The Late Cretaceous Ammonites *Scaphites leei* Reeside and *Scaphites hippocrepis* (DeKay) in the Western Interior of the United States

GEOLOGICAL SURVEY PROFESSIONAL PAPER 619

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By WILLIAM A. COBBAN

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Three chronological forms each of Scaphites leei *and* Scaphites hippocrepis *occur in dimorphic pairs and provide a means of correlating thin units of strata*

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By WILLIAM A. COBBAN

ABSTRACT

Scaphites leei Reeside and *S. hippocrepis* (DeKay) are closely related ammonites found at many localities in Montana, Wyoming, South Dakota, Colorado, Utah, and New Mexico. Both species have been found in Texas, and *S. hippocrepis* occurs also in Alabama, Georgia, Maryland, Delaware, and New Jersey, as well as in several countries in Europe and Africa.

Both species occur in dimorphic pairs which are herein interpreted as male and female. In any one collection, the adults of each sex show a considerable range in size so that the ratio of the smallest specimen to the largest may be as much as 1 : 4. The females attain a larger size than the males, but there is an overlap in the size range of the sexes. The last whorl of the female considerably overlaps the inner whorls, and this character combined with an umbilical swelling at the base of the body chamber almost does away with the umbilical opening. The males, which lack this overlap and swelling, have a larger umbilicus and a concave umbilical wall.

Each species can be separated into three chronological subspecies to which Roman numerals I, II, and III are assigned. The oldest form, *Scaphites leei* I, has a coarsely ribbed body chamber and ventrolateral nodes on both the phragmocone and body chamber. *Scaphites leei* II lacks nodes on the phragmocone. *Scaphites leei* III is more densely ribbed than *S. leei* II, and the females have fewer umbilical nodes. *Scaphites hippocrepis* I, the descendant of *S. leei* III, is more densely ribbed and has weaker ventrolateral nodes which tend to be elongated. *Scaphites hippocrepis* II is more densely ribbed than *S. hippocrepis* I and has stronger and more circular ventrolateral nodes. *Scaphites hippocrepis* III, the youngest form in the *S. leei*-*S. hippocrepis* lineage, is very densely ribbed and has an incipient third row of nodes on the flank of the body chamber between the rows of umbilical and ventrolateral nodes.

INTRODUCTION

Scaphites leei Reeside and *S. hippocrepis* (DeKay) are easily identified Late Cretaceous ammonites characterized by the adult body chamber having ventrolateral and umbilical nodes, a nearly smooth flank, and a well-ribbed venter on which the ribbing tends to be interrupted on the older part. *S. hippocrepis* is widely distributed in the western interior of North America, in the Gulf and Atlantic Coastal Plains of the United States, and in the Lower Campanian rocks in many countries in northern Europe. *S. hippocrepis* was designated by Reeside (1944) as the index fossil for rocks in the western interior region equivalent in age to that of the Eagle Sandstone of the Montana Group.

Scaphites leei and *S. hippocrepis*, in the broad sense, range through as much as 1,700 feet of strata in parts of the western interior region. Collections of the scaphites from several levels within this thick sequence reveal subtle changes in sculptural features, such as density of ribs and nodes. These changes, which are herein interpreted as subspecific in rank, are useful in subdividing the zones of *S. leei* and *S. hippocrepis* and thereby provide a means for correlating thin units of strata.

The present study was principally made possible by a large collection of *Scaphites leei* made by Glenn R. Scott, of the U.S. Geological Survey, and by the numerous collections of *S. hippocrepis* made by James R. Gill, also of the U.S. Geological Survey, in the course of his study of detailed stratigraphic sections in Wyoming, Montana, and South Dakota. James H. Smith, of the Mountain Fuel Supply Co. (Salt Lake City), kindly donated a large collection of the youngest form of *S. hippocrepis* from the Blair Formation near Rock Springs, Wyo., as well as several smaller collections of older forms of the species from Colorado and Wyoming. William D. Greene and Nelson H. James, Greybull, Wyo., donated many fine specimens of *S. hippocrepis* from the Alakali anticline area northwest of Greybull. All photographs were made by Robert E. Burkholder, of the Geological Survey. Charles C. Capraro, also of the Geological Survey, skillfully retouched many of the photographs and prepared the drawings of sutures, as well as text figure 2. The figured specimens are in the U.S. National Museum in Washington, D.C.

