



FIGURE 2—1–12, *Astrodapsis bajasurensis* n. sp., locality CSUN 1495. ① holotype, IGM 5926, aboral view,  $\times 2.1$ . ② paratype, IGM 5927, aboral view,  $\times 2.7$ . ③ paratype, IGM 5928, oral view,  $\times 2.7$ . ④⑤ holotype, IGM 5926,  $\times 2.2$ . 4, anterior view; 5, left-lateral view. ⑥ paratype, IGM 5929, cut-away figure showing the internal buttressing of right-lateral half of test,  $\times 2.2$ . ⑦ paratype, IGM 5930, posterior view,  $\times 3.9$ . ⑧ paratype, IGM 5931, aboral view of largest specimen found at locality CSUN 1495,  $\times 1.3$ . 9, paratype, IGM 5932, interior view showing lantern supports,  $\times 3.3$ . 10, 11, paratype, IGM 5930,  $\times 3.9$ . ⑩ aboral view showing plate patterns, ⑪ oral view showing plate patterns with interambulacra 2 and 3 continuous. 12, paratype, IGM 5933, oral view showing plate patterns with all interambulacra discontinuous,  $\times 3.3$ .

*Remarks.*—Gonopores are not present until specimens reach a length of about 10.5 mm. This development marks the onset of sexual maturity. Branching of the food grooves on the oral side of the test does not become apparent until specimens reach a length of about 12 mm. The posterior interambulacral lobelike protrusion is present in the smallest specimens found (i.e., 7 mm in length).

In those specimens that do show the plate patterns, about half have oral interambulacra 2 and 3 continuous and oral interambulacra 1, 4, and 5 discontinuous (Figure 2.11). These specimens are 19 mm in length or less. The other specimens that show plate patterns have all the oral interambulacra discontinuous (Figure 2.12), and these specimens are usually greater than 19 mm in length. There is some overlap, however, in the size groups between these two types of plate patterns on the oral surface. Some specimens between 15 and 19 mm in length have oral interambulacra 2 and 3 continuous, and other specimens in this size range have all the interambulacra discontinuous. In rare specimens of the new species, the width of the test is slightly greater than the length.

The test of the new species is slightly ovoid and widest posteriorly. In addition, the apical system is slightly eccentric, and on the oral surface the posterior interambulacra are discontinuous. These features have all been observed in other sand dollars, both modern and fossil (including *Astrodapsis brewerianus*), and have been shown to be the result of unequal growth patterns (Beadle, 1989).

The new species was compared to all previously known astrodapsids. Since 1856, workers had named a total of 59 species, subspecies, and varieties from California (Hall, 1962, p. 48), and a large number of these names were erected by Grant and Eaton (in Eaton et al., 1941). Hall (1962) reduced these 59 species, subspecies, and varieties to 12 species. The type specimens of Grant and Eaton (in Eaton et al., 1941) and the hypotypes and other type specimens illustrated by Hall (1962) are now stored at LACMIP. These specimens were examined during the course of the present investigation, as were specimens of various species of *Astrodapsis* collected by the senior author from the Branch Canyon Formation in the vicinity of Branch Canyon, south of New Cuyama, Santa Barbara County, California.

The new species is most similar to a few (but not all) specimens of *Astrodapsis diabloensis* Kew (1920) and to some (but not all) specimens of *A. brewerianus* var. *bitterensis* Grant and Eaton (in Eaton et al., 1941). *Astrodapsis diabloensis* is a morphologically variable species that, according to Hall (1962, p. 67–68), is synonymous with many of the taxa that Grant and Eaton (in Eaton et al., 1941) named, including *A. brewerianus* var. *bitterensis*.

