PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

Vol. XIV, No. 1, pp. 1–35, plates 1-6 JULY 21, 1925

I

PECTENS FROM THE TERTIARY OF LOWER CALIFORNIA

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In a study of a collection of Tertiary fossils from Lower California, a considerable number of species of Pectens were identified, several of which appear to be undescribed. The writer wishes to acknowledge the kind help received from Dr. J. P. Smith of the Leland Stanford Junior University; he also wishes to thank Dr. G. Dallas Hanna and Mr. Eric K. Jordan of the California Academy of Sciences for the loan of Academy material and helpful criticism of the manuscript. Permission by Dr. B. L. Clark to examine material in the collection of the University of California is gratefully acknowledged. Acknowledgment is also due especially to Mr. C. H. Beal and to Messrs. B. F. Hake, C. R. Swarts and T. J. Cullen of the Marland Oil Company of California; and also to Mr. E. Call Brown of Los Angeles, California, for the material collected by them. The greater part of this material is now in the paleontological collections of the Leland Stanford Junior University; paratypes where available, and duplicates, are in the collections of the California Academy of Sciences.

Previously described species of Pectens recognized in the collection are listed as follows, together with the L.S.J.U. and C.A.S. locality numbers from Lower California, and with the

formation as far as known. The formation-names and the names of the quadrangles in the most part follow those adopted by the Marland Oil Company geologists.

Pecten (Pecten) carrizoensis Arnold. Carrizo, Lower Pliocene.
Loc. 45 (L.S.J.U.)

Pecten (Pecten) cataractes Dall. Formation unknown.
Loc. 52 (L.S.J.U.)

Pecten (Pecten) cf. *bellus* Conrad. Salada, Pliocene.
Loc. 49 (L.S.J.U.); loc. 928 (C.A.S.)

Pecten (Pecten) hemphillii Dall. Salada, Pliocene.
Loc. 48 (L.S.J.U.)

Pecten (Pecten) keepi Arnold. Lower Pliocene?
Loc. 44, 45, 50 (L.S.J.U.)

Pecten (Pecten) lecontei Arnold. Salada, Pliocene.
Loc. 48 (L.S.J.U.); loc. 928 (C.A.S.)

Pecten (Patinopecten) cf. *coosensis* Shumard. Salada, Pliocene.
Loc. 48 (L.S.J.U.)

Pecten (Patinopecten) dilleri Dall. Salada, Pliocene.
Loc. 48 (L.S.J.U.)

Pecten (Lyropecten) near *crassicardo* Conrad.
Loc. 57 (L.S.J.U.)

Pecten (Plagioctenium) circularis Sowerby.
Loc. 47, 48, 61 (L.S.J.U.); loc. 928, 930 (C.A.S.)

Pecten (Plagioctenium) cerrosensis mendenhalli Arnold.
Carrizo, Lower Pliocene. Loc. 45, 51, 62, 69 (L.S.J.U.)

Pecten (Plagioctenium) deserti Conrad. Pliocene.
Loc. 45, 52, 55, 64 (L.S.J.U.)

Pecten (Plagioctenium) invalidus Hanna. Pliocene.
Loc. 52, 64 (L.S.J.U.)

Pecten (Plagioctenium) purpuratus Lamarck. Salada, Pliocene.
Loc. 48, 116 (L.S.J.U.); loc. 928, 930 (C.A.S.)

The localities (L.S.J.U.) and (C.A.S.) listed in the foregoing are as follows:

Locality 44 (L.S.J.U.). Arroyo Fortuna, north of San José del Cabo, Lower California; C. R. Swarts collector.

Locality 45 (L.S.J.U.). Santa Rosalia, Lower California; C. H. Beal collector.

Locality 47 (L.S.J.U.). Turtle Bay (San Bartolome), Lower California; B. F. Hake collector; Salada Pliocene.

Locality 48 (L.S.J.U.). Mouth of large arroyo, northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California; B. F. Hake collector; Salada Pliocene.

Locality 49 (L.S.J.U.). Slopes of Salada, three miles southeast of Turtle Bay, uppermost beds, San Cristobal Bay Quadrangle, Lower California; B. F. Hake collector; Salada Pliocene.

Locality 50 (L.S.J.U.). Rancho Refugio, north of San José del Cabo, Lower California; C. R. Swarts collector.

Locality 51 (L.S.J.U.). Arroyo las Palmas, Santa Rosalia, Lower California.

Locality 52 (L.S.J.U.). El Zacato, on coast north of Santiago, Lower California; C. R. Swarts collector.

Locality 55 (L.S.J.U.). Arroyo Asuncion, Scammon Lagoon Quadrangle, Lower California; B. F. Hake collector.

Locality 57 (L.S.J.U.). La Purisima Cliffs, San Ramon River, Lower California; E. Call Brown Collector.

Locality 61 (L.S.J.U.). Coronados Island, Gulf of California; T. J. Cullen collector.

Locality 62 (L.S.J.U.). Float, five kilometers north of Santa Rosalia, Lower California; C. H. Beal collector.

Locality 64 (L.S.J.U.). Arroyo near La Palma, 12 miles northwest of Santa Rosalia, from pebbly sandstone near Comondu-Salada contact, Lower California; B. F. Hake collector.

Locality 69 (L.S.J.U.). Arroyo de las Virgines, 10 miles northwest of Santa Rosalia, Santa Rosalia Quadrangle, Lower California; B. F. Hake collector.

Locality 116 (L.S.J.U.). Cedros Island, off Lower California; H. Hemphill and others, collectors. Salada Pliocene.

Locality 928 (C.A.S.). Cedros Island, off Lower California; G. D. Hanna collector; Salada Pliocene.

Locality 930 (C.A.S.). Turtle Bay, Lower California; G. D. Hanna collector; Salada Pliocene.