GEOGRAPHIC DISTRIBUTION

In the western interior of the United States, *Scaphites leei* and *S. hippocrepis* are known from many

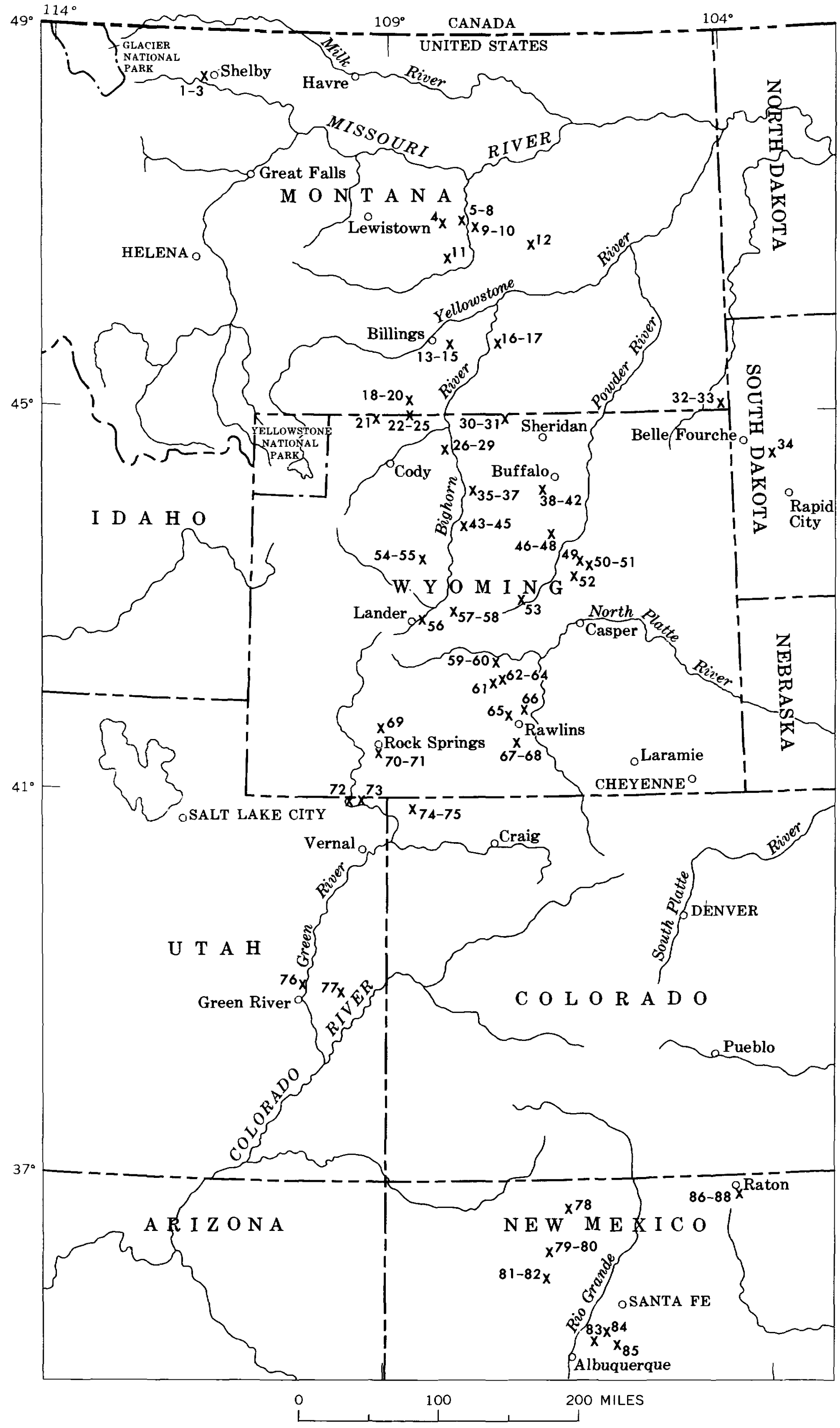

Figure 1.—Index map of the western interior of the United States showing localities of *Scaphites leei* and *S. hippocrepis* referred to in the text and in table 1.

localities in Wyoming and Montana and from fewer localities in South Dakota, Colorado, Utah, and New Mexico. The localities described in table 1 and shown on figure 1 are those pertinent to the present report and probably represent about two-thirds of the U.S. Geological Survey's localities of these scaphites.

