103) in his description of *Actoniscus ellipticus* [=*Armadilloniscus ellipticus* (Harger)] lists in addition to the four articles "another minute rudimentary terminal segment." Blake's drawing (1930, fig. 3) of the second antenna clearly shows five distinct segments. Holmes and Gay (1909, p. 377), in describing *A. tuberculatus* (=*A. holmesi* Arcangeli), also found a "minute terminal fifth joint." None of the specimens of the species examined by the writer has a second antenna with a flagellum composed of more than four articles. The designation "fifth article" of previous writers is apparently due to a misinterpretation of the attachment of the terminal hairs as a separate segment.

All California species agree in habitat, being found under stones, decaying *Zostera,* or debris along the edges of bays and estuaries at the high tide mark. The substratum varies from clay, sand, pebbles, and rock to debris. The species, although small and at times difficult to see, are abundant in their habitat.

The following pages give the description of a proposed new species, *Armadilloniscus coronacapitalis,* and brief diagnoses of *A. lindahli* and *A. holmesi,* as well as a key to the species of the genus from California.

A KEY TO THE CALIFORNIA SPECIES OF ARMADILLONISCUS

A′. Median projection of head truncate when viewed from above. Ocelli 4. Capable of rolling up into a compact ball..*A. lindahli* (Richardson)

A″. Median projection of head pointed when viewed from above. Ocelli 5(6?). Not capable of rolling up into a compact ball.

B′. Body of female covered with large elevated tubercles. Penultimate segment of peduncle of second antenna equals the preceding segment in length. Posterior border of body segments with a fringe of evenly spaced minute tubercles giving the border a beaded appearance..............................*A. coronacapitalis* n. sp.

B″. Body of female appears smooth. Penultimate segment of peduncle of second antenna 1.5 times the length of preceding segment. Posterior border of segments of body even and smooth..*A. holmesi* Arcangeli

Family: **Scyphacidae** Chilton, 1901

Genus: **Armadilloniscus** Uljanin, 1875

Armadilloniscus coronacapitalis Menzies, new species

Plates 23–25, figures 1–16.

Many descriptive details are obviated by the drawings here presented and this description is merely intended to emphasize certain details deemed important by the writer. Generic characteristics are omitted in that the species agrees in detail with the description of the genus given by Verhoeff 1916, pp. 162–163.

Eyes compound, with six visible ocelli. Body covered with characteristic large elevated tubercles which are best developed on the head and least developed on the telson. Lateral lobes of head broad and truncate at tip; median lobe pointed in dorsal view. Telson with truncate posterior margin. Posterior border of all body segments excluding telson and epimeral portions with minute, evenly spaced tubercles giving the border a beaded appearance. Peduncle of second antenna with penultimate segment as long as preceding segment and with hooked flange on lateral border. In male specimens the carpus of seventh peraeopod has a large compressed lobe on posterior part of dorsal border and a spine, which is larger and longer than ciliated spine, at ventro-distal angle. Exopodite of Plp-1 of male as wide as long; endopodite thick and coming to a point only after bending sharply near tip. The species is not capable of rolling up into a compact ball. The epimeral parts of the perion are not posteriorly produced but extend laterally and have a truncate border. Body tuberculations much reduced in males. Males much smaller and narrower than females.

Measurements of types: Female holotype-length 4.6 mm., width 2.5 mm.; male allotype-length 3.1 mm., width 1.5 mm. The specimens were measured from the frontal margin to the posterior edge of the telson at the median line for the length, and at the widest part of the second perion segment for the width.

Location of types: The California Academy of Sciences, Golden Gate Park, San Francisco, California. Dept. Paleo. Type Coll. No. 9502 (Holotype ♀) and No. 9502a (Allotype ♂).

Type locality: The cove opposite Hog Island on the east side of Tomales Point, **Tomales Bay, Marin Co., California.** The types were collected by the writer from under rocks at the high tide line on August 3, 1946. The substratum consisted of coarsely grained granite sand.

Paratypes have been deposited in the collections of the following institutions: Allan Hancock Foundation, University of Southern California, Los Angeles, California, 2 males and 2 females; American Museum of Natural History, New York, 2 males and 2 females; California Academy of Sciences, San Francisco, California, 3 males and 1 female; Pacific Marine Station, Dillon Beach, California, 11 females and 29 males; United States National Museum, Washington, D.C., 6 males and 6 females.

Material examined: 78 females and 66 males from Tomales Bay, Marin Co., California.

Armadilloniscus lindahli (Richardson, 1905)

Plate 26, figures 17–26.

Actoniscus lindahli Richardson, 1905, pp. 635–636, figs. 679–680.
Armadilloniscus lindahli (Richardson), Van Name, 1936, pp. 104–105, fig. 47.

Diagnosis: Eyes compound, with four ocelli. Body covered with small sharp tubercles. Lateral lobes of head narrow and truncate at tip; median lobe truncate when viewed from above. In frontal view median lobe of head pointed, but not sharply so. Telson with posterior margin rounded. Posterior border of all body segments smooth. Peduncle of second antenna with penultimate segment devoid of hooked flange on lateral border and approximately 1.5 times the length of preceding segment. In male specimens the carpus of seventh peraeopod lacks compressed lobe on dorsal border; no spine on ventral border exceeds ciliated spine in length. Endopodite of Plp-1 of male thick but tapers gradually to a point bending slightly and gradually near tip. The species is capable of rolling up into a compact ball. Epimeral portions of perion specially constructed to permit rolling up, being posteriorly produced and narrow near tip.

Measurements of type: length 4.5 mm., width 2.0 mm., sex not given (Richardson 1905, p. 635). Specimens other than the type: large female —length 3.4 mm., width 1.6 mm.; large male—length 3.0 mm., width 1.5 mm.

Location of types: Museum of the Cincinnati Society of Natural History. Cat. No. 16365. (Richardson 1905, p. 636).

Type locality: Oakland, California. (Richardson 1905, p. 636).

The hypotypes on which the additions to the description of this species were based are deposited in the collections of the Pacific Marine Station. Specimens have been sent to the institutions receiving types of *A. coronacapitalis.*

Material examined: 73 females (19 ovigerous), 69 males—Mission Bay, San Diego Co., California; 59 females (8 ovigerous), 3 males—Mouth of San Dieguito River, San Diego Co., California; 19 females, 5 males—Cardiff Slough, San Diego Co., California; 53 females (34 ovigerous), 10 males, 6 juveniles—Upper Newport Bay, Orange Co., California; 37 females (22 ovigerous), 1 male—Tomales Bay, Marin Co., California.

Armadilloniscus holmesi Arcangeli, 1933

Plate 27, figures 27–36.

Actoniscus tuberculatus Holmes and Gay, 1909, pp. 377–378, fig. 5.
Armadilloniscus tuberculatus (Holmes and Gay), Van Name, 1936, pp. 103–104, fig. 46.
Armadilloniscus holmesi Arcangeli, 1933, p. 59, new name; Van Name, 1940, p. 132.

Diagnosis: Eyes compound, with five (six?) ocelli. Body covered with large, low, evenly rounded tubercles. Lateral lobes of head broad and truncate at tip; median lobe pointed when viewed from above. Telson with posterior margin rounded. Posterior border of all body segments smooth. Peduncle of second antenna with penultimate segment devoid of hooked flange on lateral border and approximately 1.5 times the length of preceding segment. In male specimens carpus of seventh peraeopod lacks compressed lobe on dorsal border; no spine on ventral border exceeds length of ciliated spine. Endopodite of Plp-1 of male thick and tapering to a point bending gradually near tip. The species is not capable of rolling up into a compact ball. Epimeral portions of perion not produced posteriorly but extended laterally and truncate.

Measurements of type: Length 3.25 mm.; width and sex not given. (Holmes and Gay 1909, p. 378). Specimens other than the type: large female—length 3.9 mm., width 2.0 mm.; large male—length 2.2 mm., width 1.2 mm.

Location of type: The United States National Museum, Cat. No. 39048. (Holmes and Gay 1909, p. 378).

Type locality: San Diego, California, on moist ground near the seashore. (Holmes and Gay 1909, p. 378).

The hypotypes on which the additions to the description of this species were based are deposited in the collections of the Pacific Marine Station. Specimens have been sent to the institutions receiving types of *A. coronacapitalis.*

Material examined: 117 females (6 ovigerous), 56 males, 2 juveniles—Mission Bay, San Diego Co., California; 42 females (3 ovigerous), 14 males—Upper Newport Bay, Orange Co., California; 92 females (49 ovigerous), 19 males, 9 juveniles—Tomales Bay, Marin Co., California.

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PLATE 22

Fig. 1. *Armadilloniscus coronacapitalis* n. sp., dorsal view, female holotype.

