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NEW AND LITTLE KNOWN MIDDLE PENNSYLVANIAN GASTROPODS FROM THE FLECHADO FORMATION, TAOS COUNTY, NEW MEXICO

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Abstract—The Desmoinesian part of the Flechado Formation near the town of Talpa, Taos County, contains one of the most diverse late Paleozoic gastropod faunas in North America. Five relatively common species from this fauna are described. New taxa include *Arribazona hesperia* (a new genus and species of murchisoniid related to *Cerithioides*), *Euconodoma gavinae* (a new genus and species of microdomatid), and *Strobeus poromus*, new species. The other two species considered here, *Pseudozygopleura? (Stephanozyga) subnodosa* and *Eucochlis perminuta*, were originally established by Knight on the basis of specimens from the Desmoinesian of Missouri, but seldom have been reported subsequently.

INTRODUCTION

Outcrops of the Flechado Formation in the Taos area contain a remarkably diverse Desmoinesian marine invertebrate fauna. Some elements of this fauna were initially described by White (1881). Later, Young (1942) discussed the cephalopods and the giant scaphopod *Prodentalium*, Sutherland and Harlow (1973) the brachiopods and Kues (1983) a single polyplacophoran valve from the Flechado in this area. Kietzke (this guidebook) has studied the microfossils. The Flechado fauna also includes a high number of gastropods; nearly 100 species have been identified at one locality south of the village of Talpa (Kues, 1984). This is one of the richest records of late Paleozoic gastropods in North America.

Since the work of White (1881), who described 11 species, the gastropods have seldom been discussed in the published literature (see Knight, 1933b, 1934 and Yochelson, 1956, for additional information on three species). Young (1945), in an unpublished doctoral dissertation, described about 35 gastropod species from what is now called the Flechado Formation at or near the Talpa locality. A few years ago, I briefly discussed the Flechado fauna and illustrated 35 of the more conspicuous gastropod taxa (Kues, 1984). Study of the gastropods has continued since that time, and manuscripts describing the species in several large groups (bellerophontids, pleurotomariaceans, murchisoniids) currently are in preparation. Ultimately, the entire gastropod fauna will be studied. Most of the Flechado species are known from the midcontinent and eastern parts of the U.S., but a significant component (perhaps 20%) are undescribed or are restricted to the Colorado–New Mexico–West Texas area.

In this paper, five species that are moderately common to abundant at the Talpa locality are described. Three are new species, distributed among two new and one previously established genera. The remaining two species were established originally by Knight (1930, 1933a) on the basis of specimens from the St. Louis, Missouri, outlier, but seldom have been reported since their initial description. Specimens discussed in this paper are in the University of New Mexico (UNM) paleontology collections, and in the collections of the U.S. National Museum of Natural History (USNM), Indiana University (IU) and the University of Kansas Museum of Invertebrate Paleontology (KU).

LOCATION AND STRATIGRAPHIC SETTING

The specimens were collected from slopes of Flechado strata along the east side of NM-518 (formerly NM-3), from about 2.5 to 3.5 km south of Talpa, Taos County, New Mexico (Fig. 1). Most of the sequence consists of relatively thick, dark gray, shale or siltstone units separated by thin conglomeratic to medium-grained, locally crossbedded sandstone beds. These strata dip steeply to the north and are cut by a high-angle fault just south of the Rio Chiquito. Variations in the thickness of some of the shale/siltstone beds are pronounced, but most of the sandstone bodies could be traced for hundreds of meters along the outcrop. This predominantly fine-grained sequence is overlain by a thick succession of marginal marine and fluvial sandstone units. Following the interpretation of Casey and Scott (1979) and Casey (1980) for Flechado beds in the immediate vicinity, the sandstone units represent delta-front and fluvial channel sediments deposited in fan-delta lobes that prograded intermittently across shallow, muddy, marine shelf and prodelta environments. This sequence is reliably dated as Desmoinesian (Casey, 1980; Kues, 1984).

Several stratigraphic sections were measured along a distance of about 0.5 km, and collections were made from numerous shale/siltstone intervals (Fig. 2). Fossils were collected from the surface of the outcrops and from bulk sediment samples that were washed, sieved and searched for tiny specimens. Preservation of the shells is generally excellent, although high-spired specimens typically had suffered breakage of their apices, and post-depositional distortion of some shells also occurred.

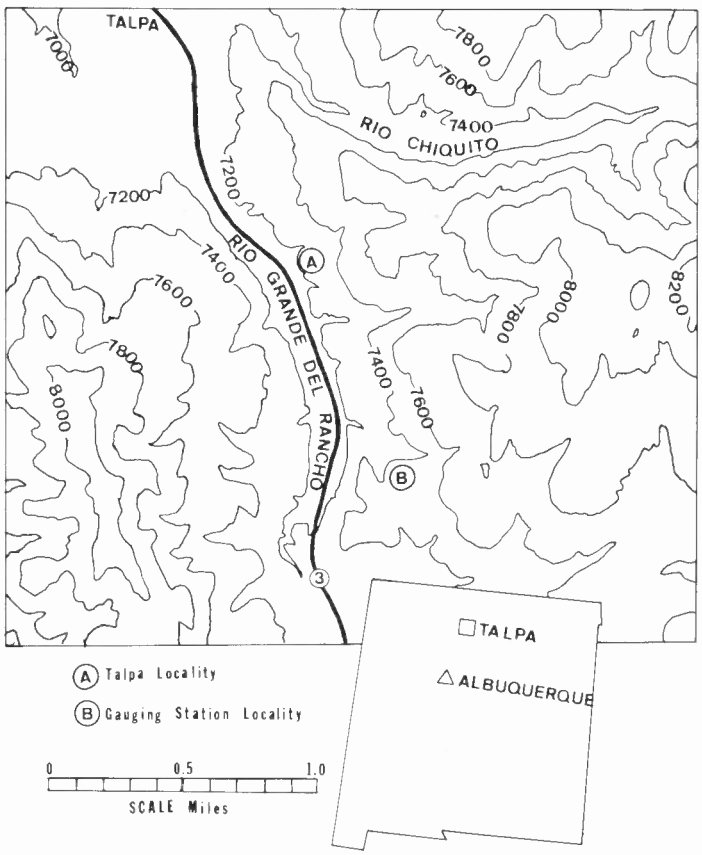


FIGURE 1. Location of Flechado Formation outcrops along east side of NM-3 (now NM-518). Specimens were collected from immediately south of Rio Chiquito to Gauging Station locality.

