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Notes on and Description of *Oleneothyris fragilis* (Morton) 1828 (Brachiopoda, Terebratulidae)

HOWARD R. FELDMAN[1]

ABSTRACT

The *Oleneothyris* biostrome, a well-known stratigraphic marker at the top of the Hornerstown Formation in the Atlantic Coastal Plain, contains two distinct species of a large terebratulid brachiopod. These two species, *O. harlani* (Morton) and *O. fragilis* (Morton), may be differentiated by the prominent sulcus and fold, along with two pronounced dorsal ridges on the less robust *O. fragilis*. The latter species is confined vertically to a lens within the biostrome and geographically to the area around New Egypt, New Jersey. A narrowly triangular, strongly arched loop, characteristically terebratulid, is found to differ slightly from that of *O. harlani*. Since the holotype of *O. fragilis*, first described in 1828 by S. G. Morton, is either no longer in existence or lost, a neotype (RU 5700) is herein designated. The neotype is housed in the Rutgers University Geological Museum, New Brunswick, New Jersey.

INTRODUCTION

The present study was undertaken in the spring of 1973 when I discovered a small lens of brachiopods in the *Oleneothyris* biostrome (fig. 1), an important stratigraphic marker in the Hornerstown Formation of the Atlantic Coastal Plain. The brachiopods in the lens differed significantly from the well-known terebratulid *Oleneothyris harlani*. Subsequently, I found additional specimens of this "variant" in collections at the Rutgers University Geological Museum and the American Museum of Natural History. In both cases the brachiopods were labeled *Oleneothyris harlani* and designated as having been collected from the biostrome at the top of the Hornerstown Formation in the vicinity of New Egypt, New Jersey (fig. 2). Upon re-examination of several hundred specimens of *O. harlani* and comparison with 93 specimens of *O. fragilis*, no significant morphological intergradation between the two was found. The existence of a prominent sulcus and fold along with two distinct ridges on the brachial valve of *Oleneothyris fragilis* possibly imply the existence of two distinct genera, but the internal morphology of all specimens in the sample was identical to that of *Oleneothyris harlani*.

Oleneothyris harlani was first described by Morton (1828) as *Terebratula harlani* at which time he referred to two distinct species—*Terebratula harlani* and *Terebratula fragilis*. Mor-

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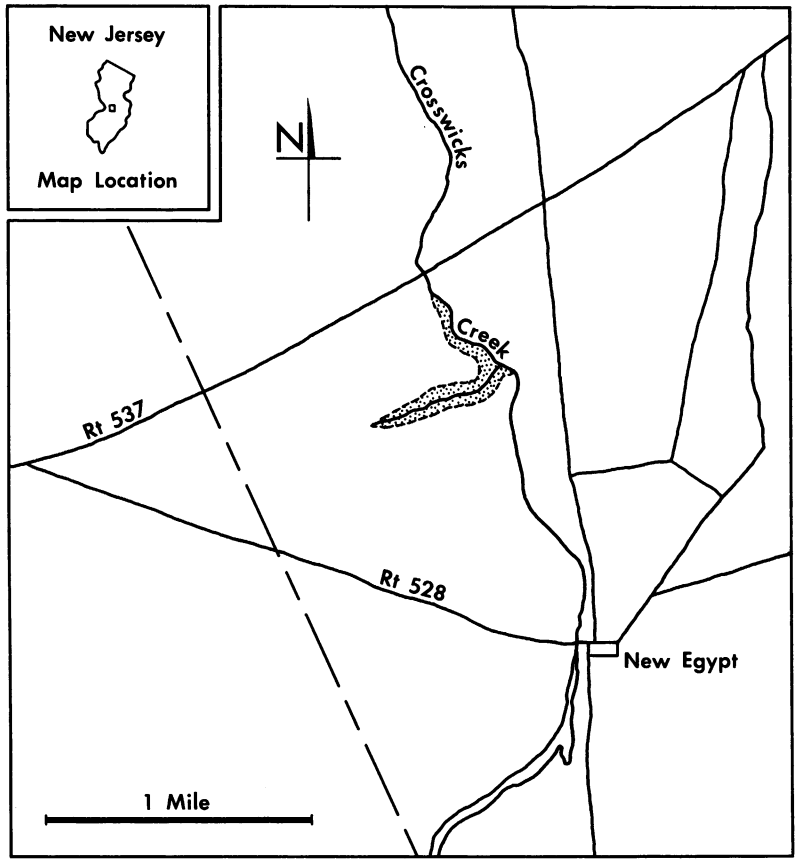

FIG. 1. Type locality of *Oleneothyris fragilis* in the Hornerstown Formation (Paleocene) of the New Jersey Atlantic Coastal Plain. Stippled area approximately in the center of map, along Crosswicks Creek and northeasterly flowing tributary, represents outcrop of Hornerstown glauconite at the top of which is the *Oleneothyris* biostrome. Immediately above the biostrome is the gradational contact between the Hornerstown and overlying Vincentown formations.

ton (1834) clarified his original descriptions of the variant forms of *Terebratula harlani*; upon further examination of a few hundred specimens he decided that two different species did not exist, rather that there were two "varieties" which graded into each other. *Terebratula fragilis* was renamed *subfragilis* by d'Orbigny (1850), as *fragilis* was preoccupied by Schlotheim (1813) for a species of *Terebratula.* The significance of the name *fragilis* was related to the supposedly fragile nature of the shell. However, I have found the shells of *fragilis* no more or less fragile than those of *Oleneothyris harlani.* Perhaps some valves were affected by dissolution to a larger extent than others, thus making them appear to be more delicate, hence fragile. In 1942 Cooper erected the genus *Oleneothyris*, which at the time was monotypic. Accordingly, after reinvestigation of available material, Morton's (1828) *Terebratula fragilis* is now placed in the genus *Oleneothyris* and the specific name *subfragilis* is no longer applicable. Morton (1828, p. 75) based his description of *Terebratula fragilis* on one specimen, which is no longer extant. Correspondence with various museums and search of collections such as those in the American Museum of Natural History, The Academy of Natural Sciences, and the Paleontological Research

Institution, has provided no evidence for the existence of Morton's holotype. However, Morton had access to another specimen of the same species that belonged to Conrad and which I located in Conrad's collection in the Academy of Natural Sciences, Philadelphia. Upon careful analysis of the brachiopod, which is slightly deformed but in a good to excellent state of preservation, the following may be concluded: The shell definitely possesses the morphologic characters of *Oleneothyris fragilis* and is not intermediate between *Oleneothyris fragilis* and *Oleneothyris harlani.* Morton was correct in originally erecting *fragilis* as a new species even though his decision was based upon a single specimen. The clarification of the morphology of the species based upon a population study is presented herein, along with an amplification of Morton's description and designation of a neotype.