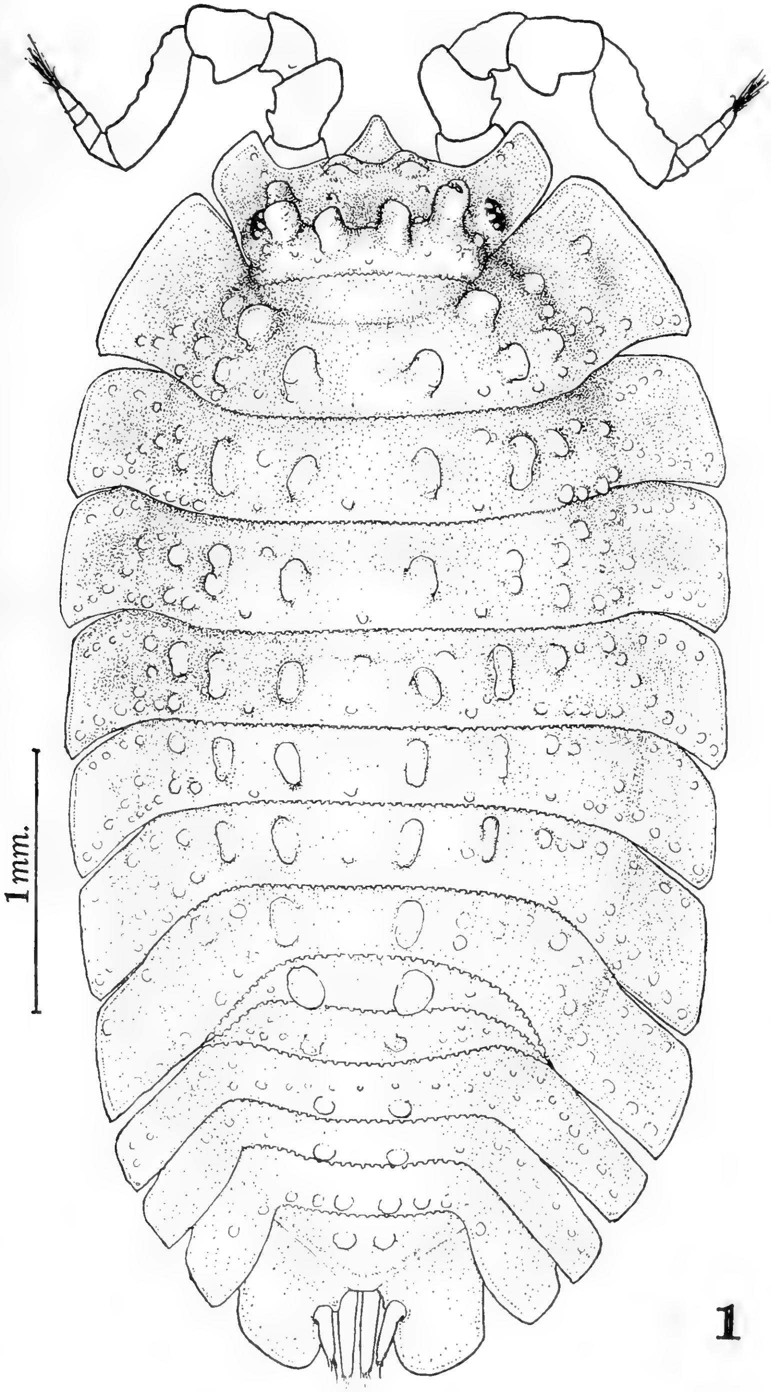

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PLATE 23

Fig. 2. *Armadilloniscus coronacapitalis* n. sp., mandible, male.

Fig. 3. *Armadilloniscus coronacapitalis* n. sp., eye, female.

Fig. 4. *Armadilloniscus coronacapitalis* n. sp., posterior edge of first perion segment, female.

Fig. 5. *Armadilloniscus coronacapitalis* n. sp., maxilliped, male.

Fig. 6. *Armadilloniscus coronacapitalis* n. sp., second antenna, male.

Fig. 7. *Armadilloniscus coronacapitalis* n. sp., antennule, male.

Fig. 8. *Armadilloniscus coronacapitalis* n. sp., tip of first maxilla, outer branch, interior view, male.

Fig. 9. *Armadilloniscus coronacapitalis* n. sp., outer branch of first maxilla, interior view, male.

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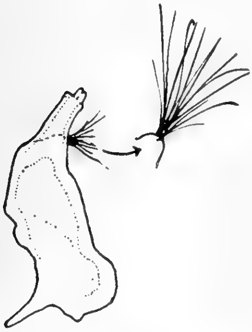

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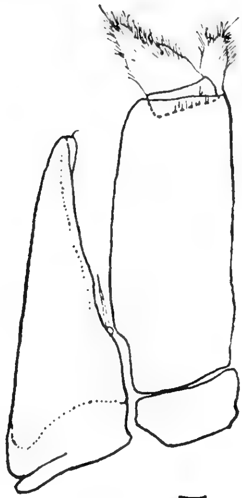

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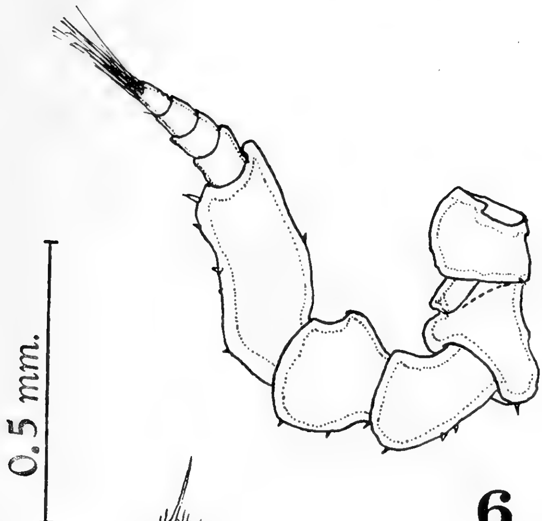

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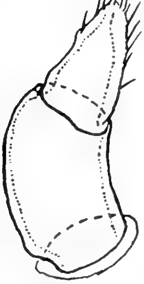

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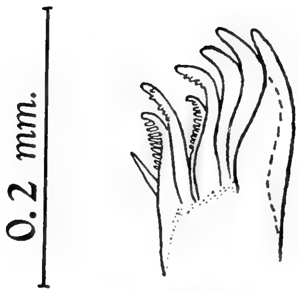

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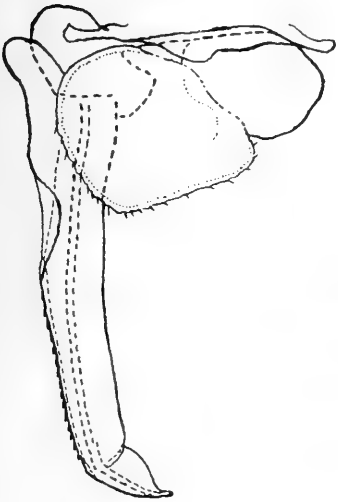
PLATE 24

Fig. 10. *Armadilloniscus coronacapitalis* n. sp., first pleopod (Plp-1), male.
Fig. 11. *Armadilloniscus coronacapitalis* n. sp., first peraeopod, male.
Fig. 12. *Armadilloniscus coronacapitalis* n. sp., Plp-2, male.
Fig. 13. *Armadilloniscus coronacapitalis* n. sp., Plp-1, female.
Fig. 14. *Armadilloniscus coronacapitalis* n. sp., Plp-2, female.
Fig. 15. *Armadilloniscus coronacapitalis* n. sp., seventh peraeopod, male.
Fig. 16. *Armadilloniscus coronacapitalis* n. sp., dactylus of seventh peraeopod, male.