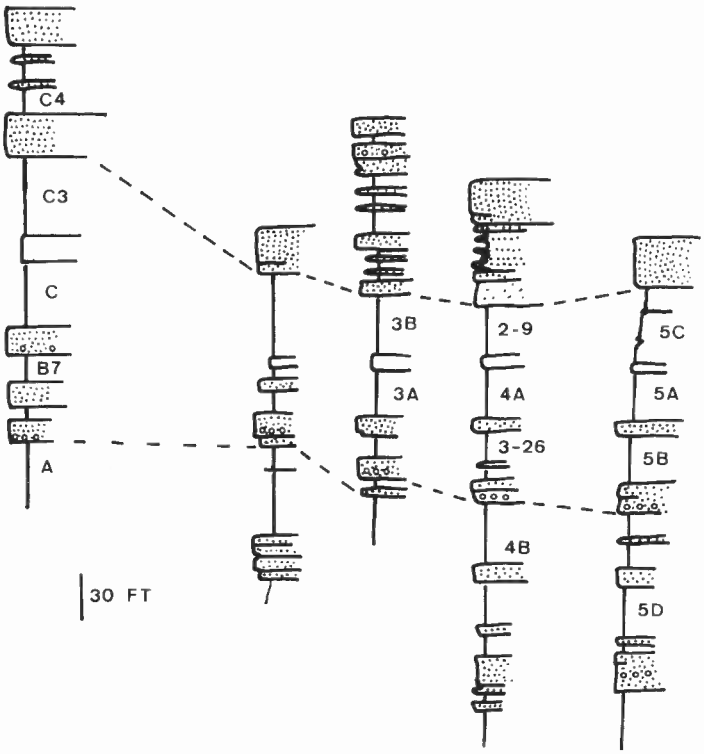


FIGURE 2. Simplified diagrammatic stratigraphic sections, Flechado Formation, along east side of NM-518. Letters indicate informal field designations for collections made from various intervals. Unshaded parts of sections are dark gray shale to siltstone lithologies. Each section begins approximately at the level of NM-518.

SYSTEMATIC PALEONTOLOGY

Order **Archaeogastropoda** Thiele, 1925
Superfamily **Murchisoniacea** Koken, 1896
Family **Murchisoniidae** Koken, 1896
Arribazona n. gen.

Type species—*Arribazona hesperia* n. sp.

Referred species—*Murchisonia matheri* Sayre (1930).

Diagnosis—Medium-sized murchisoniid having a fairly high-spired, fusiform shell with a vertically elongate oval to subround aperture, gently convex to nearly flat whorl profile and shallow sutures; selenizone is flush with the whorl surface, situated slightly above midwhorl and bounded by faint striae; shell ornamented with several narrow to obscure spiral lirae, mostly below selenizone on lower whorl face and whorl base.

Discussion—*Arribazona* is related to other late Paleozoic murchisoniids, such as *Cerithioides, Glyphodeta* and *Bellazona,* that possess a selenizone bounded by fine striae instead of threads or cords, as in *Murchisonia. Cerithioides* differs from *Arribazona* in possessing a relatively circular aperture, flattened base, and selenizone situated below midwhorl. *Cerithioides? oweni* Donald (1895), a small species from the upper Millstone Grit (approximately Morrowan) of Great Britain, differs from other species of *Cerithioides* in having its selenizone slightly above midwhorl, but in its rather flattened base and relatively angular periphery appears closer to that genus than to *Arribazona. Glyphodeta* has more inflated whorls throughout growth and a distinctly convex selenizone, also situated below midwhorl. The shell of the Late Mississippian *Bellazona* is similar in shape and size to that of *Arribazona* but possesses a selenizone situated very low on the whorl face and lacks spiral lirae (Gordon and Yochelson, 1987).

Etymology—Spanish *arriba,* above, and Latin, *zona,* zone or belt.

Arribazona hesperia n. sp.
Figs. 3.1 to 3.8

Diagnosis—Shell with general features of genus noted above; early whorls virtually flat in profile with very shallow sutures; last two whorls gently convex, with a slightly angular periphery low on whorl face of large specimens, and embracing lower on preceding whorl; aperture significantly higher than wide; ornamentation consisting of several fine to obscure spiral lirae below selenizone and one or two faint lirae above.

Description—Shell medium-sized (up to 20 mm high), high-spired, somewhat fusiform in shape, anomphalous, consisting of about 10 whorls; spiral angle averaging about 30°; whorl expansion rate constant for earlier whorls, decreasing slightly with later growth; shell height about 2.5 times maximum shell width; body whorl height about half of total height; whorl profile gently convex to nearly flat on earlier whorls, becoming more convex on last two whorls of large specimens; sutures very shallow, virtually flush, becoming deeper and impressed between last two whorls as these whorls embrace previous ones lower on whorl face; selenizone centered slightly above midwhorl, flush with adjacent shell surface, occupying about one-quarter of whorl surface between sutures, bounded at upper and lower margins by fine striae; growth lines faint, gently prosocline and arcuate (convex-forward) from upper suture to top of selenizone, sharply crescentic within selenizone, and gently opisthocline and arcuate (convex-forward) below selenizone; spiral ornamentation restricted to six to eight narrow to obscure lirae on lower whorl face and base, and one or two obscure lirae above selenizone; base of body whorl gently convex, rounding evenly into whorl face with slight angularity; aperture oval, vertically elongate, slightly oblique to shell axis, relatively sharply rounded at top and bottom, moderately convex along outer lip; slit not directly observed, but apparently shallow; columellar lip thickened, straight; parietal inductura thin, restricted to apertural area; protoconch orthostrophic, gently convex, consisting of two or three smooth whorls. Measurements are given in Table 1.

