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By

Hedwig T. Kniker

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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PREFACE

At the suggestion of Professor F. L. Whitney, the writer began the study of Cretaceous Pectinidae of Texas. Several times the scope was extended, and this paper, which was presented to the faculty of the Graduate Department of the University of Texas as thesis for the M. A. degree, was the final result.

I wish to express my sincerest thanks to Professor Whitney for his most valuable suggestions and criticisms during the preparation of this paper, as well as for his kind assistance in collecting and photographing specimens. I am indebted to him for the use of all of the Buda specimens and a number of others, which are in his private collection. To Professor Emil Boese I am grateful for his kindness in reading and criticising the manuscript. I also wish to thank Professor Dall of the Smithsonian Institute for supplying me with the necessary information concerning the genus *Janira*.

HEDWIG T. KNIKER.

COMANCHEAN AND CRETACEOUS PECTINIDAE OF TEXAS

STRATIGRAPHY AND PALEONTOLOGY

Series	Division (Group)	Formation
Gulf Series (Upper Cretaceous)	Montana	Webberville Formation Taylor Marl
	Colorado	Austin Chalk Eagle Ford Formation
	Dakota	(Missing)
Comanche Series (Lower Cretaceous)	Washita	Buda Limestone Del Rio Clay Georgetown Limestone
	Fredericksburg	Edwards Limestone Comanche Peak Limestone Walnut Clay
	Trinity	Glen Rose Formation Travis Peak Formation

(Taken from the Austin Folio, U. S. G. S.)

All the species described and figured were collected in the immediate vicinity of Austin and in a few slightly remote localities. No species are listed from some formations and only a few from others, due to the fact that these formations do not contain well preserved fossils in the outcrops where specimens were collected. More extensive collecting would doubtlessly add many additional species to the list. The results obtained indicate that there remains much work to be done in the paleontological field of the Cretaceous formations of Texas. Some new material was withheld from publication for further study with better preserved specimens.

The writer has studied the different classifications of the Pectinidae in trying to determine where the Cretaceous species belong, but has not arrived at a satisfactory conclusion. As is generally known, the type species of *Pecten* has not yet been settled. The existing classifications are based, for the most part, on recent forms and, as one author has correctly remarked, if

we were to include the fossil forms, there would probably be as many more divisions and subdivisions as now exist. Most Paleontologists when describing Cretaceous Pectinidae distinguish the genus *Pecten* from *Neithea (Vola, Janira)*. There is still some dispute as to which one of the last three generic names should be employed in preference to the other two. Since the type species of *Neithea* is a Cretaceous fossil and those of *Vola* and *Janira* are recent forms, the first name has been employed in this paper.

In the description of the type species of *Neithea*, transverse tooth-like processes alternating with depressions are mentioned. These denticles are found strongly developed in *Neithea roemeri* (Hill) and also in *Pecten bensoni* (Pl. I, fig. 10), showing that the two genera are closely related. This leads to another question. What is the systematic position of *N. roemeri?* Like *Vola fleuriausiana* d'Orb. and *Vola lapparenti* Chof., it has both valves convex and is not a typical *Neithea.*

An interesting detail of ornamentation has been noticed, especially on *N. roemeri, N. budensis,* and *N. texana,* which might be called "fourth rib symmetry." It is not necessary to discuss it here, as it is explained in the description of the above-mentioned species (pp. 44, 37, 27). No explanation of this arrangement has been found, but it has been noticed that the adductor muscle is located in the region of the fourth raised rib (note: in counting ribs, begin at the anterior side, unless otherwise stated).

STRATIGRAPHICAL DISTRIBUTION OF TEXAS PECTINIDAE

	Walnut Clay	Edwards Ls.	Georgetown Ls.	Del Rio Clay	Lower Buda Ls.[1]	Upper Buda Ls.	Austin Chalk
Pecten bonnellensis n. sp.	..	..	*	..	..	..	..
" *manchacensis* n. sp.	..	..	..	..	*	..	..
" *siedercnsis* n. sp.	..	..	..	..	..	*	..
" *bensoni* n. sp.	..	..	..	..	..	..	*
Neithea irregularis (Boese)	*	..	..	..	..	..	..
" *duplicicosta* (Roemer)	..	*	..	..	..	..	..
" *bellula* (Cragin)	..	..	*	..	..	..	..
" *wrighti* (Shumard)	..	..	*	..	..	..	..
" *texana* (Roemer)	..	..	*	..	..	..	..
" " var. *elongata* (Boese)	..	..	..	*	*	..	..
" *subalpina* (Boese)	..	..	..	*	*	..	..
" " (Boese) var. *linki* n. var.	..	..	*	..	..	..	..
" *georgetownensis* n. sp.	..	..	*	..	..	..	..
" " n. sp. var.	..	..	..	..	..	..	..
" *subirregularis* n. var.	..	..	*	..	..	..	..
" *theodori* n. sp.	..	..	*	..	..	..	..
" *altana* n. sp.	..	..	*	..	..	..	..
" *budensis* n. sp.	..	..	..	..	*	*	..
" *whitneyi* n. sp.	..	..	..	..	*	..	..
" *simondsi* n. sp.	..	..	..	..	*	*	..
" *boesi* n. sp.	..	..	..	..	*	*	..
" *roemeri* (Hill)	..	..	..	..	..	*	..
" *austinensis* n. sp.	..	..	..	..	..	..	*
" *hartmani* n. sp.	..	..	..	..	..	..	*
" *easteeli* n. sp.	..	..	..	..	..	..	*

[1] "In the vicinity of Austin the Buda Limestone displays two distinct phases: a lower chalky or marly, soft, white rock, and an upper, hard, yellowish to reddish rock." —Whitney.

V. quadricostata and *V. quinquecostata* have been incorrectly reported from many different horizons, probably due to the fact that there are a number of species with a similar arrangement of ribs. The following conditions have been noticed among Texas *Neitheas*. In *N. irregularis* from the Walnut Clay there are found fine secondary ribs at the sides of the raised ribs, which do not affect the size or shape of the latter. In *N.* sp. indet. of the Edwards Limestone these secondary ribs have become a part of the prominent ribs, modifying their slopes. The climax of this arrangement is found in *N. budensis* where the prominent ribs are trifid. Fragmentary specimens from the Georgetown Limestone show that the same arrangement exists here. Finally, in the Austin Chalk species, *N. hartmani and N. casteeli, the quadricostatus* and *quinquecostatus* mode of rib grouping is found. This latter, however, is not very closely related to that of the above mentioned Lower Cretaceous species.

Very striking likenesses have been observed between *Neithea* species of Portugal *(2)** and of Texas. The following table will show the relations and will also indicate to which other European forms the American species are related:

*Numbers in italics in parenthesis indicate the number of the article in the bibliography. Thus, (*20*, p. 16, pl. 5, fig. 5) has reference to Shattuck's Mollusca of the Buda Limestone, U. S. G. S. Bull. 205, p. 16, etc.

TEXAS		FOREIGN EQUIVALENTS	
Species	Horizon	Species	Horizon
Pecten bonnellensis n. sp.	Georgetown Ls.	*P. asper* Lam.	Upper Greensand, Chloritic Marl, Cenomanian—England.
		P. Chihuahuensis Boese	Lower Cenomanian—Mexico.
P. bensoni n. sp.	Austin Chalk.	*P. virgatus* Nilss.	
Neithea duplicicosta (Roem.)	Edwards Ls.	*V. stelfanoi* Chof.	Bellasian—Portugal. (Upper Vraconian?)
N. bellula (Crag.)	Georgetown Ls.	*V. dutrujei* Coq. var *beirensis* Chof.	Upper Cenomanian and lower Turonian—Portugal.
N. wrighti (Shum.)	Georgetown Ls.	*J. cometa* d'Orb. *J. longicauda* d'Orb.	Chloritic chalk and lower Turonian—France.
N. whitneyi n. sp.	Buda Ls.	"	"
N. texana group.	Georgetown Ls.	*J. alpina* d'Orb.	Chloritic Chalk (Cenomanian)—France.
N. roemeri (Hill.)	Buda Ls.	*J. fleuriausiana* d'Orb.	Chloritic Chalk and lower Turonian—France.
		V. lapparenti Chof.	Upper Cenomanian, lower Turonian (mostly), middle Turomian (?)—Portugal.
N. hartmani n. sp.	Austin Chalk.	*V. quadricostata*	Senonian—General distribution.
N. castecli n. sp.	Austin Chalk.	*V. quinquecostata*	"

Other similar species are *Vola* cfr. *dutemplei* d'Orb. out of the Turonian of Portugal and *N. budensis* n. sp. Likewise, there have been found some *Neithea* fragments associated with *N. duplicicosta* in the Edwards Limestone which resemble Choffat's *V. morrisi* from the Bellasian of Portugal.

It is to be noted that the European species are found in somewhat higher horizons than the corresponding Texas species, indicating that the development possibly took place here, followed by migrations eastward.

DESCRIPTION OF SPECIES

MOLLUSCA
PELECYPODA
PECTINIDAE
GENUS *PECTEN*, MUELLER
Pecten bonnellensis n. sp.

Plate I, figures 1-2

Dimensions.—Height 31.5 mm.; length 24 mm.; breadth 4 mm.

Description.—Shell medium to large, suboval, more or less equilateral, appreciably higher than long. Ears large, unequal; hinge line straight.

Only one left valve of this form has been found, but it is well enough preserved to justify describing and figuring.

The ornamentation consists of some twenty main ribs, which are rounded and somewhat elevated. They decrease in strength from the center toward the anterior and posterior borders. On and near the umbo only these principal ribs occur. A short distance from the beak, where the interspaces are wider, secondary ribs are found. These small ribs usually develop singly. As space permits, other secondary ribs appear in an irregular manner nearer the ventral margin, so that there are from three to six between two principal ribs at the base. The main ribs are always the stronger, although some of the secondary ribs very nearly approach them in size. The ribs are separated by relatively deep, concave furrows.

The ribs are spiny, but owing to the poor state of preservation of the shell, the exact nature and distribution of the spines could not be determined. They appear to be very numerous.

The antero-dorsal and postero-dorsal areas of the valve meet the ribbed portion at right angles, and are covered with prominent, strong, close-set ridges, that are almost perpendicular to the line separating the areas from the main portion of the valve.

The anterior ear is larger than the posterior, and its outer angle is acute. The indications are that the posterior ear would

have an obtuse angle, were it preserved completely. On the latter ear are found traces of spiny ribs. The anterior ear shows distinctly about fifteen spiny primary radiating ribs, besides secondary ones. Additional decoration of the ribbed portion and the ears consists of fine, crowded, concentric lines, which are interrupted at regular intervals by very pronounced concentric ridges.

Remarks.—*Pecten asper* Lam. (*25*, Vol. 56, p. 186, pl. 35, fig. 12; pl. 36, figs. 1-4) and *P. Chihuahuensis* Boese (*1*, p. 93, pl. 15, fig. 1), two species closely resembling *P. bonnellensis*, have angular ribs. The ribs of the latter species are rounded, but better preserved material would perhaps show that they, also, are angular.

Affinities.—*Pecten bonnellensis* n. sp. is easily distinguished from *P. Chihuahuensis* Boese by its shape, which is higher; by its ribs, which are rounded and spiny; and by its ears, which are covered with spiny radial ribs.

This species differs from *P. asper* Lam. in being elongate, and not circular; in having a different type of spines; in having larger ears; and in having a different arrangement of main and secondary ribs.

Number of specimens: 1.

Occurrence: Georgetown Limestone, Mt. Bonnell, Austin, Texas.

Pecten manchaccnsis n. sp.
Plate I, figures 3-4.

Dimensions.—Height 9 (?) mm.; length 9 (?) mm.

Description.—Shell small, orbicular, equilateral, practically equivalve, compressed; antero-dorsal and postero-dorsal margins somewhat concave; umbos pointed and conspicuous; ears unequal; hinge line long.

Right valve gently rounded and solid. Its surface is ornamented with delicate minute concentric folds. These latter are most pronounced on the areas and ears, where they can easily be distinguished, and on the portions of the valve adjoining the areas. Not on a single specimen can they be made out to any great extent on the main portion of the valve. This may be due

to lack of preservation, or perhaps the folds were present on only the ears and adjoining portions of the valve. The antero-dorsal area is more nearly perpendinular to a plane separating the right and left valve than the postero-dorsal.

The anterior ear is very long, ascending, and curved transversely, and is ornamented with a large number of regular concentric ridges. The posterior ear is long, narrow, and oblique.

The left valve is similar to the right in shape and ornamentation, but has more prominent concentric ridges. The anterior ear is subtrigonal, and its outer angle is rounded.

Affinities.—Pecten manchacensis differs from *P. siederensis* in having a more nearly circular outline, in having thicker valves, in having the ears of a different outline, in having an ascending anterior ear, and in being ornamented with concentric ridges.

This species is distinguished from *P. burlingtonensis* Gabb chiefly by its smaller apical angle and ears of a different shape.

Number of specimens: 14.

Occurrence: Lower division of the Buda Limestone, Austin and Manchaca, Texas.

Pecten siederensis n. sp.
Plate I, figures 5-6.

Dimensions.—Height 23.5 mm.; length 22 mm.

Description.—Shell medium to large, subequilateral, practically equivalve, compressed, suboribicular; postero-dorsal margin decidedly concave, antero-dorsal more nearly straight; umbos sharp. Ears of practically the same size; hinge line straight and relatively short.

Right valve slightly convex, *extremely* thin and more or less transparent. The surface is plain. However, very delicate lines of growth and groups of short, irregular, microscopic filiform radial lines can be made out. The latter are not on the surface, but in the shell, and may represent small cracks. The greatest convexity is in the median portion of the dorsal half of the shell.

The anterior ear is somewhat longer than the posterior, and its far border is gently rounded. A byssal sinus is present. The posterior ear is not separated sharply from the rest of the valve, and its outer angle is obtuse.

The left valve is similar to the right in general characteristics. The ears are almost equal; the outer angle of the anterior is acute, approximately as acute as the corresponding angle of the posterior ear is obtuse.

Affinities.—*Pecten manchacensis* is distinguished from this species in several ways which are mentioned in the description of the former species.

P. siederensis is not closely related to any of the European forms of the same group.

Number of specimens: 20.

Occurence: Upper division of the Buda Limestone, Sieder Springs, Austin, Texas.

Pecten bensoni n. sp.
Plate I, figures 7-13

Dimensions.—Height 16 mm.; length 14.5 mm.

Description.—Shell medium, circular, subequilateral, equivalve, compressed, antero-dorsal margin slightly concave and somewhat longer than the postero-dorsal. Ears unequal; hinge line straight.