TABLE 1.—*Localities at which fossils were collected*

Locality No. (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
1	D692	W. L. Rohrer, 1955. Nine miles west-northwest of Shelby, in the S½SW¼NW¼ sec. 31, T. 32 N., R. 3 W., Toole County, Mont. Marias River Shale, from 29.5 ft below top.
2	21419	W. A. Cobban, 1948. Eight miles west of Shelby at head of ravine 3 miles north of Marias River, in the NE¼ sec. 31, T. 32 N., R. 3 W., Toole County, Mont. Marias River Shale, from limestone concretions 10 ft below top.
3	21420	W. A. Cobban, 1948. Same locality as 21419. Telegraph Creek Formation, from thin-bedded sandstone 24–35 ft above base.
4	D4914	W. A. Cobban, 1965. Bluff three-fourths of a mile east of Winnett, in the NE¼SE¼ sec. 6, T. 14 N., R. 27 E., Petroleum County, Mont. Eagle Sandstone, from small dark-brown-weathering sandstone concretions in lowest sandstone member.
5	D5633	J. R. Gill, R. E. Burkholder, R. Fleisher, and W. A. Cobban, 1966. Three miles south of Cat Creek, in the NE¼NW¼ sec. 35, T. 15 N., R. 29 E., Petroleum County, Mont. From a ferruginous concretion 110 ft below lowest sandstone unit of Eagle Sandstone.
6	D5634	J. R. Gill, R. E. Burkholder, R. Fleisher, and W. A. Cobban, 1966. Same locality as D5633. From a limestone concretion 100 ft below lowest sandstone unit of Eagle Sandstone.
7	D5636	J. R. Gill, R. E. Burkholder, R. Fleisher, and W. A. Cobban, 1966. Same locality as D5633. From a limestone concretion 40 ft below lowest sandstone unit of Eagle Sandstone.
8	D5639	J. R. Gill, R. E. Burkholder, R. Fleisher, and W. A. Cobban, 1966. Same locality as D5633. From calcareous concretions in lowest sandstone unit of Eagle Sandstone.
9	21405	W. A. Cobban, 1948. About 3.4 miles east of Mosby Post Office, in the SW¼NE¼SE¼ sec. 5, T. 14 N., R. 31 E., Garfield County, Mont. Gammon Shale, 45 ft above base.
10	23896	W. A. Cobban, 1952. Stream cut 3.4 miles east of Mosby Post Office, in the SE¼ sec. 5, T. 14 N., R. 31 E., Garfield County, Mont. Colorado Shale, from upper part of Niobrara Shale Member.
11	2936	T. W. Stanton, 1903. Willow Creek, 6 miles [9 or 10] above old Fort Maginnis-Junction City road, Musselshell County, Mont. Eagle Sandstone, near base.
12	D3520	W. A. Cobban, 1948. Thirty-seven miles west-northwest of Forsyth, in the SE¼ sec. 27, T. 12 N., R. 38 E., Rosebud County, Mont. From lower part of Gammon Shale.
13	D4220	J. R. Gill, 1962. About 16 miles east-southeast of Billings, in the NW¼SW¼ sec. 1, T. 2 S., R. 28 E., Yellowstone County, Mont. Eagle Sandstone, lower part.
14	D4221	J. R. Gill, 1962. About 17 miles east-southeast of Billings, in the NW¼NW¼NW¼ sec. 6, T. 2 S., R. 29 E., Yellowstone County, Mont. Eagle Sandstone, same stratigraphic level as D4220.
15	D4280	J. R. Gill, R. E. Burkholder, and W. A. Cobban, 1963. Seventeen miles southeast of Billings, in the W½SW¼ sec. 5, T. 2 S., R. 29 E., Yellowstone County, Mont. Telegraph Creek Formation, from gray silty limestone concretion in ridge-forming sandy unit 43 ft above base.
16	5745	T. W. Stanton and C. A. Fisher, 1908. On road from mouth of Little Horn River, 7 miles northeast of Hardin, Big Horn County, Mont. Eagle Sandstone [probably from Gammon Ferruginous Member of Cody Shale near loc. 21206].
17	21206	W. A. Cobban, 1947. Seven miles east of Hardin, near the center of the north line of sec. 13, T. 1 S., R. 34 E., Big Horn County, Mont. Cody Shale, from silty limestone concretions in Gammon Ferruginous Member.
18	9649	C. J. Hares, 1916. Near Jack Creek about 7 miles south of Bridger, in sec. 27, T. 7 S., R. 23 E., Carbon County, Mont. From 150 ft below Elk Basin Sandstone Member of Telegraph Creek Formation.
19	21937	J. B. Reeside, Jr., and D. A. Andrews, 1938. Ten miles northwest of Warren, in the SW¼ sec. 20, T. 8 S., R. 24 E., Carbon County, Mont. Telegraph Creek Formation.
20	D4637	J. R. Gill and R. C. Givens, 1964. Near Jack Creek 13 miles south-southeast of Bridger, in the NW¼SE¼ sec. 21, T. 8 S., R. 24 E., Carbon County, Mont. Telegraph Creek Formation, from basal 80-ft sandy unit.
21	18148	J. B. Reeside, Jr., and W. G. Pierce, 1938. South of Line Creek, in the NW¼SW¼SE¼ sec. 26, T. 58 N., R. 103 W., Park County, Wyo. Cody Shale, from concretionary lens of fine-grained sandstone 1,600 ft above base.
22	9625	C. J. Hares, 1916. Elk Basin, sec. 25, T. 58 N., R. 100 W., Park County, Wyo. Telegraph Creek Formation, Elk Basin Sandstone Member.
23	17645	D. A. Andrews, 1936. Three miles southwest of Frannie, in the SE¼ sec. 10, T. 57 N., R. 98 W., Park County, Wyo. Cody Shale, from basal part of Telegraph Creek Member.
24	D1446	W. A. Cobban, 1957. Northwest side of Elk Basin, from conspicuous butte in the NW¼SW¼ sec. 35, T. 9 S., R. 23 E., Carbon County, Mont. Telegraph Creek Formation, from Elk Basin Sandstone Member.
25	D3295	J. R. Gill and L. G. Schultz, 1961. Elk Basin oil field, in the SE¼ sec. 19, T. 58 N., R. 99 W., Park County, Wyo. Telegraph Creek Formation, 15 ft below top of Elk Basin Sandstone Member.