Discussion—*Arribazona hesperia* displays moderate variation in shell shape, with spiral angles ranging from 24° to 33°. Deepening of sutures and increasing convexity of the last two whorls is a persistent trend on

FIGURE 3. Gastropods from the Flechado Formation near Talpa. 1–8, *Arribazona hesperia,* n. gen., n. sp. 1, Paratype, USNM 4473,212, adapertural view, ×3; 2, Holotype, UNM 10,474, adapertural view, ×3.8; Paratype, UNM 10,483, apertural view, ×3; 4, Paratype, UNM 10,485, side view, specimen with crushed outer lip, ×3; 5, Paratype, UNM 10,489, side view, specimen with crushed outer lip, ×2; 6, Paratype, UNM 10,484, adapertural view, ×3.5; 7, Paratype, UNM 10,479, apertural view of a weathered specimen, ×3; 8, Paratype, IU 17,491, apertural view, ×3.8. 9–19, *Euconodoma gavinae* n. gen., n. sp. 9, Paratype, IU 17,492, apertural view, ×4; 10, Paratype, UNM 10,553, adapertural view, ×4; 11, Paratype, UNM 10,569, apertural view, ×4; 12, Paratype, UNM 10,549, apertural view, ×3; 13, UNM 10,550, adapertural view, ×3.5; 14, Paratype, USNM 447,213, apertural view, ×4; 15, Paratype, UNM 10,563, adapertural view of a specimen with earlier whorls displaced slightly, ×4; 16, Paratype, 10,561, apertural view of a juvenile specimen, ×5; 17, Paratype, UNM 7,238, adapertural view, ×4; 18, Paratype, UNM 10,555, apertural view of a specimen with rather enlarged peripheral nodes, ×4; 19, Holotype, UNM 10,554, apertural view, ×4. 20, 21, *Euconodoma ornatus* (Sayre), 20, Syntype, KU 58,114, apertural view, ×6; 21, Syntype, KU 58,122, adapertural view, ×6. 22–27, *Eucochlis perminuta* Knight, 22, 26, UNM 10,542, apertural and dorsal views, ×30; 23, UNM 10,547, apertural view, ×30; 24, UNM 10,543, apertural view, ×25; 25, UNM 10,539, oblique side view, ×40; 27, UNM 10,545, apertural view of a large, high specimen, ×20. 28, *Pseudozygopleura*? (*Stephanozyga*) sp., UNM 10,570, side view of small fragment, ×1.5. 29–34, *Pseudozygopleura*? (*Stephanozyga*) *subnodosa* Knight, 29, UNM 10,491, adapertural view, ×1.5; 30, UNM 10,494, apertural view, ×1.5; 31, 32, UNM 10,498, apertural view and oblique basal view showing columellar flange, ×1.5; 33, UNM 10,499, adapertural view, ×1.5; 34, UNM 10,504, adapertural view of a specimen with short peripheral nodes, ×1.5. 35–40, *Strobeus poromus,* n. sp. 35, Holotype, UNM 10,522, apertural view, ×2; 36, Paratype, USNM 447,214, adapertural view, ×2; 37, Paratype, UNM 10,512, apertural view, outer lip broken back to show columellar fold, ×3; 38, Paratype, UNM 10,521, apertural view, ×3; 39, Paratype, IU 17,493, apertural view, ×3; 40, Paratype, UNM 10,507, apertural view of a specimen with inductural node rows, ×2.

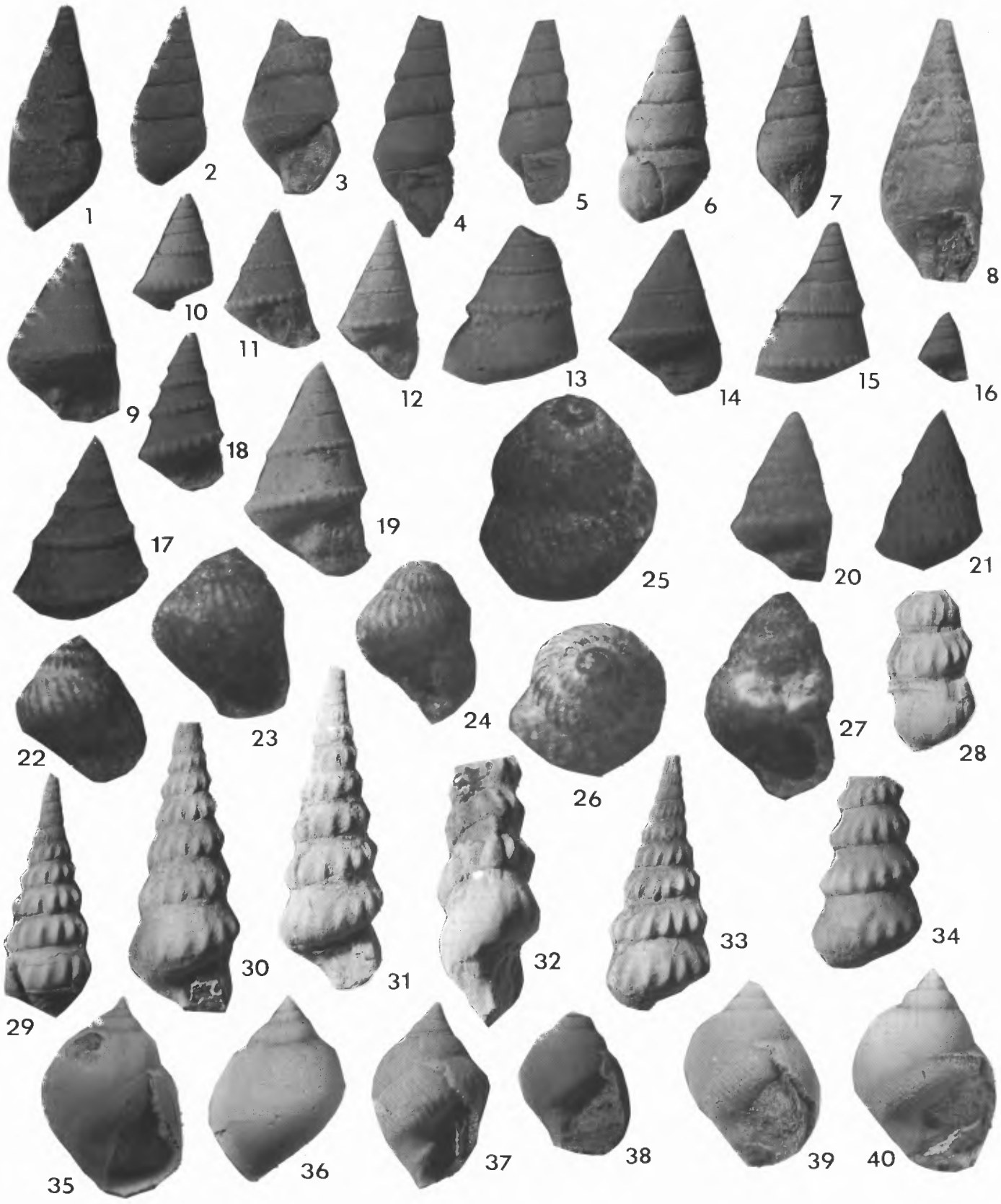

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TABLE 1. Measurements (in mm) of *Arribazona hesperia* n. gen., n. sp. Wh, whorls; H, shell height; W, maximum shell width; BH, body whorl height; SA, spiral angle.