Right valve slightly convex. The surface is ornamented with radiating, diverging, dichotomous furrows. These furrows are separated by broader, rounded, low folds. The latter appear to be the real decoration of the shell, while the furrows seem to have been sunk into the surface of the shell. The valve is further ornamentated with very strong concentric ridges that are slightly inclined ventrally. Their distribution is not regular. They are found close together on the umbo, but towards the base they are often far apart and may disappear entirely for a distance. They do not interfere with the furrow-fold decoration of the shell, and seem to weather more readily than this ornamentation. Consequently, it is often hard to determine whether ridges are normally absent on a given area, or whether they have been eroded. Some specimens show portions that apparently have only the furrow-fold decoration, but upon closer study, remnants of ridges are found. The anterior ear is long, and has a rounded margin at the far side. The byssal sinus is well-marked. The posterior ear is the smaller, and its outer

angle is obtuse. Both ears show the same manner of decoration as the main portion of the valve.

The left valve is similar to the right in shape and ornamentation. The anterior ear is subtrigonal and practically twice as large as the posterior.

Remarks.—The writer is inclined to believe that the form from the Austin Chalk described by Roemer (*19*, p. 66, pl. 8, fig. 5) as *P. virgatus*, is closely related to *P. bensoni* n. sp. Roemer said that on first sight the shell appears to be smooth, and he did not find concentric ridges. However, on a third specimen he noticed these ridges on the left ear. In *P. bensoni* the ornamentation is distinctly visible to the naked eye. As Austin Chalk specimens are not very well preserved, it is possible that Roemer had imperfect *Pectens* as the basis of his work. Under the conditons the writer feels justified in considering this form a distinct species. The writer agrees with Gabb (*10*, p. 365) that *P. virgatus* Roem. is distinct from *P. virgatus* Nills. Gabb continues by saying: "I have frequently observed casts in the New Jersey marls, and there is a piece of shell from Alabama in the collection of the Academy which I cannot separate from this species as described and figured by Roemer. It may be that they differ by the sides, from the beaks to the widest portion of the shell, being longer and straighter." He renamed Roemer's form *P. texanus*.

Affinities.—*P. bensoni* n. sp. differs from the European forms of *P. virgatus* in being more nearly circular, in having more numerous furrows, and in having strong concentric ridges in addition to the furrow-fold ornamentation.

Number of specimens: 50.

Occurrence: Austin Chalk, Austin, Texas.

GENUS *NEITHEA*, DROUET

Neithea irregularis (Boese)
Plate II, figures 1-6

Vola irregularis Boese, 1910, Instituto Geol. de México Boletín 25, pp. 97-98, Lám. 15, figs. 10-18.

Dimensions.—Height 17 mm.; length 14 mm.; breadth 5 mm.

Description.—Shell small to medium, subtrigonal, more or less elongate, almost equilateral; ventral margin polygonal. Ears large; hinge line straight.

Right valve convex, rounded; umbo incurved. The surface is ornamented with sixteen principal radiating ribs. These are high, narrow, and rounded on top. In young specimens they have a triangular shape. But on all large shells the ribs are rounded, and are never flattened on top. As in *Neithea texana*, every third rib is raised only slightly above the others. These prominent ribs are decidedly wider than those in the depressions, which are subequal, althought they appear to be equal in the smaller specimens. The intercostal spaces are concave and are narrower than the ribs, more decidedly so in large specimens. The furrows adjoining the raised ribs are wider than the ones separating the ribs in the depressions. At the base of the slope of the prominent ribs are found very thin secondary ribs that are much lower than the others. They are, however, distributed in an irregular manner. On some specimens there are almost as many as are possible under the conditions, while on others there is a small number. They are missing altogether on a few shells. Thus far, a law of distribution could not be determined. But, whenever present, these secondary ribs are at the base of raised ribs. The second and fourth of these latter, more frequently than the others, have a secondary rib on each side. Boese has sometimes found a very low secondary rib on the areas, but this has not been noticed on the Texas specimens. Rather coarse lines of growth are found all over the shell.

The left valve is decorated with sixteen or seventeen sharp, radiating ribs, which correspond to the principal furrows of the right valve. Whenever there is a secondary rib in a furrow of

the right valve, a twin-rib is found in the corresponding place on the left valve. Consequently, these double ribs are distributed irregularly. Thus, beginning at the posterior side, on one specimen the fourth, seventh, eighth, eleventh, fourteenth, and seventeenth ribs show this characteristic. On another specimen the first, fourth, eleventh, fourteenth, and seventeenth ribs are double. Boese noticed that these ribs are higher than others, but this is characteristic of the group, as mentioned in the discussion of *N. texana.*

Affinities.—This species is closely related to *N. subalpina* (Boese), and belongs to the group of *N. alpina* (d'Orb.). There are clear distinctions between *N. irregularis* and *N. subalpina.* The former is higher, shorter, and less convex than the latter. The secondary ribs and their irregular distribution, so characteristic of *N. irregularis*, are never found in *N. subalpina.* In addition, the ribs are more triangular, and there is less difference in their height in *N. irregularis.* There are also marked differences in the left valves. *N. irregularis* has sharp triangular ribs, whereas *N. subalpina* has rounded ones. Besides, *N. subalpina* never has the double ribs that are found distributed in an irregular manner on *N. irregularis.*

Number of specimens: More than 100.

Occurrence: Glen Rose Formation, Mt. Bonnell; and Walnut Clay, Mt. Barker, Austin, Texas.

Neithea duplicicosta (Roemer)

Plate II, figures 7-8; Plate III, figures 1-2

Pecten duplicicosta Roemer, 1849, Texas, p. 398.

Pecten duplicicosta Roemer, 1852, Kreidebild. v. Texas, p. 65, pl. 8, fig. 2a, b.

Neithea duplicosta Gabb, 1864, Smithsonian Miscellaneous Collections, No. 177, p. 7.

Pecten duplicosta Hill, 1889, Geol. Survey Texas, Bull. No. 4, p. 8.

Vola duplicicosta Cragin, 1892, Fourth Ann. Rept. Geol. Surv. Texas, p. 217.

Original description (translated).—The larger [illegible] valve

[1]Roemer evidently mistook the right valve for the left and confused the dimensions.

strongly arched, almost circular, somewhat broader than long, periphery angular, polygonal on the surface covered with radiating folds and ribs. The folds are thick, protrude, and form angles at the base. The radiating ribs are regular, of almost the same width, and cover in the same manner the folds and the spaces between them. In the almost level depressions between every two folds there are two or three of them. The surface of each fold proper is covered with three or four ribs.

This species has caused considerable discussion. Hill (*12*, p. 8) thought it was the same as *N. roemeri* (Hill), but Cragin (*5*, p. 217) later stated that the two forms were distinct species and that *N. duplicicosta* (Roem.) belonged either to the Fredericksburg Division or to the Alternating Beds.

A form has been found in the Edwards Limestone that is so similar to Roemer's species that the writer considers the two identical. Roemer admits that his type was an imperfect specimen, and a cast at that. It came from the upper course of the Pedernales River. Most of our specimens are casts, and, furthermore, are badly distorted. However, a few individuals have the shell preserved, although the specimens are imperfect. Roemer described and figured only the right valve.

To Roemer's description might be added that the ribs are relatively low and flattened. On a weathered specimen they are very low and flat. The middle rib in the depressions is broader than its neighbor on either side. The ribs on the folds are nearer together than is the case in the depressions, and there is often a small one next to the summit rib and occasionally in the depressions. No secondary ribs have been found on the areas.

The ears are large and strong and the hinge line straight. The whole shell is covered with very pronounced concentric lines.

The left valve is flat and has six raised areas corresponding to the folds of the right valve. The folds and depressions are covered with radiating flattened ribs that correspond to the depressions on the right valve. Prominent growth ridges cover the ribbed area and the ears.

Affinities.—Roemer pointed out that *N. duplicicosta* (Roem.) differs from *Pecten striato-costatus* Goldf. and *Janira striato-*

costata d'Orb. in not having in the depressions, secondary folds covered with ribs. Furthermore, in the European forms the radiating ribs are more unequal, smaller, and more numerous.

The European species most resembling ours is *N. stefanoi* (Chof.), from which *N. duplicicosta* (Roem.) differs principally in its form, which is not so long; and in its ribs, which are more or less flattened. But there is a possibility that in well preserved specimens the ribs of the Texas species are also rounded. Choffat (2, p. 155) does not mention folds, but says that the sectors are separated by ribs that are somewhat stronger than those in the depressions. On the Texas specimens these ribs are not stronger, and there are several close together on most folds.

As has been stated above, *N. duplicicosta* and *N. roemeri* (Hill) were at first considered identical. But the ornamentation of the latter is much more elaborate than that of *N. duplicicosta,* and the shape of the left valves is entirely different. In *N. roemeri* the folds are very prominent, and a rather broad depression separates the last rib on one fold from the first rib on the adjoining one. On the other hand, in *N. duplicicosta* the folds are not so prominent and there are definite spaces between two neighboring ones. In the latter form the ribs are sub-equal and the left valve is almost as globose as the right, while in *N. roemeri* the ribs vary greatly and the left valve is flat. There are also the differences in the ribs. Furthermore, *N. roemeri* has radiating ribs on the ears, which are missing in *N. duplicicosta.*

Shattuck (20, p. 16, pl. 5, fig. 5) has described a form from the Buda Limestone as *Pecten duplicicosta* (?). His description fits Roemer's species approximately, but the illustration shows that the two are distinct. The writer has not found any specimens similar to Shattuck's form in the Buda Formation. Neither have any *Neithea*s that resemble his *Pecten quinquecostatus* (?) been found. Evidently these forms are very rare, for Professor Whitney and paleontology students of the University of Texas have collected fossils from the Buda Limestone for the past eight years and have not seen them.

Number of specimens: About 50.

Occurrence: Edwards Limestone, Austin, Texas.

Neithea bellula (Cragin)
Plate III, figures 3-11

Vola bellula Cragin, 1892, Fourth Ann. Rept. Geol. Surv. Texas, p. 216.

Dimensions.—Height 19.5 mm., length 17 mm., breadth 7 mm.

Description.—Shell medium subtrigonal, practically equilateral, fragile, length almost equaling height; postero-dorsal margin slightly longer than antero-dorsal, ventral margin subsemicircular with six faint prominences. Ears imperfect on our specimens, but appear to be conspicuous and unequal.

Right valve globose, beak rounded and incurved. The valve is ornamented with forty-four fine, radiating, subequal, low, flattened ribs separated by depressions that are narrower, or practically equal to them. No ribs are raised noticeably, but at definite intervals there is a change in the size and arrangement of the ribs, which makes these areas appear prominent. Thus, the surface is divided into six facets comprising unequal groups of ribs. Often it is hard, or even impossible, to designate the boundary ribs between two groups. There is no definite arrangement of the boundary ribs. Frequently two adjoining groups are separated by a prominent rib noticeably wider than its neighbors. This boundary rib is often separated from the rib on each side by a furrow equal to it in width. At other places a double rib takes the place of the wide one. In such cases the two individual ribs are narrower than those of the groups. Also, two ordinary ribs separated by a very narrow depression may serve as a boundary. Sometimes the boundary is formed by three or four narrow ribs, or by two double ones. In some instances the boundary is entirely obliterated, there being a normal arrangement between the two groups, so that no transition can be detected. In the most anterior and the most posterior section the ribs are smaller and usually unequal in size, and the depressions are wider than the ribs. Besides the above mentioned irregularity, there is also a slight difference in the strength of ribs in different specimens. In such specimens as the one on which the description above is based the ribs are low and flattened, and there are narrower interspaces. On the other shells the ribs appear to be slightly higher and the intercoastal depressions wider

in proportion. However, these changes are not constant and are looked upon as individual variations. The number of ribs on the different specimens is not constant, varying from forty to forty-eight, the larger numbers being found on specimens with double ribs or a larger number of boundary ribs. Ribs are absent on the areas and ears.

The valve is further ornamented with very fine concentric striæ, which are almost invisible on the body of the shell, but can be plainly distinguished, with the aid of the microscope, on the areas and ears. On these latter, growth ridges, also, are present.

No perfect specimens of the left valve have been found. But this valve is slightly concave, has ribs corresponding to those of the right valve, and has six distinctly elevated regions, corresponding to the boundary ribs of the right valve. The depressions between the elevated areas are gently curved. The concentric striæ are distinct.

Affinities.—*N. bellula* differs from *N. dutrujei* (Coq.) var. *beirensis* (Chof.) (2, p. 150, pl. 2, figs. 1-2) in its shape and ornamnetation. The Texas form is shorter in the dorsal regions. *N. dutrujei* var. *beirensis* is larger, has more ribs, and appears to be more robust than *N. bellula*. Furthermore, the ribs of Choffat's variety are rounded and are present on the areas, on the posterior ear, and *perhaps* on the anterior ear, whereas on *N. bellula* they are flattened and are absent on the areas and ears. Choffat says that no facets are distinguishable on the left valve. On the left valve of *N. bellula* six areas are prominently raised and are separated by rounded depressions. There is, however, a marked similarity in the arrangement of ribs on the right valve of the two forms. In both cases the number of ribs between two prominent areas varies, and, furthermore, the boundary ribs of the two *Neitheas* show the same system of arrangement.

Number of specimens: About 60.

Occurrence: Georgetown Limestone, Austin, Texas.

Neithea wrighti (Shumard)
Plate IV, figures 1-3

Janira Wrightii Shumard, 1860, Trans. Acad. Sci., St. Louis, Vol. 1, p. 607.

Neithea Wrightii Gabb, 1864, Smithsonian Miscellaneous Collections, No. 177, p. 7.

Vola (Janira) wrightii Hill, 1889, Geol. Surv. Texas, Bull. No. 4, p. 8.

Vola writghtii Craigin, 1892, Fourth Ann. Rept. Geol. Surv. Texas, p. 217, Pl. 32, figs. 2, 3.

Dimensions.—Height 42 mm.; length 37 mm.; breadth 14 mm.

Description.—Shell large, subtrigonal, inequilateral, anterior, and posterior sides of approximately the same length. Anterior ear pointed, prominent, surface rounded transversely; posterior ear rudimentary. Ventral margin sinuous.

Right valve convex, beak incurved, posterior slope truncate. On this valve are found four prominent rounded ribs, which have a prominent costella at the summit. This gives them an angular appearance. A smaller costa is found at the posterior side of the shell, while a still smaller inconspicuous one is found on the slope of the anterior rib near the anterior margin. The middle costa is the most conspicuous one, but is practically equal to the adjacent one on the posterior side. The two anterior ribs are almost equal, but the most anterior one curves outward considerably and is higher. The costae are separated by broad, unequal, flattened depressions. The depression anterior to the middle costa is the widest one, being somewhat wider than this costa. Posteriorly to the middle and to the most anterior costa are found furrows practically equal to these ribs. At the base of the shell the ribs are prolonged into prominent extensions which are separated by broad, rounded sinuses corresponding to the intercostal depressions.

Left valve almost flat. The costae correspond to those of the right valve and have similar ornamentation.

As in *Neithea whitneyi* n. sp., growth ridges are found on both valves, especially near the base and on the anterior ear. Each valve has a fluted border on the interior side.

Remarks.—Cragin (5, p. 217) in his discussion of this species, says: "Summits of costae in both valves formed, in each instance, by a somewhat salient round-backed costella, there being on the two slopes and included valley which constitute the surface between any two summit-costellae, ten or twelve feebly elevated

radial costellae delimited by impressed striæ and crossed by innumerable raised lines of such fineness as to be barely visible to the naked eye." The costellae are not always so pronounced on our specimens, nor arranged in so regular a fashion as described by Cragin and shown in his drawings or *N. wrighti*. The "raised lines" are distributed on this species as on *N. whitneyi* n. sp.