Of the species listed in the foregoing *P. circularis* and *P. cataractes* are found living in the Gulf of California at the present time. *P. bellus* has been listed from the Fernando, San Diego, and Santa Barbara Pliocene of California, and *P. hemphillii* has been listed from the Fernando and San Diego Pliocene formations of southern California. *P. carrizoensis, P. deserti* and *P. keepi* have been reported from the Carrizo formation. *P. lecontei* has been reported from the Pliocene of Cedros Island. *P. invalidus* was described from the San Diego Pliocene of Pacific Beach near San Diego, California. *P. crassicardo* has been reported as occurring throughout the Miocene of California, though it is most abundant in the Monterey-Temblor and Santa Margarita-San Pablo formations. *P. cerrosensis mendenhalli* was originally described from the Plio-

cene of Lower California near Santa Rosalia, which was thought to be equivalent to the Carrizo. *P. purpuratus* occurs in the Salada Pliocene of Cedros Island and Turtle Bay, also in the Pliocene and Pleistocene of Chile, and it is at present found living in the waters of the Peruvian province of the Pacific ocean. *P. coosensis* occurs in the Miocene, Empire formation on the coast of Oregon and in the Montesano, Miocene of Washington. *P. dilleri* occurs in the Pliocene, Wildcat formation on Eel River in northern California and in the Fernando of the Santa Maria district near Santa Maria, California.

The numerous species of the sections Pecten s. str., Lyropecten, Aequipecten, and Plagioctenium, indicate that warm water conditions prevailed in Lower California in the later Tertiary. The identity of many of the previously described species with those known from the Tertiary of California is of interesting significance, as are also the relations of the new species. The stratigraphy of Lower California has not been worked out in great detail as yet, nor has any great advance been made in the way of correlation with the Tertiary formations of the western United States. Excellent work has, however, been accomplished by Dr. Arnold Heim and others. A recent paper by Heim[1] gives a good outline of the Tertiary stratigraphy of the southern half of the Peninsula of Lower California.

Several Tertiary and Quaternary formations were recognized by Heim. The Tepetate formation, considered to be of probable Upper Eocene age, is well developed at the Rancho El Tepetate, (Lat. 24° 23′, Long. 111° 8′). A stratum of about 20 meters of white siliceous shale appears at the base of the formation. This is followed by a considerable thickness of sandstones with smaller amounts of shales. Numerous *Orthophragmina pratti* Mich., occur in these beds, and *Amphistegina niasi* Verbeek, is also mentioned. The facies of the Tepetate formation, according to Heim, are chiefly neritic.

The next younger formation recognized by Heim is the Purisima Nueva (Lat. 26° 11′, Long. 112° 4′). These beds are said to be composed chiefly of light colored sandstones, with some

[1] Geol. Mag. Vol. 59, p. 529-547, 1922.

layers of broken shells. The facies are neritic. At places the beds are considerably metamorphosed. Some of the species listed from this formation are: *Mactra dariensis* Dall, *Pecten condylomatus* Dall, *Pecten oxygonum optimum* Brown & Pilsbry, *Raeta gibbosa* Gabb, *Turritella tristis* Brown, Balanus sp. The age of this formation was considered to be Upper Oligocene.

Along the Arroyo Cadegomo and at Rancho San Ramon (Long. 112° 12′), the Monterey formation is typically developed. This formation is composed largely of white siliceous shale with smaller amounts of sandstones and, according to Heim, is quite similar to the Monterey formation of California.

Conformably overlying and intergrading with the Monterey formation is the Isidro, named from the town of San Isidro on the left bank of the Arroyo San Gregorio. It consists largely of sandstones and shales and is neritic in facies. Genera of some of the fossils reported are: Arca, Chione, Mytilus, Psammobia, Tellina(?), Chrysodomus, Balanus.

The Isidro is overlain, at some localities conformably, elsewhere unconformably, by the usually flat-lying Comondú, named for the oasis village of that name. This formation is chiefly composed of brownish sandstones and conglomerates, which are thought to be continental, of great extension, and Upper Miocene, or possibly Lower Pliocene, in age.

Above, and slightly unconformable on the Comondú formation, are the Cuesta sandstones, well developed at La Cuesta de La Purisima. No fossils have been found and the beds are probably continental and Pliocene in age.

Unconformably overlying the Monterey at La Ventana, Heim found a marine conglomerate, which he suggested probably corresponds to the Fernando Pliocene of California, but to which no formational name was given.

At the cattle ranch La Salada, on the left bank of the Arroyo de La Salada, a marine Pliocene formation is well exposed, to which Heim gave the name Salada. This is composed largely of sandstones and occasional conglomerates with an upper calcareous stratum. These beds are thought to have been deposited in shallow water. The formation appears to be quite

extensively developed along the coast and at moderate distances inland, and was recognized at several points. Genera of some of the fossils listed are: Chione, Mytilus, Tellina, Calliostoma, Conus, Oliva, Polinices, Turritella, Balanus.

Along the Pacific coast, the Pliocene beds are covered by the Médanos, or older sand dunes. Marine shells are found in them which are thought to be of Pleistocene age. Some of the species found were: *Arca tuberculata* Sby., *Donax* cf. *cayennensis* Lam., *Tivela bryoniana (radiata* Dall), oysters, etc.

The writer has been informed by Mr. C. H. Beal that the conclusions reached by him and his associates concerning the Miocene stratigraphy of Lower California do not coincide in all respects with those of Dr. Heim. The Purisima Nueva of Heim was not recognized by them, and no fauna comparable to that listed by Arnold and Clark has been found in their collections. In the Pliocene, the Cuesta was not differentiated from the Comondú, and both together were considered to be the continental equivalent of the Salada.

In this paper, the writer, following Arnold, has used the term Carrizo for certain beds in Lower California, notably in the vicinity of Santa Rosalia. He recognizes that, as pointed out by Vaughan[2], the name Carrizo has been used several times in North American stratigraphy; furthermore, examination of faunas from Imperial County, California, indicates a possibility that the so called Carrizo of Carrizo Creek, Alverson Canyon and Coyote Mountain, may perhaps comprise more than one horizon.