Specimen	Wh	H	W	BH	SA	H/W	BH/H
UNM 10,474 (holotype)	1–9	8.6	3.8	4.6	29°	2.3	0.53
10,475	2–10	13.9	5.6	6.8	30°	2.5	0.49
10,479 (paratype)	2–10	12.5	4.7	6.6	30°	2.7	0.53
10,480	3–9	7.9	3.1	4.3	28°	2.5+	∠ 0.54
10,482	last 3	8.7	4.5	–	–	–	–
10,483 (paratype)	last 2.5	10.7	5.9	7.2	–	–	–
10,484 (paratype)	2–9	11.1	4.6	6.3	33°	2.4	0.57
10,485 (paratype)	last 5	13.9	5.4	7.2	24°	–	–
10,486	1–9	7.7	3.2	4.1	29°	2.4+	0.53
10,487	last 6	12.9	5.1	7.3	29°	2.5+	∠ 0.57
10,488 (paratype)	last 5	13.2	6.0	7.0	31°	2.2+	∠ 0.53
10,489 (paratype)	last 5	16.3	6.4	8.1	25°	2.5+	∠ 0.50
USNM 447,212 (paratype)	last 7	14.0	5.9	7.4	33°	2.4+	∠ 0.53
IU 17,491 (paratype)	last 7	12.9	4.9	6.2	31°	2.6+	∠ 0.48

large specimens, some of which develop a slightly angular periphery low on the whorl that is surmounted by an enlarged spiral lira. Smaller individuals display a nearly flat whorl profile and very shallow sutures throughout, and closely resemble *Bellazona* in shell shape. The striae bordering the selenizone are subtle and are not clearly visible on weathered shells. On some large specimens the striae appear to become very fine lirae on the last whorl. Number, position, and boldness of spiral lirae on the lower part of the whorl is variable, but typically these lirae are narrow, widely spaced and best expressed on later whorls. On some specimens the lirae are very faint.

Arribazona hesperia most closely resembles *Murchisonia matheri* Sayre (1930), from the Missourian Drum Limestone of Kansas. The two species are similar in shell size and number of whorls, size and position of selenizone, and the presence of several fine spiral lirae below the selenizone. Sayre (1930) noted that the selenizone of *M. matheri* is obscure and marked only by growth lines, but his illustrations (pl. 16, figs. 1–2) appear to indicate the presence of fine bounding lirae or striae. The characteristic features of *M. matheri* fall within the concept of *Arribazona* employed here, and the species is transferred to that genus. However, the shell of *A. matheri* has a smaller pleural angle (18°), its earlier whorls are somewhat more convex, and its aperture is more rounded and less vertically extended than in *A. hesperia*. Comparison with *Cerithioides*? *oweni* was noted above. Another British Carboniferous species, *C.*? *gleanensis* Longstaff (1926), is similar to *A. hesperia* in shell shape and growth line pattern, but its selenizone is slightly lower and it apparently lacks spiral lirae. Batten (1966) considered *C.*? *gleanensis* a possible synonym of *C.*? *oweni*. Both species exhibit an array of morphological features intermediate between *Cerithioides* and *Arribazona*.

Etymology—Greek, *hesperia,* western.

Collections—About 40 specimens from level A through C-3, Flechado Formation, Talpa locality.

Type specimens—Holotype, UNM 10,474; paratypes, UNM 10,479, 10,483, 10,484, 10,485, USNM 447,212, IU 17,491.

Superfamily **Trochacea** Rafinesque, 1815
Family **Microdomatidae** Wenz, 1938
Euconodoma n. gen.

Type species—*Euconodoma gavinae,* n. sp.

Referred species—*Microdoma ornatus* Sayre (1930).

Diagnosis—Shell small, trochiform, moderately high spired, with a flattened base, shallow sutures and an obscure shallow umbilical depression; a prominent nodose carina forms the periphery low on the whorl, immediately above the suture; a smaller spiral cord just below the upper suture consists of incipient to well developed small nodes, or is lacking; collabral ornamentation typically absent or restricted to very fine prosocline, closely spaced lirae on later whorls, with coarse transverse costae variably present on one or more early whorls.

Discussion—*Euconodoma* is closely related to *Microdoma*. Although species assigned to *Microdoma* are varied (Batten, 1966), they typically possess a relatively narrow, high spired shell with three or more nodose spiral cords on each whorl, often intersecting strong collabral costae. In several species, including the type species, *M. conicum* Meek and Worthen, both spiral and collabral ornamentation become dominated by prominent, more-or-less isolated, evenly spaced nodes developed at the intersection points and situated suturally as well as medially across the whorl face. *Euconodoma* encompasses microdomatids having a broader, more trochiform shell, spiral ornamentation restricted to the sutural areas, especially in the development of a nodose carina forming the periphery low on the whorl surface, and an absence of coarse collabral ornamentation on later whorls. Muted transverse costae may be present on one or two early whorls of *Euconodoma,* as they are also early in the growth of *M. conicum,* emphasizing the close affinities of the two genera. The family Microdomatidae is here considered part of the Trochacea, following the reasoning of Erwin (1988).

Etymology—Greek, *eu-,* good; *conos,* cone; *domos,* house

Euconodoma gavinae n. sp.
Figs. 3.9 to 3.19

Microdoma? n. sp. Kues, 1984, fig. 3.34.

Diagnosis—Small microdomatid having a rather broadly conical, trochiform shell with flattened base and shallow sutures; ornamented with a nodose carina forming periphery just above lower suture; subsutural node row lacking or consisting of obscure incipient nodes on a slightly swollen band; collabral ornamentation of very fine, closely spaced prosocline lirae, and on some specimens poorly developed coarse ribs on one or more earlier whorls.