In the original description of this species, costellae are not mentioned. This is probably explained by the fact that this ornamentation is often very indistinct on young individuals, and, according to Shumard's measurements, his was an immature specimen.

Affinities.—The species described under the name of *N. whitneyi*, n. sp. differs from *N. wrighti* in several ways, which are mentioned in that description. *N. wrighti* is distinguished from *N. cometa* (d'Orb.) and *N. longicauda* (d'Orb.) by its shape, which is more inequilateral and broader; and by its ears, which are smaller and more triangular. Furthermore, the interspaces are flat or flattened in *N. wrighti*, whereas they are rounded in the French forms. In *N. longicauda* the ribs of the right valve show distinct costellae, are very broad, and the intercostal spaces are narrow, and there are prominent costellae and tubercles on the left valve. Thus, this species differs considerably from ours in ornamentation.

Number of specimens: 18.

Occurrence: Georgetown Limestone, Austin, Texas.

Neithea texana (Roemer)

Plate IV, figures 4-7; Plate V, figure 1

Pecten aequicostatus Roemer, 1849, Texas, p. 398.

Pecten texanus Roemer, 1852, Kreidebild. v. Texas, p. 65, Pl. 8, fig. 3a, b.

Neithea texana Conrad, 1857, Mexican Boundary Report, p. 151, Pl. 5, fig. 2a, b.

Vola texana Boese, 1910,, Institute Geol. de México, Boletín 25, pp. 93-95, Lám. 15, fig. 3.

Not *Pecten texanus* Gabb, Proc. Phila. Acad. Nat. Sci., 1861, p. 365.

Dimensions.—Small specimen; height 29 mm.; length 28 mm.; breadth 9.5 mm. Large specimen: height 39 mm.; length 35.5 mm.; breadth 11 mm.

Description.[1]—Shell medium to large, subtrigonal, subequilateral solid; height exceeding length only slightly; postero-dorsal margin distinctly longer than antero-dorsal margin; ventral margin semi-circular with six projections formed by the extensions of the six raised ribs of the right valve. Ears large, hinge-line straight.

Right valve inflated, umbo greatly incurved, extending beyond the hinge line. Ornamentation consists of sixteen radiating principal ribs. In a young specimen these, on first sight, appear to be flattened only towards the base. But in a mature specimen they are distinctly flattened, especially as they increase in size towards the ventral margin. The ribs are separated by narrower, flattened depressions. Each third rib is raised above the adjoining ones, the first and the last rib being among the prominent ones. The raised ribs differ very little in height from the others, but are not quite so wide, are rounded, and only slightly flattened on top. Between the last rib and the margin anteriorly and posteriorly, is found a semi-lunar band or area. This is at times entirely plain, but more often shows a few low and rounded secondary ribs near the principal ones. The ornamentation is not always symmetrical. On some shells one of the areas is plain and the other one covered with two or three ribs, or there are one or two ribs on one side and three or four on the other. On the specimens at hand the last rib posteriorly usually shows a shallow sinus on top, dividing it into two smaller ribs, and thus beginning a group of secondary ribs. The lines of growth are extremely fine.

The left valve is slightly concave and is ornamented with sixteen very narrow ribs corresponding to the furrows of the other valve. The ribs have steep slopes and are more or less flattened on top. They are separated by very wide, flat furrows, which are practically twice as wide as the ribs.

[1]The descriptions of *N. texana* and its variety *elongata*, *N. subalpina* and *N. irregularis* are, to a large extent, translations from the Spanish of Dr. Boese (*1*).

Even in this simple form the center of symmetry can be detected. On the right valve the fourth raised rib is slightly higher and more rounded than the others. On the left valve, the ribs corresponding to the depressions at the side of the raised ribs of the right valve, are raised slightly. Therefore, we always find a pair of them prominent. The fourth, fifth, seventh, eighth, tenth, eleventh, thirteenth, fourteenth, and the two most anterior and the posterior rib are thus higher than the others. Furthermore, the tenth and eleventh ribs are the most prominent ribs among the prominent ones, and are the center of symmetry.

Remarks and Affinities.—Most of the specimens have been compressed somewhat, which accounts for the fact that the breadth is less in proportion to the other measurements than in Boese's measurements. Roemer (*18*, p. 398) at first referred this species to *N. equicostata* (Lam.), but it belong to an entirely distinct group of which *N. alpina* (d'Orb.) is an example. *N. alpina*, like the Texas form, has sixteen ribs on the right valve. Every third rib is higher than the others, but these raised ribs are much more marked than those of *N. texana*. Consequently the ventral margin of the French form is more polygonal in outline than is the case in *N. texana* and the depressed areas are very pronounced, which is not the case in the latter species. Also, the ribs of *N. alpina* are distinctly rounded, and not flattened. Furthermore, the left valves show a marked difference. In d'Orbigny's species the ribs are much wider and the depressions narrower than in *N. texana*.

Shattuck (*20*, p. 17, p. 5, figs. 6-8) seems to have confused *N. subalpina* (?) and a similar species under the name of *N. texana*. He lists *Pecten texanus* Gabb (*10*, p. 365) as synonymous with *P. (Neithea) texanus*. The former is a *Pecten* and is considered by Gabb to be identical with *P. virgatus* Roem.

Roemer (*19*, p. 65) says: "Die obere Klappe ist eben und mit ganz flachen, ungleichen, ausstrahlenden Rippen bedeckt, deren ebene Zwischenraeume den Rippen selbst on Breite etwa gleichkommen." This evidently is a mistake, if Roemer's form and the writer's are the same. For, in the Texas species, the ribs are narrow and the depressions about twice as wide.

The left valves, however, are alike.
Number of specimens: About 30.
Occurrence: Georgetown Limestone, Austin, Texas.

Neithea texana (Roemer) var. *elongata* (Boese)
Plate V, figures 2-3

Vola texana, Roem var. *elongata* Boese, 1910, Instituto Geol. de México, Boletín 25, p. 95, Lám. 15, figs. 2, 4. 6.

Description.—There are a number of specimens at hand that differ from *Neithea texana* in certain definite respects. But since no perfect shells have been found, and since the differences between the typical *N. texana* and this form are not very great, the writer considers it a variety of *N. texana.* It is distinguished from this latter species by being higher, and, consequently, having a smaller apical angle. The ribs on the right valve are slightly higher and the six prominent ones appear to be somewhat stronger than in the type. But the shape and arrangement of the ribs is the same in the two forms; that is, the ribs are flattended on top and every third one is raised and is somewhat rounded on top. However, the ribs are slightly narrower than in the type, and the intercostal spaces are proportionally wider.

At one locality this variety was found in the upper layers of the Del Rio Clay, in the transition beds, and in the lower beds of the Buda Limestone.

Number of specimens: About 20.

Occurrence: Lower division of the Buda Limestone, Austin; and Del Rio Clay, Austin and San Marcos, Texas.

Neithea subalpina (Boese)
Plate V, figure 4

Vola subalpina Boese, 1910, Instituto Geol. de México, Boletín 25, pp. 96-97, Lám. 15, figs. 5, 7, 8, 9.

Dimensions.—Height 29 mm.; length 27 mm.; breadth 8 mm.

Description.—Shell medium to large, subtrigonal, not much higher than long; ventral margin polygonal. Ears prominent; hinge line straight.

Right valve globose; umbonal slope curved, passing beyond the hinge line. The ornamentation of this valve consists of sixteen prominent radiating ribs, high, narrow, and rounded. Even in adult individuals they are flattened very little on top. The ribs are separated by narrower furrows having a slightly flattened bottom. Every third rib, including the first and the last, is raised. Thus, between every two raised ribs we find two narrower, lower ones which are practically equal. The areas are generally smooth, but on some shells one or two secondary ribs have been noticed. Prominent growth ridges are present on both valves.

The slightly convex left valve is decorated with seventeen principal radiating ribs. A cross section of these presents a more or less wavy appearance. As in similar species, the ribs correspond to the depressions, and the furrows to the ribs, of the right valve.

Remarks.—Boese (*1*, p. 96) says the furrows of the left valve have a level bottom, but this is hardly the case in our specimens, since the ribs of the right valve are only slightly, if at all, flattened. However, the ribs of the former valve are narrower than the furrows.

Affinities.—*N. subalpina* is easily distinguished from *N. texana* by its shape, which is longer and narrower; by its rounded and narrower ribs; by its deeper furrows; and by its more angular ventral margin. This latter is due to more prominent raised ribs. In *N. texana* the six prominent ribs are raised only slightly above those in the depressions and equal them in width. In *N. subalpina* the prominent ribs are noticeably higher and wider than in the former species. Furthermore, there is considerable difference in the ribs of the left valve of the two species. In *N. texana* the depressions and tops of the ribs are flattened, and the slopes of the ribs are very abrupt. In *N. subalpina*, on the other hand, both ribs and depressions are rounded more or less, and the slopes are gentle. Besides, there is less difference in width between ribs and depressions in the latter species than is the case in *N. texana*.

A part of what Shattuck (*20*, p. 17, pl. 5, fig. 6) describes as

N. texana is evidently closely related to *N. subalpina,* if not identical with it.

This species clearly belongs to the group of *N. alpina* (d'Orb.) This latter species also has six raised ribs, and between each pair of these there are two narrower and lower ribs. The chief difference is in the broader shape of *N. alpina* and its stronger ribs. The ribs in the depressions are lower in *N. subalpina.* Moreover, the left valve shows some differences.

Cragin's (*6*, p. 52), *V. fredericksburgensis* is possible identical with *N. subalpina.* He says: "This name is proposed for the species of *Vola* described by Roemer from Fredericksburg, Texas, in his *Kreidebildungen von Texas,* as 'Pecten quadricostatus, var.,' and is based on his description and illustrations . . . . It is easily distinguished from *V. texanus,* Roemer, by its much narrower and more elevated ribs, more triangular form, and usually (in adult examples) by its larger size. It has been referred to by authors under various names; but it is distinct from any of the species to which it has hitherto been referred. It is, however, closely allied to *V. alpina,* d'Orb." The horizon given is the Fredericksburg Division. Cragin seems to have confused several species. Roemer's *P. quadricostatus* var. is an Austin Chalk (Upper Cretaceous) form and is distinct from the *alpina* group. Fragments of specimens closely related to *N. irregularis* (Boese) have been found in the Fredericksburg Series, and since Cragin considers his species identical with Roemer's variety, the writer is inclined to believe that he had a form with secondary ribs and mistook it for a representative of the *quinquecostata* group of the Upper Cretaceous.

Number of specimens: More than 50.

Occurrence: Del Rio Clay, Austin and San Marcos; and lower division of the Buda Limestone, Austin, Manchaca, Buda, and San Marcos, Texas.

Neithea subalpina (Boese) var. *linki* n. var.
Plate V, figures 5-6

Dimensions.—Height 49 mm.; length 44 mm.; breadth 15 mm.

Description.—Among the *Neitheas* of the Georgetown Limestone, a form closely related to *N. subalpina* exists, which is regarded as a variety of this species. Like the type, it has sixteen radiating ribs on the right valve, and every third one is raised. But the ribs, instead of being high, narrow, and rounded, are lower, broader, and rounded, presenting a depressed appearance. Since they are broader, they appear to be more flattened than those of the type. The relation of width of ribs and intercostal spaces is the same in both forms. Moreover, the left valve shows some differences. In the Georgetown form the ribs are lower and the interspaces flatter than in *N. subalpina*.

Number of specimens: 10.

Occurrence: Georgetown Limestone, Austin, Texas.

Neithea georgetownensis n. sp.
Plate VI, figures 1-3

Dimensions.—Large specimen: Height 46 mm.; length 40 mm.; breadth 16 mm. Small specimen: Height 34.5 mm.; length 29 mm.; breadth 11 mm.

Description.—Shell medium to large, solid, subtrigonal, higher than long, globose, subequilateral. Ears small and triangular. Ventral margin semicircular, and polygonal in outline. Postero-dorsal margin appreciably longer than antero-dorsal.

The right valve is strongly convex and has a prominent incurved umbo that passes beyond the short hinge line. As in the other forms of this group, there are six prominent radiating ribs, the anterior and posterior being slightly smaller. In each one of the level depressions there are two lower ribs. The ribs, especially the prominent ones, are exceedingly strong in this species. In this form there are present compound ribs, each having a number of elevations and depressions on top. In addition to this, there is a fine rib in each intercostal depression, extending from the umbo to the base. The prominent ribs are high, broad, and round, while those in the depressions are also broad, but low, and flattened considerably. The latter usually have one main depression in the middle of the top and a smaller one on each side. On a few ribs a riblet is in the middle, but this seems to be an exception. Occasionally the main depression is

somewhat to the side, and there have been found two secondary depressions on one side. The prominent ribs are wider than the others, and, as a rule, have one or two more depressions on their upper portion. Usually two of the furrows on top are more or less equal. On account of the fine ribs in the intercostal spaces, these latter are wide, often approximating the ribs in width, or even surpassing them occasionally, especially in the anterior and posterior groups of ribs. As a rule, they are somewhat narrower. On the areas there usually are from one to four fine ribs.

On both valves, on the areas, and on the ears are found delicate concentric lines of such fineness that they are barely visible to the naked eye.

Since at the base the convexities of one valve fit into the concavities of the other, there is not so very much difference in width between ribs and intercostal spaces in the left valve. The fine ribs in the spaces of the right valve are usually to one side. Consequently the main furrow on the ribs of the left valve is in the same position. Near the base of the slope there is often a secondary furrow corresponding to a small rib far down on the slope of a rib of the right valve. In the depressions there is usually one principal rib and a few secondary ones. This valve is slightly concave and usually has a few secondary ribs on the areas.

Remarks.—Only a very well preserved specimen shows the characteristics as described above. In a weathered shell the prominent ribs of the right valve are rounded and have a few faint radial lines impressed upon them. A cross-section is dome-shaped. The lower ribs show a sinus down the center. There are also variations in the ornamentation. Occasionally there is not a complete set of fine ribs in the intercostal spaces, and sometimes some of the secondary sinuses on the ribs are missing.

Affinities.—In *Neithea budensis* n. sp. it is found that the prominent ribs are made up of a number of secondary ones, and that the two in the depressions are always plain. In *N. georgetownensis* the secondary ribs on the prominent ones are not really so prominent as those in the form mentioned above. The two species are, furthermore, distinguished by the split ribs in the

depressions and the fine ribs in the interspaces of both valves of *N. georgetownensis*, which are not found in *N. budensis*. Moreover, the antero-dorsal and postero-dorsal margins of *N. georgetownensis* are shorter and, consequently, the ventral margin longer than is the case in *N. budensis*. This causes them to differ in shape.

In *N. texana* there also are rounded prominent ribs, and flat ones in the depressions. But these differ from the ribs of *N. georgetownensis* in being plain, wider, and closer together. The shape of the two species is entirely different, *N. georgetownensis* being more convex and more elongate than *N. texana*. Besides, the raised ribs of the former species are much more prominent and the ventral margin more sinuous than is the case in the latter.