ACKNOWLEDGMENTS

I thank Dr. G. A. Cooper, National Museum of Natural History, Smithsonian Institution, Washington, D.C., for discussion and critical review of the manuscript. Dr. Cooper made available for study two rare silicified specimens of the loop of *Oleneothyris harlani.* I am grateful to Dr. E. A. Shapiro, Academy of Natural Sciences (ANSP), Philadelphia, Pennsylvania, for the loan of material from S. W. Conrad's collection. Drs.

STAGE		AGE	FORMATION	THICKNESS	ENVIRONMENT	LITHOLOGY
Ypresian	Wilcox	Eocene	Manasquan Fm. Farmingdale Mbr.	40 ft.	Mid-outer shelf	Slightly clayey, medium coarse quartzose glauconitic sand.
Thanetian	Wilcox	Paleocene	Vincentown Fm.	15-100 ft.	Mid-inner shelf	Quartz sands with calcarenite facies. Silt facies in shallow subsurface.
Montian	Midway	Paleocene	····· biostrome ·····			
Danian	Midway	Paleocene	Hornerstown Fm.	20-30 ft.	Mid-inner shelf	Almost pure glauconitic sand. Little fine-grained matrix.
Maestrichtian	Navarro	Cretaceous	Tinton Fm.	22 ft.	Inner shelf	Argillaceous, quartz, glauconite sand.

FIG. 2. Upper Cretaceous and Lower Tertiary formations of northeastern New Jersey (modified from Olsson, 1975), illustrating the stratigraphic setting of the Hornerstown Formation and the *Oleneothyris* biostrome.

N. Eldredge, W. K. Emerson, E. Eisenmann, and Mr. S. Horenstein, all of the American Museum of Natural History (AMNH), rendered invaluable suggestions and advice. Drs. R. K. Olsson and S. K. Fox of Rutgers University (RU), New Brunswick, New Jersey, kindly provided material from the Rutgers University Geological Museum and allowed me to search through their large collection of Tertiary faunas. I am indebted to Mr. G. R. Adlington for the excellent photographs and to Mr. F. Lombardi for his technical skill in reconstructing damaged specimens. Mr. S. Shank deserves thanks for his draftsmanship.

I am especially grateful to Dr. N. Eldredge and the American Museum of Natural History for providing space and facilities in the Department of Fossil and Living Invertebrates where I was able to do the research for this investigation.

SYSTEMATICS

TEREBRATULIDA WAAGEN, 1883

TEREBRATULIDINA WAAGEN, 1883

TEREBRATULACEA GRAY, 1840

TEREBRATULIDAE GRAY, 1840

TEREBRATULINAE GRAY, 1840

OLENEOTHYRIS COOPER, 1942

Oleneothyris fragilis

Figures 3-7A-D; 8

Terebratula fragilis Morton, 1828, p. 75, pl. 3, figs. 3-4; Morton 1830, p. 250, pl. 3, fig. 17; Morton, 1834 (*non* Sowerby 1825), p. 70, pl. 3, fig. 2.

Terebratula camella Morton, 1834, p. 70, in text.

Terebratula subfragilis d'Orbigny, 1850, p. 258, in text.

Terebratula harlani Whitfield, 1886, pp. 6-9, pl. I, figs. 15-18.

Oleneothyris harlani Feldman (*pars*) (In press), pl. 2, figs. 1-4.

Type Species. Terebratula fragilis Morton, 1828.

Type Specimens. The following figured type specimens are deposited in the American Museum of Natural History, the Rutgers University Geological Museum, and the Academy of Natural Sciences. Not illustrated are four additional specimens labeled by F. B. Meek in the collection at the National Museum of Natural History (G. A. Cooper, personal commun.):

Neotype. RU 5700 (figs. 3D-F; 8F). Collected from the biostrome at the top of the Hornerstown Formation near New Egypt, New Jersey. Collector: H. R. Feldman, 1973.

Topotype. ANSP 19476 (fig. 3A-C). Same formation and locality. Collector: S. W. Conrad, 1828 (?).

Topotype. AMNH 32680 (figs. 4A-C; 8D). Same formation and locality. Collectors: H. R. Feldman and S. Feldman, 1974.

Topotype. AMNH 32681 (figs. 4D-F; 8A). Same formation and locality. Collectors: H. R. Feldman and M. Perlman, 1974.

Topotype. AMNH 32682 (figs. 5A-C; 8E). Same formation and locality. Collector: unknown.

Topotype. AMNH 32683 (figs. 5D-F; 8C). Same formation and locality. Collector: H. R. Feldman, 1975.

Topotype. AMNH 32684 (figs. 6A-C; 8B). Same formation and locality. Collector: H. R. Feldman, 1975.