TABLE 1.—*Localities at which fossils were collected*—Continued

Locality No. (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
26	D4193	J. R. Gill and W. R. Vaughn, 1962. Alkali anticline, in the N½SE¼ sec. 9. T. 54 N., R. 95 W., Big Horn County, Wyo. Cody Shale, 1,630 ft above base.
27	D4194	J. R. Gill and W. R. Vaughn, 1962. West flank of Alkali anticline, about 12.5 miles southeast of Lovell, in the N½SE¼ sec. 9, T. 54 N., R. 95 W., Big Horn County, Wyo. Cody Shale, from sandy limestone concretions 1,780 ft above base.
28	D4198	W. D. Greene, R. E. Burkholder, N. H. James, and W. A. Cobban, 1963. Nine miles southeast of Lovell, in the SE¼ sec. 29, T. 55 N., R. 95 W., Big Horn County, Wyo. Cody Shale, from zone of large brown calcareous sandstone concretions, same stratigraphic level as D4194.
29	D4199	W. D. Greene, R. E. Burkholder, N. H. James, and W. A. Cobban, 1963. Eight miles southeast of Lovell, in the SW¼ sec. 20, T. 55 N., R. 95 W., Big Horn County, Wyo. Cody Shale, same bed as at D4198.
30	6053	T. W. Stanton and R. W. Stone, 1909. Pass Creek, 2 miles northeast of Slack, Sheridan County, Wyo. Cody Shale, from sandstone 900 ft below top.
31	D3312	J. R. Gill, L. G. Schultz, and W. A. Cobban, 1960. About 4.5 miles west of Parkman, in the NW¼NW¼ sec. 30, T. 58 N., R. 87 W., Sheridan County, Wyo. Cody Shale, from a glauconitic ridge-forming sandstone bed.
32	23477	W. A. Cobban, 1941. Head of Owl Creek, in the NE¼NE¼ sec. 13, T. 9 S., R. 61 E., Carter County, Mont. Pierre Shale, from a gray limestone concretion in the Gammon Ferruginous Member about 165 ft below top of Groat Sandstone Bed.
33	23478	W. A. Cobban, 1941. Same locality as 23477. Pierre Shale, from a ferruginous concretion in the Gammon Ferruginous Member about 130 ft below top of Groat Sandstone Bed.
34	D1847	J. R. Gill, 1958. Three miles north of Bear Butte, in the NE¼NE¼ sec. 6, T. 6 N., R. 6 E., Meade County, S. Dak. Pierre Shale, from lens of marlstone in lower part of Gammon Ferruginous Member.
35	D4181	J. R. Gill and W. R. Vaughn, 1962. Nine miles southeast of Manderson, in the NE¼NW¼NW¼ sec. 20, T. 49 N., R. 91 W., Big Horn County, Wyo. Cody Shale, from an orange-brown sandy limestone concretion 160 ft above top of Niobrara Shale Member.
36	D4182	J. R. Gill and W. R. Vaughn, 1962. About 8 miles southeast of Manderson, in the NW¼NW¼NW¼ sec. 20, T. 49 N., R. 91 W., Big Horn County, Wyo. Cody Shale, from sandy limestone concretions 395 ft above top of Niobrara Shale Member.
37	D4185	J. R. Gill and W. R. Vaughn, 1962. West flank of Manderson anticline, 8 miles southeast of Manderson, in the NW¼NE¼NE¼ sec. 19, T. 49 N., R. 91 W., Big Horn County, Wyo. Cody Shale, from ridge-forming sandstone bed 665 ft above top of Niobrara Shale Member.