Number of specimens: 20.

Occurrence: Georgetown Limestone, Austin, Texas.

Neithea georgetownensis n. sp. var. *subirregularis*, n. var.
Plate VI, figures 4-5.

Description.—There are in the writer's collection some specimens which resemble *Neithea georgetownensis* in shape and proportions, but have smooth ribs. It is a fact that there is considerable individual variation in *N. georgetownensis* (see *Remarks* on that species), but the ribs are always split. On the specimens under consideration, there are found occasionally a few fine intercostal ribs distributed in an irregular manner on the valve, but the main ribs are always without furrows and costellae. Consequently, there are very globose, rounded, and prominent raised ribs, and in each depression two narrower subequal and very low, flat ribs. The relation between width of ribs and intercostal spaces varies in different specimens. In fact, there is a series of gradations. Ordinarily, the ribs are appreciably wider than the spaces, but the width of the former gradually decreases until it approximates that of the spaces.

The left valve is missing.

Affinities.—This form is similar to *N. texana* var. *elongata*, because of its rounded raised ribs, and flat ribs in the depressions. However, there are great differences between the two. *N.*

georgetownensis var. *subirregularis* is more blobose than the above mentioned variety, and there is a greater difference between raised and low ribs. In *N. texana* var. *elongata* the prominent ribs are raised only slightly above the others, and all are of practically the same width, while in *N. georgetownensis* var. *subirregularis* the raised ribs are far more conspicuous and wider than the others, and these latter are very low and flat, lower than those of the former species.

Number of specimens: 30.

Occurrence: Georgetown Limestone, Austin, Texas.

Neithea theodori n. sp.
Plate VI, figures 6-9

Dimensions.—Large specimen: Height 33 mm.; length 31 mm.; breadth 14 mm. Small specimen: Height 27 mm.; length 25.5 mm.; breadth 9 mm.

Description.—Shell medium to large, almost equilateral, broad, height practically equaling length, polygonal outline, ventral margin sub-semicircular with six definite angles. Ears missing.

Right valve convex; umbo gently incurved. On the surface are found sixteen plain, principal, radiating ribs. Every third one is raised above the others high enough to be distinctly recognized on first sight. These prominent ribs are rounded, while those in the depressions are low, and flat on top. All have rather steep sides. The depressions as a whole, as well as the intercostal spaces, are flat or flattened. The raised ribs, if at all, are only slightly wider than the others. The intercostal spaces approach the ribs in width. In some specimens the most posterior rib is a double one, while in others the anterior one shows this characteristic. Secondary ribs are distributed on the areas in an irregular manner. Sometimes there is none, whereas on other areas there is one or as many as three or four. On the two areas of the same specimen, the same number is not always found.

Fine concentric lines are present on the body of the shell, the areas, and the ears.

Remarks.—In the above description it was mentioned that the ribs are plain. There are, however, a number of specimens that show a slight variation from this condition; namely, split ribs.

Since there is a gradual transition from the plain ribbed specimens to the ornamented ones, and since those specimens which show the split ribs in the greatest abundance do not show this characteristic to a very great extent, the writer does not feel justified in classing the specimens having split ribs as a distinct variety. No difference in shape, and proportions of the shell, and relative size of the ribs can be detected in the two forms.

The prominent ribs are hardly ever affected, but occasionally a few show a very faint sinus. If only a few ribs on the shell show the furrow, these are located in the middle and never near the anterior and posterior borders. As it is, most specimens show the splitting to a very limited extent, but there are a few specimens in which practically all the ribs have a shallow groove on top.

The left valve has sixteen promninet flat-topped ribs. These are plain, low, and not very much narrower than the intercostal spaces. In the spaces there is an extremely fine rib, whenever there is, corresponding to the former, a split rib in the right valve.

Affinities.—There is considerable likeness between *N. theodori* and *N. georgetownensis* and its variety *subirregularis*. The typical specimens of the former resemble more the variety of the latter, and the two split forms are more or less alike. But *N. georgetownensis* and its variety are elongate forms, whereas *N. theodori* is broad and short. In the latter species the prominent ribs are only slightly wider and not much higher than those in the depressions, and there are no fine ribs in the intercostal spaces, while in *N. georgetownensis* and its variety there are very conspicuous raised ribs that are much higher and wider than the others, and fine ribs in the spaces. The split ribbed forms of *N. theodori* differ from *N. georgetownensis* primarily in the shape of the shell and relative size and proportions of the ribs, the differences having been pointed out above. Furthermore, there are no ribs in the interspaces and the manner of splitting is much more simple in the former than in the latter form.

This species differs from *N. texana* in its shape, which is more globose; in the greater difference in height between low and raised ribs; in its narrower ribs; and in its more sinuous ventral margin.

Number of specimens: About 175.
Occurrence: Georgetown Limestone, Austin, Texas.

Neithea altana n. sp.
Plate VII, figures 1-3

Description.—Shell medium, short and broad (?), subtrigonal; ventral margin gently rounded; ears imperfect, but appear to be prominent.

Right valve moderately convex, rounded.

The writer has not been able to find perfect specimens of this form, but it is so different from the other Georgetown *Neitheas* that it will be described and figured.

As in the other species of this group, there are sixteen strong, radiating ribs on the right valve. But, contrary to the ordinary arrangement, every third rib is raised so slightly that it can be detected only with difficulty. Furthermore, the ribs are high and narrow. All are flattened on top and equal in width. They are practically twice as wide as the interspaces. On account of this, and because they are narrow, they seem to be crowded in the umbonal region, and, consequently, appear to be sharp, and not flattened on top. However, near the base of the shell they are distinctly flattened. A few secondary ribs are sometimes found on the areas. The lines of growth are indistinct.

The left valve is missing.

Affinities.—This species is easily distinguished from *N. subalpina* by its ribs, which are practically equal in height and width, and are distinctly flattened on top.

Number of specimens: About 15.
Occurrence: Georgetown Limestone, Austin, Texas.

Neithea budensis n. sp.
Plate VII, figures 4-12.

Dimensions.—Height 22 mm.; length 18 mm.; breadth 10 mm.

Description.—Shell medium to large, subtrigonal, slightly higher than long, equilateral. Ears conspicuous, but not well preserved on the type. Other specimens show the anterior ear to be short and triangular and separated from the body of the shell

by a groove. The posterior ear appears to be larger and is a continuation of the posterior area. Basal margin sinuous.

Right valve ventricose, umbo curved over the hinge line which is short. Decorations consist of six prominent trifid ribs radiating from the umbo to the angles of the ventral margin, with two smaller ribs in the depressions between these raised areas. Two of these areas form the anterior and posterior boundary of the ribs. The three ribs on the prominent ridges are arranged in a characteristic manner. The middle rib is the highest one and is smaller than the two ribs in the depressions but approaches them in width.

The fourth ridge is the center of symmetry. Here is found the only exception to the trifid arrangement. Instead of a more prominent rib between the other two, there are, in this case, two smaller ribs in place of the central one. They are equal, are on top of the ridge, and separated by a gently rounded depression equaling them in width. Halfway down on the posterior slope is a smaller rib separated from the adjoining ribs on top of the ridge by a very narrow depression. On the lower part of the anterior slope there is a conspicuous rib somewhat stronger than the two on top of the ridge.

The arrangement of the ribs on the fifth and sixth ridges is the reverse of that on the first three. In each case the middle rib is the larger one. On the extreme upper portion of the slope on all five ridges there is a slightly smaller rib on the side towards the center of symmetry. On the other side, at the base of the slope there is a rib similar to the other secondary rib on the same ridge. All ribs are flattened on top and have almost perpendicular sides, which give them a rectangular appearance. The two ribs in the depressions are, relatively speaking, higher than those on the ridges, so that they extend upward almost as high. The ribs on the ridges are, for the most part, separated by very narrow furrows. This is, however, not the case in the depressions, which are flat as a whole. The different ribs have between them gently curved narrower depressions. At the base the ridges form irregularly curved projections which are separated by sinuses that are practically equal to them.

This species is further ornamented with very pronounced

growth ridges, which are so prominent that they give the ribs a ropy appearance. Ribs are absent on the areas, but prominent lines of growth are found here. The ears are covered with similar crowded, concentric lines.

Not all of the specimens show the above ornamentations completely. The shells weather easily. This obliterates the concentric striæ and often the ribs on the ridges. In this condition these prominent areas have the appearance of smooth elevations that have had a few radial lines impressed upon them. The ribs in the depressions are protected and are not affected so much.

No perfect left valves have been collected. This valve is slightly concave and has six elevated areas corresponding to those of the right valve. As far as can be determined, the arrangement of ribs on the areas seems to be more regular than on the right valve. Here are found three ribs, practically equal, on top of the ridges. On the fourth ridge there is added a smaller rib on the posterior slope. There are two larger ribs in each depression. The furrows separating the ribs are practically equal to the latter in width. The shape of the ribs, and pronounced concentric lines correspond to those of the right valve.

Affinities.—This species is perhaps a descendent of *N. irregularis*. In that form secondary ribs are distributed in an irregular manner. Here the six raised ribs have practically disappeared, and ridges have taken their place with secondary ribs grouped upon them in a definite manner. Besides this difference, there are other definite ones. The shape of the ribs is entirely different in the two forms. Also, *N. budensis* is more globose and not so high. In the left valve there are ridges covered with ribs in *N. budensis* in contrast to the double ribs in *N. irregularis*.

Shattuck and Boese have described a form from the Lower Cretaceous as *N. quinquecostata*. Evidently *N. budensis*, or a similar species, was the basis of the description of these two authors.

Number of specimens: 21.

Occurrence: Both divisions of the Buda Limestone. Austin, Round Rock, and Manchaca, Texas.

Neithea whitneyi n. sp.
Plate VII, figures 13-17

Pecten wrighti Whitney, 1911, Univ. of Texas Bull. No. 184, p. 13, Pl. I, fig. 4.

Dimensions.—Height 10 mm.; length 7 mm.; breadth 4.5 mm.

Description.—Shell small, subtrigonal, higher than long, almost equilateral; postero-dorsal margin slightly shorter than antero-dorsal margin. Anterior ear large and prominent, pointed, rounded transversely; posterior ear rudimentary, triangular and pointed. Ventral margin convex and sinuous.

Right valve strongly convex, the beak considerably incurved, posterior slope truncate. The ornamentation consists of four simple, but very prominent, subtriangular, radiating costae or ribs, with a smaller one at the posterior side. In addition to these, there is a minute rib near the anterior margin on the slope of the prominent anterior rib. The central costa is the most prominent one. The two adjacent ribs, which are practically equal, do not differ greatly from it. The anterior rib differs from the second one somewhat more than this latter differs from the central costa. The posterior rib is really a part of the posterior area. The central costa is separated from the two adjoining ones by moderately deep furrows slightly flattened at the bottom and practically equaling the ribs in width. The anterior and posterior ribs are separated from the others by narrower, angular depressions. At the ventral margin the ribs are produced as subtriangular extensions which have between them sinuses corresponding to the interecostal depressions. Over the whole surface are found fine concentric ridges barely visible to the naked eye. These are parallel to the undulated ventral margin and are inclined. From the anterior and posterior ribs the ridges are continued on the areas where they run parallel to the margin and are greatly crowded and become growth ridges. From the posterior area the ridges pass on to the posterior ear. On the anterior ear are seen concentric ridges and undulations. Humps which are probably due to growth thickenings are occasionally found on the ribs.

The left valve is more or less flat. The costae correspond to those of the right valve in ornamentation and relative size, but

are more globose and somewhat more prominent, and the interspaces are comparatively wider than in the other valve. Growth ridges are found on both valves, especially along the ventral margin. The interior of each valve shows a distinct fluted border.

Remarks.—The above is a description of a young shell. In older specimens the relative proportions are the same. On mature forms are found indications of the costellae that are characteristic of *N. wrighti.*

Affinities.—This species is distinguished from *N. wrighti* by its shape, which is more nearly equilateral, narrower, and more convex; by the ribs of its right valve, which are bluntly pointed at the summit, more solid, more triangular, and more prominent; and by its furrows, which are deep, narrow, and more or less angular, whereas those of the Georgetown form are broad and flat. Moreover, the ribs of the left valve of *N. whitneyi* are more prominent than those of *N. wrighti,* having steep sides, whereas those of the latter species have sloping sides.

This form belongs to the same group as *N. longicauda* (d'Orb.) and *N. cometa* (d'Orb.). It is distinguished from the former by being more robust and shorter in proportion. In *N. longicauda* there are distinct costellae or secondary ribs on both valves, besides tubercles in the furrows of the left valve, which are all absent in the Texas species. Moreover, the ribs of the French form are broad, rounded, and low, whereas those of *N. whitneyi* are subtriangular, bluntly pointed, and high. In *N. cometa* there are broad rounded depressions between the narrow, sharp ribs, and prominent costellae contrasting with the narrow furrows and prominent ribs of our species. In addition to this, *N. whitneyi* is shorter, broader, and has a less convex ventral margin than *N. cometa.*

This form is relatively rare in the Buda Limestone. When Professor Whitney described it as *P. wrighti* a few years ago, the material on hand did not justify making it a new species.

Number of specimens: 14.

Occurrence: Lower division of the Buda Limestone, Austin and Manchaca, Texas.

Neithea simondsi n. sp.
Plate VIII, figures 1-10.

Dimensions.—Height 5.5 mm.; length 5 mm.; breadth 2 mm.

Description.—Shell small, almost as long as high; ventral margin semicircular and rounded. Ears subtriangular and relatively large; hinge line straight and short.

Right valve moderately convex, umbonal slope gently curved over the hinge line, antero-dorsal and postero-dorsal margins relatively long. This valve is ornamented with nineteen prominent, flattened, radiating ribs of which every fourth one, beginning at the anterior and posterior borders, is slightly raised, in the umbonal region, above the three at each side, which lie in a broad, shallow, gently sloping valley. In the middle and the basal regions of the shell, however, all ribs are of the same height. The four ribs that are raised on the umbo are always somewhat wider than the others. The ribs are separated by rather deep, narrower, flattened depressions. Adjoining the four wide ribs are found furrows wider than those that separate the other ribs. Moreover, all ribs are scaly on the umbo and for some distance farther down on the valve. The anterior ear is separated from the body of the shell by a groove, while the posterior one is an extension of the posterior area. Both areas and ears are covered with prominent concentric ridges, and the former show no secondary ribs. However, on a few specimens a shallow depression has been noticed on the areas and adjoining the ribs, but it dies out before reaching the umbonal regions.

The left valve is missing.

Remarks.—On weather specimens the scales on the ribs are indistinct or entirely obliterated.

One of the specimens shows a modification of the ordinary arrangement of ribs. Instead of having four wider ribs, it shows four groups of two wide ribs each. There are three narrower ribs in the median group of the valve, but at the other places there are only two. Thus, the usual number of nineteen is retained.

