

TABLE 3—Measurements in mm of *Anchura callosa* Whiteaves. For abbreviations and symbols used, see introduction.

Specimen	H	Hp	Db	Dp	Dp/Hp	R	PA	S	Ct	Cp	A	Remarks
GSC 5790	56.6	8.4	16.7	13.0	1.55	—	23°	—	8	4	14	body + 7 whorls
CASG 28738.21	47.3	8.6	20.5	14.3	1.66	16.6	—	18.1	7	3	—	body + 1 whorl
CASG 27838.22	36.5	8.1	—	14.1	—	—	21°	—	8	4	14	7 spire whorls
CASG 27838.23	25.6	6.1	—	10.1	—	—	21°	—	8	4	12	6 spire whorls
LACMIP 11312	58.3	9.4	18.4	13.7	1.46	—	20°	—	8	4	15	body + 10 whorls
LACMIP 11313	22.8	4.0	—	6.7	—	—	20°	—	9	4	10	10 spire whorls
LACMIP 11314	48.5	7.7	17.0	12.5	1.62	15.1	—	—	8	4	—	body + 2 + rostrum
LACMIP 11315	38.6	7.5	14.6	—	—	—	23°	—	—	—	—	body + 5 whorls
LACMIP 11316	50.0	10.0	18.5	15.6	1.56	—	22°	12.0	8	4	14•	body + 4 whorls
LACMIP 11317	26.6	7.0	—	11.5	1.64	—	20°	—	11	6	12	5 spire whorls
LACMIP 11318	32.7	5.4	10.8	8.9	1.65	—	21°	—	7	4	12	juv. 8 whorls
LACMIP 11319	30.0	4.7	9.8	7.8	1.66	—	20°	—	—	—	—	juv. 11 whorls
LACMIP 11320	18.3	3.4	7.0	5.8	1.70	—	23°	—	7	4	14	juv. 8 whorls
LACMIP 11344	53.4	8.5	19.5	14.5	1.71	—	21°	—	8	5	15	body + 4 whorls

and no complete specimen has been recovered from that locality. Most specimens from this horizon have a narrower pleural angle and fewer axial ribs than do specimens farther up section, such as those from UCLA locality 3643. The specimen figured by Whiteaves (1879) as *A. stenoptera* from 2.25 miles up the Nanaimo River, Vancouver Island, British Columbia, resembles specimens from about 885 m above the base. That specimen, therefore, appears to fall within the range of the Chico Creek species but is not representative of its most distinctive form. In 1903, Whiteaves decided that he had been mistaken in identifying his Vancouver Island specimen with a species from Westphalia and provided the new name *Anchura callosa* for it. Accordingly, *A. callosa* is taken as the appropriate name for the Chico Creek species.

At the same time that Whiteaves (1903) provided a name, he reported the locality as "Trent River" without indicating that this was a rectification of his earlier locality description. Bolton (1965, p. 7) gave the locality as 2.5 miles up the Nanaimo River, also without indication that this was a correction for Whiteaves' published locality data. According to Muller and Jeletzky (1970, p. 32), Whiteaves' original locality "2 1/4 miles up the Nanaimo River" is within the Cedar District Formation and is the type locality of *Inoceramus vancouverensis* Shumard, 1859, which ranges through the *Submortoniceras chicoense* and *Hoplitoplacenticeras vancouverense* Zones (Ward, 1978, p. 416). A precise locality on the Trent River is not specified, but beds of the Pender Formation that have yielded *Submortoniceras chicoense* are present along the lower Trent River, Vancouver Island. (Haggart and Ward, 1989). The type locality of *Forsia popenoei* Saul, 1988, was inferred to be 2.5 miles up the Nanaimo River. This species occurs with *A. falciformis* and comes from a younger horizon than does *A. callosa* along Chico Creek, Butte County, California. Perhaps future collecting in the Nanaimo basin will elucidate which of the indicated localities would be the most probable provenance for the holotype of *A. callosa*.

Although Whiteaves' illustration strongly resembles *Anchura falciformis*, he did not mention *A. falciformis* and instead (Whiteaves, 1903) compared *A. callosa* to *Anchura transversa* Gabb (1869). "*Anchura*" *transversa* is based on a specimen 10 mm high and 12.4 mm in diameter including the wing (Stewart, 1927). Its horizon is uncertain, and it does not appear to belong in *Anchura*.