Several of the species listed in the present paper are from the Pliocene of Lower California. The Pecten fauna indicates that the Pliocene of Cedros Island is in general the equivalent of the San Diego Pliocene of Pacific Beach, near San Diego, California. The Salada is apparently equivalent to the Pliocene of Cedros Island. There is, however, an indication in the fauna, that a horizon older than the Salada may be present on the west coast of Lower California, as well as on the east coast, and it is probable that some of the species referred to the Salada may belong to an older horizon.

[2] Prof. Paper U. S. Geol. Survey No. 98, 1917, p. 357.

1. **Pecten (Pecten) refugioensis** Hertlein, new species

Plate 1, figure 2; plate 5, figure 9

Shell of medium size. Right valve practically smooth, ornamented, however, by fine concentric lines of growth, and close to the beaks also by fine, faint, radiating ribs which, however, disappear at the umbo; ventral margin smooth; interior of the shell ornamented by about 19 dichotomous ribs; ears about equal and concentrically sculptured; a slight groove showing where the ears meet the margins of the shell; a slight byssal notch present on the anterior ear. Left valve fairly smooth, ornamented interiorly much as right, a depressed area which is lower than the margins extends from the beaks to about one-half the height of the shell; ears slightly concave, ornamented by concentric lines of growth. Altitude 56 mm.; longitude 57 mm.; diameter of right valve approximately 14 mm.; apical angle of right valve approximately 97°.

Type: Right valve, No. 49 (L.S.J.U. type collection), from Loc. 50 (L.S.J.U.), **Rancho Refugio, north of San José del Cabo, Lower California**; *Paratypes:* No. 50 (L.S.J.U. collection), and Nos. 1764, 1765, 1766 (C.A.S. collection), C. R. Swarts collector; Upper Miocene or Lower Pliocene.

This species also occurs at Loc. 44 (L.S.J.U.), from Arroyo Fortuna, north of San José del Cabo, Lower California; C. R. Swarts collector; Upper Miocene or Lower Pliocene.

Pecten refugioensis appears to be a step between the sections Amusium and Pecten s. str. It has, in general, the shape of a Pecten s. str. and the concentric sculpture, ears and ribs are suggestive of an Amusium. It differs from *P. keepi* Arnold by showing scarcely any ribs on the exterior of the shell, and by its somewhat different shape. *P. refugioensis* differs from *P. revolutus* Mich., from the Miocene of Italy in having a smaller apical angle, a flatter shell, and differently shaped ears.

2. **Pecten (Pecten) aletes** Hertlein, new species

Plate 2, figures 1 and 4

Shell of medium size. Right valve moderately convex, ornamented by about 11 rather broad, flat-topped radiating ribs, which anteriorly and posteriorly decrease in size, each rib with one to four narrow, slight, radial sulcations; interspaces flat-bottomed, narrower than the ribs, occasionally bearing a tiny radiating riblet, the whole surface of valve sculptured by fine, close, concentric striæ; ears subequal, marked by growth lines, but lacking all radial sculpture. Left valve slightly concave, with a pronounced depression toward the beak; about nine flat-topped radial ribs, separated by interspaces about as wide as the ribs, the ribs and interspaces both covered by fine, sharp, concentric sculpture; ears subequal, and somewhat concave, ornamented only by fine incremental lines. Altitude 62 mm.; longitude 65 mm.; diameter of right valve approximately 13 mm.; apical angle of right valve approximately 100°.

Type: Right valve, No. 44 (L.S.J.U. type collection), from Loc. 50 (L.S.J.U.), **Rancho Refugio, north of San José del Cabo, Lower California**; *Paratypes:* No. 45 (L.S.J.U. collection), and No. 1767 (C.A.S. collection), C. R. Swarts collector. Horizon not known; probably Upper Miocene or Lower Pliocene.

Pecten aletes differs from *P. bellus* Conrad in the smaller number of ribs, which are finely sulcate. It differs from *P. laqueatus* Sowerby, from Japan, to which it is most closely related, in the fewer ribs; also in that the ears on the right valve of the present species appear to be straighter and not quite as arcuate as those of *P. laqueatus.*

3. **Pecten (Pecten) hartmanni** Hertlein, new species

Plate 1, figures 4 and 6

Right valve excessively arched, ornamented by about 16 or 17 rounded radiating ribs which become flattened toward the ventral margin of the shell; anterior and posterior margins highly arcuate, smooth except for faint lines of growth; ears somewhat convex and turned up slightly at the ends, the an-

terior sculptured by about four poorly defined radiating riblets which are crossed by concentric incremental lines, and cut by a slight byssal notch; left ear with a few faint radial riblets and slight concentric striæ. Altitude 75 mm.; longitude 65 mm.; diameter of right valve approximately 30 mm.; apical angle of right valve approximately 88°.

Type: Right valve, No. 48 (L.S.J.U. type collection), from Loc. 54 (L.S.J.U.), **Arroyo Mesquital, Lower California,** above the yellow silts which are well exposed in this arroyo; C. R. Swarts and T. J. Cullen collectors; Lower Pliocene?

Pecten hartmanni differs from *P. hemphillii* Dall in possessing a more highly arched right valve and in the shape of the ears, which in the present species are somewhat more concave. It differs from *P. cataractes* Dall in having fewer ribs, and in that the margins of the shell descend abruptly rather than expanding laterally, as in the case in Dall's species, and also in *P. vogdesi* Arnold.

This species is named in honor of Mr. A. Hartmann, whose work in Lower California has added to the knowledge of that region.