Affinites.—Of all the Texas Cretaceous *Neitheas* heretofore described, *N. bellula* (Crag.) resembles *N. simondsi* n. sp. most. There is a general similarity between the shape of the shell and

the shape of the ribs of the right valve of the two species. But the facets and varying number of ribs in each, so characteristic of the former species, are not found on the latter. In *N. simondsi* there is regularity in the distribution of ribs. There are always three ribs between two wider ones, and the wide ribs are never replaced by twin-ribs or a group of very narrow ribs. Here are found only four wide ribs, whereas there are six such areas in *N. bellula*. Furthermore, the number of ribs in *N. bellula* is more than twice that in *N. simondsi*.

This species is distinguished from *N. irregularis* (Boese), *N. subalpina* (Boese), *N. texana* (Roem.), and allied species principally in having three ribs between two broader ones and having all of the same height, except in the umbonal regions, whereas in the forms mentioned above there are only two principal ribs between the prominent ones, and every third rib is distinctly raised. Moreover, there are no secondary ribs on the areas of *N. simondsi* n. sp., which is not the case in these other species.

N. simondsi n. sp. differs from *N. boesi* n. sp. in certain respects that are mentioned in the discusson of that species. The former species can be easily distinguished from *N. laevis* Drouet by being higher and having totally different ribs.

Number of specimens: 13.

Occurrence: Both divisions of the Buda Limestone, Austin, Manchaca, and Round Rock, Texas.

Neithea boesi n. sp.
Plate VIII, figures 11-19

Dimensions.—Height 14 mm.; length 10.5 mm.; breadth 5 mm.

Description.—Shell small, not much higher than long, ventral margin rounded. Ears subtriangular and conspicuous; hinge line short and straight.

Right valve moderately globose, umbo broad and curved over the hinge line. The decoration consists of twenty-one subequal, subtriangular, radiating ribs which are narrow, very high, and scarcely flattened on top. Every fourth rib and the most anterior and the most posterior ribs are somewhat wider and higher than the others, but only so slightly that it is hardly noticeable. The ribs are separated by narrower depressions. In the anterior

and posterior regions, the ribs are distinctly inclined towards the median line. On the umbo there are concentric folds instead of ribs. Below this, there are the radiating ribs but much interfered with by very strong lines of growth. On the remainder of the shell there are ordinary concentric lines which are also found on the areas and ears where they increase in strength as they approach the umbo. As in *N. simondsi*, a groove separates the anterior ear from the anterior area, while there is no such demarcation on the posterior side. No secondary ribs have been found on the areas.

The left valve is missing.

Affinities.—This species differs from *N. simondsi* n. sp. in its form, which is somewhat higher; in the number of ribs on the right valve, having two more, a prominent one being added anteriorly and posteriorly; in the shape of the ribs, which are subtriangular, slightly flattened on top, and considerably higher; and, in having concentric ridges, and not scales, on the umbo.

N. boesi n. sp. is distinguished from *N. altana* n. sp. in being much higher; in having rather sharp, and not rectangular ribs; and in having three ribs between every two conspicuous ones.

Number of specimens: 14.

Occurrence: Both divisions of the Buda Limestone, Austin and Round Rock, Texas.

Neithea roemeri (Hill)

Plate IX, figures 1-3; Plate X, figure 1

Pecten (Vola?) roemeri Hill, 1889, Pal. of the Cret. Formation of Texas, pt. 1, Pl. I.

Pecten (Vola) roemeri Hill, 1889, Bull. Geol. Surv. Texas No. 4, p. 8.

Pecten roemeri Shattuck, 1903. U. S. Geol. Surv. Bull. 205, p. 15, Pls. 2-4, p. 5, fig. 1.

Not *Pecten roemeri* Weerth, 1884, Paleont. Abhandl., Vol. 2, p. 54.

Dimensions.—Height 60 (?) mm.; length 70 mm.; breadth 31 (?) mm.

Description.—Shell large, thick, compressed, asymmetrical, inequivalve, length only sligthly greater than height; outline sub-

octahedral. The subsemicircular, scalloped ventral margin shows six projections formed by the extensions of the folds. At the base, the convexities of one valve fit into the concavities of the other. Ears prominent, posterior larger than anterior; hinge line long and straight, and equal to about three-fourths the length of the shell.

Right valve convex, somewhat larger than the left, beak prominent and elevated. The surface is decorated with six unequal radiating folds that are distributed in an irregular manner and ornamented with costae and costellae of different sizes and shapes. On first sight, it appears as if there is no regularity whatever about the arrangement, but upon closer investigation, a system can be made out. Each fold has a prominent rib at the summit and others of different sizes on the slopes. The summit costae are practically equal, and similar in shape. Between the several folds are found narrow depressions scarcely wider than those between the prominent ribs.

The fourth fold, although not the largest, is most pronounced, and projects farther out than the others at the ventral margin. It is also the highest one and the center of symmetry. Its summit is formed by a narrow rib rounded on top. On each slope are two small ribs varying somewhat in size, the lower ones tending to be more prominent. Across the intercostal depression posterior to this fold a broad flat-topped rib is found near the summit of the fifth fold, and on the summit there is a prominent costa. On the posterior slope are two smaller ribs, one of them being almost in the interfold furrow. On the anterior slope of the sixth fold is a small rib practically equal to its neighbor across the furrow. On the posterior slope are found four ribs, the first and last being insignificant, and the second more prominent than the third.

The third fold is broader than any of the others. Its summit also shows a prominent, narrow, rounded rib, which has a fine radial plication on the anterior side. The ribs on the posterior slope correspond in shape and arrangement to those on the anterior slope of the fifth fold. On the anterior slope are found two prominent unequal ribs. The larger rib is similar to the corre-

sponding one on the other slope of this fold and is nearer the summit.

The second fold has a conspicuous rib near the base on either side, and a smaller one higher up on the anterior slope.

There is a prominent costa on the posterior slope of the first fold, being even larger than the one forming the summit. On the slope adjoining the ear there are three small ribs, more or less alike.

In young specimens the folds are relatively higher than in the more mature forms.

The conspicuous ears are ornamented with prominent radiating and practically uniform costae.

Left valve somewhat less convex than the right, beak depressed. As in the right valve, there are six folds. But as the ribs alternate with those of the right valve, there is a furrow on the summit of each fold. Most furrows tend to be wider than the ribs, in contrast to the relation on the right valve.

On the anterior slope of the first fold there are three rather conspicuous ribs. There is a prominent rib posterior to the summit furrow, which is followed by a depression. On the anterior slope of the next fold, are found two well developed ribs. There is a smaller rib just beyond the summit and leaning against a very broad sloping costa. In the valley between this fold and the next lies a narrow, sharp rib. On the third fold two very prominent ribs enclose the summit furrow. On the fourth fold is found a high, narrow rib, followed by a broad, low one, which is separated from the former by a deep rounded depression. A deep narrow depression follows and, adjoining it, there are two medium sized costae separated by a very narrow furrow. The ornamentation of the posterior slope corresponds to that on the anterior. Between this fold and the next occurrs the broadest depression. The fifth fold consists of merely a distinct rib on either side of the summit furrow. This fold and the next are separated by a deep rounded furrow. On the anterior slope of the sixth fold is found a small, rounded rib and then a broad one adjoining the summit depression. On the posterior slope the ribs merge into those of the posterior ear. The ears are marked as on the right valve.

On some specimens additional fine ribs have been noticed in some of the depressions.

The posterior ear extends almost from the end of the projection of the posterior fold in a gentle curve to the end of the long hinge line. The anterior ear is smaller and is separated from the body of the shell by a deep groove.

Further ornamentation consists of fine concentric striæ, which are always parallel to the serrate margin, passing from the body of the shell to the ears. Growth ridges are also evident.

Remarks.—This species attains great size, the largest specimens collected having a height of 120 mm. and a length of 130 mm.

Affinities.—This form groups with *N. fleuriausiana* (d'Orb.) and *N. lapparenti* (Chof.). *N. roemeri* differs from d'Orbigny's species in having the folds more unequal in every respect, in having fewer ribs and these very dissimilar, and in having broad furrows. The hinge line and the ears also are different. The Texas species has the former longer than and the latter more unequal than *N. fleuriausiana*. As has been mentioned in the description, the posterior ear of the right valve of *N. roemeri* extends almost to the projection of the posterior fold. Furthermore, the shell of *N. roemeri* is more asymmetrical and shows a different relation between the valves. In *N. fleuriausiana* the left valve is only slightly convex, whereas in the American species both valves are inflated, there being only a slight difference in the convexity.

This form is not so long in proportion as *N. lapparenti* and its valves are evidently more convex than those of the latter species. Moreover, the shape and distribution of the ribs is entirely different in the two species.

Number of specimens: 22.

Occurrence: Upper division of the Buda Limestone, Austin, Texas.

Neithea austinensis n. sp.

Plate IX, figures 4-6; Plate X, figure 2

Dimensions.—Height 32.5 mm.; length 28.5 (?) mm.; breadth 10.5 (?) mm.

Description.—Shell rather large, subtrigonal, practically equilateral, solid; ventral margin shows six blunt projections formed by the prolongations of the six prominent ribs. Ears triangular and medium; hinge line straight.

Right valve moderately globose, umbo gently incurved. This valve is decorated with sixteen prominent and rather high radiating ribs of which every third one, including the most anterior and the most posterior, is somewhat stronger and is raised slightly above the others. There is an unusual arrangement of the two ribs in each depression. These ribs are close together and are separated by a furrow that is shallower than those by the side of the prominent ribs. The ribs appear to be rounded, but upon closer investigation it is found that they are flattened to some extent. The intercostal spaces adjoining the raised ribs are flattened and are as wide as, or slightly wider than, these latter. The ribs in the median depression are separated by a very narrow groove scarcely half as wide as one of these ribs. In the depressions anterior and posterior to the median one, the corresponding groove is slightly wider. And in the two remaining depressions grooves and ribs are practically equal in width. However, the ribs in the latter depressions are greatly reduced in size. As in similar species, the anterior ear is separated from the shell by a deep groove, while the posterior ear curves outward from the posterior area.

This valve is further ornamented with delicate radial ridges. From two to five or more can be made out on each rib. In the intercostal spaces they are not so abundant, and not more than two have been noticed in any one space. Better material might show these ridges distributed in a regular manner.

On the areas there are very fine radiating ribs. The number is not constant, but usually there are five, and they are distributed over the whole surface of the area.

Fine, crowded, concentric lines cover the whole shell and the ears.

The left valve is flat and is ornamented with fifteen principal radiating ribs, the ribs corresponding to the depressions on the right valve. The ribs that correspond to the furrows by the side of the prominent ribs of that valve, are the raised ribs of the left

valve. They are broad and flattened and appear in pairs. In the depression between two adjoining pairs, there is a low, narrow, sharp rib. As on the right valve, there are found radial ridges or fine secondary ribs on these ribs, distributed in an irregular manner, and more on the ribs than in the interspaces. A few fine secondary ribs are present on each area. On the posterior ear there are some marks which indicate that perhaps several small, radiating ribs are present near the hinge line. However, the specimens are not well enough preserved to determine them definitely. Delicate, yet distinct, concentric lines cover the whole shell. They are somewhat stronger on the ears.

Affinities.—*N. austinensis* n. sp. differs from all similar Texas Comanchean and Cretaceous *Neitheas* in having the two ribs in the depressions close together and separated by a furrow that is shallower than the other interspaces.

This species differs from *N. budensis* n. sp. in being less globose, in having radial ridges on the ribs and in the depressions, in not having its prominent ribs trifid in character, and in the general shape of the ribs. Moreover, the left valves are entirely different.

From *N. georgetownensis* n. sp., *N. austinensis* n. sp. differs in its form, which is much less convex and not so solid; in the ribs in the depressions of the right valve, which are higher and more rounded, in the raised ribs of this valve, which are not so prominent; in the ornamentation of radial ridges on both valves, which, however, have a parallel in the stronger riblets and depressions on the shell of *N. georgetownensis*.

Number of specimens: About 25.

Occurrence: Austin Chalk, Austin, Texas.

Neithea hartmani n. sp.
Plate X, figures 3-6, 12

?Pecten quadricostatus Roemer, 1852, Kreidebild. v. Texas, p. 64.

Dimensions.—Height 11 mm.; length 10.4 mm.; breadth 5 mm.

Description.—Shell small, subequilateral, subtrigonal, length practically equaling height; gently curved base with six prom-

inent projections formed by the extensions of the raised ribs and separated by shallow concavities; postero-dorsal margin longer than antero-dorsal, but both rather long. Greatest length below the middle. Ears medium; hinge line straight.

Right valve moderately convex, umbo prominent and incurved. The ornamentation consists of twenty-one simple, principal, radiating ribs of which every fourth one, including the first and the last, is much stronger than the others. The ribs curve gently outward. Of the three ribs in the depressions the middle one is sometimes very slightly stronger than the other two, or two are of the same strength and an outside one is somewhat smaller. In other depressions, no difference in the strength of the ribs can be made out. When there is a difference, as in the cases mentioned above, it is so slight that it can be detected only upon close study. The prominent ribs are practically three times as wide and as high as those in the depressions, which really are very insignificant. On all of the specimens the most posterior prominent rib, which is reduced in size, has a smaller rib on the anterior side. All ribs are rounded, and the depressions, as a whole, are flat. The intercostal spaces are rounded and are as wide as, or wider than, the ribs in the depressions, those adjoining the prominent ribs being no exception. The ribs of the first and the last group are not so strong as those in the others. At the base the six prominent ribs form blunt projections, and the depressions are bounded by gently curved incisions. Narrow, radial, secondary ribs are present on the areas. On the posterior area there are usually five, but one specimen shows six. On the anterior area the number could not be determined definitely, due to lack of preservation of these areas. But indications are that secondary ribs are just as abundant here as on the other area. Although the ears are poorly preserved, the posterior one of one specimen clearly shows radial ribs. These have the same shape and arrangement as those on the areas and seem to be but a continuation of them.

Fine, crowded, concentric ridges further ornament this valve, including the areas and ears.

The left valve is flat or slightly concave, and is ornamented with prominent radiating ribs that correspond to the intercostal spaces of the right valve. The same general manner of arrange-

ment of ribs is found as in *N. texana* and allied forms, only there are two ribs in each depression, instead of one. There are alternately two high and two low ribs. The ribs are rounded, subequal, and generally are wider than the interspaces. Of course, the furrow separating each pair of raised ribs is an exception to this and is considerably wider than the ribs. Concentric ridges are present as on the right valve.

The areas and ears are missing.

Remarks.—One right valve shows only two ribs in one of the depressions, and on one left valve there is a small rib in one of the broad furrows. Whether these are abnormalities or variations is an open question. Stoliczka (*22*, p. 438) has found all manners of gradations between *N. quadricostata* (Sow.) and *N. quinquescostata* (Sow.) of the Southern Indian Cretaceous. There is a possibility that a similar condition exists in the Austin Chalk between *N. hartmani* n. sp. and *N. castecli* n. sp. More extensive collecting in different portions of the State is necessary in order to determine this.