Whitfield's (1886) collection, housed at the American Museum of Natural History, was studied in order to determine whether the designation of a neotype was necessary. Since Morton's (1828) holotype was either lost or destroyed, Whitfield's types might have helped establish the identities of the closely similar species, as required by the Code (Art. 75ai). However, Whitfield's specimen AMNH 32697 is incorrectly described as *fragilis* var.; it is actually a form of *O. harlani.* Also confusing is AMNH 32698, which is described as *fragilis* var. but appears to be intergradational between *O. fragilis* and *O. harlani.* It possesses a dorsal sulcus and weakly defined median ridge on the ventral valve but is extremely lobate, closely resembling Feldman's (In press) Type A. In addition, it is a juvenile and its morphology may change significantly during ontogeny. Whitfield's remaining types labeled *fragilis* var. are:

AMNH 32699: a neanic specimen of *O. fragilis.* AMNH 32700, 32701: elongately deformed specimens of *O. fragilis.* AMNH

32702, 32703, 32704, 32705: Specimens of *O. fragilis* which closely resemble the types of the present paper.

Specimens designated *O. harlani* by Whitfield (1886) include:

AMNH 32706: labeled var. *perovalis* (Morton) but is actually *O. harlani*, Type A of Feldman (In press). AMNH 32707: resembles AMNH 32698 but has a less distinct sulcus and fold and lacks a ventral median ridge. It is also intergradational between *O. fragilis* and *O. harlani.*

Subsequent to the discovery of Whitfield's collection in the American Museum of Natural History I located the specimen from S. W. Conrad's collection which was referred to by Morton (1828, p. 76) in his description of the new species *T. fragilis*: "I possess but a single specimen, from which the annexed drawing was taken: another in S. W. Conrad's collection has its sides much more rounded, but appears to be specifically the same." Although slightly deformed and a bit damaged, Conrad's shell (ANSP 19476) is definitely *O. fragilis* and is not at all intergradational with *O. harlani.*

Although Morton did not use the word "holotype," his specimen served the same function, which can be inferred from his description of a new species based on a single shell. As stated in Art. 73(b) of the Code (1961), if an author says in the description of a new nominal species that one specimen and only one is "the type" or uses *some equivalent expression*, that specimen is the holotype. [Italics mine.] Thus, Morton's single specimen was, in actuality, the holotype. Since the holotype is either lost or no longer in existence, and since Morton had no type series (hypodigm)—only the single specimen—no paratypes, lectotype, or syntypes could possibly exist. Conrad's specimen, although seen and mentioned by Morton, was not part of the original hypodigm. Therefore, in accordance with the Code (*ibid.*, Art. 75), I herein designate RU 5700 the neotype for *Oleneothyris fragilis.* The neotype is deposited in the Rutgers University Geological Museum, New Brunswick, New Jersey.

Type Locality. Shingle Run, an easterly flowing tributary of Crosswicks Creek near New Egypt, New Jersey (See fig. 1).

Type Horizon. A lens approximately in the middle of a biostrome of *Oleneothyris harlani* shells situated at the top of the Hornerstown Formation. The matrix is almost pure glauconitic sand.

Material. 93 specimens: 57 articulated (27 well preserved, 30 damaged), 30 pedicle valves, six brachial valves, most of which are in an excellent state of preservation.

Geographic Distribution. The species is known only from the biostrome at the top of the Hornerstown Formation in the area of New Egypt, New Jersey. Although *O. harlani* has been found in Delaware, Maryland, and Alabama there are no reports or references in the literature to the existence of *O. fragilis* in areas other than the type locality.

DESCRIPTION

Exterior. The shells are medium-sized and range from slightly lobate to cylindrical. All forms are rostrate and nonstrophic. The pedicle valve of adult specimens is strongly convex; the convexity is accentuated when viewed laterally. The brachial valve is plano-convex to convex. The maximum depth of the shell is reached at or posterior to midlength. The anterior commissure, strongly paraplicate, is alternately folded such that the brachial valve has a deep sulcus bounded laterally by two distinct ridges which extend posteriorly at least halfway to the end of the dorsal umbo.

A large fold is evident in the pedicle valve, which often extends the entire length of the valve as a median ridge. In some gibbous adult specimens a slight incurvedness is present at the lateral and anterior commissures. The beak is slightly incurved to erect and the ventral umbo is swollen in many adults. The ventral beak ridges range from angular to rounded but are most often rounded. A symphitium is present due to the fusion of the deltidial plates on the posterior edge of the pedicle valve. The pedicle foramen is divided by the beak ridges such that a mesothyridid to permesothyridid condition may be

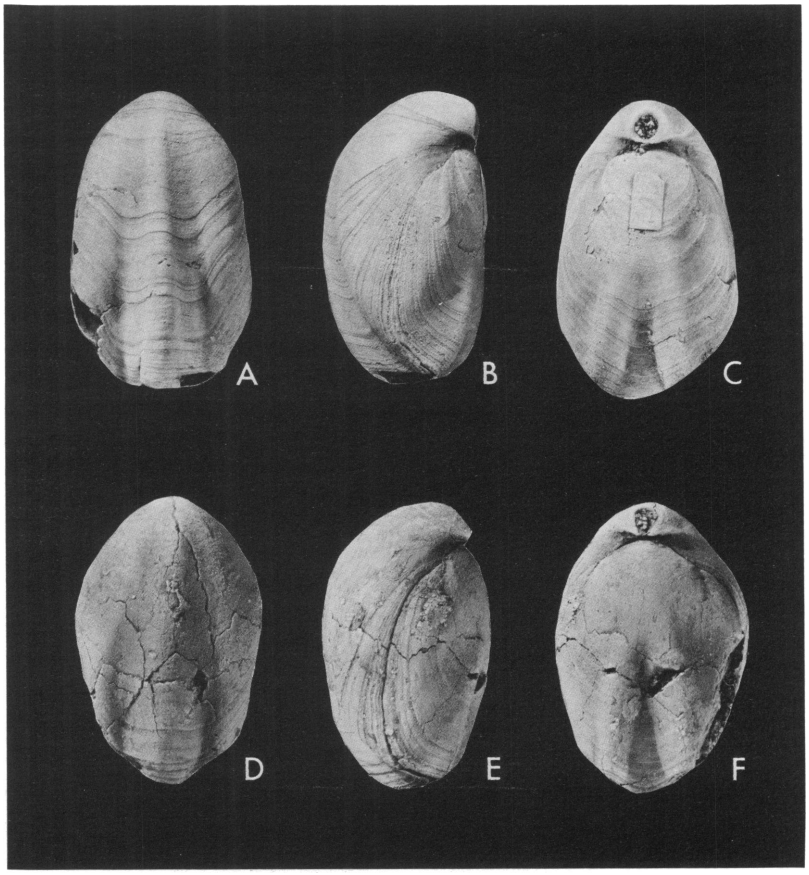

FIG. 3. *Oleneothyris fragilis* (Morton). A,B,C. Ventral, lateral, and dorsal views, ANSP 19476. ×1. D,E,F. Ventral, lateral, and dorsal views, RU 5700. ×1.