38	22821	R. K. Hose and W. J. Mapel, 1950. Elgin Creek, in the NE¼NW¼ sec. 13, T. 49 N., R. 83 W., Johnson County, Wyo. Cody Shale, about 365 ft below Shannon Sandstone Member.
39	22822	R. K. Hose and W. J. Mapel, 1950. Same locality as 22821. Cody Shale, from limestone concretions 748 ft below base of Shannon Sandstone Member.
40	22825	R. K. Hose and W. J. Mapel, 1950. Same locality as 22821. Cody Shale, from a ferruginous layer 213 ft below base of Shannon Sandstone Member.
41	22828	R. K. Hose and W. J. Mapel, 1950. Same locality as 22821. Cody Shale, from a limestone concretion 278 ft below base of Shannon Sandstone Member.
42	22830	R. K. Hose and W. J. Mapel, 1950. Same locality as 22821. Cody Shale, from limestone concretions 268 ft below base of Shannon Sandstone Member.
43	D4681	J. R. Gill and R. C. Givens, 1964. Zimmerman Butte area, in the NE¼NE¼ sec. 26, T. 44 N., R. 93 W., Hot Springs County, Wyo. Cody Shale, from limestone concretions 1,665 ft below top.
44	D4682	J. R. Gill and R. C. Givens, 1964. Zimmerman Butte area, in the SE¼NE¼SE¼ sec. 28, T. 44 N., R. 92 W., Washakie County, Wyo. Cody Shale, 1,560 ft below top.
45	D4685	J. R. Gill and R. C. Givens, 1964. Zimmerman Butte area, in the center of sec. 23, T. 44 N., R. 93 W., Hot Springs County, Wyo. Cody Shale, 1,465 ft below top.
46	D4243	J. R. Gill and others, 1963. About 3.5 miles northwest of Kaycee, in the NW¼NW¼ sec. 26, T. 44 N., R. 82 W., Johnson County, Wyo. Cody Shale, 480 ft above top of Niobrara Shale Member.
47	D4248	J. R. Gill, 1962. About 3.5 miles north-northwest of Kaycee, in the SW¼SE¼ sec. 23, T. 44 N., R. 82 W., Johnson County, Wyo. Cody Shale, 1,050 ft above top of Niobrara Shale Member.
48	D4249	W. A. Cobban, 1963. Same locality as D4248. Cody Shale, from gray limestone concretions 1,210 ft above top of Niobrara Shale Member.
49	D3244	W. A. Cobban, 1960. Nine miles northwest of Midwest, in the NE¼ sec. 35, T. 41 N., R. 80 W., Natrona County, Wyo. Cody Shale, 35 ft below bed "A" of Richardson (1957).
50	D3197	J. R. Gill, 1961. Salt Creek oil field, in the N½ sec. 34, T. 40 N., R. 79 W., Natrona County, Wyo. Cody Shale, 75 ft above Fish-tooth sandstone.
51	D3200	J. R. Gill, 1961. Same locality as D3197. Cody Shale, from limestone concretions 385 ft above Fish-tooth sandstone.
52	D4168	J. R. Gill and W. R. Vaughn, 1962. About 16 miles southwest of Midwest, in the SE¼ sec. 34, T. 39 N., R. 81 W., Natrona County, Wyo. Cody Shale, top of bed "A" of Richardson (1957).
53	D4474	W. A. Cobban, 1964. Two miles west of Powder River, in the SW¼ sec. 34, T. 36 N., R. 85 W., Natrona County, Wyo. Cody Shale.
54	23110	J. B. Reeside, Jr., W. R. Keefer, M. L. Troyer, and R. J. Burnside, 1950. East Sheep Creek, in the NW¼SE¼NE¼ sec. 23, T. 6 N., R. 2 E., Fremont County, Wyo. Cody Shale, about 1,275 ft below top.