Affinities.—D'Orbigny (*8*, p. 644, pl. 447, figs. 1-7) and many writers after him have described a Senonian form as *Neithea quadricostata*. Later Pictet and Campiche (*17*, p. 253) showed that d'Orbigny's species is distinct from Sowerby's and named the former *N. faujasi*. Choffat (*2*, p. 149) believes *N. faujasi* to be identical with *regularis* Schl. D'Orbigny's species differs from Sowerby's, in being smaller, in having much smaller ears and a shorter hinge-line; in the anterior and posterior areas sloping outward only slightly; in a smaller apical angle; in having seven or eight ribs on the areas, instead of a smaller number like the true *quadricostata;* in the six prominent ribs being of a lesser elevation and, consequently, the groups less clearly demarcated; and in having the greatest length of the shell *below* the middle.

It remains to be shown how *N. hartmani* n. sp. differs from similar forms of Senonian age.

N. hartmani n. sp. differs from *N. quadricostata* (d'Orb.) chiefly in its shape, which is not so long and less globose; in its more angular base; in its stronger raised ribs; and in having longer antero-dorsal and postero-dorsal margins and more secondary ribs on the areas.

Zittel (*26*, p. 115, pl. 18, fig. 4) describes an Upper Cretaceous form as *N. quadricostata*. It differs from the Texas species in being higher, less angular at the base, and in having only two or three secondary ribs on the areas, or none at all. Moreover, Zittel says, six of the ribs on the left valve are characterized by greater strength. This certainly is not the case with the Texas specimens, where alternate pairs are raised. Judging from Zittel's figures, the arrangement of ribs on the left valve of his form is entirely different from that of the left valve of *N. hartmani* n. sp.

Another *quadricostata* of the Upper Cretaceous is White's (*23*, p. 37, pl. 4, figs. 1-2) form from Brazil (province Sergipe.). It is higher than *N. hartmani*, and has no secondary ribs on the areas. Furthermore, judging from White's pictures, there is less difference in size between the prominent ribs and those in the depressions, than in the Texas species. The intercostal spaces in *N. hartmani* seem to be wider.

In conclusion it ought to be mentioned that *N. hartmani* varies from the Upper Cretaceous *quadricostata* form, as generally described, in having radial ribs on the ears and only five or six ribs on the areas, instead of seven or eight, and having the prominent ribs at least three times as strong as those in the depression, instead of nearly the same size. As has been pointed out above, other Upper Cretaceous forms have only two or three ribs on the areas, or none at all.

Number of specimens: 12.

Occurrence: Upper layers of the Austin Chalk, Walnut Creek, Sprinkle, Texas.

Neithea casteeli n. sp.
Plate X, figures 7-11

Dimensions.—Height 28 mm.; length 26 mm.; breadth 10 mm. (distorted specimen.)

Description.—Shell large, subovate, almost equilateral; height slightly greater than length; base board, angular; antero-dorsal and postero-dorsal margins long; greatest length below the middle. Ears large; hinge line straight.

Right valve gently convex, umbo broad and incurved. This valve is decorated with twenty-six prominent radiating ribs. Every fifth one, including the most anterior and the most posterior, is distinctly elevated. The ribs curve moderately outward. Among the ribs in the depressions the two middle ones, which are practically equal, are sometimes stronger than the other two. More often three are of practically the same size, and an external one is smaller. The two outer ones usually differ somewhat in size. The prominent ribs are appreciably higher than those in the depressions, and almost twice as wide as the widest in these groups. The ribs are rounded, and the depressions are flat. The most posterior (prominent) rib is split by a radial sinus.

The intercostal spaces are rounded, subequal, and usually narrower than the ribs. An exception to the latter characteristic is often found in the first and the last group, where the strength of the ribs is reduced. As in similar species, the extensions of the prominent ribs form the angles at the base. The concavities between these projections are not very deep.

The antero-dorsal area is not preserved, but on the postero-dorsal there are very prominent secondary ribs. Six can be made out distinctly and a few more may have been obliterated by weathering. They are relatively broad, high, and rounded, and decrease in size as they are located nearer the margin. However, they are continued on the ear, where they are very prominent and numerous.

Fine, regular, concentric lines cover the ribs, interspaces, areas, and ears.

The left valve is flat or somewhat concave. The ornamentation consists of subequal, radial ribs, corresponding to the interspaces of the right valve. The ribs are subtrigonal in shape, rounded on top, and narrower than the intercostal spaces. The two ribs adjoining the furrows corresponding to the raised ribs of the right valve, are elevated above a group of three on each side, that lie in a slightly concave depression. Hardly any two adjoining ribs are of the same strength. Most of the broader ones are elevated, thus showing that the corresponding furrows at the side of prominent ribs of the right valve are wide. On

this valve are found concentric ridges arranged as on the right valve. Only fragments of this valve have been collected.

Remarks.—Attention has been called to the fact that the ribs in the depressions of the right valve vary in strength. In one of the depressions of one specimen there are only three ribs. This leads the writer to believe that probably the same variations exist in the Texas form that have been observed in *N. quinquecostata* by European paleontologists. It is very seldom that one of the small exterior ribs in the depressions is so near the prominent rib as to seem to be connected with it. Usually a broad furrow separates the two. This is indicated also by the raised ribs of the left valve, which are often exceptionally broad.

Affinities.—Roemer (*19*, p. 64), Conrad (*3*, p. 269), Gabb (*10*, p. 366) and Boese (*1*, p. 99) have pointed out that the *quinquecostata* form of North America is distinct from the typical *N. quinquecostata.*

Roemer (*19*, p. 64) desribed a *quinquecostata* form from Fredericksburg as *Pecten quadricostata* var. His right valve differs from ours in having a fine linear rib on each side of the prominent rib, combined more or less with this latter, thus giving the raised ribs a trifid appearance. With regard to the left valve, he says: "Je vier Rippen sind buendelweis gweissermassen zu einer einzigen flachen Rippe vereinigt und die Mitte des Zwichenraums zwischen je zwei solchen breiten, flachen Falten nimmt eine einzelne schmale gerundete Falte ein. Die breiten aus der Vereinigung von vier entstehenden Falten entsprechen uebrigens in ihrer Lage den fuenf staerkeren Rippen der anderen Klappe und stossen mit diesen am Rande zusammen." There is no such arrangement on the left valves of *N. casteeli* n. sp.

Moreover, Roemer's shell is higher and has shorter areas than *N. casteeli,* and the author does not mention secondary ribs on the areas and ears.

Conrad (*3*, p. 269; *4*, p. 150, pl. 5, fig. 1) lists Roemer's *quadricostatus* var. as synonymous with his *occidentalis.* His species differs from the writer's in being higher, in having shorter areas, and in not having fine ribs on the areas and ears.

Neithea quinquecostatus (Mort.) (*15*, p. 57, pl. 19, fig. 1) was

included by Gabb (*10* p. 365) in his species *Neithea mortoni*. Gabb, in speaking of the left valve, says: "There is, very rarely, the slightest approach to the sexradiate arrangement of the other valve." As has been mentioned in the description above, this arrangement is very pronounced in *N. casteeli*. Furthermore, there seems to be a greater variation in the strength of the ribs of the Texas species. Judging from Morton's figure, there are certain definite differences between the shape of *N. quinquecostatus* Mort. and *N. casteeli*. Since Gabb considers Roemer's *quadricostata* var. identical with his species, and since the writer believes the former to be distinct from *N. casteeli*, *N. mortoni* is regarded as distinct from *N. casteeli*.

Boese's *N. quinquescostata* is not closely related to the other American *quinquecostata forms*, since the latter are Upper Cretaceous species. His specimens came out of Lower Cretaceous Formations.

Number of specimens: About 40.

Occurrence: Austin Chalk, Austin, Texas.

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PLATES

PLATE I

Plate I.

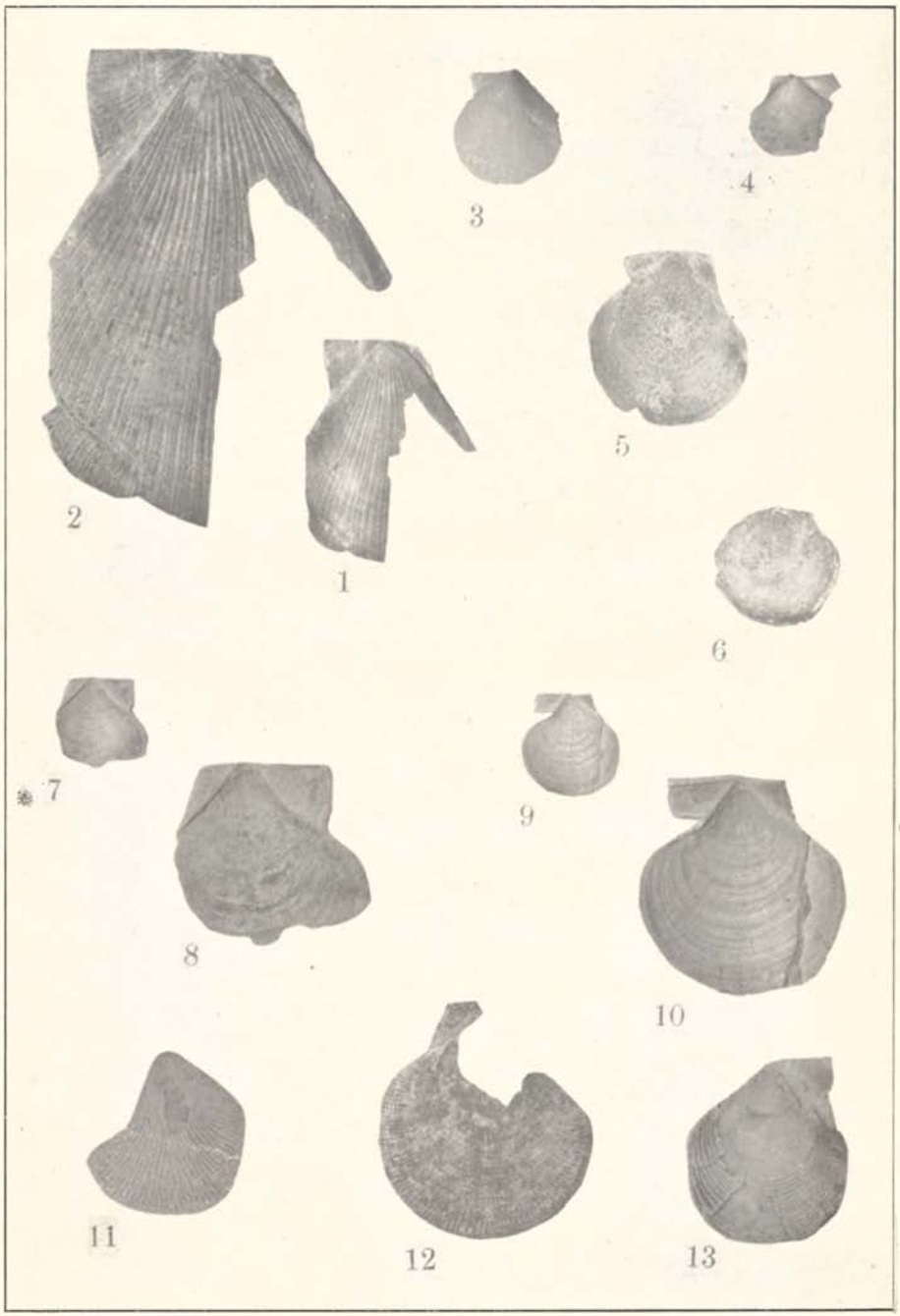

PLATE II

Plate II.

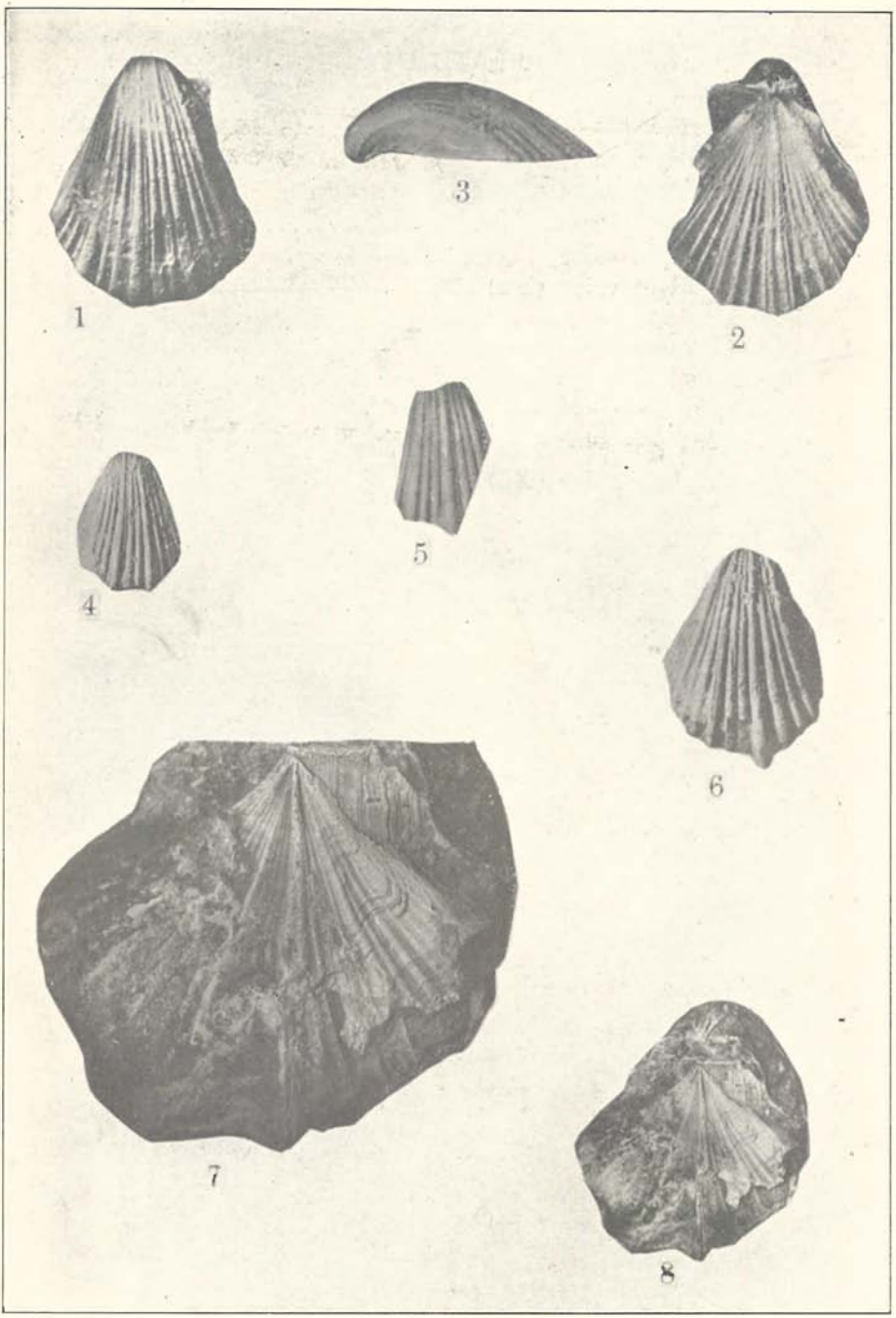

PLATE III

Plate III.