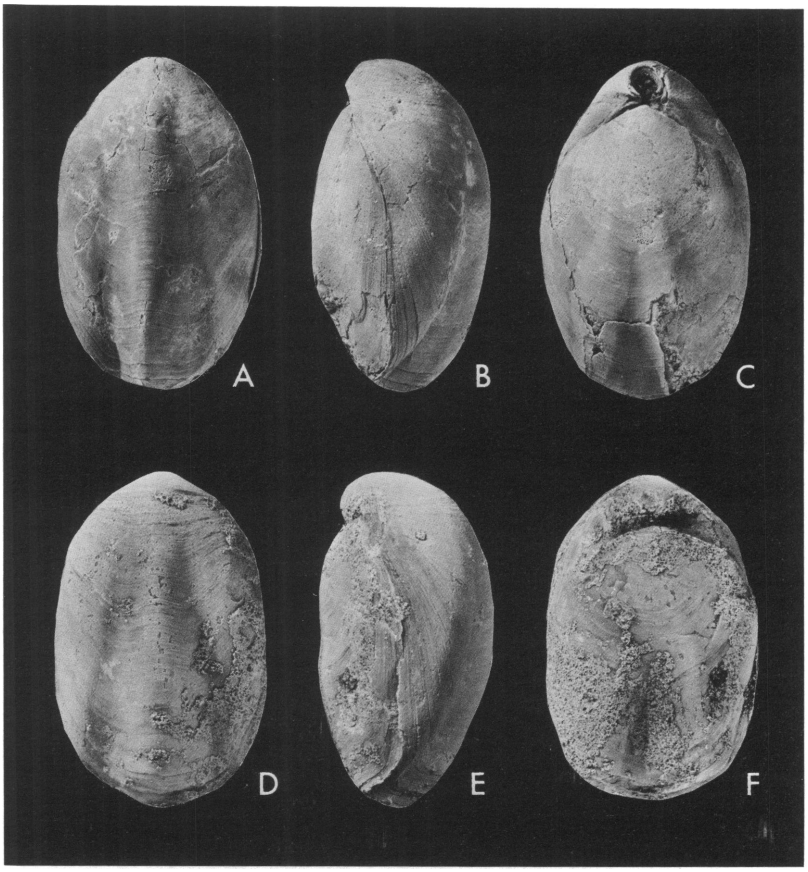

FIG. 4. *Oleneothyris fragilis* (Morton) A,B,C. Ventral, lateral, and dorsal views, AMNH 32680. ×1. D,E,F. Ventral, lateral, and dorsal views, AMNH 32681. ×1.

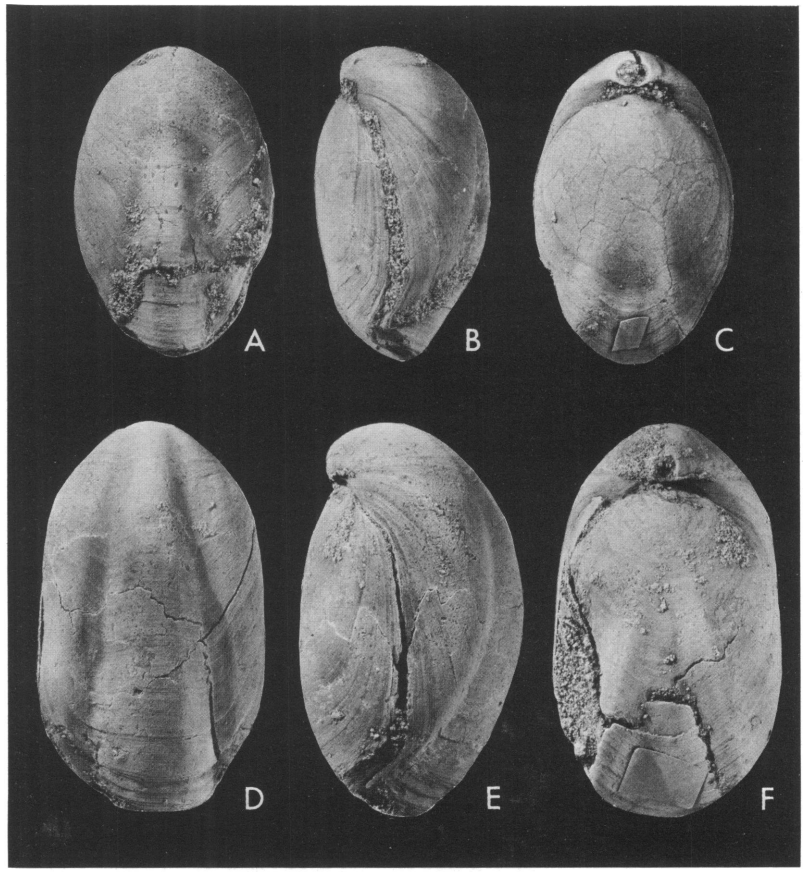

FIG. 5. *Oleneothyris fragilis* (Morton). A,B,C. Ventral, lateral, and dorsal views, AMNH 32682. ×1. D,E,F. Ventral, lateral, and dorsal views, AMNH 32683. ×1.