4. **Pecten (Pecten) heimi** Hertlein, new species

Plate 1, figure 3; plate 3, figure 3

Shell concavo-convex, equilateral, inequivalve. Right valve highly arched, and ornamented by about 20 or 21 rounded, radiating ribs which become flattened toward ventral margin, these separated by round-bottomed interspaces about one-half as wide as the ribs; ribs and interspaces crossed by concentric incremental lines of growth; ventral margin of shell rounded; ears somewhat convex; a distinct groove on right ear close to margin of shell, and byssal notch also present; anterior margin of right ear somewhat convex; ear ornamented by about four or five radiating riblets and by concentric incremental lines. Left valve slightly concave and ornamented by about 17 or 18 radiating ribs which are separated by round-bottomed interspaces, the ribs and interspaces crossed by fine concentric incremental lines; a depressed area present just below the beaks; anterior and posterior margins of valve flattened, higher than

the depressed inner area near beak, sloping abruptly to ears; ears concave and sculptured by fine incremental lines only. Altitude 75 mm.; longitude 85 mm.; diameter of right valve approximately 25 mm.; apical angle of right valve approximately 97°.

Type: Right valve, No. 46 (L.S.J.U. type collection), from Loc. 65 (L.S.J.U.), **southern part of Arroyo San Gregorio, Lower California**; *Paratype:* No. 47 (L.S.J.U. collection), E. R. Swarts and T. J. Cullen collectors; Lower Pliocene?

Pecten heimi differs from *P. hemphillii* Dall in the number of ribs, which is greater in *P. heimi,* and in the ears which are smooth, and more convex in the present species than in *P. hemphillii.* From *P. coalingensis* Arnold and *P. auburyi* Arnold it is distinguished by its larger size and the more rounded shape of its ribs; from *P. vogdesi* Arnold, by the fact that the shell in *P. heimi* does not flatten out at the ventral margin as does *P. vogdesi,* and *P. heimi* has a greater number of ribs than Arnold's species. *P. heimi* differs from *P. hartmanni* Hertlein, in being longer in proportion to the altitude, less inflated, and in possessing differently shaped ears. From *P. aztecus* Böse, *P. heimi* is distinguished by the fewer, more rounded, broader ribs, in the present species; furthermore, *P. heimi* is larger and apparently more convex.

This species is named in honor of Dr. Arnold Heim, whose work has added much to the knowledge of the geology of Lower California.

5. **Pecten (Pecten) beali** Hertlein, new species

Plate 2, figure 3; plate 5, figure 8

Shell inequivalve, plano-convex, equilateral, the ventral margin evenly rounded. Right valve convex, ornamented by about 23 or 24 prominent, square, flat-topped, strongly medially sulcate radial ribs, with in some cases, fainter radial grooves superimposed; interspaces flat-bottomed and slightly narrower than the ribs, the whole surface sculptured by fine, regular, concentric lines; posterior ear sculptured by about four radial riblets, and by fine incremental lines. Left valve flat or slightly concave, ornamented by about 21 radiating ribs

separated by flat-bottomed interspaces, each of which bears a single small intercalated riblet, the ribs and interspaces crossed by fine concentric lines; a somewhat depressed area is found just below the beak; margins of shell somewhat concave, bearing four or five radiating ribs and fine concentric imbricating lines; ears somewhat concave, ornamented by three or four radiating riblets and by fine concentric lines of growth. Altitude 55 mm.; longitude 56 mm.; diameter of right valve approximately 10 mm.; apical angle of right valve approximately 114°.

Type: Right valve, No. 55 (L.S.J.U. type collection), from Loc. 64 (L.S.J.U.), pebbly sandstone near Comondú-Salada contact, **Arroyo near La Palma, Lower California**; *Paratype:* Left valve No. 56 (L.S.J.U. collection), B. F. Hake collector, Salada, Pliocene.

Pecten beali appears to be related to *P. carrizoensis* Arnold, but is larger, and the ribs are more numerous and more deeply sulcate. On the left valve the radial interspaces are ornamented by small midribs which are lacking in Arnold's species. *P. carrizoensis* also is longer in proportion to the height than *P. beali.*

This species is named in honor of Mr. C. H. Beal, whose information concerning Lower California has been much appreciated by the writer.

6. **Pecten (Lyropecten) modulatus** Hertlein, new species

Plate 3, figure 6

Shell moderately convex, fairly heavy, showing slight areas of constricted growth. Right valve ornamented by about 14 longitudinally sculptured radiating ribs, which are rounded in the earlier part of the shell, but which, toward the ventral margin, show a tendency to become flattened; interspaces of varying width but all narrower than the ribs, all containing a small midrib; anterior and posterior margins of shell ornamented by fine longitudinal riblets; ears unequal, the anterior ear large, with large byssal notch and sculpture consisting of about seven well defined radial riblets and concentric growth lines, the left ear small in comparison with the large right, its

posterior edge sloping down almost vertically to the margin of shell, the surface of the ear ornamented by about eight or more radiating riblets over which are superimposed fine longitudinal and concentric lines. Altitude 58 mm.; longitude 60 mm.; diameter of right valve approximately 14 mm.; apical angle, right valve approximately 92°.

Type: Right valve, No. 39 (L.S.J.U. type collection), from Loc. 43 (L.S.J.U.), **Mesa west of Mesa de las Auras, Scammon Lagoon Quadrangle, Lower California;** B. F. Hake collector; Salada, Pliocene.

Pecten modulatus bears some resemblance to *P. vaughani* Arnold, but is much larger and also has sculptured margins and prominent midriblets in the interspaces, while in *P. vaughani* the interspaces bear fine striæ only.