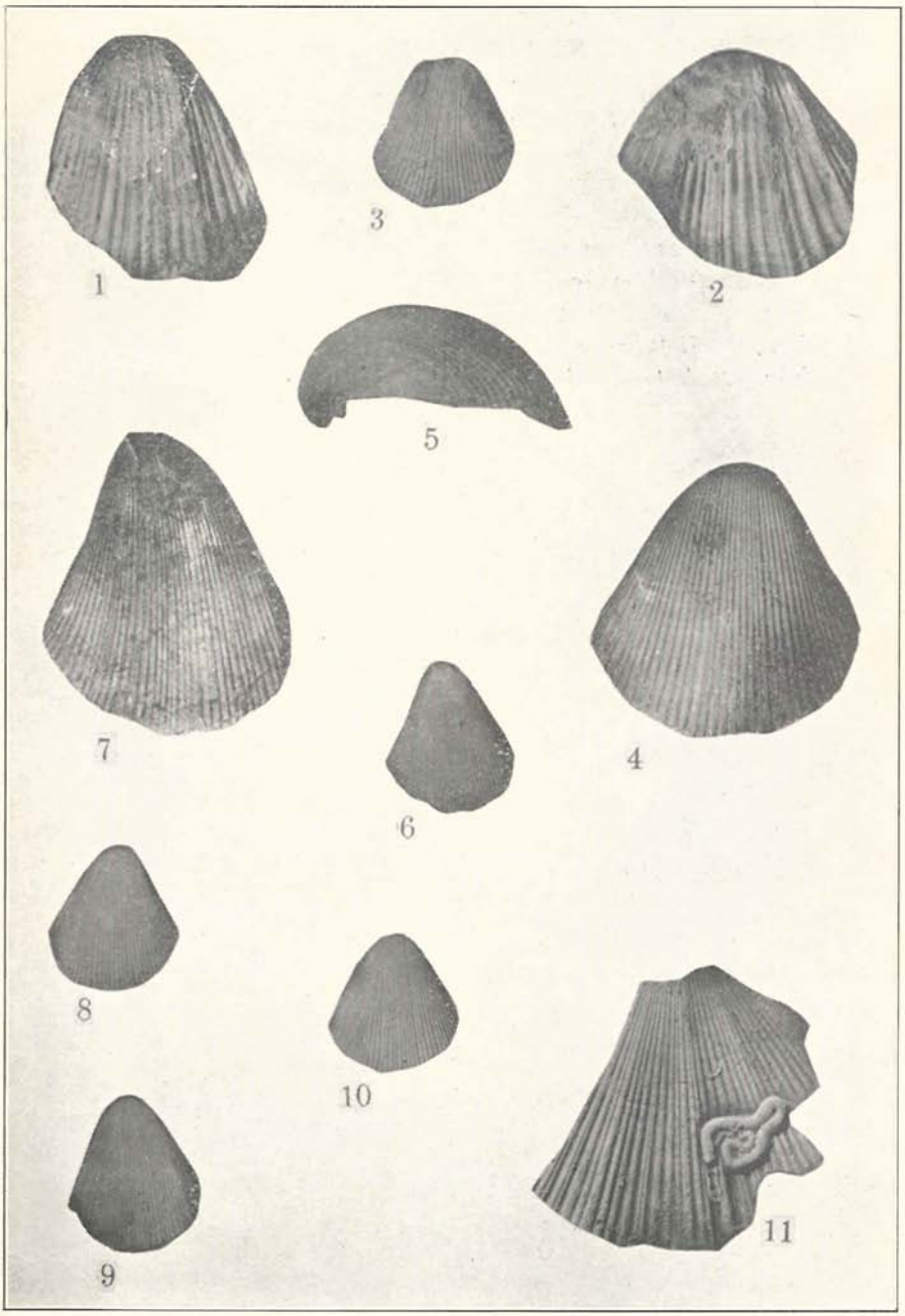

PLATE IV

Page

Neithea wrighti (Shumard) 23

Fig. 1. Right valve (X2)

Fig. 2. Right valve of another specimen

Fig. 3. Anterior view of the same

Neithea texana (Roemer) 25

Fig. 4. Right valve

Fig. 5. Same, (X2)

Fig. 6. Left valve of the same specimen (X2)

Fig. 7. Anterior view of another specimen

Plate IV.

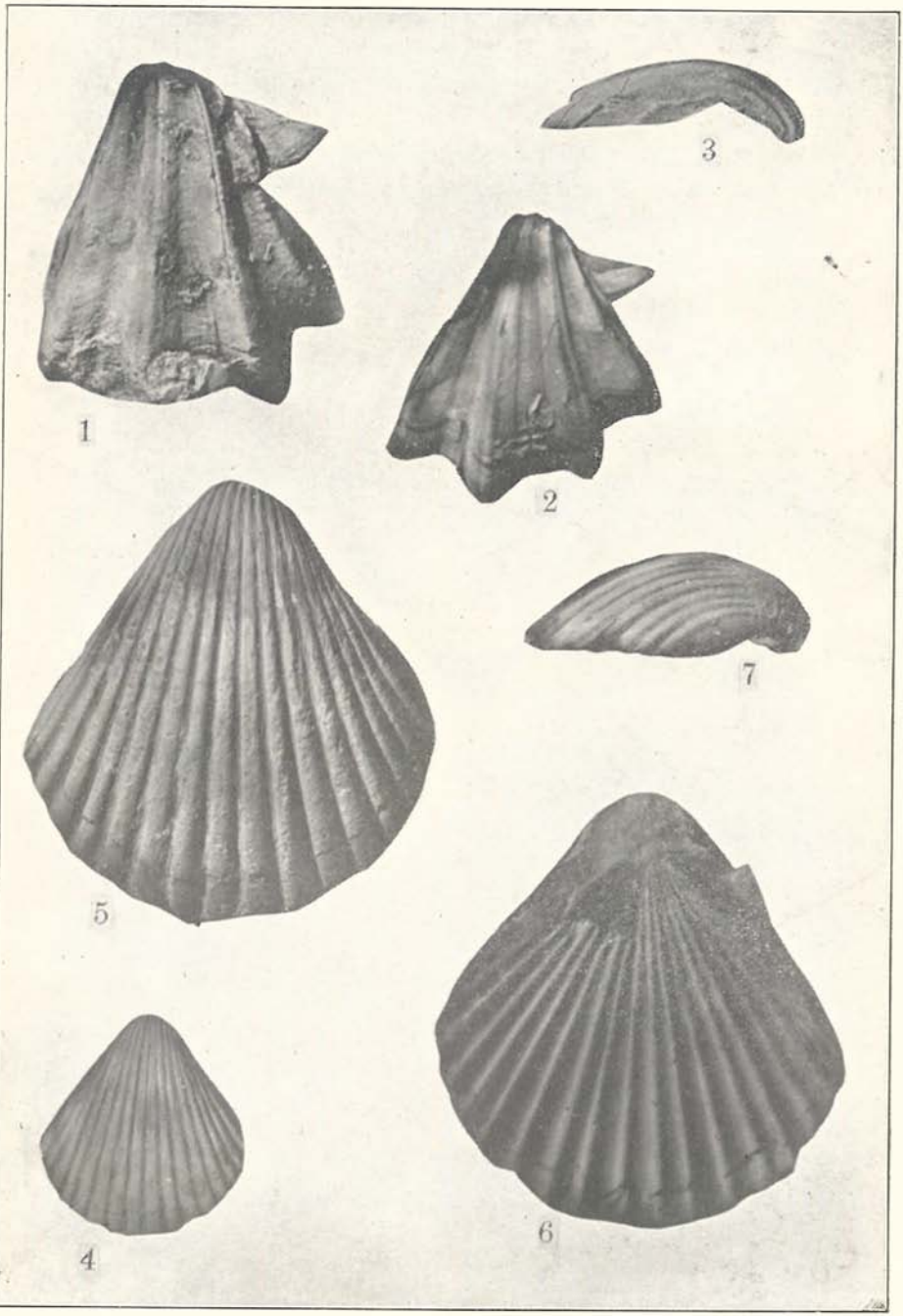

PLATE V

Page

Neithea texana (Roemer) 25

Fig. 1. Right valve (the same specimen as fig. 7, pl. IV)

Neithea texana (Roemer) var. *elongata* (Boese) 28

Fig. 2. Right valve

Fig. 3. A portion of a left valve

Neithea subalpina (Boese) 28

Fig. 4. Right valve

Neithea subalpina (Boese) var. *linki* n. var 30

Fig. 5. Right valve

Fig. 6. Left valve

Plate V.

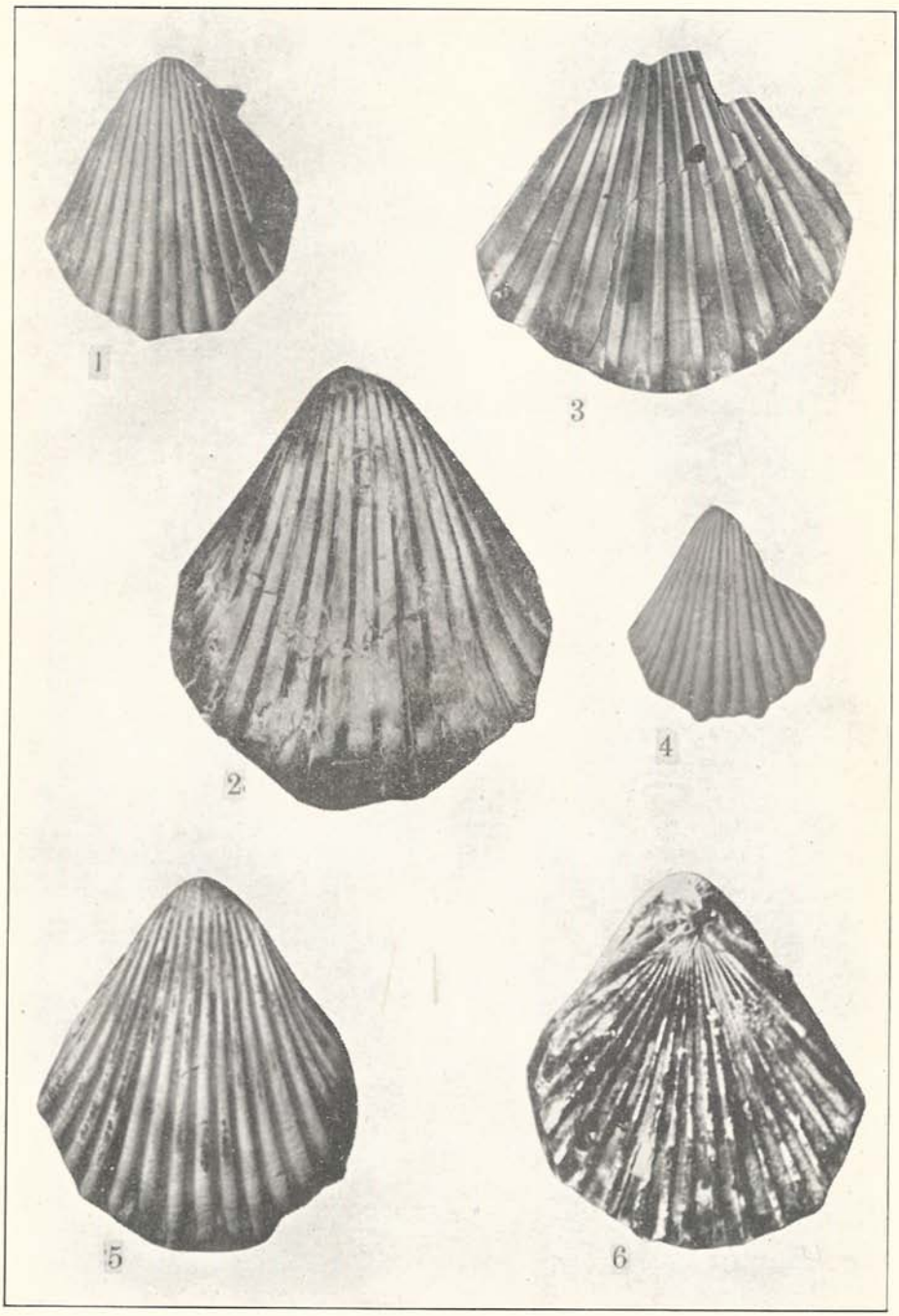

PLATE VI

Plate VI.

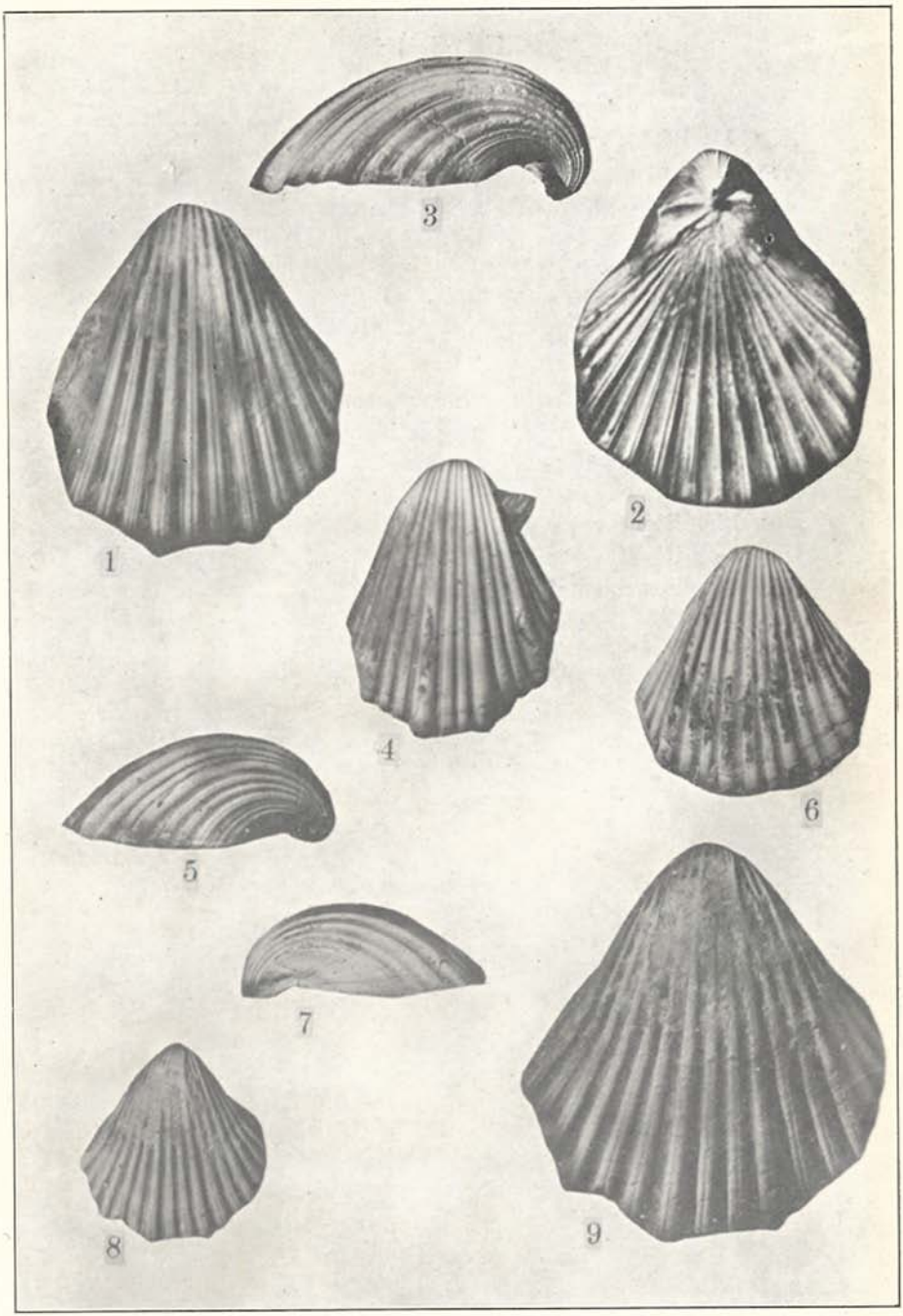

PLATE VII

Page

Neithea altana n. sp. 36

Fig. 1. Right valve

Fig. 2. Same, (X2)

Fig. 3. Right valve of another specimen

Neithea budensis n. sp. 36

Fig. 4. Right valve (X2)

Fig. 5. Anterior view of the same (X2)

Fig. 6. Portion of a right valve, showing arrangement of ribs (X2)

Figs. 7, 9. Weathered specimens, showing worn ribs

Figs. 8, 10. Same, (X2), respectively

Figs. 11, 12. Portions of a left valve (X2)

Neithea whitneyi n. sp. 39

Fig. 13. Right valve (X2)

Fig. 14. Right valve (X2)

Fig. 15. Posterior view of the same (X2)

Figs. 16, 17. Left valves (X2)

Plate VII.