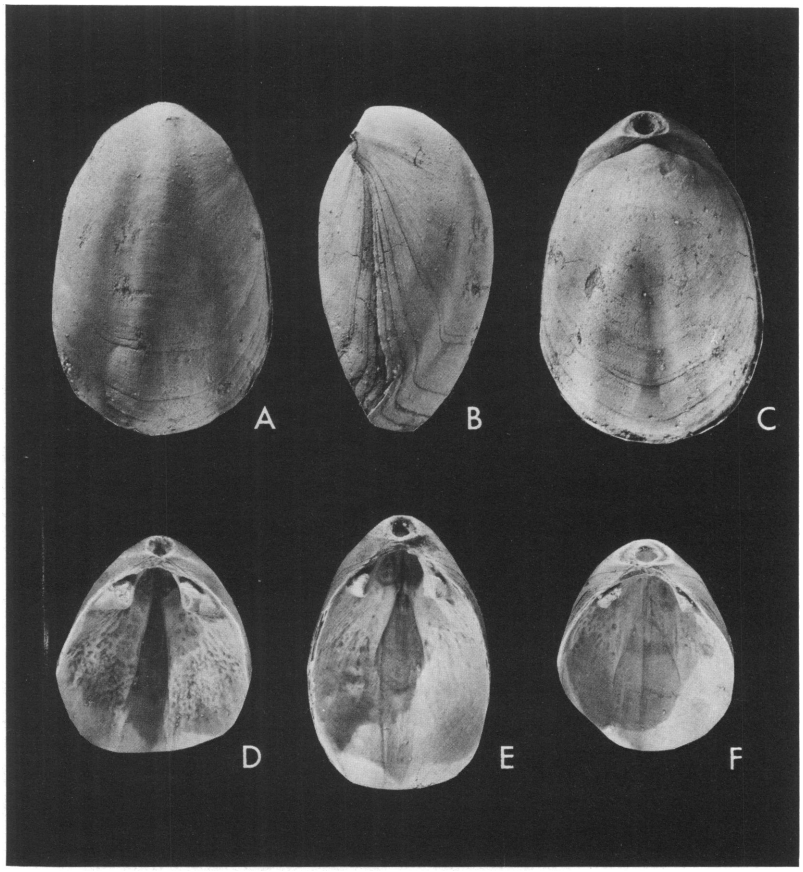

FIG. 6. *Oleneothyris fragilis* (Morton). A,B,C. Ventral, lateral, and dorsal views, AMNH 32684. ×1. D. Pedicle interior. Note deposit of secondary shell material and constriction at anterior end of umbonal cavity, AMNH 32773. ×1. E. Pedicle interior, AMNH 32769. ×1. F. Pedicle interior, AMNH 32768. ×1.

present. The cardinal margin is highly variable. The hinge axis intersects the cardinal margin at only two points, each posterolateral of the concealed dorsal umbo. The palintrope is weakly defined on the brachial valve but is much more developed on the pedicle valve. Secondary shell material deposited in the umbonal regions of many specimens thins anteriorly. Growth lines, strongly defined in most instances, are evident on both valves and are variably distributed with a greater concentration noticeable toward the anterior commissure of mature specimens. The shell is finely punctate with a distinct lack of radial ornamentation.

Pedicle Interior. Two well-developed dental plates originate anterior to the pedicle collar. The plates terminate with a constriction of the umbonal cavity at varying distances from the pedicle foramen. Two strong hinge teeth are dorsal to the dental plates. The teeth are cyrtomatodont resulting in strong articulation with the brachial valve. The denticular cavity is well defined and progressively deeper posteriorly.

The muscle field is narrow and elongate, fanning out triangularly with the broad base of the field anterior. Immediately anterior to the constriction of the umbonal cavity are found the impressions of the adductor muscles which shallow out as the anterior comissure is approached.

Brachial Interior. The exterior hinge plates are short, slightly concave, and joined with the crural base posteriorly almost to the cardinal process. The cardinalia are distinct with massive inner socket ridges. The cardinal process is variable, the most common form being cup-shaped with a distinct median ridge on well-preserved specimens. The crural processes are long, blunt, and thick. Deep dental sockets diverge strongly from the cardinal process.

The muscle field is about one-half as long and one-fourth as wide as the valve, with strongly impressed scars. Elongate adductor muscle scars extend from the crural base throughout three-fourths of the muscle field.

The Loop. The loop (fig. 7C) is about four-tenths of the total valve length. It is narrowly triangular with a transverse band, strongly arched, forming an inverted U, the base of which points posteroventrally. The crura are large, ending in sharp ventrally directed, hooklike apophyses. The loop is characteristically terebratulid, and more angular than that of *O. harlani.*

Comparison. Oleneothyris fragilis differs from *Oleneothyris harlani* primarily by the deep sulcus and associated fold in the brachial and pedicle valves respectively. Shells of *O. fragilis* are less robust and generally smaller in size than those of *O. harlani* (table 1). Internally the two species are identical. There is, however, a characteristic deposit of secondary shell material in the posterior areas of the pedicle interiors of most specimens which may possibly be related to life orientation on the sea floor (Paul Boyer, personal commun.). This feature is discussed in greater detail in conjunction with the morphologic variation of *Oleneothyris harlani* (Feldman, In press).

Variation in Oleneothyris fragilis. Less than 1 percent of the hypodigm displayed any lobate characteristics. Aside from AMNH 32686, which is a distinctly lobate neanic specimen, all adult forms were characteristically cylindrical. Growth lines are evident on most shells.