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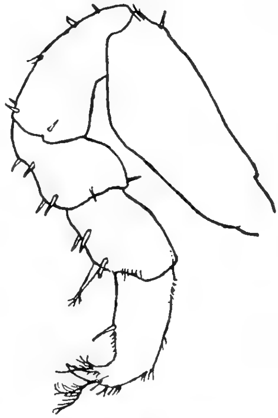

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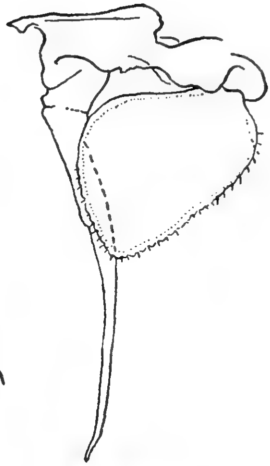

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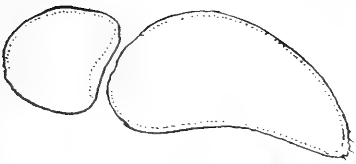

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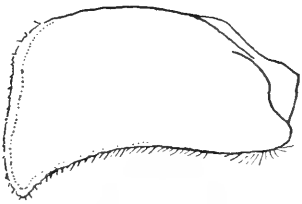

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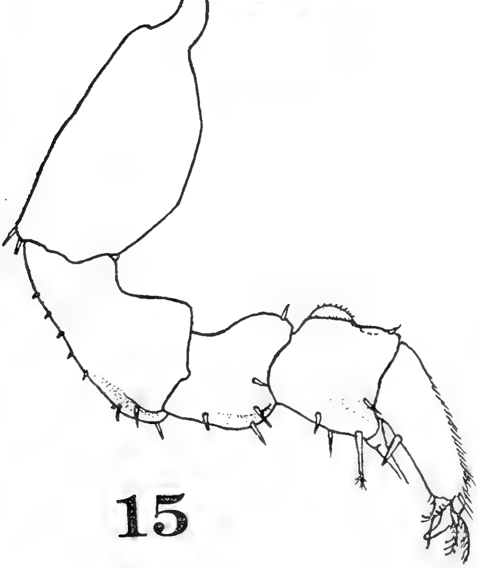

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PLATE 25

Fig. 17. *Armadilloniscus lindahli* (Richardson), posterior edge of first perion segment, female.

Fig. 18. *Armadilloniscus lindahli* (Richardson), eye, female.

Fig. 19. *Armadilloniscus lindahli* (Richardson), head, fronto-dorsal view, female.

Fig. 20. *Armadilloniscus lindahli* (Richardson), seventh peraeopod, male.

Fig. 21. *Armadilloniscus lindahli* (Richardson), Plp-1, male.

Fig. 22. *Armadilloniscus lindahli* (Richardson), second antenna, male.

Fig. 23. *Armadilloniscus lindahli* (Richardson), first peraeopod, male.

Fig. 24. *Armadilloniscus lindahli* (Richardson), Plp-2, male.

Fig. 25. *Armadilloniscus lindahli* (Richardson), Plp-2, female.

Fig. 26. *Armadilloniscus lindahli* (Richardson), Plp-1, female.

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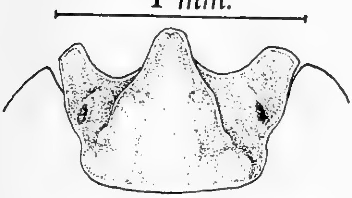

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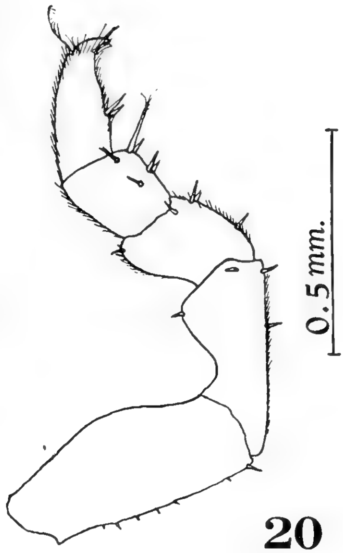

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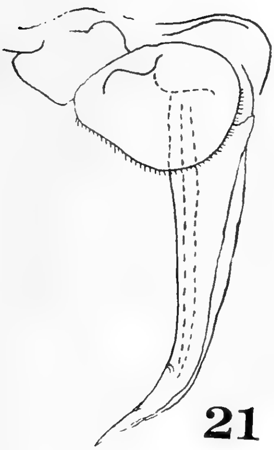

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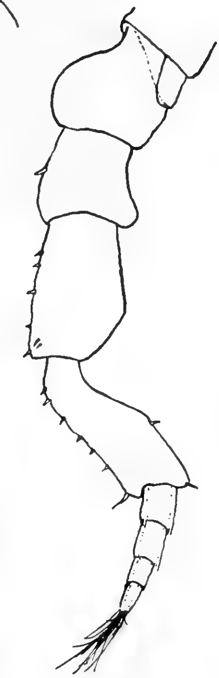

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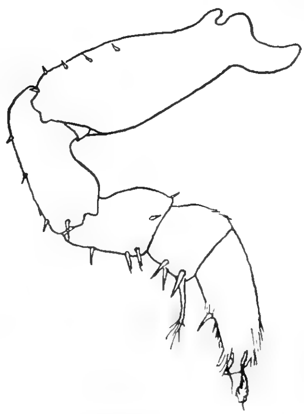

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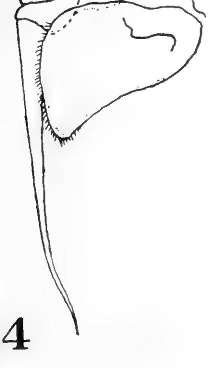

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PLATE 26

Fig. 27. *Armadilloniscus holmesi* Arcangeli, posterior edge of first perion segment, female.

Fig. 28. *Armadilloniscus holmesi* Arcangeli, eye, female.

Fig. 29. *Armadilloniscus holmesi* Arcangeli, head, dorsal view, female.

Fig. 30. *Armadilloniscus holmesi* Arcangeli, seventh peraeopod, male.

Fig. 31. *Armadilloniscus holmesi* Arcangeli, Plp-1, male.

Fig. 32. *Armadilloniscus holmesi* Arcangeli, second antenna, male.

Fig. 33. *Armadilloniscus holmesi* Arcangeli, first peraeopod, male.

Fig. 34. *Armadilloniscus holmesi* Arcangeli, Plp-2, male.

Fig. 35. *Armadilloniscus holmesi* Arcangeli, Plp-1, female.

Fig. 36. *Armadilloniscus holmesi* Arcangeli, Plp-2, female.


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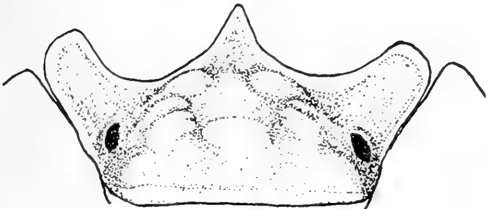
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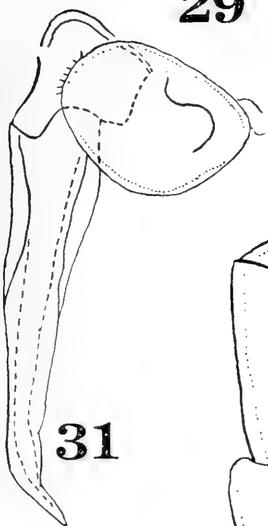
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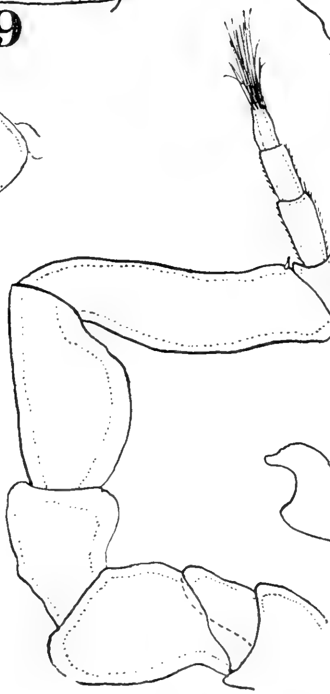
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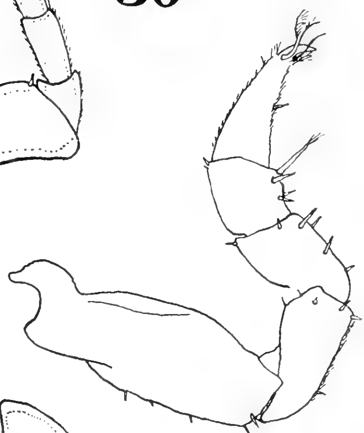
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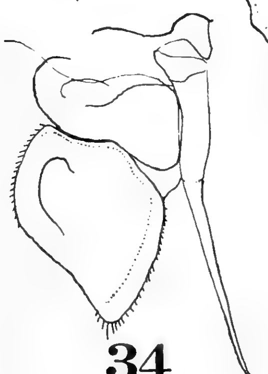
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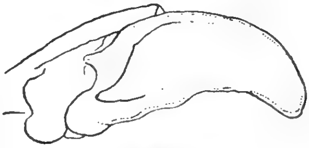
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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVI, No. 14, pp. 483-505, pls. 27-30. June 29, 1950