Specimen GSC 5790 appears to be somewhat worn, and the sculpture is subdued. The shell breakage on the body whorl of Whiteaves' (1879, plate 15, figure 11a) drawing corresponds with that of this specimen, but less outer lip is present and more of the spire is missing than in the illustration. The specimen has

either been additionally broken since the drawing was made, or the original was in part a reconstruction.

The last whorl of the protoconch is present on LACMIP 11319 but its surface is too poorly preserved to determine whether or not sculpture was present. The fifth? whorl, the first juvenile whorl, has faint remnants of fine, arched axial ribs. Two or three whorls display these arched ribs, which are approximately twice as numerous per whorl as the axial ribs on the adolescent whorls. The change from juvenile to adolescent sculpture is abrupt.

*Anchura callosa* differs from *A. phaba*, *A. gibbera*, and *A. baptos* in having stronger and fewer axial ribs, as well as more numerous and relatively weaker spiral cords. *Anchura callosa* further differs from *A. phaba* and *A. gibbera* in having a less protuberant callus pad.

**Type specimens.**—Holotype GSC 5790 (Bolton, 1965, p. 7). Hypotypes LACMIP 11312–11313 from UCLA locality 3635; LACMIP 11314–11317 from UCLA locality 3637, LACMIP 11318–11320 from UCLA locality 3643; CASG 27838.21 (ex 5794) (figured by Taff et al., 1940, plate 2, figure 9), CASG 27838.22 (ex 5794A) (Taff et al., 1940, plate 2, figure 7), CASG 27838.23 (ex 5794B) (Taff et al., 1940, plate 2, figure 8) from CASG locality 27838, Chico Creek, Butte County, California.

**Type locality.**—2.25 miles up the Nanaimo River, Vancouver Island, British Columbia (Whiteaves, 1979, p. 123); Trent River (Whiteaves, 1903, p. 359; 2.5 miles up the Nanaimo River. Vancouver Island, British Columbia (Bolton, 1965, p. 7).

**Measured specimens.**—See Table 3.

**Age.**—Santonian(?) to early middle Campanian, *Submortoniceras chicoense* Zone, *Turritella chicoensis holzana* Zone. This species is present in the lower part of the Tenmile Member of the Chico Formation on Chico Creek, throughout the zone of reversed magnetic polarity chron 33r and into the beginning of the succeeding normal polarity zone (from UCLA locs. 3632 to 3643).

**Geographic distribution.**—Cedar District Formation, Nanaimo Basin, Vancouver Island, British Columbia; lower part of the Tenmile Member of the Chico Formation on Chico Creek [from UCLA localities 3632 to 3643], lower beds near Pentz [UCLA locality 4340], Butte County, Tenmile Member of the Chico Formation on Deer Creek [LACMIP localities 15790 and 15792], and Mill Creek [UCLA localities 4662 and 4664], Tehama County, California.

#### ANCHURA FALCIFORMIS (Gabb, 1864)

Figure 4.1–4.12

*Aporrhais falciformis* Gabb, 1864, p. 127, pl. 20, fig. 83.

*Anchura falciformis* Gabb, 1864, Gabb, 1868, p. 145, pl. 14, fig. 14;

Gabb, 1869, p. 165; Grabau and Shimer, 1909, p. 755, fig. 1099; Stewart, 1927, p. 360, pl. 22, fig. 9; Shimer and Shrock, 1944, p. 497, pl. 203, fig. 26; Anderson, 1958, p. 165 (in part); Elder and Saul, 1993, pl. 3, fig. 4.

**Diagnosis.**—An *Anchura* with about 14 straight to slightly curved axial ribs per whorl; carina and axial ribs suppressed abaperturally on body whorl; whorl profile subangulate on spire with greatest curvature about at anterior third of whorl, angulate on body whorl.