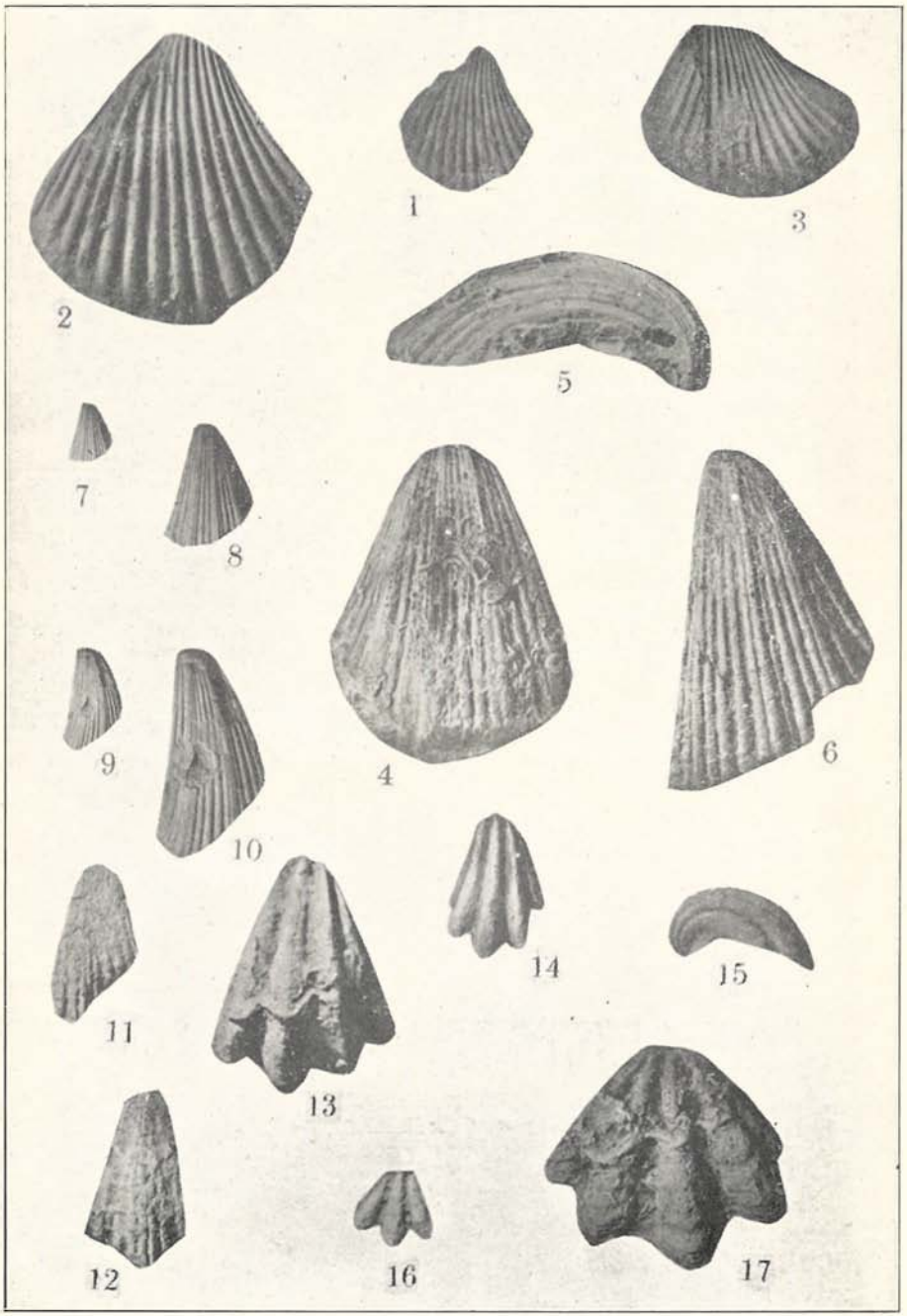

PLATE VIII

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Neithea simondsi n. sp. 41

Fig. 1. Right valve
Fig. 2. Same, (X2)
Fig. 3. Right valve (X3)
Fig. 4. Anterior view of the same (X3)
Fig. 5. Right valve (X3)
Fig. 6. Right valve
Fig. 7. Right valve
Fig. 8. Same, (X2)
Fig. 9. Right valve
Fig. 10. Same, (X2)

Neithea boesi n. sp. 42

Fig. 11. Right valve (X3)
Fig. 12. Posterior view of the same (X3)
Fig. 13. Right valve (X3)
Fig. 14. Posterior view of the same (X3)
Fig. 15. Right valve
Fig. 16. Right valve
Fig. 17. Same, (X2)
Fig. 18. Same as fig. 13, natural size
Fig. 19. Same, (X2)

Plate VIII.

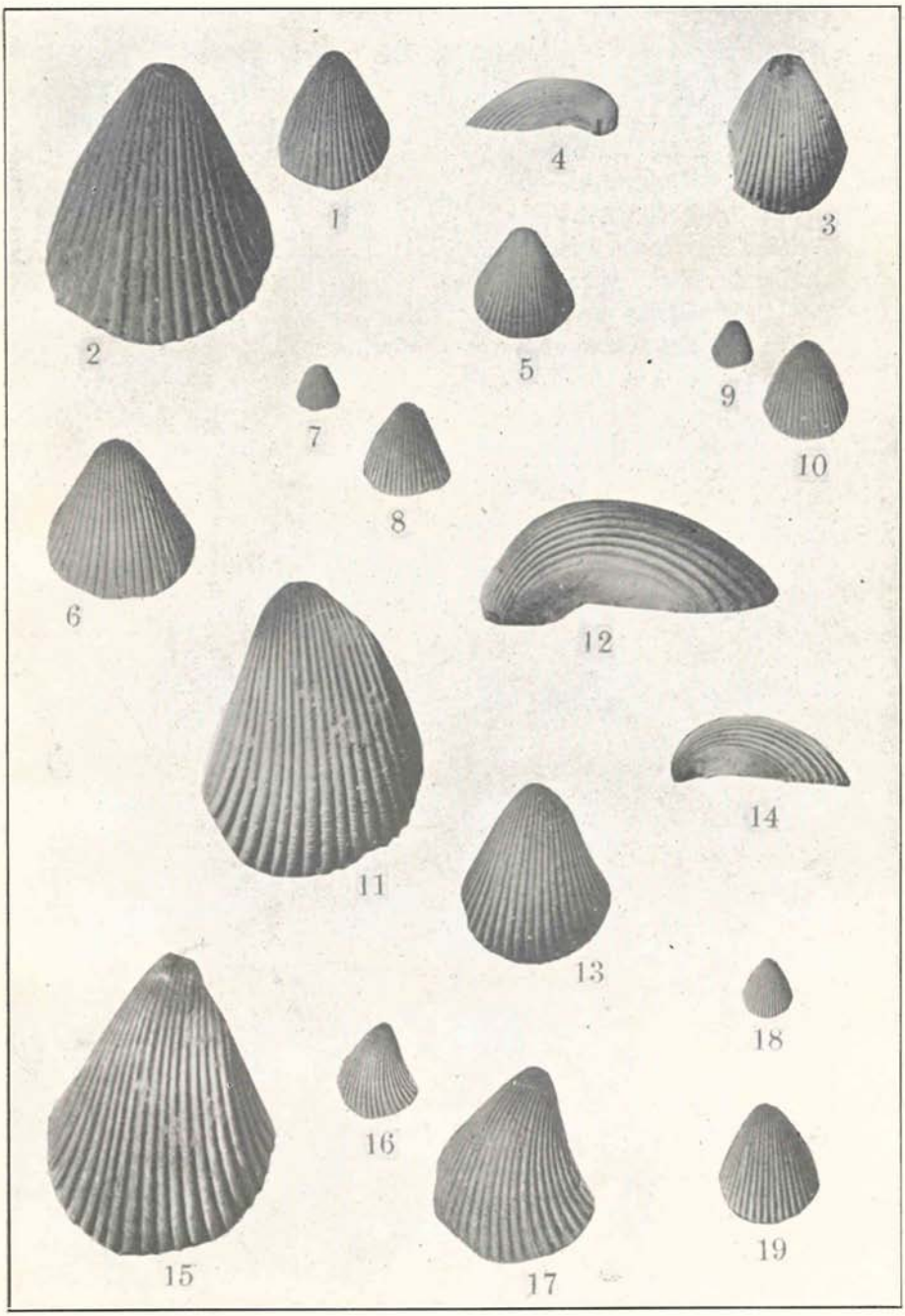

PLATE IX

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Neithea roemeri (Hill) 43

Fig. 1. Left valve

Fig. 2. Right valve

Fig. 3. Left valve

Neithea austinensis n. sp 46

Fig. 4. Right valve

Fig. 5. Right valve

Fig. 6. Left valve of the same specimen

Plate IX.

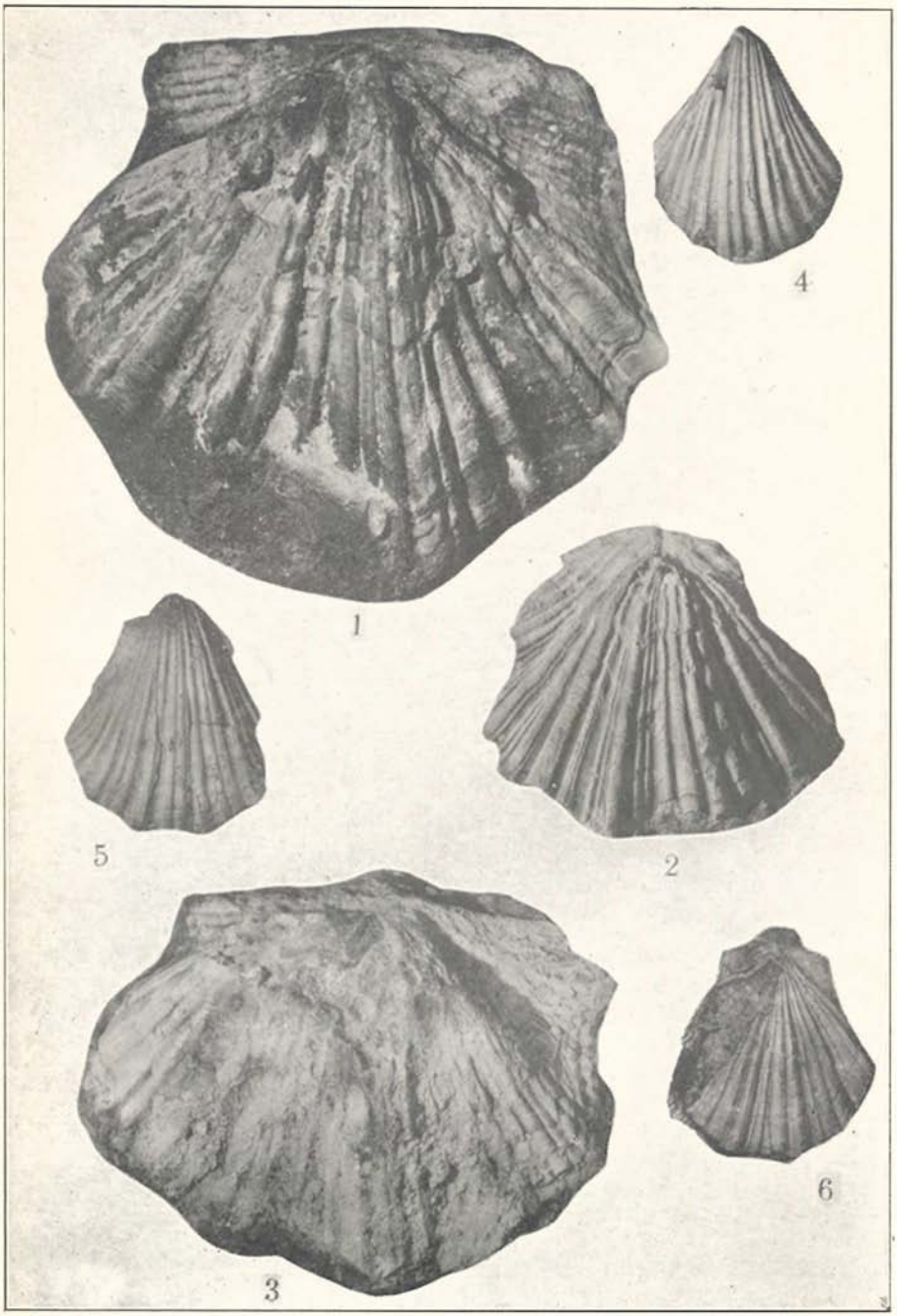

PLATE X

Page

Neithea roemeri (Hill) 43

Fig. 1. Right valve of the same specimen as fig. 3, pl. IX

Neithea austinensis n. sp. 46

Fig. 2. Portion of a right valve

Neithea hartmani n. sp. 48

Fig. 3. Right valve (X2)

Fig. 4. Posterior view of a specimen (X2)

Fig. 5. Portion of a right valve (X2)

Figs. 6, 12. Parts of left valves (X2)

Neithea castecli n. sp. 51

Figs. 7, 8, 9. Portions of right valves

Figs. 10, 11. Portions of left valves

Plate X.