TWO NEW SPECIES OF MARINE OSTRACODA (PODOCOPA) FROM CALIFORNIA

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While collecting benthoic species of ostracods (Podocopa) in the littoral and in the shallow waters along the coast of central California, the writer established that these forms are very strongly represented in this region; the number of species is very large, indeed. In spite of this abundant representation, only a few species of the group have been recorded or described from California. The first paper to deal with this group in California was that of Juday (1907), in which two species from southern California are listed, viz.: *Xestoleberis dispar* Müller and *Paracytheroma pedrensis,* the latter described as a new species under a new genus. Of the former species, only the male and female shells are described and figured. As a consequence, the specific identity of this form is uncertain. The only thing which we can say with full certainty is that it is not identical with Müller's species of this name. With less certainty, it may also be said that the male and female described belong to different species. In regard to *Paracytheroma pedrensis,* see below under the discussion of *Cytheroma.* The second paper on this subject to appear, viz., that of Baker (1912), also dealt with material from the southern part of this state. In it Baker described two marine species under the names of *Xestoleberis transversalis* and *Xestoleberis flavescens.* Unfortunately, these forms were treated in such a defective and incompetent manner that their generic and specific status must be judged either incorrect or uncertain. *Xestoleberis transversalis* probably refers to two species of *Loxoconcha,* although his figure 62:A may represent a species of *Xestoleberis.* Most of the figures of *Xestoleberis flavescens* evidently were drawn from a species of the genus *Cythereis;* but figures 63:B and D may have been drawn from a species of *Xestoleberis.* The third and last paper dealing with members of the Podocopa in the shallow waters of California is that of Skogsberg (1928), describing five new species of *Cythereis,* viz., *C. aurita, C. glauca, C. montereyensis, C. pacifica,* and *C. platycopa.* One of these species, *C. montereyensis,* may be specifically identical with *Xestoleberis flavescens* Baker, but Baker's (1912, p. 114) statement that the shell is "translucent throughout" seems to contradict this conclusion sufficiently to justify the postponement of this identification pending supplementary investigation of Baker's material. Baker's figures and description of the appendages and of the penis (called "anal armature") evidently are too erroneous to be utilized for specific identification.

As will be seen from this brief review, the information available on this subject is not only scanty but also in part uncertain. This report is, unfortunately, only a minor contribution to help correct the present undesirable situation. However, it is hoped that it will help in a fundamental manner by showing the necessity for detailed descriptions of minute accuracy. It would be fortunate, indeed, if the specific descriptions of this group of the west coast of North America would be done in such an accurate and thorough manner that confusion such as that prevailing in regard to the European marine ostracod forms could be avoided. After many years of intensive work on the ostracods, the writer (Skogsberg, 1920, p. 8) arrived at the conclusion that "as many organs as possible must be subjected to a careful investigation and described correctly, attention being paid to the variety of the details." This necessity evidently is still not clearly seen by a great number of later investigators, but the above statement is unquestionably true.

Cytheroma G. W. Müller

Cytheroma G. W. Müller (1894, p. 349); *Paracytheroma* C. Juday (1907, p. 137); *Cytheroma* and *Paracytheroma* G. W. Müller (1912, pp. 314-315).

Diagnosis: See the three references given above.

Shell: No distinct sexual dimorphism. Smooth, transparent, very thin, and fragile. With a small clasping tooth at anterior and posterior ends of hinge and a narrow clasping lip between teeth on opposite valve; teeth sometimes so small that they can hardly be clearly distinguished. Inner line descends more or less abruptly just in front of eye; in posterior part of shell, this line is somewhat sigmoid. (This line may be somewhat incorrectly represented by Juday, 1907, pl. 18:3.) Selvage well developed, thin, hyaline, with smooth edge.

First antenna: No distinct sexual dimorphism. Of moderate length, strong, with six segments. When at rest, last four segments form distinct knee with second segment being bent upwards. Total length of segments 3-5 subequal to length of second segment. Fifth and sixth segments with parallel sides; fifth segment about twice longer than wide, sixth segment from about two to five times longer than wide. Probable number of bristles: second and third segments each one; fourth segment, two; fifth segment, four; and sixth segment, three. All of these bristles either of moderate length or rather short; a varying number of those on segments 3-6 are more or less claw-like; one of the three bristles on end segment is claviform and sensory.

Second antenna: No distinct sexual dimorphism. Strong and of moderate length. Situated on well-developed, segment-like process which is supported by a strong, chitinous exoskeleton. Protopodite about twice as long as high; without bristles. Exopodite 2-segmented; first segment sub-equal in width throughout and about as long as endopodite; second segment decidedly narrower than first and about half as long. Endopodite with three segments, of which the second is about twice longer than first and becomes narrower distally at a fairly uniform rate; length of third segment subequal to distal width of segment. First segment with one postero-distal bristle. Second segment with two closely-set bristles near middle of anterior side. Somewhat distal to these, there is on posterior side of segment a group of three bristles, one of which is claviform and sensory. Postero-distally on this segment, there is situated a moderately long bristle and (always?) a vestigial one. Distal segment with two fairly long and strong claws, one of which is postero-proximal in position.

Mandible: No distinct sexual dimorphism. First segment of protopodite (masticatory) large and strong or of moderate size and strength, wedge-shaped, without rounded hump on anterior side, and with sigmoid posterior side. Toothed edge of pars incisiva with about seven teeth, decreasing fairly regularly the more posteriorly they are situated; the anterior tooth is large, strong, fang-like, the remaining ones are 2- to 3-pointed distally. Between teeth number 1 and 2 there are two narrow bristles about as long as tooth number 1; and between teeth number 2 and 3 there is a similar, although shorter, bristle; finally, there is a fairly short bristle somewhat proximal to most posterior tooth. Somewhat ventral to palp, this segment has on anterior side a single bristle. Palp of moderate strength and about 0.5-0.7 as long as masticatory segment is high; fairly distinctly 4-segmented. Of these four segments, the second segment of protopodite is somewhat larger than either of the first and second segments of endopodite which are subequal; distal segment very small and about as long as wide. Second segment of protopodite with two ventral bristles. Epipodial appendage situated dorso-laterally on second segment of protopodite, its number of bristles varying from two to four. Endopodite: First segment with five distal bristles; one of these is dorsal, two are ventral, and two are medial. Number of bristles of second and third segments is not known except for species described below, but is probably constant, or nearly so. In this species, the following numbers are to be found: Second segment with two ventro-distal bristles, and dorso-medially to these a single bristle occurs. Dorsal and somewhat distal to middle of segment, there is a transverse row of seven bristles. Third segment with four distal bristles. All the bristles of endopodite either of moderate strength or weak; almost all of them are either naked or furnished with very short and fine hairs; a few of them may have some fairly long, fine hairs.

Maxilla: No distinct sexual dimorphism. Epipodial appendage with 15-17 marginal bristles, the antero-ventral one of which is "aberrant," i.e., directed forward and naked or nearly so, of about the type figured for *Cytheroma variabilis* by G. W. Müller (1894, pl. 26:12). The number may be constantly 17; in other words, Juday's plate 18:7, in which only 15 marginal bristles are drawn, may be erroneous. Protopodite with three endites which increase somewhat in length the more distally they are located, the distal one slightly shorter than the palp. Number of bristles on each endite probably seven to eight. Palp distinctly 2-segmented; distal segment about half as long as, and distinctly narrower than proximal one. Bristles of palp uncertain except in species described below. In this species, first segment has six distal bristles, four of which are dorsal and two ventro-lateral; distal segment with three bristles.

Fifth limb: No distinct sexual dimorphism. Comparatively short and weak; total length of exopodite either subequal to or somewhat less than length of protopodite. Protopodite with four bristles on anterior side, two of which are distal, one at about middle, and one somewhat proximal. On posterior side, there is a single bristle somewhat proximal to middle of segment. Exopodite 3-segmented, with one bristle, besides the end claw, viz.: a ventro-distal one on first segment.

Sixth limb: No distinct sexual dimorphism. Of about ordinary size, thus distinctly larger than fifth. Total length of second and third segments of exopodite somewhat less than length of first segment of exopodite. Differs from description of fifth limb given in last paragraph in having one bristle at knee and posterior bristle of protopodite somewhat more proximal.

Seventh limb: No distinct sexual dimorphism. Decidedly larger than sixth, with total length of second and third segments of exopodite subequal to length of first segment of exopodite. Number of bristles of protopodite apparently variable; in species described below, it is four, i.e., the same as in sixth limb, and at the same locations; in Juday's (1907) species, it is three, one of the anterior above the knee bristle being absent; and in Müller's (1894) species only one is present, viz.: one of those on anterior side proximal to knee. Bristles on anterior side of protopodite, proximal to knee, always reduced; even when two of them are present they are vestigial or nearly so. Exopodite with same bristles as in case of sixth limb.

Fifth to seventh limbs: Protopodites of these limbs have no complicated chitinous skeletons, such as are found, for instance, in the genus *Cythereis,* where they serve to guide the tendons of the extensor and flexor lodged in the protopodite. A most remarkable feature in regard to these limbs of the species described below is that the second segment of exopodite is furnished with a well developed extensor. This muscle is present in the genera of the family Cypridae, but, evidently, is frequently absent in members of Cytheridae. Compare, for instance, text figure VIII in Skogsberg (1928) and figure 3:30 in Skogsberg (1917). This feature is not known for Juday's and Müller's species, but it is, of course, highly probable that we are concerned with a generic character. *Cytheroma* would thus be very primitive in this particular respect.