7. **Pecten (Lyropecten) pretiosus** Hertlein, new species

Plate 2, figure 6; plate 3, figure 4

Shell small. Right valve moderately arched, and ornamented by about 17 or 18 rounded, radiating ribs, separated by somewhat narrower interspaces; ribs and interspaces sculptured by fine, radiating lines and crossed by fine, concentric lines of growth; anterior and posterior margins turning down abruptly, and smooth except for incremental striæ; ventral margin rounded and turned down abruptly; anterior ear with a distinct byssal notch, and a slight groove also present between ear and margin of shell; about five radiating riblets crossed by incremental lines ornament the ear; posterior ear sculptured by about six or seven radiating riblets, crossed by incremental striæ, the ear sloping downward and slightly posteriorly from the hinge line. Left valve ornamented by about 14 or 15 radiating ribs, the whole surface with sculpture similar to that of right valve; ears sculptured much as on right valve. Altitude 27 mm.; longitude 29 mm.; diameter of right valve approximately 10 mm.; apical angle of right valve approximately 87°.

Type: Right valve, No. 38 (L.S.J.U. type collection), from Loc. 59 (L.S.J.U.), Turritella bed above San Gregorio Lagoon, **120 miles north of Magdalena Bay, Lower California,** on the

trail from Arroyo Mesquital to La Purisima; *Paratypes:* No. 1770 (C.A.S. collection), from Loc. 59 (L.S.J.U.), and Nos. 89 (L.S.J.U. collection), and 1771 (C.A.S. collection), from Loc. 57 (L.S.J.U.), La Purisima Cliffs, on San Ramón River, Lower California; E. Call Brown collector; Isidro formation, Lower Miocene.

The characteristic shape, sculpture, and shape of ears distinguish this beautiful little Pecten from other species.

8. **Pecten (Aequipecten) percarus** Hertlein, new species

Plate 2, figures 2 and 5

Shell moderately large, equilateral, subequivalve, moderately thin, somewhat compressed, the outline round. Right valve ornamented by about 22 moderately strong, rounded ribs, separated by round-bottomed interspaces which are not quite as wide as the ribs; ribs and interspaces sculptured by regular, wavy, incremental lines, and, at irregular intervals, by stronger lines of growth; hinge line about one-half as long as the disk and slightly indented at the beaks; ears unequal, the anterior with a large byssal notch and sculpture consisting of about six or seven radiating riblets, the posterior ear ornamented by about seven radiating riblets, both ears sculptured by incremental lines. Left valve more arched and sharper at umbo than right, and somewhat one-sided in appearance, the disk ornamented by about 25 or 26 rounded, radiating ribs, and also concentrically sculptured much as on right valve; ears ornamented by about six or seven radiating ribs, crossed by concentric incremental lines; ears slightly concave, anterior with a slight byssal notch. Altitude 82 mm.; longitude 91 mm.; diameter approximately 12 mm.; apical angle of valves approximately 118°.

Type: No 42 (L.S.J.U. type collection), from Loc. 48 (L.S.J.U.), **mouth of large arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California;** *Paratypes:* No. 43 (L.S.J.U. collection) and Nos. 1768, 1769 (C.A.S. collection), B. F. Hake collector, Salada Pliocene.

This species is also found at Loc. 76 (L.S.J.U.), Salada on white clay northwest of Elephant Mesa west of Arroyo,

Scammon Lagoon Quadrangle, Lower California; B. F. Hake collector; Salada, Pliocene. Also Loc. 928 (C.A.S.), Cedros Island; G. D. Hanna collector; Upper Pliocene. Also Loc. 930 (C.A.S.), from Turtle Bay, Lower California; G. D. Hanna collector; Salada, Pliocene.

Pecten percarus is distinguished from other west American Aequipectens by its large size, number of ribs, and its clear concentric incremental lines.

9. **Pecten (Plagioctenium) purpuratus** Lamarck

Plate 1, figure 1; plate 4, figures 2 and 4

1836. *Pecten purpuratus* LAMARCK, Hist. des Animaux sans Vertebres (edition by Deshayes and Edwards), Vol. 7, 1836, p. 134.
1843. *Pecten purpuratus* LAMARCK, SOWERBY, Thesaurus Conch., Vol. 1, 1843, p. 53, pl. 15, fig. 113; pl. 16, figs. 123-125.
1855. *Pecten purpuratus* LAMARCK, REEVE, Conchologia Iconica, Vol. 8, 1855, *Pecten*, pl. 5, fig. 25.
1910. *Pecten purpuratus* LAMARCK, DALL, Proc. U. S. Nat. Mus., Vol. 37, 1910, p. 149, pl. 26, figs. 5, 6.

Lamarck's description is as follows:

"P. testa alba, purpureo et nigro purpurascente varia; radiis 26, convexis; intus zona purpureo-nigricante."

Dall's description is as follows:

"Shell orbicular, moderately convex, subequivalve, rather thin, with about 26 flat-topped ribs, laterally fringed, and separated by channeled interspaces; colors white, rose color, and different shades of purple distributed in an irregular manner; the interior zoned with blackish purple."

Dall gave the recent distribution as being from Coquimbo, Chile, northward to Ecuador.

The three heavy, radiating riblets on the anterior ear of the right valve, and the sharply serrated edges of the radial ribs are characteristic of *Pecten purpuratus* Lamarck. *P. purpuratus* is found at the present time in the waters of the Peruvian province in the Pacific ocean. It occurs in the Pliocene and Pleistocene of Chile, but has not been reported previously from the Tertiary north of Panama. Specimens have been identified

from the Salada Pliocene at Turtle Bay, Lower California, and from the Pliocene of Cedros Island. The right valve figured in this paper came from Turtle Bay, the left from Cedros Island.

Possibly the left valve described as *P. subventricosus* by Dall from southern California and referred to *P. cerrosensis* by Arnold, is identical with *P. purpuratus* Lamarck.

10. **Pecten (Plagioctenium) cerrosensis** Gabb

Plate 6, figure 1

1869. *Pecten cerrosensis* GABB, Geol. Surv. Calif., Pal., Vol. 2, 1869, p. 32, pl. 9, figs. 55, 55a.