When viewed dorsally, many specimens appear to be pyriform at the posterior portion of the shell (AMNH 32680). Some shells are oval, almost egg-shaped (AMNH 32682). In lateral view, truncation of the pedicle foramen varies largely due to weathering and erosive action. No consistent conclusions may be drawn regarding this feature other than to note that in the majority of specimens the pedicle foramen is truncated such that the angle of truncation parallels the lateral commissure. The incurvature of the dorsal umbo ranges from suberect (AMNH 32680) to erect (AMNH 32682, 32683) to slightly incurved (AMNH 32681). The size of the pedicle foramen is unusually small in some specimens (AMNH 32683). This feature probably correlates with degree of turbulence or some other type of stress applied to the attachment potential (e.g., the pedicle) as described by Feldman (1974). However, a comparison and statistical analysis of the internal morphology of several hundred specimens of *O. fragilis* would be necessary before any valid conclusions may be drawn and the above hypothesis substantiated.

Most specimens, in anterior view, display a characteristic deep sulcus and prominent sharp

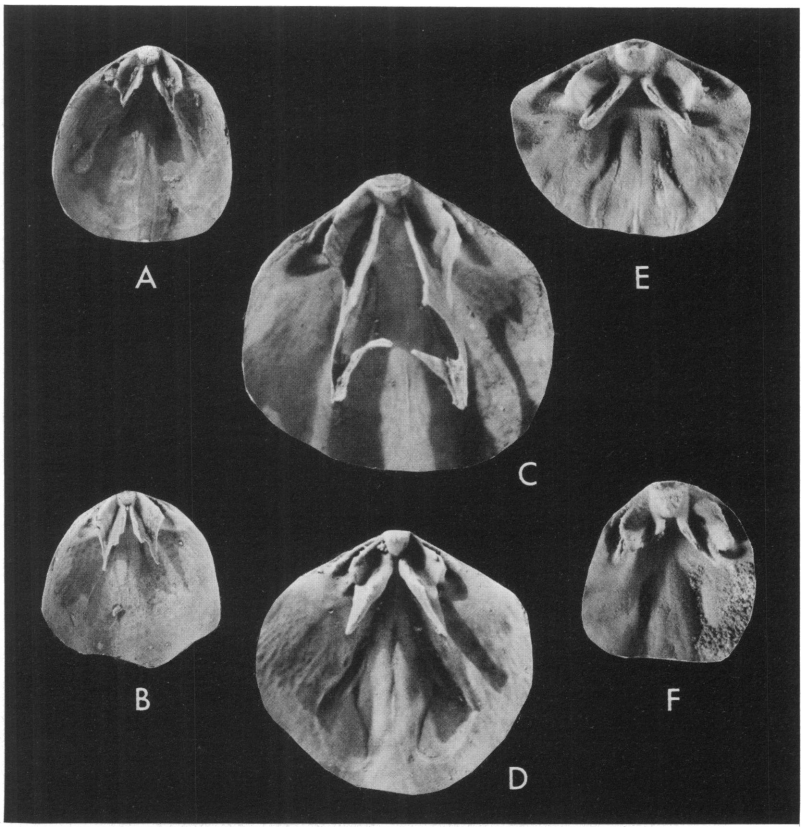

FIG. 7A-D. *Oleneothyris fragilis* (Morton). A. Brachial interior, AMNH 32772. ×1. B. Brachial interior, AMNH 32771. ×1. C. Brachial interior. Note characteristically terebratulid loop, significantly more angular than that of *O. harlani*, AMNH 32708. ×1. D. Brachial interior, AMNH 32770. ×2.

E,F. *Oleneothyris harlani* (Morton). E. Brachial interior, AMNH 32774. ×1. F. Brachial interior, AMNH 32775. ×1.

TABLE 1
Statistical Characterization of *Oleneothyris fragilis* and *Oleneothyris harlani* (Measurements in Millimeters where applicable)

Character	*Oleneothyris fragilis* X=length Y=width	*Oleneothyris fragilis* X=length Y=thickness	*Oleneothyris harlani* X=length Y=width	*Oleneothyris harlani* X=length Y=thickness
N	26	26	206	206
$\bar{X}$	43.7	43.7	46.98	46.98
$\bar{Y}$	28.1	24.1	30.84	25.31
S_X	7.16	7.16	10.91	10.91
S_y	3.55	4.19	5.35	6.35
r	0.68	0.74	0.82	0.93
OR_X	29.6-56.9	29.6-56.9	16.0-69.9	16.0-69.9
OR_y	21.6-35.7	15.2-34.1	13.9-43.2	8.5-38.9
a	0.50	0.59	0.49	0.58
σ_a	0.07	0.08	0.02	0.01
b	6.25	-1.68	7.82	1.94
D_d	1.66	1.80	13.10	8.80
V_X	16.38	16.38	23.22	23.22
V_y	12.63	17.39	17.35	25.09
$\sigma\bar{X}_{(x)}$	1.40	1.40	0.77	0.77
$\sigma\bar{Y}_{(y)}$	0.70	0.82	0.38	0.45

Because they were incomplete three specimens of *O. fragilis* (AMNH 32689, 32690, 32691) were not included in length measurements; therefore, for calculations of $\bar{X}$, S_X, and OR_X, N = 23. For all other calculations N = 26. For calculation of $r_{x,y}$ the mean ($\bar{X}$) was substituted for the missing data. (note: $r_{w,t}$ = 0.81). ANSP 19476 was not included in the above analysis as it was obtained on loan after the completion of all calculations. Data for characterization of *O. harlani* taken from Feldman (In press).

Abbreviations: N = total number of measurements; $\bar{X}$ = mean of X; $\bar{Y}$ = mean of Y; S_X = standard deviation of X; S_y = standard deviation of Y; r = coefficient of correlation; OR = observed range; a = slope of the growth line (growth ratio); σ_a = standard error of the slope; b = initial growth index; D_d = coefficient of relative dispersal from the reduced major axis; V_X = coefficient of variation for X; V_y = coefficient of variation for Y; $\sigma\bar{X}_{(x)}$ = standard error of the mean for X; $\sigma\bar{Y}_{(y)}$ = standard error of the mean for Y.

fold (AMNH 32680; ANSP 19476). In gerontic individuals the shell becomes robust and the sulcus broad and deep; prominent growth lines are usually visible especially near the anterior commissure (AMNH 32683). Variation in the sulcus and fold ranges, in adults, from sharp and deep to broad and shallow (AMNH 32681). The dorsal median ridges in all specimens are distinct and in most instances extend more than 50 percent of the valve length (table 2).