Furca: Small and furnished with three bristles in males and two in females.

Posterior extremity of body rather long and conical. Chitinous skeleton of body and appendages rather colorless, without the pronounced yellowish color present in some genera, e.g., in *Cythereis*.

Type species: Cytheroma variabilis G. W. Müller, from Naples, Italy.

The genus is probably of wide distribution, having been recorded from the Mediterranean and from the Pacific coast of North America. Undoubtedly benthoic in all cases. Juday (1907, p. 138) reported his species to have been taken in plankton. This mode of occurrence, however, if correct, was undoubtedly due to the swirl of heavy surf, a water movement which often causes bottom organisms to be raised temporarily into the upper waters along the California coast.

Remarks: The species described below is undoubtedly very closely related to *Paracytheroma pedrensis* Juday (1907, p. 138). The question as to whether it is specifically identical with this form will not be possible to settle until a detailed re-examination of Juday's material has been undertaken. However, even though several errors unquestionably occur in Juday's pictures of this species, there are some features in these figures which at least strongly suggest that *P. pedrensis* and the form described below are specifically distinct; see, for instance, Juday's plate 18:11, of the postabdomen of the female, and note especially the shape of the genital verruca.

Juday made his species the type of a new genus, but he did not discuss the relationship between this genus and previously established genera. However, by choosing the name *Paracytheroma,* he undoubtedly expressed the opinion that it was most closely related to *Cytheroma,* a genus established by G. W. Müller (1894, p. 349) on a single species, *C. variabilis.*

In his large, synoptic work on the ostracods, G. W. Müller (1912, p. 315) accepted *Paracytheroma* as a valid genus. After having stressed the close relationship between the two genera, Müller noted the following characters, in which *Paracytheroma* would differ from *Cytheroma.* Distal segment of first antenna about five times longer than wide, as compared with a length twice the width in *C. variabilis.* Only one of the three bristles of this segment is claw-like, while in *C. variabilis* two of them are. The epipodial appendage of the mandible has two long bristles, instead of one long and one short. The protopodite of the seventh limb has only one bristle in *C. variabilis,* while in *Paracytheroma* there are in addition to this one, one bristle at knee and one on posterior side of segment. In regard to the last two characters, *C. variabilis* would thus have suffered losses, and loss variations have, as we know, comparatively small systematic significance. However, even though we accept these characters at their face value, it seems hardly advisable to consider the relatively minute differences which they represent as sufficient ground for generic differentiation. At the most, they may justify the retention of *Paracytheroma* as a subgenus of *Cytheroma,* in order to stress a possible geographic differentiation. If genera within the ostracods were to be founded consistently on characters of this small magnitude, it would be necessary to establish a very large number of new genera, a procedure of very questionable value to science.

A close comparison between *Cytheroma variabilis,* as described by Müller (1894, p. 350) and the species described below will show that although these two species are quite closely related, nevertheless they are mutually somewhat farther removed than are Juday's *Paracytheroma* and my species. A striking indication of relationship between *Cytheroma variabilis* and the new species is found in the line of concrescence of the shell; the latter species exhibits the same peculiar variability in this character as that noted by Müller (1894, pl. 26:5, 10) in the former species. The most conspicuous difference between Müller's species and that of the writer is to be found in the external genitalia of the female (a feature usually very conservative in this family). However, in this connection notice should be taken of the fact that, according to Juday's figure of this organ (1907, pl. 18:11), *Paracytheroma pedrensis* differs very strikingly from both these species, being contrary to the others, very primitive in this respect.

Cytheroma similis Skogsberg, new species

Plates 27 and 28, Figures 1-13

Description: Male:

Shell: Length, 0.66-0.70 mm. Length: height, 2.2-2.3:1. Right and left valves of about identical size and shape. Seen from side, shell is of about the shape represented in figure 1; in other words, it resembles that of *Paracytheroma pedrensis* (Juday, 1907, pl. 18:3), except that its posterior end is somewhat lower relatively. Seen from above, of about the same type as in *Cytheretta intermedia,* only slightly more pointed at extremities (pl. 27, fig. 1). Pores of surface of shell rather conspicuous and moderate in number, some of them with short, simple hair. Line of concrescence rather complicated and somewhat variable; usually of type represented by appended figure, but may approach condition represented by Müller (1894, pl. 26:10). Most marginal pores furnished with short, simple hair. Inner line usually of type represented by appended figure, but slight variations occur. Selvage reaches somewhat beyond margin of shell; its edge smooth (oc. 4; oil immersion 1/12). In transmitted light, shell has light brownish-grey color; in reflected light it is milky white.

First antenna (pl. 27, fig. 2): Of about same shape as in *Paracytheroma pedrensis* Juday (1907, pl. 18:5); in other words, distal segment about five times longer than wide. Bristle of second segment is postero-distal, about as long as posterior side of segment, rather weak, slightly annulated, naked or almost so. Bristle of third segment antero-distal, about as long as or slightly longer or shorter than total length of three distal segments, and fairly strong. The two bristles of fourth segment are both medial and distal, and one is anterior, the other is posterior; both are rather strong, the anterior being distinctly the stronger; subequal in length to bristle of third segment. Of the four bristles of fifth segment, three are antero-distal and one postero-distal. Of the three anterior, two are subequal and about as long as total length of two distal segments, the third is somewhat longer; one of the two shorter is strong, the others are weak. Posterior bristle of this segment is weak and somewhat longer than distal segment. The anterior of the three bristles of distal segment is moderately strong and about 1.5 as long as segment; the remaining two are joined at base and of same types and relative lengths as in *Paracytheroma pedrensis.* All bristles of distal four segments naked and non-annulated. Pilosity: First segment with row of short, fine hairs dorso-distally. On anterior side of second segment there are a number of rather long hairs; and distally on this segment there is both on medial and lateral sides a dense row of short, fine hairs.

Second antenna: (pl. 27, fig. 4): Of about the same type as in *C. variabilis* Müller (1894, pl. 26:11). Bristle of first segment of endopodite somewhat shorter than posterior side of second segment, its tip reaching to or somewhat beyond the sensory bristle of second segment; of moderate strength, non-annulated and furnished with short, scarcely visible hairs. The two anterior bristles of second segment of endopodite located at middle of this segment; one of them about twice the length of the other and about as long as segment; both of them are naked. Of the group of three bristles on posterior side of this segment, the sensory, claviform bristle extends to tip of distal segment; the remaining two somewhat longer and either of mutually subequal length or one may be about 0.25 shorter than the other; the lateral of the last two bristles is naked or nearly so, the medial is furnished with fine, short hairs. Of the two postero-distal bristles of this segment, one agrees with the just mentioned lateral bristle except that it is somewhat shorter; the other is vestigial. Of the two large claw-like bristles of distal segment, the proximal is about half as long as endopodite, the distal is somewhat shorter (the tips of these bristles extending about equally far); both bristles naked. Pilosity: Ventro-proximally on protopodite, there are a few moderately long hairs which may be absent. Dorso-distally this segment has a row of short, fine hairs; and such a row is also to be found ventro-distally on lateral side. On anterior side of first segment of endopodite, there are numerous rather long hairs. Such hairiness is also to be found on proximal half of anterior side of second segment of endopodite; and along greater part of posterior side of this segment there are numerous short transverse rows of short, fine hairs. Along medio-distal edge of this segment, there is a series of fine, short hairs.

Mandible (pl. 27, figs. 3, 5): Toothed edge of pars incisiva with seven teeth. Second and third teeth 3-4-pointed distally; remaining teeth usually 2-pointed; bristle slightly proximal to posterior tooth is about as long as this tooth. Bristle on anterior side of masticatory segment about as long as or somewhat longer than anterior tooth of pars incisiva, sometimes slightly annulated, and furnished with short hairs, or almost naked. Second segment of protopodite usually not very distinctly separated from first segment of endopodite. Of its two ventral bristles, one is nearly distal, the other located somewhat proximally to middle of segment; both about as long as segment, and naked. Epipodial appendage with four bristles; the two posterior ones long, the next about half this length, and the anterior only about one-third the length of its neighbor; all four seem to be furnished with long, fine hairs. Dorso-distal bristle of first segment of endopodite about as long as or somewhat longer than second segment of endopodite and has a moderate number of fairly long hairs. The two ventro-distal bristles of this segment subequal and about as long as, or slightly longer or shorter than, endopodite. Of the two medio-distal bristles, the dorsal one is nearly twice as long as the ventral, and about as long as the ventral side of first and second segments of endopodite, or somewhat shorter; the ventral one of these two bristles furnished with a few long hairs. Second segment of endopodite: Of the two ventro-distal bristles, one is about as long as the longer of the two last-mentioned bristles, the other is about half as long or somewhat shorter. Of the seven dorsal bristles, five are about as long as endopodite, the remaining (dorsal) two are shorter, the smaller of them being only about one-third this length. The remaining bristle of this segment is somewhat stronger than the others, and slightly longer than total length of distal two segments of endopodite. The four bristles of end segment of somewhat different lengths, the longest being of the size of the last-mentioned bristle. Most bristles of palp non-annulated, a few of them with weak annulation; all of them, except those specially noted above, are naked or furnished with exceedingly fine and short hairs. This limb seems to be without pilosity.