Description—Shell small (up to about 11 mm high), trochiform, moderately high spired, consisting of up to nine whorls; whorl expansion rate generally constant with growth; pleural angle rather variable (37°–53°) but normally about 45°; shell height averaging a little more than 1.5 times width; body whorl height about 60% of total height; whorl profile of last 4+ whorls flat, sloping at a 60° angle from horizontal, with a raised, nodose carina forming periphery immediately above lower suture; earlier whorls with a rounded, non- or sub-nodose periphery and a slightly convex profile tending to flatness; sutures very shallow, impressed; transverse ornamentation consisting typically only of numerous, fine (10–15/mm), regular, closely spaced, gently arcuate prosocline lirae, with obscure to moderately well developed, low, widely spaced transverse costae present on earlier whorls of some specimens; spiral ornamentation consisting of a low peripheral carina adorned with strong, transversely elongate to round, evenly spaced nodes, and on some specimens a row of much smaller, obscure nodes on a slightly swollen band immediately below upper suture; base of body whorl flattened, slightly depressed in umbilical area, with fine prosocline lirae continuing from lateral whorl surface; aperture subround to somewhat angular, about one-third height of shell; outer lip thin, strongly convex, angular at position of carina; columellar lip short, arcuate, slightly thickened; inductura thin, restricted to aperture area; protoconch of two orthostrophic, low, unornamented whorls. Measurements are given in Table 2.

Discussion—*Euconodoma gavinae* is one of the most abundant species in the Flechado Formation near Talpa, and the general elements of its shape and ornamentation are both distinctive and stable through the Flechado section. Examination of about 800 specimens representing all growth stages allows good understanding of the variability of this species.

The rate of whorl expansion was nearly constant with shell growth, and commonly produced shells having a spiral angle of about 45°. A small number of individuals, however, are unusually narrow (e.g., Fig. 3.18) with a spiral angle as low as 37°, and turreted in appearance. Others are much more broadly conical, with spiral angles of greater than 50° (e.g., Fig. 3.14). In a sample of 50 shells from level C-3, the

TABLE 2. Measurements (in mm) of *Euconodoma gavinae* n. gen., n. sp. AH, height of aperture; PA, pleural angle; see Table 1 for other abbreviations.

Specimen	Wh	H	W	BH	AH	PA	H/W	BH/H
UNM 10,554 (holotype)	3-8	9.8	5.6	6.0	3.5	43°	1.75+	0.61
10,549 (paratype)	1-9	9.9	5.4	5.9	3.4	39°	1.83	0.60
10,550 (paratype)	last 3	8.6	6.8	5.8	3.4	-	-	-
10,551	1-8	6.4	4.1	3.5	2.4	43°	1.56	0.55
10,552	1-8	7.0	4.6	4.3	2.3	45°	1.52	0.61
10,553 (paratype)	1-7	5.2	3.1	3.1	2.0	45°	1.68	0.60
10,555 (paratype)	1-8	7.4	4.1	4.0	2.5	37°	1.80	0.54
10,556	1-6	3.7	2.6	2.4	1.5	48°	1.42	0.65
10,557 (paratype)	1-6	3.8	2.7	2.2	1.4	47°	1.41	0.58
10,558	1-6	2.8	1.9	1.8	1.1	43°	1.47	0.64
10,559	1-6	2.8	2.0	1.7	1.1	45°	1.40	0.61
10,560	1-6	2.7	2.0	1.7	1.1	48°	1.35	0.63
10,561 (paratype)	1-6	2.5	1.8	1.6	1.0	46°	1.39	0.64
10,562	1-5	2.1	1.5	1.4	0.8	47°	1.40	0.67
10,563 (paratype)	1-8	7.5	5.0	4.8	2.8	-	1.50	0.64
10,566	1-7+	8.0	5.0	4.5	2.1	45°	1.60	0.56
10,567	3-8	8.4	6.2	5.1	2.8	53°	1.35+	0.61
10,568 (paratype)	1-8	8.3	5.2	5.2	3.2	45°	1.60	0.63
10,569 (paratype)	1-7	5.7	3.8	3.6	2.1	43°	1.50	0.63
7,238 (paratype)	1-8	9.0	6.0	5.1	2.9	49°	1.50	0.57
USNM 447,213 (paratype)	2-7	7.9	5.6	4.6	2.8	50°	1.41+	0.58
IU 17,492 (paratype)	2-7+	8.3	5.5	5.0	2.8	46°	1.51+	0.60

TABLE 3. Measurements (in mm) of syntype specimens of *Euconodoma ornatus*, Drum Limestone of Kansas. Abbreviations as in previous tables.

Specimen	Wh	H	W	BH	AH	PA	H/W	BH/H
KU 32,293	1-7	6.5	4.3	3.8	2.4	45°	1.51	0.58
32,294	1-7	5.0	3.1	2.9	1.5	40°	1.61	0.58
58,114	3-7	5.3	3.5	3.2	2.1	48°	1.51+	≤ 0.60
58,115	1-6+	5.0	3.0	2.9	1.6	43°	1.67	0.58
58,116	1-6	3.9	2.6	2.4	1.3	45°	1.50	0.62
58,117	1-6?	3.5	2.1	2.0	1.2	44°	1.67	0.57
58,118	last 3	2.9	2.3	-	-	54°	-	-
58,120	2-6	3.4	2.2	2.1	1.1	47°	1.55+	0.62
58,122	1-6	5.0	3.2	2.8	-	46°	1.56	0.56
58,123	1-6?	3.0	2.0	1.8	1.1	43°	1.50	0.60
58,127	1-6	4.2	2.5	2.4	1.5	41°	1.68	0.57

mean spiral angle is 45°, with 72% of the specimens between 43° and 47°, and a total of 8% of the specimens below 40° or above 50°.

Typically the spiral ornamentation is limited to the nodose carina low on the whorl surface, transverse ornamentation to delicate, closely spaced prosocline lirae, and the whorl surface is flat from the carina to the upper suture. The nodes develop gradually along the periphery, beginning about whorl 4 or 5 (at shell height of 2 to 3 mm), and rapidly become sharp and conspicuous. Very small specimens that lack nodes, and display the more convex whorl surface characteristic of earlier whorls, could easily be mistaken for a separate species if growth stages intermediate between juvenile and mature forms of *E. gavinae* were not available for study. The nodes tend to become obscure on the last third of the body whorl of large specimens.

On approximately one-third of the specimens a slightly convex band develops immediately below the suture, and this band may support poorly developed, very small, narrow transverse nodes. A much smaller number of specimens, perhaps 10–15%, display transverse, low, rounded, widely spaced, prosocline costae or wrinkles, upon which the much finer lirae are superimposed. These incipient transverse costae are most pronounced in early growth stages, and vanish by about the fourth or fifth whorl. On rare specimens the costae are better developed and more persistent, and may connect a single subsutural node to a node on the periphery. These extreme variants trend more towards the ornamentation present in *Microdoma* than is the case with typical examples of *E. gavinae*.