**Description.**—Shell large, high-spired, drawn out anteriorly into a moderately long anterior rostrum; rostrum deflected abaperturally; pleural angle about 25 degrees; whorls about nine in number, unevenly convex, strongly carinate on last whorl; suture appressed. Protoconch apparently smooth, of four whorls, rapidly expanding. Three juvenile whorls scarcely expanding, with fine, curved axial ribs and very fine spiral cords, approximately twice as many ribs per whorl as on mature whorls. Adolescent whorls expanding as in adult, two whorls with coarser axial ribs and stronger spiral cords; next whorl with 12–14 axial ribs, medially angled giving appearance of a medial row of nodes; growth line antipirally concave on spire. Mature sculpture of both axial ribs and spiral cords; axial ribs straight to curved concavely toward the aperture, distant, about 14 on penultimate whorl, forming nodes where crossed by cords, nodes strongest on angulation; seven to eight cords on spire, fifth being strongest, forming bluntly noded keel on ultimate whorl, base of whorl with two strong cords and four to five weaker cords. Outer lip expanded into falcate wing with broad shank of moderate length and longer posterior arm; fifth spiral cord extended onto wing as keel near thickened posterior margin; anterior margin of wing expanded, slightly sinuous, and rounded anteriorly at posteriorward bend; wing interior channeled opposite keel; distal margin bent adaperturally; posterior arm inclined adaperturally at about 10 degrees to axis of spire. Aperture with broad posterior sulcus and broad anterior sulcus delineated posteriorly by parietal callus pad. Inner lip forming a broad, thin wash to whorl angulation and onto whorl face, developing an elongate, thick callus pad at two strong subperipheral spiral cords. Callus wash continued around base and onto base of rostrum.

**Remarks.**—Gabb's (1864) original figure of *A. falciformis* differs from topotype specimens in having the pleural angle 20 degrees, rather than about 26 degrees, lacking a carina on the last whorl, having a secondary spur on the shank, and in having a more sharply angled wing. However, Stewart (1927) considered this figure to be a synthetigraph, and the lectotype that he designated corresponds well to worn topotype specimens. Well-preserved topotypes commonly have finely beaded cords adiacal to the carina. No specimen of *A. falciformis* has been found to have a secondary spur on the shank.

The protoconch of *A. falciformis* described above is from a specimen (LACMIP 11326) from the Cedar District Formation on Sucia Island (UCLA locality 4878). UCLA 11323 has a rostrum 29.5 mm long and UCLA 11324 has a rostrum 29.3 mm long; both are from Butte Creek and in both the rostrum is about one-third of the height of the shell.

The whorl profile of *A. falciformis* is less angulate than that of *A. phaba* or *A. gibbera*, and *A. falciformis* has fewer axial ribs than *A. phaba*. Spiral cords of *A. falciformis* are more numerous than in *A. baptos* and the latter two species. The carina and axial ribs of *A. falciformis* are commonly suppressed on the abapertural side of the body whorl. Although the parietal callus pad is variable in size and shape, the callus pad of *A. falciformis* is usually less elongate and thicker than that of *A. callosa* but less protuberant than those of *A. baptos* and *A. gibbera*. *Anchura*

*falciformis* lacks the anteriorly directed prong at the bend in the wing that is present in *A. abrupta* and *A. gibbera*. *Anchura falciformis* has a narrower pleural angle than does *A. abrupta*, and a rostrum deflected backward rather than to the left. The wing of *Anchura falciformis* is more similar to that of *A. haydeni* White, 1879, from the Pierre Shale of Colorado, than to the wing of *A. abrupta*.

Anderson (1958, p. 41) reported *A. falciformis* from CASG locality 28323 on Del Puerto Creek, Stanislaus County, California, in the Panoche Formation, but that specimen is too poorly preserved to be identified to genus.

**Type specimens.**—Lectotype ANSP 4269; hypotypes LACMIP 12127, 11322–11324 from UCLA locality 6044, Butte Creek, LACMIP 11321 from UCLA locality 3648, Chico Creek, Butte County, LACMIP 11325 from CIT locality 1018, Pentz, Butte County, California, LACMIP 11326 from UCLA locality 4878, Sucia Island, San Juan County, UWBM 16734 from UWBM locality A9254, Sucia Island, San Juan County, Washington.

**Type locality.**—Chico Creek, Butte County, California

**Measured specimens.**—See Table 4.

**Age.**—Middle Campanian, late *Submortoniceras chicoense* Zone to *Hoplitoplacenticeras vancouverense* Zone; *Turritella chicoensis* Zone.