Maxilla: Epipodial appendage with 17 bristles; differs from that of *C. variabilis* (Müller 1894, pl. 26:12) mainly in having the aberrant bristle somewhat longer, about as shown by Müller (1894, pl. 26:16). Other parts very similar to type represented for *Loxoconcha mediterranea* by Müller (1894, pl. 26:38). First endite with seven bristles, the ventral one of which is rather long and strong and situated markedly proximally with reference to the others; remaining ones comparatively short and weak. Second endite with seven to eight bristles; third endite with seven bristles. All of these bristles of moderate length and strength (about as in the noted figure), some of them naked or almost so, the others furnished with more or less long hairs. The four dorso-distal bristles of first segment of palp are about as long as, or somewhat longer than palp, naked or with short or moderately long hairs. Of the two remaining bristles of this segment, one is about twice longer than end segment or somewhat more, naked or almost so; the other (more dorsal one) is so short and weak as to be nearly invisible even with Leitz oil immersion 1/12. The three bristles of distal segment mutually of somewhat different lengths about as long as, or somewhat longer than twice the length of this segment; naked or almost so; one of the more ventrally located of them is rather strong, the others of moderate strength, like the remaining bristles of the palp. Limb seems to have no pilosity.

Fifth limb (pl. 28, fig. 6): Protopodite subequal in length to exopodite. Bristle at about middle of anterior side of protopodite about as long as this side; the somewhat more proximal bristle extends about to tip of segment, both these bristles slightly annulated and almost naked. Of the two bristles at knee, the lateral is rather strong, non-annulated, with short, fine hairs, and usually not quite so long as first segment of exopodite. The medial is short, weak, and its length is subequal to distal width of protopodite. Posterior bristle of this segment about half as long as posterior side of segment, at most with slight traces of annulation, and naked or almost so. Exopodite: Length of first segment subequal to total length of second and third segments; these are about equal in length, or third segment is slightly the shorter. Bristle of first segment distinctly longer than second segment, naked or with very fine and short hairs. End claw slightly shorter than first segment, nearly evenly curved, and almost naked. Pilosity: Protopodite apparently naked. Along ventral side of exopodite numerous transverse rows of very short and fine hairs.

Sixth limb (pl. 28, fig. 8): Protopodite about as long as, or rather slightly longer than first segment of exopodite. Its anterior bristles usually somewhat shorter than corresponding bristles of fifth limb; its posterior bristle somewhat longer relatively; all these bristles non-annulated, and naked or almost so. Exopodite: Second and third segments subequal in length. End claw somewhat more than one-half length of first segment, uniformly curved. Fine pectination at distal ends of first and second segment of exopodite. In other respects this limb agrees with fifth limb.

Seventh limb (pl. 28, fig. 9): Proportions between segments about as in preceding limb. Protopodite with same number of bristles as in sixth limb. The bristle at knee rather strong, its length slightly exceeding distal width of protopodite, naked or nearly so. The remaining two of anterior bristles of protopodite very small, the more distal of them even vestigial, nearly impossible to detect. Bristle on posterior side of this segment somewhat shorter than in preceding limb. Exopodite: Bristle of first segment with very fine, short hairs. End claw with vestigial pectination. Third segment with distal pectination. In other respects as sixth limb.

Chitinous support of the last three limbs, at sides of body, rather constant, and of type represented in plate 28, figure 7.

Brush-shaped organ (pl. 28, fig. 12) : Long and narrow, about eigth times longer than average width; with a fairly large number of terminal bristles, about half as long as stem of organ.

Penis (pl. 28, fig. 13) : right and left organs similar. Copulatory appendage with narrowly rounded tip; free end of vas deferens rather short, curved. Behind the two penes a shield-like plate with fine, rather short marginal hairs.

FEMALE:

Shell: Two of the three females which I examined had the line of concrescence of the type figured by Müller (1894, pl. 26:5), only the number of marginal pores was somewhat larger than in this figure.

Genital verruca (pl. 28, fig. 11) : Quite characteristic, subquadrangular; furnished with three processes; two of these situated antero-ventrally and of these the medial one is ovoid, the other lanceolate; the remaining process situated near middle of ventral side, small and pointed. This organ located relatively far behind seventh limb.

Furca (pl. 28, fig. 11) : The two bristles of moderate length, about length of genital verruca, finely annulated, with short hairs.

Posterior end of body rounded mammilliform, with a bunch of moderately long hairs.

Two males and two females were carefully examined.

Type locality: Pacific Grove, Monterey Bay, California: depth, 15 m., sand and rocks; Dec. 15, 1920: 4 males, 3 females.

Xestoleberis G. O. Sars

For diagnosis, see Müller (1894, p. 332).

This genus, which was established in 1865 by G. O. Sars, is one of the largest among the Ostracoda and apparently is represented throughout all the seas of the world. Since a large number of the described species are very incompletely known and since much of the knowledge of the genus is very uncertain, it seems most advisable to postpone the attempt to give to the genus a more elaborate description than the one presented by Müller (1894). Judging by material which I have examined, the number of undescribed species is very great.

Xestoleberis hopkinsi Skogsberg, new species

Plates 29 and 30, Figures 1-16

Description: MALE.

Shell (pl. 29, figs. 1-4) : Length, 0.51-0.54 mm. Length :height, about 1.8 :1. Length :width, about 2.1 :1. Seen from the side and from above, of about the shape described and figured for *Xestoleberis granulosa* by G. S. Brady (1880, p. 125, pl. 30:5, a-d). All the specimens examined by the writer agree almost perfectly with the appended figures. Surface with moderate number of distinct pores. In regard to pores along anterior margin, see appended figure; along posterior margin, pores are about as widely spaced as along dorsal portion of anterior margin; along posterior half of ventral margin they are somewhat more numerous, not quite so numerous as along ventral portion of anterior margin, however. On surface of shell, a moderate number of fine rather short hairs occur; and such hairs are fairly numerous along anterior margin and anterior portion of ventral margin. Muscular impressions about as in appended figure. Color whitish in reflected light, light brown in transmitted light, the posterior one-half to one-third being usually somewhat reddish brown.

First antenna (pl. 29, fig. 5): Rather slender; 6-segmented, narrowing gradually distally. Proportions among segments about as follows:

$$\text{I}\ \frac{6.5\ (7)}{6.5\ (7)} \qquad \text{II}\ \frac{10}{7} \qquad \text{III}\ \frac{4}{4.5} \qquad \text{IV}\ \frac{5}{5} \qquad \text{V}\ \frac{5}{5} \qquad \text{VI}\ \frac{2\ (2.5)}{2\ (2.5)}$$

Second segment with one bristle, situated distally and medially, subequal in length to fourth segment. Third segment with one antero-distal bristle, about half as long as fourth segment or somewhat more. Fourth segment with one postero-distal and two antero-distal bristles; postero-distal bristle about as long as fifth segment or total length of two distal segments; of the two antero-distal bristles, one is somewhat shorter than fifth segment, the other is about or not quite twice this length. Fifth segment with same equipment of bristles as the fourth, the shorter of the two antero-distal bristles, however, being somewhat longer. Distal segment with four bristles, three being of ordinary type and one sensory and narrowly claviform. Sensory bristle apparently not attached at base to its neighbor, and about twice longer than distal segment; the posterior one about twice the length of the sensory, the remaining ones of intermediate lengths. All bristles, except the sensory, are well pointed, non-annulated (that of second segment may have slight annulation), naked or almost so, weak, the shorter of the antero-distal ones of fourth and fifth segments being somewhat, though rather slightly, stronger than their neighbors. Pilosity: Along proximal half of anterior side of second segment and antero-distally on this segment a number of moderately long to fairly short hairs.