The specimens of *Astrodapsis diabloensis* that are most similar to the new species are from the upper Miocene Santa Margarita Formation, San Luis Obispo County, southern central California. Examples of these types of specimens of *A. diabloensis* are illustrated by Hall (1962, Pl. 1, figs. 10, 12–14, 17, 20). The specimens of *A. brewerianus* var. *bitterensis* that are most similar to the new species are from the Branch Canyon Formation, Branch Canyon area, south of New Cuyama, Santa Barbara County, California. Perri and Fritsche (1988) assigned the Branch Canyon Formation in the Branch Canyon area to the middle Miocene. An example of this type of specimen of *A. brewerianus* var. *bitterensis* is illustrated by Grant and Eaton (in Eaton et al., 1941, Pl. 5, fig. 9).

The new species differs from the above-mentioned specimens of *Astrodapsis diabloensis* and its junior synonym *A. brewerianus* var. *bitterensis* in the following features: ambitus much more indented, petaloids bisected by a prominent food groove, petal-

TABLE 1—Dimensions (in mm) of the type specimens of *Astrodapsis bajasurensis* n. sp.

IGM specimen	Length	Width	Height
5926	29.5	27.0	5.7
5927	22.5	20.6	4.5
5928	22.5	20.7	3.9
5929	27.8	*	4.4
5930	15.8	14.9	2.7
5931	38.5	36.6	6.8
5932	31.4	*	*
5933	18.9	17.0	3.1

\* Incomplete specimen, measurement not possible.

oids narrower and more elevated, petaloids not as open near margin and do not flare, interporiferous areas on petaloids twice as wide rather than three times as wide as poriferous areas, trifurcating food grooves on oral surface, and posterior aboral interambulacral area with two food grooves and corresponding indentations at ambitus. The new species shows the following additional differences when compared to the rest of the many illustrated specimens of *A. diabloensis* in Hall (1962): posterior lobe region present, petaloids do not flare near the margin, and poriferous areas converge toward ambitus.

The new species superficially resembles a few (but not all) specimens of *Astrodapsis pabloensis* (Kew, 1915) from the Branch Canyon Formation, Branch Canyon area, south of New Cuyama, Santa Barbara County, California, and from the Santa Margarita Formation, San Luis Obispo County, California. An example of this type of specimen of *A. pabloensis*, which has moderately elevated petaloids and a distinct posterior lobe, is illustrated in Hall (1962, Pl. 7, fig. 1). The new species differs in the following features: test more elongate and usually smaller, ambitus much more indented, periproct submarginal (in most specimens), petaloids less elevated, petaloids bisected by a prominent food groove, and poriferous areas much more convergent.

The new species also resembles *Vaquerosella tejonensis* (Kew, 1920, p. 76–77, Pl. 12, fig. 2a, 2b) from the lower Miocene upper Vaqueros Formation, Tejon Hills, Kern County, California. The new species differs in the following features: test more elongate, petaloids not flared, all petaloids somewhat elevated, odd anterior petaloid same size as other petaloids, poriferous area width narrower, distal ends of rows of pores converge, posterior and anterior parts of upper surface with even slopes, ambulacral food grooves on oral surface strongly developed and branching near margin, each interambulacral area with a pair of food grooves, a more notched ambitus, and periproct indentation much less prominent. *Vaquerosella* Durham, 1955, is closely related to genus *Astrodapsis*, and work is needed to establish how they interrelate.

Although the species-level taxonomy of the genus *Astrodapsis* is quite confusing, there are broad patterns in the evolution of the genus, and these patterns have long been recognized for their biostratigraphic value. Richards (1936), Grant and Hertlein (1938, p. 69), and Weaver et al. (1944) all recognized a succession of *Astrodapsis* zones in the provincial "upper Miocene" and "lower Pliocene" (now known to be middle and upper Miocene). In the comparisons discussed above, *Astrodapsis bajasurensis* n. sp. was reported to be most similar to *A. brewerianus* var. *bitterensis* and to *A. diabloensis*. Both of these are early forms and can be referred to the old "Briones" and "Cierbo" "Stages," as used by Eaton et al. (1941, fig. 12) and by Weaver et al. (1944). These units form the lower part of the "Margaritan Stage" (Addicott, 1972). As noted above in the geologic age discussion of the Isidro Formation, the "Margaritan