**Geographic distribution.**—Cedar District Formation, Sucia Island, San Juan County, Washington; Chico Formation, upper part of Tenmile Member, Chico Creek, Butte Creek, higher beds near Pentz, Butte County, and Tuscan Springs (UCLA locality 4082), Tehama County, California.

#### ANCHURA PHABA new species

Figure 5.1–5.13

*Anchura* aff. *A. falciformis* (Gabb, 1864). Elder and Saul, 1993, p. 184, pl. 2, figs. 3, 4. Not *Anchura falciformis* (Gabb, 1864).

**Diagnosis.**—An *Anchura* with about 20 arching axial ribs per whorl forming noticeable nodes on prominent keel (=4th or 5th spiral cord); axial ribs weaker than spiral cords; whorl profile subangulate, angulation at anterior one-third of whorl.

**Description.**—Shell large, high-spired, drawn out anteriorly into an anterior rostrum; pleural angle about 27 degrees; whorls about nine in number, slightly angulate at fourth spiral cord on spire, strongly carinate on last whorl; suture appressed; protoconch unknown; growth line antipirally concave on spire. Sculpture of both axial ribs and spiral cords; axial ribs curved concavely to the aperture, distant, about 20 on penultimate whorl, forming nodes where crossed by cords; cords dominant, especially on more mature whorls, six to seven cords on spire; cords noticeably noded, especially on penultimate and ultimate whorls; nodes strongest on angulation at fourth cord; base of whorl with two strong and at least two weaker cords; falcate wing with shank relatively short and broad; fourth spiral cord extended onto wing as keel near posterior margin; wing expanded anteriorly an unknown length at posteriorward bend. Anterior margin slightly sinuous. Rostrum nearly straight.

**Remarks.**—Although more than 30 specimens are identified as *A. phaba*, all are fragmental, and most are poorly preserved. No juvenile specimens without some exfoliation of the shell are known. In all available specimens of *A. phaba*, the anterior rostrum is broken; the longest preserved is that of LACMIP 11333, which is 14.6 mm long and nearly straight. The falcate wing is also incomplete; specimen USNM 468578 shows the shank and the posteriorward bend, but lacks the tip of the anterior extension and part of the posterior arm. That specimen suggests that the shank was relatively wide and short, and that