Second antenna (pl. 29, fig. 6): Relatively powerful and with proportions among segments quite similar to condition in *Cythereis* but protopodite is slightly larger and second endopodite segment slightly longer, relatively. Exopodite about as long as anterior side of endopodite, its first segment about three to four times longer than the second. Endopodite: First segment with one postero-distal bristle, about as long as anterior side of segment, with short hairs but without distinct annulation. The two bristles on anterior side of second segment situated well proximally to middle of segment; one of them about as long as bristle of first segment, the other about half as long or less; both naked. Just opposite these two bristles, or slightly distal to them, there are three bristles on posterior side of segment; one of them agrees with bristle of first segment of endopodite; one is of same type but is slightly shorter; the last of the three is often situated somewhat away from the others, narrowly claviform, and about one-half as long as its longer neighbor. Posteriorly, near distal end of this segment, there are two bristles, about as in *Cythereis;* one of these is strong, gently curved near tip, its length subequal to proximal width of segment, naked or nearly so; the other is very weak and about half as long as its neighbor or somewhat more. Distal segment with two claws, evenly and moderately curved, the distal one about as long as the strong postero-distal bristle of preceding segment, naked or almost so; the other somewhat shorter and weaker, strongly pectinate. The end claws of the specimens examined were held in the position shown in appended plate 29, figure 6. Posteriorly and at base of posterior end claw, there is an exceedingly minute spine, the vestige of a third end claw. Pilosity: Proximally, on ventral side of protopodite, a few short hairs occur. About at middle of lateral side of first segment of endopodite, there is a longitudinal chitinous thickening, furnished with moderately long, stiff hairs. On anterior side of this segment, both proximally and distally, a few hairs are to be found. On second segment of endopodite, a few short hairs occur on anterior side, near proximal end of segment; and such hairs occur also along postero-distal portion of this segment.

Mandible (pl. 29, fig. 7): Masticatory segment wedge-shaped; in the specimens examined by the writer almost constantly of the type shown in the appended figure; in other words, rather long, broadest at level of attachment of palp, upper half narrowing fairly evenly dorsally, ventral half with decided constriction just below palp. Toothed edge of pars incisiva with seven teeth, the anterior (antero-lateral) of which is fairly large and powerful; the others decrease rather regularly in size and strength the more posteriorly they are situated, except the second which is distinctly smaller than the third. Anterior (first) tooth bifurcated, one of its points being distinctly shorter than the other; with two low, broad protuberances at base of inner side. Next four teeth obliquely truncated, the slanting edge armed with three more or less developed, usually rounded points. The two posterior teeth bifurcated, their points more or less sharp. Between teeth numbers 1 and 2, there is one weak bristle, often slightly longer than tooth number 2, and one short, fine spine, about half as long as its neighbor. A short, fine spine is also found between teeth numbers 2 and 3, 3 and 4, and 4 and 5. Behind toothed edge, there is a fine bristle about as long as first tooth. On anterior edge of pars incisiva, just below palp, there is a moderately large but weak bristle with short hairs, its length subequal to proximal width of pars incisiva. Palp of moderate strength, about half as long as masticatory segment is high; its proximal height subequal to width of toothed edge; becomes fairly evenly narrower distally; end segment about as long as high; quite distinctly 4-segmented; lengths of segments of following proportions:

$$\text{I}\ \frac{16}{12} \qquad \text{II}\ \frac{13}{10} \qquad \text{III}\ \frac{13}{9} \qquad \text{IV}\ 5$$

Epipodite situated fairly far back on lateral side of second protopodite segment; rather short, with three or four bristles, of proportions shown in appended figure (number of bristles difficult to ascertain since these structures are weak and often more or less tangled); bristles appear to have scarce, long, soft hairs. Second segment of protopodite has, near distal end, a medial bristle subequal in length to two distal segments. *Endopodite:* First segment with one dorso-distal bristle subequal in length to endopodite; ventro-distally this segment has two bristles, one of which is subequal to dorso-distal bristle or somewhat less, the other shorter, sometimes even but half as long as its neighbor. Slightly dorsal to these two bristles, on medial side, there are two bristles somewhat longer or shorter than second segment of endopodite. Second segment with a group of four bristles, somewhat distal to middle of dorsal side; longest of these bristles subequal in length to endopodite; the shortest about half as long or somewhat more. Ventro-distally, this segment has two bristles, above which occurs a single bristle on medial side; this bristle and one of the two ventral ones are about as long as, or somewhat longer or shorter than the two distal segments; the remaining of the two ventral is about half as long. All bristles of palp so far noted are of medium strength or fairly weak, non-annulated, naked or almost so. Distal segment with four distal bristles; the two dorsal are rather strong, evenly curved claws, subequal in length to two distal segments, or one of them is somewhat shorter; the two ventral bristles are somewhat shorter and quite weak; all naked or almost so, and non-annulated. The limb seems to lack pilosity.

Maxilla (pl. 30, fig. 11): Epipodial appendage with 16-17 marginal bristles, 16 being present when the short and weak dorsal one is not developed; "aberrant bristle" of moderate length and naked. Palp and endites rather long and narrow; palp the longest, endites decreasing in length the more proximally they are attached, as shown in appended figure. Each of endites with seven bristles of moderate lengths, those on first endite on an average somewhat shorter than those of second and third endites. Lengths, strengths, and positions of bristles about as in appended figure; thus it is noted that one bristle on each endite is distinctly stronger than the others, viz., the next to the ventral one on first endite and the ventral one on the remaining endites. Most of these bristles seem to be naked, but some of them are furnished with fine, nearly invisible hairs. (Number of bristles apparently constant; however, it is sometimes very difficult to establish.) Palp without distinct joints. Dorsally, at about two-thirds the length from the proximal end, there is a group of four bristles; bristles either subequal, about half as long as dorsal side of palp or somewhat more; or they are somewhat different in length, about as in the appended figure; bristles of moderate strength and naked or furnished with very short hairs. Ventrally, a short distance from tip of palp, two bristles occur; and there are three distal bristles; the ventral of the last three is a powerful, evenly curved claw, pectinated distally; the others of moderate strength or rather weak, naked or one to two of them furnished with short hairs; lengths of last five bristles about as in appended figure.

Fifth limb (pl. 30, fig. 14): Length of protopodite subequal to total length of first and second segments of exopodite; second segment of exopodite about half as long as the first; and the third somewhat longer than the second. Protopodite has at about middle of anterior side a bristle about half as long as this side or slightly more; naked or almost so. At knee, there are two bristles either subequal or somewhat different in length, the longer being about as long as anterior side of protopodite, both naked or furnished with short, exceedingly fine hairs. At about proximal one-third of posterior side of protopodite there is one bristle, about as long as or slightly shorter than segment, and furnished with short, fine hairs. All these bristles of moderate strength and non-annulated. Bristle of first segment of exopodite fairly strong, about as long as second exopodite segment, and with short, fine hairs. End claw rather powerful, about half as long as distal segment, nearly rectangularly bent just beyond middle, naked. Latero-distally the segments of exopodite have fine pectination; ventrally on first segment of exopodite there are very minute hairs, and such may be found also on the next two segments. No complex chitinous thickenings, such as are found in *Cythereis,* in distal end of protopodite. Same true in regard to next two limbs.

Sixth limb (pl. 30, fig. 15): Differs from fifth mainly in the following respects: Somewhat larger. First segment of exopodite somewhat longer relatively, being nearly equal in length to protopodite. Protopodite with only one bristle at knee; its bristle near middle of anterior side perhaps somewhat longer. Bristle of first segment of exopodite slightly weaker, and end claw perhaps slightly less hooked.

Seventh limb (pl. 30, fig. 16): Differs from sixth mainly in the following respects: Somewhat larger. First segment of exopodite slightly longer relatively, fully as long as protopodite. Posterior bristle of protopodite somewhat shorter, relatively. Bristle of first segment of exopodite distinctly weaker, almost or perfectly naked. End claw fairly gently curved.

Chitinous support of last three limbs, at sides of body, about as in the appended plate 30, figure 12; somewhat variable.

Brush-shaped organ (pl. 30, fig. 13): Two to three times longer than wide, fairly suddenly constricted near distal end; bent outward in a characteristic manner. Bristles somewhat more than half as long as organ, of unknown number.

Penis (pl. 30, fig. 9): Of type represented in appended figure. Stippled area in this figure, around tip of ejaculatory duct, represents a mass of brownish-reddish, granular matter which was present in all specimens examined. Copulatory appendages of the two penes practically of similar shape, as represented in figure.

Furca: Located just behind penes; with three bristles of moderate lengths and naked or with short, fine hairs.

End of body, at place where the two penes meet (pl. 30, fig. 9), represented by a small, hairy or naked verruca, furnished with a terminal bristle, with short hairs or naked.

Female: Differs from male chiefly in the following respects:

Shell: Length, 0.54-0.60 mm.

Second antenna (pl. 29, fig. 8): Proximal claw of end segment of about same shape and size as the distal; both claws furnished with oblique row of very fine, weak spines.