1906. Not *Pecten (Plagioctenium) cerrosensis* GABB, ARNOLD, Prof. Paper U. S. Geol. Survey, No. 47, 1906, pp. 123-124, pl. 44, fig. 5; pl. 49, figs. 1, 1a, 1b.

Gabb's original description is as follows:

"Shell equivalve, subcircular, broader than long, convex; beaks small; sides sloping concavely above, rounded below; ears small, subequal, roughened and irregular, sinus very small. Surface marked by eighteen or twenty flat ribs, with flat or slightly concave interspaces; margins undulated, the ends of the ribs being deeply emarginated, and the interspaces being prolonged into tongue-like processes."

"*Locality:* Cerros Island, off the coast of Lower California: probably Miocene. Collected by Dr. J. A. Veatch."

The dimensions of the type are approximately: altitude 210 mm.; longitude 220 mm.; diameter 90 mm. It is No. 1091 (Univ. Calif. Coll.) and is figured herewith through the kindness of Prof. Bruce L. Clark.

It appears to the writer that several different species have been assigned to *P. cerrosensis* Gabb. Having examined the type which is in the collections of the University of California, it appears that the description and figures given by Arnold can hardly belong to the species described by Gabb; the description and figures given by Arnold do not coincide with the type, original figure or description. *P. cerrosensis* Gabb has 18 to 20 ribs, a very slight byssal notch, and the ears, except for growth lines, are perfectly smooth, while in the figures shown by Arnold a deep byssal notch is present in the anterior

ear of the right valve, there are more than 20 radiating ribs, and the ears are sculptured by radiating riblets. As stated elsewhere in this paper, one of Arnold's figures may be *P. purpuratus* Lamarck, and the others appear to be *P. subdolus* Hertlein.

The slight byssal notch, unsculptured ears, and the number of ribs are characteristic of *P. cerrosensis.*

11. **Pecten (Plagioctenium) cerrosensis mendenhalli** Arnold

Plate 1, figure 5

1906. *Pecten (Plagioctenium) cerrosensis* var? *mendenhalli* Arnold, Prof. Paper U. S. Geol. Survey, No. 47, 1906, pp. 84-85, pl. 25, figs. 2, 2a, and 2b.

Arnold's original description is as follows:

"Shell, when adult, averaging about 75 millimeters in altitude. Similar to *P. cerrosensis* in shape, convexity, and ribbing, but differing from the latter in being much smaller when adult, having fewer ribs (about 19 in the former, while the latter has usually 21 or more), much less prominent incremental lines, and a relatively longer hinge line."

"Dimensions (of a medium-sized specimen).—Alt. 43 mm.; long. 44 mm.; hinge line 28 mm.; diameter 17 mm."

"The type is from beds of probable Miocene age (the equivalent of the Carrizo Creek beds) at Santa Rosalia, Lower California, directly west of and across the Gulf of California from Guaymas, Mexico."

Several different species have been referred to *Pecten cerrosensis mendenhalli* Arnold by various workers. A specimen from near the type locality is figured herewith. This form is apparently more closely related to the true *P. cerrosensis* Gabb than are the other forms referred to the latter by Arnold.

It should be mentioned that Gabb's original description of *P. cerrosensis* states that the ribs are 18 to 20 in number and not 21 or more.

12. **Pecten (Plagioctenium) calli** Hertlein, new species

Plate 4, figures 5, 6 and 7

Shell small, inequivalve. Right valve slightly arched, ornamented by about 16 or 17 rather high, narrow, rounded, radiating ribs separated by interspaces of about the same width as

the ribs; anterior ear with a large byssal notch and sculpture consisting of about five radiating riblets crossed by concentric lines of growth; posterior ear sculptured by radiating riblets crossed by concentric lines of growth. Left valve slightly prolonged posteriorly, much more highly arched than right, and sloping rather abruptly from the umbos, sculptured by about 19 well developed, rather sharp, rounded, radiating ribs separated by interspaces about as wide as the ribs, ribs and interspaces crossed by fine concentric lines; ears slightly concave, the anterior with a small notch and ornamentation consisting of five or six radiating riblets crossed by concentric lines of growth; posterior ear slightly prolonged at the hinge line, sculptured as right. Altitude 24 mm.; longitude 24 mm.; diameter of left valve approximately 7 mm.; apical angle approximately 90°.

Type: Left valve, No. 68 (L.S.J.U. type collection), from Loc. 53 (L.S.J.U.), **first arroyo east of Santiago, Lower California,** C. R. Swarts collector; Miocene? *Paratype:* No. 125 (L.S.J.U. collection), same locality as the type; also No. 126 (L.S.J.U. collection), from Loc. 63 (L.S.J.U.), intersection of Arroyo Fortuna with Arroyo Refugio, near San José del Cabo, Lower California, C. R. Swarts collector; also No. 127 (L.S.J.U. collection) from Loc. 60 (L.S.J.U. collection), west side of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California, B. F. Hake collector: Isidro formation, Lower Miocene; also No. 1772 (C.A.S. collection), from Turtle Bay, Lower California, E. C. Johnson collector; Pliocene.

Pecten calli differs from *P. andersoni* Arnold, in its narrower ribs and more highly arched left valve. From *P. discus* Conrad, and *P. raymondi* Clark, the present species is distinguished by the differently shaped ribs and less circular outline of the valves. From *P. deserti* Conrad and *P. impostor* Hanna, *P. calli* is distinguished by its high narrow, rounded ribs and only slightly arched right valve. From *P. santarosanus* Böse, *P. calli* is distinguished by the fewer higher ribs and by the presence of a profound rounded notch in the posterior ear of the left valve of the present species, which notch is lacking in *P. santarosanus.*

July 21, 1925

This species is named in honor of Mr. E. Call Brown, whose collection has added to the knowledge of the stratigraphy of Lower California.