The only species that closely resembles *E. gavinae* is *Microdoma ornatus*, from the Missourian Drum Limestone of Kansas. This species has not been reported since its original description by Sayre (1930). In order to compare the two species, the syntypes of *M. ornatus* (KU 32293, 32294, 58114–58128), including the specimen Sayre illustrated (pl. 16, fig. 4; KU 58114), were borrowed (see Figs. 3.20–21 and Table 3). Examination of these specimens form the basis for the following observations.

Microdoma ornatus is very similar to *E. gavinae* in shell shape and proportions, and in the nature of the aperture. The pleural angle of *M. ornatus* averages 45° and ranges from 40° to 54°, essentially the same as on *E. gavinae*. The largest syntype of *M. ornatus* is 6.5 mm high, and the average height of the 11 measured syntypes is 4.4 mm, indicating that it is a significantly smaller species than *E. gavinae*. The main distinguishing features between the two species are whorl profile and ornamentation. The basal peripheral carina of *M. ornatus* is prominent and composed of nodes that are a little larger, more widely spaced, and less numerous than those of *E. gavinae*. In addition, all specimens of *M. ornatus* possess a second, subsutural row of well-developed nodes, one-half to two-thirds the size of those on the carina. Both spiral node rows originate abruptly on about the fourth whorl, where, on some specimens coarse, prosocline ribs connect the two rows. As noted above, subsutural nodes are lacking on most specimens of *E. gavinae*, and when present are considerably less pronounced than on *M. ornatus*.

In contrast to the flat whorl face of *E. gavinae*, the area between the two nodose cords on *M. ornatus* varies from flat to distinctly concave. Finally, the fine, closely spaced, prosocline lirae so well displayed on the whorls of *E. gavinae* are not present on *M. ornatus*, which possesses only faint growth lines. It is possible that the absence of this ornamentation on *M. ornatus* is a result of preservation; the syntype specimens were collected from a coarsely crystalline limestone and fine details of the shell surface may have been lost during diagenesis. The specimen of *M. ornatus* figured by Sayre is somewhat atypical, in that of all of the syntypes its subsutural node row is least well developed.

In summary, although the two species are closely related, *M. ornatus* is smaller and possesses two well developed node rows instead of the single nodose carina present on most specimens of *E. gavinae*. The ornamentation of *M. ornatus* is clearly closer to the patterns characteristic of species of *Microdoma*. However, in their broader, trochiform shape, de-emphasized collabral ornamentation, and restriction of the spiral ornamentation to high and low on the whorl face, especially in a nodose peripheral carina, *M. ornatus* and *E. gavinae* are closely allied, and are best grouped together in *Euconodoma*.

Euconodoma gavinae at present is known only from New Mexico and West Texas Desmoinesian strata. Abundant in the Flechado Formation of the Taos area, the species was also reported in Desmoinesian rocks of the Mud Springs Mountains, south-central New Mexico (Kues, 1987, as *Microdoma*? n. sp.), and occurs in the Bishops Cap Formation of the Franklin Mountains, north of El Paso, Texas. Erwin (written commun., 1990) noted that this species may be present in USNM collections from Wolfcampian (Early Permian) strata of the Hueco Mountains, Texas, and that a closely similar form was reported by Harper from the Lower Mississippian Gilmore City Limestone of the midcontinent.

Etymology—This species is named for Mary Gavin, of Santa Fe, who for many years has been a strong supporter of paleontology in New Mexico.

Collections—Approximately 800 specimens from levels A through C-3, Flechado Formation, near Talpa.

Type specimens—Holotype, UNM 10,554; paratypes, UNM 10,549, 10,550, 10,553, 10,555, 10,557, 10,561, 10,563, 10,568, 10,569, 7,238, USNM 447,213, IU 17,492.

Family **Elasmonematidae** Knight, 1956
Genus ***Eucochlis*** Knight, 1933
Eucochlis perminuta Knight, 1933
Figs. 3.22 to 3.27

Eucochlis perminuta Knight, 1933a, p. 53, pl. 9, figs. 2a–f; pl. 12, fig. 5; Knight, 1941, p. 116–117, pl. 51, fig. 5; Knight, 1944, p. 471, pl. 193, fig. 20; Knight et al., 1960, p. I243, fig. 155, no. 5.

Discussion—*Eucochlis perminuta* has been documented in the published literature only by Knight's descriptions and illustrations of specimens from the Desmoinesian Labette Shale near St. Louis, Missouri. However, it is apparently widespread, as Knight (1941, p. 117) noted that the species "is a familiar one to me in many collections from various horizons and localities in American Pennsylvanian strata." In addition, Hoare (written commun., 1990) stated that it is a common component of Pennsylvanian gastropod faunas in the Appalachian Basin, and the genus is present in the Lower Permian Hueco Group of the Southwest (Erwin, written commun., 1990). Because of its small size, less than 2 mm high, this species would probably not be seen or collected unless bulk sediment samples were examined carefully. *Eucochlis perminuta* is common in some horizons of the Flechado Formation near Talpa, and is discussed here in order to augment the currently sparse information available about the species.

The Flechado Formation specimens range from about 0.5 to 1.7 mm in height and consist of 3.5 to 5 whorls. They agree closely in all characters with the Missouri specimens described by Knight, and no consistent variation that might reflect geographic separation was observed. The shell is turbinate and moderately inflated, becoming higher-spired with growth. Small specimens are scarcely higher than wide, but height/width increases to about 1.5 on the largest individuals. The orthostrophic protoconch consists of 1.5 to 2 whorls; the initial whorl is low and largely surrounded by the second whorl. Teleoconch ornamentation consists of numerous, narrow, slightly arcuate, prosocline transverse ribs of equal size, separated by slightly wider interspaces. These ribs continue onto the base of the body whorl. As Knight (1933a, 1941) observed, there is a tendency for the ribs to become more closely spaced on the body whorl of larger individuals. The number of body whorl ribs ranges from 28 to 35, averaging 30. Measurements are given in Table 4.

Collections—About 180 specimens from levels B-7 (rare) to C-3 (common), Flechado Formation, near Talpa.