TABLE 1.—*Localities at which fossils were collected*—Continued

Locality No. (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
55	23113	J. B. Reeside, Jr., W. R. Keefer, M. L. Troyer, and R. J. Burnside, 1950. West Dry Creek, in the SE¼SE¼NW¼ sec. 24, T. 6 N., R. 2 E., Fremont County, Wyo. Cody Shale, 65 ft below top.
56	21550	J. B. Reeside, Jr., J. D. Love, R. M. Thompson, and M. L. Troyer, 1949. Three miles south of Hudson, in the NW¼SW¼ sec. 4, T. 33 N., R. 98 W., Fremont County, Wyo. Cody Shale, about 1,035 ft below top.
57	21544	Keith Yenne and G. N. Pipiringos, 1949. Near Alkali Butte, in the SE¼NE¼SW¼ sec. 23, T. 34 N., R. 95 W., Fremont County, Wyo. Cody Shale, about 200 ft below top (Yenne and Pipiringos, 1954).
58	21753	J. B. Reeside, Jr., J. D. Love, and K. Yenne, 1949. Near Alkali Butte, in the NE¼SE¼SE¼ sec. 23, T. 34 N., R. 95 W., Fremont County, Wyo. Cody Shale, about 200 ft below top (Yenne and Pipiringos, 1954).
59	D4592	M. W. Reynolds, J. R. Gill, and R. C. Givens, 1964. About 5 miles west of Muddy Gap, in the east center of the SW¼SE¼ sec. 26, T. 28 N., R. 90 W., Fremont County, Wyo. Cody Shale, about 1,100 ft below top.
60	D5164	M. W. Reynolds, 1965. Ten miles north-northwest of Lamont, in the SW¼NE¼SW¼ sec. 5, T. 27 N., R. 89 W., Carbon County, Wyo. Cody Shale, about 300 ft below Cody Sandstone of Weimer and Guyton (1961).
61	10455	A. E. Fath and G. F. Moulton, 1920. About 3 miles west-northwest of Lamont, in the SW cor. NW¼ sec. 12, T. 26 N., R. 90 W., Sweetwater County, Wyo. Cody Shale.
62	10456	A. E. Fath and C. Y. Hsieh, 1920. About 4 miles east-northeast of Lamont, in sec. 7, T. 26 N., R. 88 W., Carbon County, Wyo. Cody Shale, same stratigraphic level as 10455.
63	D5169	M. W. Reynolds, 1965. About 4.5 miles northeast of Lamont, in the SW¼SE¼SE¼ sec. 36, T. 27 N., R. 89 W., Carbon County, Wyo. Code Shale, about 2,675 ft above base.
64	D5171	M. W. Reynolds, 1965. About 6 miles east-northeast of Lamont, in the SW¼NW¼SE¼ sec. 5, T. 26 N., R. 88 W., Carbon County, Wyo. Cody Shale, about 2,500 ft above base.
65	D6035	J. R. Gill, 1967. Nine miles northwest of Rawlins, in the NE¼SE¼SE¼ sec. 19, T. 22 N., R. 88 W., Carbon County, Wyo. Cody Shale, 3,240 ft below base of nonmarine Mesaverde Formation.
66	D5554	J. R. Gill, 1966. Eight miles northeast of Rawlins, in the NW¼NW¼SW¼ sec. 7, T. 22 N., R. 86 W., Carbon County, Wyo. Cody Shale, 3,350 ft below base of the nonmarine Mesaverde Formation.
67	D3053	J. H. Smith, 1961. Ten miles south-southwest of Rawlins, in the NW¼ sec. 14, T. 19 N., R. 88 W., Carbon County, Wyo. Steele Shale, 1,468 ft above base.
68	D3095	J. H. Smith, 1961. Twelve miles south of Rawlins, in the center of the N½ sec. 23, T. 19 N., R. 88 W., Carbon County, Wyo. Steele Shale, 1,053 ft above base.