13. **Pecten (Plagioctenium) hakei** Hertlein, new species

Plate 4, figures 1 and 3

Shell moderately arched, coarse and thick, slightly longer than high. Right valve ornamented by about 23 or 24 rounded to slightly flat-topped ribs, separated by narrower, round-bottomed interspaces, both the interspaces and ribs crossed by concentric incremental lines, and, in some cases, by rather strong lines of growth; anterior ear with a large byssal notch, and sculpture consisting of about five or six radiating riblets, crossed by concentric incremental lines; anterior and posterior margins of valves smooth except for concentric incremental lines; ventral margin rounded; posterior ear ornamented by about eight radiating riblets and by lines of growth, the posterior edge of the ear forming nearly a right angle with the hinge line. Left valve convex, higher at the umbo than the right valve, and ornamented by about 24 or 25 squarish, flat-topped, rounded ribs, separated by narrower, round-bottomed interspaces, the whole valve sculptured by concentric lines of growth; ears slightly concave, ornamented by about six or seven radiating riblets. Altitude 90 mm., longitude 95 mm.; diameter of right valve approximately 15 mm.; apical angle of right valve approximately 114°.

Type: Right valve, No. 40 (L.S.J.U. type collection), from Loc. 47 (L.S.J.U.), **Turtle Bay, Lower California**; *Paratypes:* No. 41 (L.S.J.U. collection) and Nos. 1773, 1774 (C.A.S. collection), B. F. Hake collector; Salada, Pliocene.

This species is also found at Loc. 46 (L.S.J.U.), post-Eocene sandstone, at north edge of a tilted mesa about five miles north of Abreojos Point, Ballenas Bay Quadrangle, Lower California, B. F. Hake collector; Salada, Pliocene; also Loc. 42 (L.S.J.U.) above San Juan Arroyo, about five miles southwest of Jesus Maria, Jesus Maria Quadrangle, Lower California, C. H. Beal collector; Salada, Pliocene.

Pecten hakei differs from *P. cerrosensis mendenhalli* Arnold in its larger size, more numerous ribs and stronger concentric sculpture and large byssal notch. It differs from *P. purpuratus* Lamarck in bearing more numerous ribs, and in having a less rounded outline; also in lacking the lateral serrations on the radial ribs which characterize *P. purpuratus.* From *P. cerrosensis* Gabb, proper, it is distinguished by the much larger byssal notch in the anterior ear of the right valve, by the strongly sculptured ears, which, except for growth lines, are smooth in *P. cerrosensis,* and by the number of ribs, 23 to 24 in the present species rather than 18 to 20 in the species described by Gabb.

This species is named in honor of Mr. B. F. Hake, who collected considerable material which has added to the knowledge of the stratigraphy of Lower California.

14. **Pecten (Plagioctenium) cristobalensis** Hertlein, new species

Plate 3, figures 1, 2 and 5

Shell large, fairly thick, in several specimens with strong lines of restricted growth; valves moderately arched. Right valve ornamented by about 24 flat-topped, squarish, radiating ribs, separated by flat-bottomed, slightly narrower, interspaces, the whole surface crossed by well defined, wavy, concentric lines of growth; anterior and posterior margins of valve smooth except for concentric incremental sculpture; ventral margin evenly rounded; ears unequal, the anterior ear with a large byssal notch, and ornamented by about five radiating riblets crossed by concentric lines of growth; the posterior ear also bearing about five or six radiating riblets crossed by growth lines. Left valve slightly more convex than right and sculptured much as the latter, the anterior and posterior margins with concentric lines of growth only; ears ornamented by about eight or nine radiating riblets, the anterior ear with a slight notch. Altitude 117 mm.; longitude 135 mm.; diameter right valve approximately 17 mm.; apical angle of right valve approximately 100°-110°.

Type: Right valve, No. 36 (L.S.J.U. type collection), from Loc. 49 (L.S.J.U.), **slopes of Salada three miles southeast of**

Turtle Bay, uppermost beds, San Cristobal Bay Quadrangle, Lower California; *Paratypes:* No. 37 (L.S.J.U. collection) and Nos. 1775, 1776 (C.A.S. collection), B. F. Hake collector; Salada, Pliocene.

The species was also found at Loc. 48 (L.S.J.U.), at the mouth of a large arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California.

Pecten cristobalensis is distinguished from *P. cerrosensis mendenhalli* Arnold, by its squarish, more numerous ribs. The greater number of radial, squarish ribs, separated by narrower interspaces, and the less strong development of concentric incremental lines, distinguish the present species from *P. cerrosensis* Gabb proper. *P. cristobalensis* has a large byssal notch in the anterior ear of the right valve, and the ears are more strongly sculptured by radiating riblets than in *P. cerrosensis,* in which the byssal notch is very slight, and, except for lines of growth, the ears are smooth. From *P. callidus* Hertlein, *P. cristobalensis* differs in the more numerous ribs, different ears, and rounder outline. The distinction between the present species and *P. purpuratus* Lamarck is based largely upon the character of the radial ribs and of the anterior ear of the right valve. The ribs of *P. purpuratus* are wider and lower than those of *P. cristobalensis;* and conversely, the interspaces are narrower in *P. purpuratus;* furthermore the ribs of the latter species expand much more rapidly toward the ventral margin than do those of *P. cristobalensis.* The lateral serrations on the radial ribs, so strongly developed in Lamarck's species, are very slight in the present form. The presence of three very strong ribs on anterior ear of right valve of *P. purpuratus* with only a vestige of a fourth, rather than five less strong riblets as in *P. cristobalensis,* is also an evident and apparently constant difference.

15. **Pecten (Plagioctenium) subdolus** Hertlein, new species

Plate 5, figures 2, 4 and 7

1906. *Pecten (Plagioctenium) cerrosensis* GABB, ARNOLD, Prof. Paper U. S. Geol. Survey, No. 47, 1906, pp. 123-124, (ex parte), pl. 49, figs. 1, 1a, 1b.