A characteristic by which *O. fragilis* may be distinguished from *O. harlani* is the nature of the alternate folding (plication) along the anterior commissure. Whereas *O. harlani* ranges from rectimarginate to uniplicate to sulciplicate, *O. fragilis* is distinctly paraplicate. The distribution pattern that emerges when the two species are compared (fig. 9) provides strong support for the differentiation into separate species.

No significant variation was noted in the cardinal processes of studied specimens. Some evidenced a greater amount of weathering resulting in a concave depression but the vast majority were essentially flat.

Ontogeny. Few juveniles were collected in the field, and only two were present in any of the museum collections (AMNH 32686, 32698). Ontogenetic changes, from the juvenile state, are therefore difficult to analyze. The paucity of younger forms may be due to any one or a combination of several factors: 1) Winnowing, 2) Dissolution of smaller shells, and 3) Collecting bias.

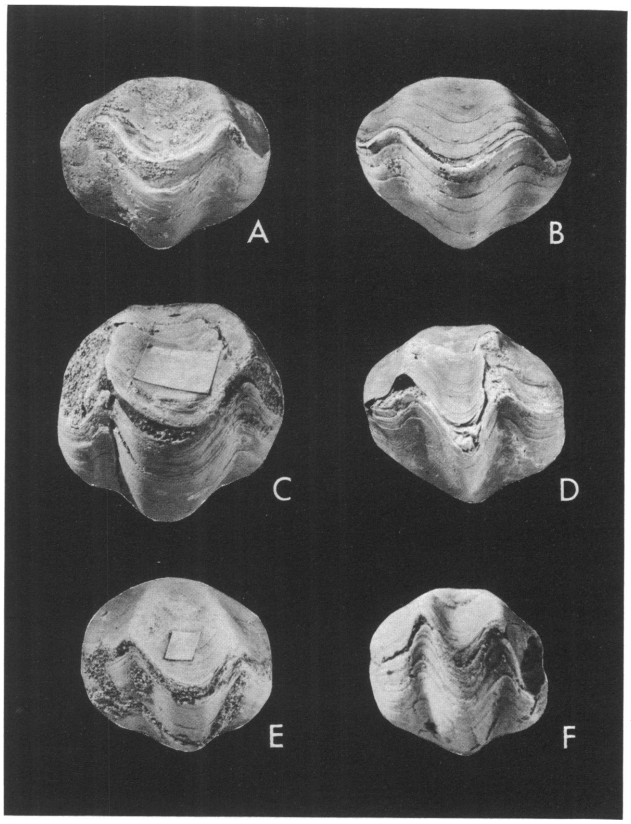

FIG. 8. *Oleneothyris fragilis* (Morton). A. Anterior view, AMNH 32681. ×1. B. Anterior view, AMNH 32684. ×1. C. Anterior view of gerontic specimen, AMNH 32683. ×1. D. Anterior view of slightly deformed specimen, AMNH 32680. ×1. E. Anterior view, AMNH 32681. ×1. F. Anterior view of neotype, RU 5700. ×1.

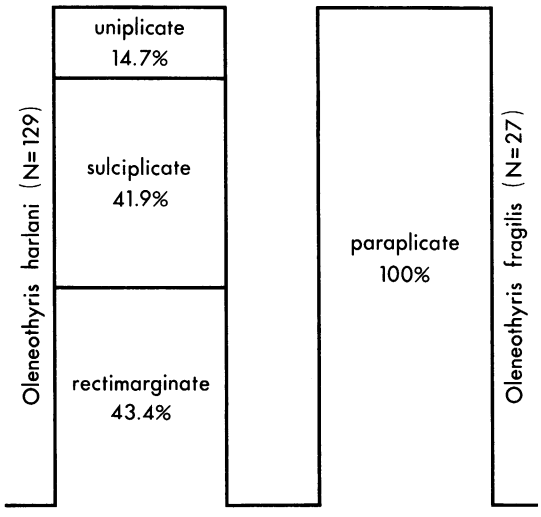

FIG. 9. Distribution of alternate folding in the genus *Oleneothyris*.

Adult forms, which comprise most of the sample, seem to have a greater range in length than in either width or thickness (fig. 10a). Whereas, in the juvenile forms studied, the sulcus and fold were not well developed (but still recognizable), the adult forms possessed a sharp, well-defined sulcus and fold, in most cases. Gerontic forms were relatively few (AMNH 32683, 32693, 32694, 32719, and RU 5704), and all individuals had a smoothed-out, shallow sulcus and associated fold. Growth lines were very strongly defined in gerontic specimens, present in adults, and barely noticeable in juveniles. The deltidial plates, fused into a symphitium in the juvenile stage, remained a constant morphologic characteristic throughout all ontogenetic stages. Shells of older individuals are generally more rounded laterally than in younger specimens and the ventral median ridge becomes less prominent.