Order **Mesogastropoda** Thiele, 1925
Superfamily **Loxonematacea** Koken, 1889
Family **Pseudozygopleuridae** Knight, 1930
Genus ***Pseudozygopleura*** Knight, 1930
Subgenus ***Stephanozyga*** Knight, 1930
Pseudozygopleura*? (*Stephanozyga*) *subnodosa Knight, 1930
Figs. 3.29 to 3.34

TABLE 4. Measurements (in mm) of *Eucochlis perminuta*. R, number of ribs on body whorl; see previous tables for other abbreviations.

Specimen	Wh	H	W	BH	R	H/W	BH/H
UNM 10,536	1-4.5	1.1	0.9	0.75	29	1.22	0.68
10,537	1-4.5	0.9	0.9	0.7	30	1.00	0.77
10,538	1-4.5	1.1	0.9	0.8	30	1.22	0.73
10,539	1-4.5	1.0	1.0	0.75	31	1.00	0.75
10,540	1-4.5	1.45	1.0	1.0	33	1.45	0.69
10,541	1-3.5	0.65	0.65	0.55	-	1.00	0.85
10,543	1-4.5	1.1	0.85	0.9	30	1.29	0.73
10,544	1-5	1.6	1.1	1.1	34	1.45	0.69
10,545	1-5	1.7	1.1	1.1	30	1.55	0.65
10,546	1.4.5	1.05	0.8	0.85	28	1.31	0.81
10,547	1-4.5	1.05	0.85	0.9	29	1.24	0.86
10,548	1-4.5	1.1	0.9	0.85	30	1.22	0.77

Pseudozygopleura (*Stephanozyga*) *subnodosa* Knight, 1930, p. 62, pl. 4, fig. 1.
Stephanozyga subnodosus Knight, 1944, p. 463, pl. 187, fig. 12.
Palaeostylus (*Stephanozyga*)? *subnodosa* Hoare, 1961, p. 171, pl. 21, figs. 15, 16.
Stephanozyga subnodosa Kues, 1984, fig. 3.46.

Description—Shell large for genus (up to 45+ mm high), very high-spired, consisting of an estimated 17 or 18 whorls, anomphalous, with a spiral angle of 20–25°; rate of whorl expansion constant or increasing slightly with growth; shell height more than three times maximum width; body whorl height about one-third of total height; whorl profile of earlier whorls gently convex, slightly pendant; profile of last five to seven whorls strongly pendant owing to development of high, nodose costae along lower two-thirds of whorl; sutures adpressed, shallow between earlier whorls but becoming deeply set between later whorls; ornamentation of earlier whorls (to diameter of about 5 mm) consisting of 12 to 17 strong, relatively narrow, straight to slightly arcuate, gently opisthocline costae extending from upper to lower sutures; costae changing through one or two succeeding whorls to prominent, broad, transversely elongate, rather sharp-crested nodes numbering 12 to 15 per whorl, separated by interspaces a little less wide, and limited to lower one-half to two-thirds of whorl surface; area between upper suture and onset of nodes gently concave; nodes ascending gradually ventrally to near lower suture, then descending abruptly, typically becoming obscure or absent on body whorl; ventral termination of nodes covered by succeeding whorl on some specimens; growth lines very gently opisthocline; aperture subround; outer lip strongly convex; columellar lip thickened, gently arcuate; parietal inductura relatively thick, extending a short distance beyond plane of aperture, forming a reflexed, flange-like layer extending abaxially from outer margin of columellar lip and ornamented with fine, low lirae; base of body whorl gently convex, somewhat flattened, unornamented, rounding with strong convexity into whorl face; protoconch unknown. Measurements are given in Table 5.

Discussion—Specimens of *Stephanozyga* are known from only a few late Paleozoic localities and are rare at those sites. Assignment of the subgenus to *Pseudozyglopleura* remains questionable because the protoconch whorls are not known. Thus, the possibility exists that *Stephanozyga* belongs to a homeomorphic palaeozygopleurid or zygopleurid genus (see Hoare and Sturgeon, 1978; Batten, 1985). Previously, *P.*? (*Stephanozyga*) *subnodosa* had been described only from two incomplete specimens from the Desmoinesian of the St. Louis, Missouri area, upon which Knight (1930) based the species, and rare Desmoinesian specimens from one locality in southwestern Missouri (Hoare, 1961). In contrast, this species is moderately common and conspicuous in the Flechado Formation near Talpa, although most specimens are fragments consisting of a few whorls.

TABLE 5. Measurements (in mm) of *Pseudozygopleura*? (*Stephanozyga*) *subnodosa*. N, average number of nodes or costae per whorl; N-6, number of nodes or costae on whorl closest to 6 mm in diameter; see previous tables for other abbreviations.

Specimen	Wh	H	W	BH	SA	N	N-6	H/W	BH/H
UNM 10,490	last 9	29.2	10.6	11.3	25°	13.4	13	2.75+	< 0.39
10,491	last 11	29.2	9.3	-	25°	12.5	12	3.14+	-
10,492	last 8	25.0	10.6	-	-	15.4	16	2.36+	-
10,493	8.5	18.1	6.8	-	27°	13.5	12	2.66+	-
10,494	last 8	37.5	14.4	15.6+	23°	14.4	14	2.60+	< 0.42
10,495	last 4.5	29.1	13.1	-	-	13.3	13	-	-
10,496	6	12.8	5.4	-	-	13.0	12	-	-
10,497	6.5	23.2	8.5	-	-	12.3	12	-	-
10,498	last 10	41.3	13.7	15.0	23°	12.8	12	3.01+	< 0.36
10,499	last 9.5	34.5	12.8	12.7+	25°	15.8	15	2.70+	< 0.37
10,500	last 4	28.8	15.3	14.3	-	13.7	-	-	-
10,501	6	13.2	5.2	-	20°	13.8	-	-	-
10,502	6.5	22.4	9.6	-	-	12.7	12	2.33+	-
10,503	7	18.8	8.0	-	22°	13.4	13	-	-
10,504	4	23.8	13.7	-	-	16.3	-	-	-

Pseudozygopleura? (*Stephanozyga*) *subnodosa* in the Flechado Formation displays moderate variation in the shape, number and position of its whorl nodes. The strong, narrow costae that extend from suture to suture on the earlier whorls are similar to the ornamentation present on all whorls of many species of *Pseudozygopleura* (*Pseudozygopleura*). The transition to broad, ventrally situated nodes occurs gradationally but rather abruptly through one or two whorls at a shell diameter of about 4.5 to 5.5 mm. Typically, only the last five to seven whorls of large individuals display the nodes that characterize the subgenus. Commonly, the nodes become obscure by dwindling to groups of irregular growth lines on part or all of the body whorl. Knight's (1930) type specimens consist only of the nodose whorls, but Hoare (1961) illustrated more complete specimens that display the transition from costae to nodes.