69	D2221	J. H. Smith, 1959. About 1 mile southeast of Winton, in the SE¼SE¼ sec. 5, T. 20 N., R. 104 W., Sweetwater County, Wyo. Blair Formation, from sandstone 100–125 ft below top (Smith, 1961, p. 107).
70	D2413	J. H. Smith, 1959. Four miles south of Rock Springs, in the SE¼ sec. 13, T. 18 N., R. 105 W., Sweetwater County, Wyo. Blair Formation, from sandstone 150–200 ft below top.
71	D2598	J. H. Smith, 1960. Near Rock Springs in the NW¼ sec. 6, T. 18 N., R. 104 W., Sweetwater County, Wyo. Blair Formation, 140–160 ft below top (Smith, 1961, p. 108).
72	D3420	A. D. Zapp and W. A. Cobban, 1961. Five miles east of Linwood, in the SW¼SW¼-NE¼ sec. 22, T. 3 N., R. 21 E., Daggett County, Utah. Baxter Shale, from thin-bedded sandstone in upper part.
73	D3421	A. D. Zapp and W. A. Cobban, 1961. Twelve miles east of Linwood, in the SW¼NE¼ sec. 23, T. 3 N., R. 22 E., Daggett County, Utah. Baxter Shale, same stratigraphic level as D3420.
74	11709	J. B. Reeside, Jr., W. H. Bradley, and J. D. Sears, 1923. Vermilion Creek [sec. 1, 2, or 12] T. 10 N., R. 101 W., Moffat County, Colo. Mancos Shale, 1,324 ft below top.
75	D2418	J. H. Smith, 1959. Vermilion Creek, in the SW¼ sec. 7, T. 10 N., R. 100 W., Moffat County, Colo. Mancos Shale, 1,065 ft below top.
76	D3785	A. D. Zapp, 1962. Six miles north of Green River, in the NW¼SE¼ sec. 17, T. 20 S., R. 16 E., Emery County, Utah. Mancos Shale, about 1,600 ft below top.
77	D2513	A. D. Zapp and W. A. Cobban, 1960. Half a mile northeast of Thompson, in the NW¼NE¼NE¼ sec. 21, T. 21 S., R. 20 E., Grand County, Utah. Mancos Shale, from a long brown-weathering limestone concretion in upper part.
78	D3678	C. H. Dane, R. E. Burkholder, and W. A. Cobban, 1961. East side of U.S. Highway 84, 3.5 miles south of Tierra Amarilla, Rio Arriba County, N. Mex. Mancos Shale, from limestone concretions about 175 ft below top.
79	D4075	G. R. Scott and family, 1963. On top of low ridge about 3 miles west of Gallina, in the SE¼SE¼NE¼ sec. 11, T. 23 N., R. 1 W., Rio Arriba County, N. Mex. Mancos Shale, from a limestone concretion about 590 ft below top.
80	D4076	G. R. Scott and family, 1963. Same locality as D4075. Mancos Shale, from limestone concretions about 560 ft below top.
81	4453	J. H. Gardner, 1907. Three-quarters of a mile north of Copper City, T. 20 N., R. 1 W., Sandoval County, N. Mex. Mesaverde Formation, near base.
82	16796	C. B. Hunt, 1933. East of Senorita in the NW¼SE¼ sec. 11, T. 20 N., R. 1 W., Sandoval County, N. Mex. Mancos Shale, from upper 350 ft.
83	6778	W. T. Lee, 1910. Hagan coal field, T. 13 N., R. 6 E., Sandoval County, N. Mex. Mesaverde Formation, near base.
84	7165	W. T. Lee, 1911. One mile southwest of Waldo, Santa Fe County, N. Mex. Mancos Shale, upper 200 ft.