TABLE 2

Morphologic Characters of Articulated Type Specimens of *Oleneothyris fragilis* (Measurements in Millimeters)

Type specimen		(L)	(W)	(T)	DVMR	SP	MP	WP	R>50%	R=50%	R<50%
Neotype	RU 5700	38.5	24.7	23.3	X	X	–	–	X	–	–
Topotype	AMNH 32680	42.9	26.5	23.2	X	X	–	–	X	–	–
Topotype	AMNH 32681	42.2	27.4	22.9	X	X	–	–	X	–	–
Topotype	AMNH 32682	40.1	26.2	22.4	X	X	–	–	X	–	–
Topotype	AMNH 32683	51.4	29.4	29.6	X	X	–	–	X	–	–
Topotype	AMNH 32684	44.2	28.9	23.4	X	X	–	–	X	–	–
Topotype	AMNH 32685	37.2	21.6	19.5	X	X	–	–	X	–	–
Topotype	AMNH 32686	29.6	23.6	15.2	X	–	X	–	–	–	X
Topotype	RU 5701	29.1	24.6	21.0	X	X	–	–	–	X	–
Topotype	AMNH 32687 (*)	44.9	28.4	24.9	X	X	–	–	X	–	–
Topotype	AMNH 32688	38.5	26.6	21.6	X	X	–	–	X	–	–
Topotype	AMNH 32689	–	25.5	25.0	X	X	–	–	X	–	–
Topotype	AMNH 32690	–	29.9	25.9	X	X	–	–	X	–	–
Topotype	RU 5702	47.3	31.7	24.6	X	X	–	–	X	–	–
Topotype	RU 5703	48.8	33.0	26.6	X	X	–	–	X	–	–
Topotype	AMNH 32691	–	28.9	25.9	X	X	–	–	X	–	–
Topotype	AMNH 32692	47.6	32.2	26.9	X	X	–	–	X	–	–
Topotype	AMNH 32693	54.4	35.7	29.6	X	X	–	–	X	–	–
Topotype	AMNH 32694 (*)	56.9	31.4	30.4	X	X	–	–	X	–	–
Topotype	AMNH 32695	55.2	30.0	30.7	X	X	–	–	–	X	–
Topotype	RU 5704	53.6	33.9	34.1	X	X	–	–	X	–	–
Topotype	RU 5705	41.3	24.0	20.1	X	–	X	–	X	–	–
Topotype	RU 5706	42.4	30.7	20.2	X	–	X	–	X	–	–
Topotype	RU 5707	36.8	25.1	21.4	X	X	–	–	–	X	–
Topotype	RU 5708	36.4	25.9	19.3	X	X	–	–	X	–	–
Topotype	AMNH 32696 (*)	35.7	25.0	18.8	X	–	X	–	X	–	–
Topotype	ANSP 19476	41.4	25.1	23.3	X	X	–	–	X	–	–

Abbreviations: (L), length; (W), width; (T), thickness; DVMR, distinct ventral median ridge; SP, strongly paraplicate; MP, moderately paraplicate; WP, weakly paraplicate; R>50%, the two dorsal ridges extend more than 50% of the valve length; R=50%, the two dorsal ridges extend approximately one-half of the valve length; R<50%, the two dorsal ridges extend less than 50% of the valve length; (*), internal molds.

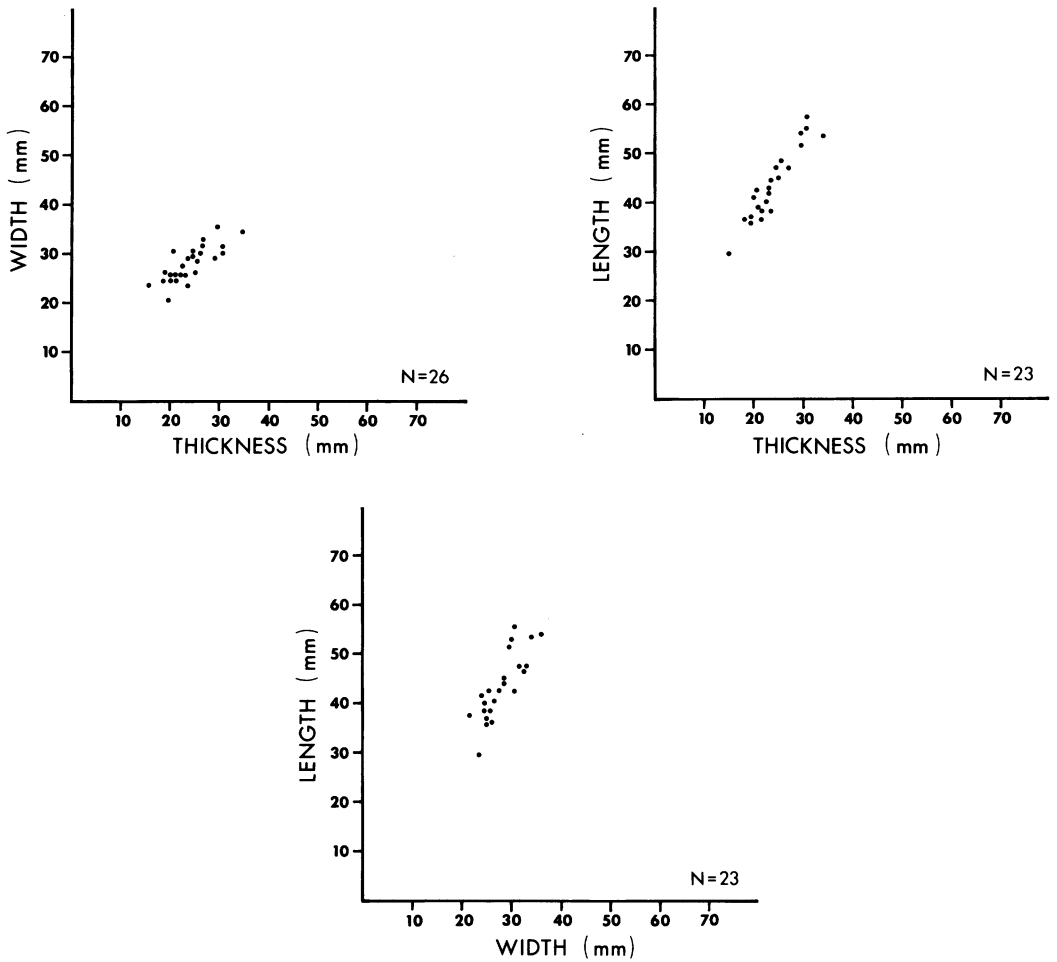

FIG. 10. Scatter diagrams showing measurements of *Oleneothyris fragilis.* Compare with measurements of *O. harlani* (Feldman, In press) for evaluation of the two populations.

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