1869. Not *Pecten cerrosensis* GABB, Geol. Surv. Calif., Vol. 2, 1869, p. 32, pl. 9, figs. 55, 55a.

Shell of medium size, the valves moderately convex. Right valve ornamented by about 21 rounded, radiating ribs which become broader toward the ventral margin, the ribs separated by round-bottomed, narrower interspaces, the whole surface ornamented by very fine radial striations and by concentric lines of growth; anterior and posterior margins sculptured only by concentric incremental lines; ventral margin rounded; ears unequal, the anterior with a well defined byssal notch, and sculpture of about six radiating riblets crossed by incremental lines; the posterior also sculptured by about six or seven slight radiating riblets crossed by lines of growth, a very slight notch present. Left valve more arched than right and somewhat one-sided in appearance, ornamented by about 21 rounded, radiating ribs separated by round-bottomed interspaces about as wide as the ribs, the whole surface finely longitudinally striate and crossed by concentric lines of growth; ears slightly concave, the posterior sculptured by very slight radiating riblets and concentric lines of growth, the anterior with a rounded notch, the surface sculptured by a few very slight radiating riblets and by concentric growth lines, the ornamentation indistinct on weathered specimens. Altitude 50 mm.; longitude 50 mm.; diameter approximately 17 mm.; apical angle in each valve approximately 105°.

Type: No. 51 (L.S.J.U. type collection), from Loc. 115 (L.S.J.U.), **Pacific Beach, San Diego, California;** *Paratypes:* No. 52 (L.S.J.U. collection), and No. 1777 (C.A.S. collection), C. H. Sternberg collector; San Diego, Pliocene.

This species also occurs at Loc. 116 (L.S.J.U.), in the Pliocene of Cedros Island, from which locality a specimen attains an approximate height of 110 mm.; length 110 mm.; diameter 30 mm.

From *P. cerrosensis, P. subdolus* differs in its more numerous rounded ribs, large byssal notch, sculptured rather than smooth ears and usually smaller size. It differs from *P. callidus* in its rounded ribs which are not as high as those of the latter, in the presence of fine radial striæ on the disk, and in the less strong sculpture of the ears in the present species.

16. **Pecten (Plagioctenium) callidus** Hertlein, new species

Plate 5, figures 1, 3, 5 and 6

Shell of medium size, the valves moderately arched. Right valve ornamented by about 21 or 22 rather high, flat-topped, radiating ribs separated by narrower interspaces, tops of ribs smooth, but sides and interspaces sculptured by fine, sharp lamellæ; anterior and posterior margins sculptured by concentric lines of growth only; ventral margin rounded; ears unequal, the anterior with a large byssal notch and ornamented by about five or six radiating riblets crossed by concentric lines of growth; the posterior sculptured by several radiating riblets. Left valve more convex than right and somewhat one-sided in appearance, with sculpture quite similar to that of right valve except that the interspaces are slightly wider; anterior ear carrying a small, rounded notch and ornamentation consisting of small, radiating riblets and concentric lines of growth; posterior ear sculptured much as the anterior. Altitude 55 mm.; longitude 55 mm.; diameter 19 mm.; apical angle of valves approximately 105°.

Type: No. 53 (L.S.J.U. type collection), from Loc. 116 (L.S.J.U.), **Cedros Island, Lower California;** *Paratypes:* No. 54 (L.S.J.U. collection), H. Hemphill collector; Salada, Pliocene.

This species was found also at Loc. 48 (L.S.J.U.), from mouth of big Arroyo northwest of Elephant Mesa, Scammon Lagoon Quadrangle, Lower California; B. F. Hake collector; Salada Pliocene.

In the Fernando Lower Pliocene of southern California, at several localities, this species also appears to be quite abundant.

Pecten callidus differs from *P. subdolus* Hertlein in having higher, narrower, smooth rather than striate, flat-topped ribs, the interspaces crossed by very fine lamellæ which are largely lacking in *P. subdolus.* It differs from *P. cerrosensis* Gabb, in its larger byssal notch, radially sculptured ears, more numerous ribs, and usually smaller size. Possibly *P. callidus* was the square-ribbed species from the Fernando formation of southern California which Arnold referred to *P. cerrosensis.*

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PLATE I

Fig. 1. *Pecten* (*Plagioctenium*) *purpuratus* Lamarck; X⅔; plesiotype, left valve, No. 90 (L. S. J. U. Type Coll.), from Loc. 116 (L. S. J. U.), Cedros Island, Salada Pliocene; p. 14.

Fig. 2. *Pecten* (*Pecten*) *refugioensis* Hertlein, new species; natural size; type right valve, No. 49 (L. S. J. U. Type Coll). ,from Loc. 50 (L. S. J. U.), Rancho Refugio, north of San Jose del Cabo, Lower California. Upper Miocene or Lower Pliocene; p. 7.

Fig. 3. *Pecten* (*Pecten*) *heimi* Hertlein, new species; X⅔; type, right valve, No. 46 (L. S. J. U. Type Coll.), from Loc. 65 (L. S. J. U.), southern part of San Gregorio Arroyo, Lower California; p. 9.

Fig. 4. *Pecten* (*Pecten*) *hartmanni* Hertlein, new species; X⅔; type, right valve, No. 48 (L. S. J. U. Type Coll.), from Loc. 54 (L. S. J. U.), Arroyo Mesquital, Lower California. Above the yellow silts which are well exposed in this arroyo. Lower Pliocene?; p. 8.

Fig. 5. *Pecten* (*Plagioctenium*) *cerrosensis mendenhalli* Arnold; X⅔; plesiotype, right valve, No. 91 (L. S. J. U. Type Coll.), from Loc. 62 (L. S. J. U.), float five kilometers north of Santa Rosalia, Lower California. Carrizo, Lower Pliocene? p. 16.

Fig. 6. *Pecten* (*Pecten*) *hartmanni* Hertlein, new species; natural size; type, same specimen as figure 4; p. 8.