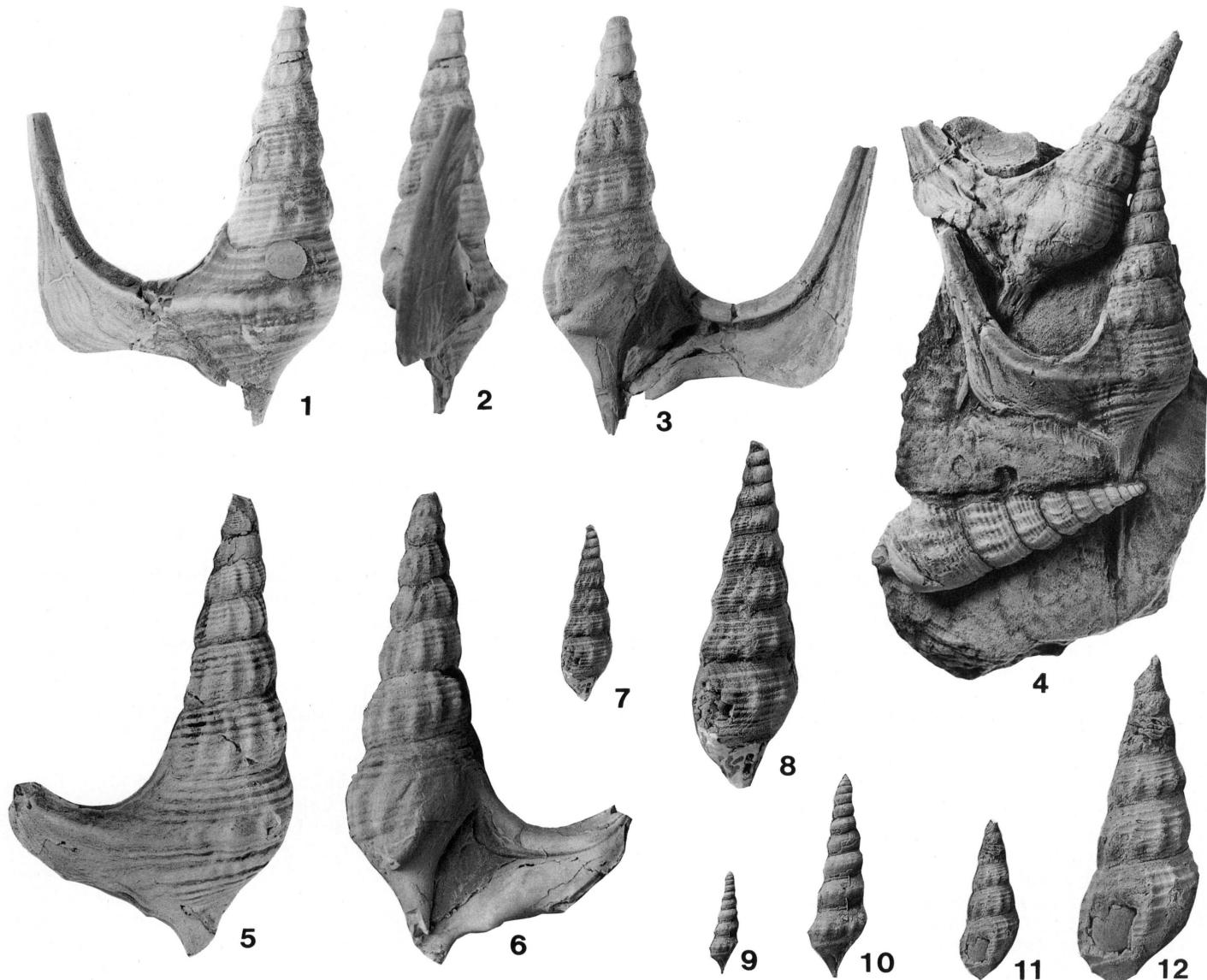


FIGURE 4—*Anchura falciformis* Gabb. 1–3, hypotype, abapertural, side, and apertural views,  $\times 1$ , LACMIP 12127, locality UCLA 6044; 4, hypotypes, slab with one unmeasured and two measured specimens,  $\times 0.75$ , LACMIP 11323 and LACMIP 11324, locality UCLA 6044; 5, 6, hypotype, abapertural and apertural views,  $\times 1$ , LACMIP 11321, locality UCLA 3648; 7, 8, hypotype, abapertural view,  $\times 1$  and  $\times 2$ , UWBM 16734, locality A9254; 9, 10, hypotype, abapertural view with protoconch,  $\times 1$  and  $\times 2$ , LACMIP 11326, locality UCLA 4878; 11, 12, hypotype, abapertural view,  $\times 1$  and  $\times 2$ , LACMIP 11325, locality CIT 1018.

the anterior expansion at the posteriorward bend was relatively broad and may have developed into a short spur. In general, *A. phaba* appears to have had the same type of wing as *A. falciformis*.

The geologically oldest of the specimens identified as *A. phaba* are from the Holz Shale Member of the Ladd Formation in the Santa Ana Mountains, Orange County. These and specimens from the stratigraphically lowest outcrops of the Chatsworth Formation in Bell Canyon, Ventura County, have slightly fewer axial ribs with larger nodes and a stronger whorl angulation on the spire than specimens from younger horizons such as the Pleasants Sandstone Member of the Williams Formation in the Santa Ana Mountains, Orange County, and higher beds of the Chatsworth Formation in Dayton Canyon, Los Angeles County. Specimens from Manzanita Mountain, Santa Barbara County,

also correspond to this younger morphology which has a stronger angulation on the body whorl. The holotype from Pigeon Point appears to have intermediate characteristics.

*Anchura phaba* differs from *A. falciformis* in having a more angulate whorl profile, more numerous axial ribs that are more concave, a keel lower on the whorl, stronger cords with stronger and more nodes on them, and the basal two cords more distant from each other. The inner lip of *A. phaba* is thicker, and the parietal callus pad is thicker and more elongate than in *A. falciformis*.

*Anchura phaba* has stronger nodes, more axial ribs per whorl, a more angulate whorl profile, and thicker inner lip and parietal callus pad than *A. callosa*. It is stouter than *A. gibbera* and has stronger nodes on the keel, a shorter and broader lateral arm, stronger axial ribs, and a less protuberant parietal callus pad.