Genital verruca rounded (pl. 30, fig. 10). Furca with two naked or nearly naked bristles. Posterior end of body irregularly cone-shaped, with a distal bristle and a varying number of stiff, moderately long hairs, some of which are arranged in a transverse row at base of distal bristle, and some in two bunches, one on either side of body, somewhat more proximally.

Remark: Because of the more or less incomplete nature of the hitherto published descriptions of the species of this genus, I have refrained from attempting to differentiate between generic and specific characters in the above description. Many of the features presented undoubtedly are of generic nature.

Type Locality: Pacific Grove, Monterey Bay, California, in rocky tide pool full of brown algae, just outside the Hopkins Marine Station on holdfasts of algae. November 23, 1920: 4 males and 3 females.

The species is named for Mr. Timothy Hopkins, the benefactor of the mentioned marine laboratory of Stanford University.

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Cytheroma similis Skogsberg, new species

PLATE 27

1. Left shell. ♂.
2. Left first antenna. ♂. x365.
3. Left mandible. ♂. x575.
4. Right second antenna. ♂. x365.
5. Masticatory process of male mandible. x535.


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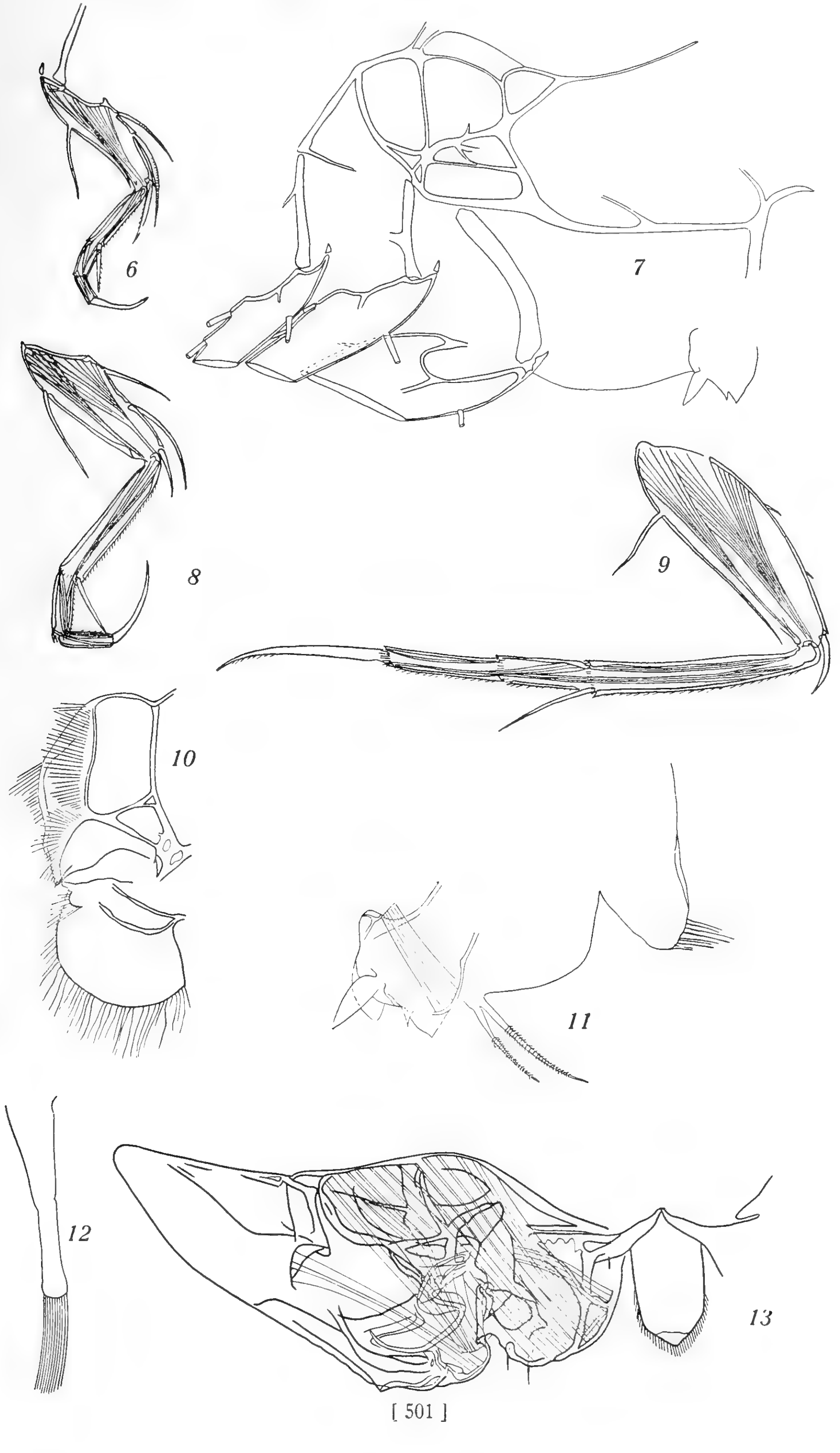
Cytheroma similis Skogsberg, new species

PLATE 28

6. Left fifth leg, from inner side. ♂. x200.
7. Chitinous skeleton on sides of female body. x225.
8. Left sixth leg, from inner side. ♂. x200.
9. Left seventh leg, from inner side. ♂. x200.
10. Upper and lower lips, seen from side. ♂. x265.
11. Hind part of female body, with genital verruca. x340.
12. Brush-shaped organ. x460.
13. Penis, optic section, from outside. x200.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Xestoleberis hopkinsi Skogsberg, new species

PLATE 29

1. Shell, left. ♂.
2. Shell, from dorsal side. ♂.
3. Front portion of left shell, seen from inside. ♂. x180.
4. Shell, right. ♂.
5. Left first antenna, seen from outside. ♂. x345.
6. Left second antenna, seen from outside. ♂. x345.
7. Right mandible. Ventral portion slightly pressed under cover slip, seen obliquely from outside which makes it appear somewhat narrow. ♂. x460.
8. Tip of female second antenna, seen from outside. x500.


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Xestoleberis hopkinsi Skogsberg, new species

PLATE 30

9. Left penis, from outside. x265.
10. Female abdomen and furca. x265.
11. Male maxilla, slightly compressed. x500.
12. Chitinous skeleton of thoracic sides. ♂. x265.
13. Brush-shaped organ. x345.
14. Left fifth leg. ♂. x345.
15. Left sixth leg. ♂. x345.
16. Left seventh leg. ♂. x345.


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INDEX TO VOLUME XXVI

FOURTH SERIES

New names in **bold-face** type

ERRATA

Page 77. Line 6 from bottom: for **Blandfordia** read **Blanfordia.**

Page 79. Line 18 from bottom: for *M. ningpoensis Lea* read *M. ningpoensis* Lea.

Page 129. Line 9 from top: for **Cypraea andersoni** Ingram read **Cypraea andersoni** Ingram, new species.

Page 162. Line 17 from top: for *O. laperouseii* read *O. laperousii.*

Page 186. Line 13 from top: for *Exilioidia rectirostris* read *Exilioidea rectirostris.*

Page 192. Line 6 from top: for *Balvis rutila* read *Balcis rutila.*

Page 192. Line 20 from bottom: for *Turbonilla (Turbonillo) cayucosensis* read *Turbonilla (Turbonilla) cayucosensis.*

Page 199. Line 10 from bottom: for *Egregia menziesii* read *Egregia Menziesii.*

Page 200. Line 5 from top: for *A. cassis nacelliodes* read *A. cassis nacelloides.*

Page 203. Line 25 from bottom: for *H. aulaea* read *H. aulea.*

Page 212. Line 3 from top: for new species read new subspecies.

Page 232. Line 5 from top: for *Cyanoplax hartwegii nuttallii* read *Cyanoplax hartwegii nuttalli.*

Page 268. Line 10 from bottom: for *incurvus* read *recurvus.*

Page 285. Line 7 from top: for Plate 6 read Plate 5.

Page 289. Line 5 from bottom: for Plate 8, Figures 1, 2, 3; Plate 8, Figure 4 read Plate 8, Figures 1, 2, 3; Plate 9, Figure 4.

Page 309. Line 1 from top: for *Conus californicus fossils* read *Conus californicus fossilis.*

Page 340. Line 18 from top: for *Cymathaere triplicata* read *Cymathere triplicata.*

Page 343. Line 13 from bottom: for *Kellia laperousi* read *Kellia laperousii.*

Page 346. Line 12 from top: for *Crepidula nummeria* read *Crepidula nummaria.*

Page 348. Line 15 from bottom: for *Haliclonia cinereus* read *Haliclona cinerea.*

Page 373. Line 15 from top: for *Gutierezia californica* read *Gutierrezia californica.*

Page 450. Line 17 from top: for *(Elaphe p. porphracea)* read *(Elaphe p. porphyracea).*