On some Flechado specimens one or two of the earlier whorls are noncostate or have very subdued costae (e.g., Figs. 3.29, 3.33). This does not appear to be a result of wear or weathering, as whorls above and below display well developed costae; rather, it suggests a short term cessation of costa development during the early growth of some shells. About 3% of the Flechado specimens possess nodes restricted to the lower half of later whorls (Fig. 3.34). Sixteen or 17 nodes occur on each whorl. These specimens are identical to *Pseudozygopleura*? (*Stephanozyga*) *nodosa* (Girty, 1915), the only other North American member of the subgenus, from the Virgilian of Missouri. Knight (1930) believed this species descended from *P.*? (*S.*) *subnodosa*. However, *P.*? (*S.*) *nodosa* was described from a few specimens that included only the later whorls, and the variability in shape and extent of the nodes on these whorls in an adequate sample is not known. Thus, degree of overlap between the two species and significance of the minor difference in node shape and position as a taxonomic feature separating them cannot be ascertained at present. In Flechado Formation specimens, restriction of nodes to the lower half of the later whorls clearly represents only a minor, gradational departure from the typically more transversely elongate nodes characteristic of *P.*? (*S.*) *subnodosa*, and is of no taxonomic significance.

Several incomplete specimens possess costae that are narrow, very sharp-crested, and separated by interspaces 1.5 to 2 times the width of a costa (Fig. 3.28). They appear to be related to *Pseudozygopleura*? (*Stephanozyga*) *subnodosa* in that the costae begin some distance below the upper suture, have the same shape and position (although being laterally much more compressed), and produce a similar pendant whorl profile. These specimens are here referred to as *Pseudozygopleura*? (*S.*) sp. Whether the sharp, narrow, widely spaced costae of these specimens is a consistent feature of a separate species or simply an unusual development of the broader nodes of *P.*? (*S.*) *subnodosa* is not evident from the specimens available.

Collections—This species is moderately common from level A through C-3 of the Flechado Formation near Talpa. About 230 specimens were examined.

Superfamily **Subulitacea** Lindstrom, 1884
Family **Subulitidae** Lindstrom, 1884
Subfamily **Soleniscinae** Wenz, 1938
Genus ***Strobeus*** de Koninck, 1881
Strobeus poromus n. sp.
Figs. 3.35 to 3.40

Strobeus? n. sp. Kues, 1984, fig. 3.44.

Diagnosis—Medium-sized *Strobeus*, having a low, sharp spire, strongly inflated body whorl, low, broad, obliquely oriented columellar fold, and relatively thick to callus-like, extensive inductura ornamented with numerous costae.

Description—Shell medium-sized, anomphalous, consisting of seven whorls, with a short, sharp spire and inflated body whorl comprising about 85% of total shell height; whorl expansion rate high, increasing greatly at body whorl; pleural angle averaging about 80°; shell height about 1.5 times maximum width; whorl profile gently and evenly convex on spire whorls, becoming strongly convex on body whorl, lacking shoulder or angulation; sutures adpressed, shallow; growth lines gently sinuate, orthocline; shell surface otherwise smooth, devoid of ornamentation; aperture tear-drop shaped, with posterior margin very acute and base rather broadly rounded, forming a shallow, wide siphonal canal; height of aperture slightly more than half total shell height; outer lip thin, increasingly expanded and convex basally; columella with relatively low, broad, obliquely oriented fold located about at midpoint of inner apertural margin; fold recessed within aperture and manifested on columellar lip as a low, elongate swelling; parietal and columellar areas covered by a thick inductura, extending rather far beyond plane of aperture, forming a callus on some specimens; inductura ornamented with numerous, well-developed, parallel, undulose to nodose costae; protoconch orthostrophic, consisting of two low, smooth whorls. Measurements are given in Table 6.

TABLE 6. Measurements (in mm) of *Strobeus poromus* n. sp. AW, width of aperture; see previous tables for other abbreviations.

Specimen	Wh	H	W	BH	AH	AW	PA	H/W	BH/H
UNM 10,522 (holotype)	1-7	18.0	11.6	15.5	9.5	6.0	81°	1.55	0.86
10,506 (paratype)	1-6+	18.5	12.8	15.2	9.4	5.8	75°	1.45	0.82
10,507 (paratype)	1-6+	19.1	12.7	16.0	10.0	7.5	82°	1.50	0.84
10,521 (paratype)	last 2.5	9.5	6.5	8.5	5.4	3.3	72°	1.73+	∠0.89
USNM 447,214 (paratype)	1-6+	17.0	12.3	15.0	10.4	4.1	83°	1.38	0.88
IU 17,493 (paratype)	last 3.5	11.8	8.6	11.0	7.5	3.8	81°	1.37+	∠0.93

Discussion—The thick, ornamented inductura extending a considerable distance beyond the aperture is the most distinctive feature of *Strobeus poromus*. The inductural costae vary somewhat in expression among the specimens at hand, ranging from bold, sharp and straight, to relatively low; in a few specimens the costae are divided into lines of nodes. The shape and proportions of the shell most closely resemble *S. brevis* (White) and *S. primigenius* (Conrad). *Strobeus brevis*, established on the basis of specimens from the Taos area, possesses a sharper, more transversely oriented columellar fold that is conspicuous at the inner margin of the aperture. These differences are clearly evident on examples of these species from the Flechado Formation near Talpa. *Strobeus primigenius* bears a low, rounded fold nearly identical to that of *S. poromus*, but attains a much larger size and has a lower height/width ratio. Both *S. brevis* and *S. primigenius* possess a relatively thin, smooth inductura (Knight, 1931) that is quite different from the thicker, ornamented inductura of *S. poromus*. *Strobeus medialis* (Meek and Worthen) displays a conspicuously thickened inductura, but it is unornamented except for faint vertical grooves on some specimens. Its body whorl is less inflated and more elongate than that of *S. poromus*.

Etymology—Greek, *poroma*, callus.

Collections—Approximately 35 specimens from level A through C-3, Flechado Formation, near Talpa.

Type specimens—Holotype, UNM 10,522; paratypes, UNM 10,506, 10,507, 10,512, 10,521, USNM 447,214, IU 17,493.

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