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TABLE 1.—*Localities at which fossils were collected*—Continued

Locality No. (fig. 1)	U.S. Geol. Survey Mesozoic locality	Collector, year of collection, description of locality, and stratigraphic assignment
85	7180	W. T. Lee, 1911. Omera mine on east flank of Ortiz Mountains, Santa Fe County, N. Mex. Mancos Shale, uppermost part.
86	8352	W. T. Lee, 1913. About 2.5 miles southeast of Clifton House and about 10 miles southeast of Raton, Colfax County, N. Mex. Pierre Shale.
87	D4835	G. R. Scott, 1965. Gully west of road, in the SE¼SE¼ sec. 31, T. 30 N., R. 24 E., Colfax County, N. Mex. Pierre Shale, from ironstone concretions in lower part.
88	D4836	J. R. Gill, G. R. Scott, and W. A. Cobban, 1965. Beside road in the NE¼SE¼ sec. 31, T. 30 N., R. 24 E., Colfax County, N. Mex. Pierre Shale, from conspicuous bed of large orange-weathering limestone concretions 81 ft stratigraphically above D4835.

SEQUENCE OF FOSSILS

The sequence of scaphites of late Santonian and early Campanian Age in the western interior region was determined as follows in regard to a study of the genus *Haresiceras* (Cobban, 1964, p. I10–I11).

Early Campanian:

Haresiceras natronense and a fine-ribbed form of *Scaphites hippocrepis*
H. placentiforme and a coarse-ribbed form of *S. hippocrepis*
H. montanaense (late form) and a coarse-ribbed form of *S. hippocrepis*
H. montanaense (early form) and *S. leei*

Late Santonian:

Haresiceras (*Mancosiceras*) *mancosense* (late form), *S. leei*, and *Desmoscaphites bassleri*
H. mancosense (early form), *S. leei*, and *D. erdmanni*

In the present study, *Scaphites leei* and *S. hippocrepis* were found to change gradually as they were traced upward through the rocks. These changes might warrant the introduction of formal infraspecific names, but the use of Roman numerals seems just as useful and certainly easier to handle (Jeletzky, 1950, p. 24–25). Accordingly, the two species are interpreted in a broad sense and six chronological subspecies are recognized which are as follows:

Scaphites hippocrepis	III	(youngest)
	II	
	I	
Scaphites leei	III	
	II	
	I	(oldest)

In the sequence of *Haresiceras* presented in the preceding paragraph, *S. leei* I occurs with the early form of *H. mancosense*, *S. leei* II occurs with the late form of *H. mancosense*, and *S. leei* III is found with the early form of *H. montanaense*. *S. hippocrepis* I occurs with *H. placentiforme* and the late form of *H. montanaense*, *S. hippocrepis* II also occurs with *H. placentiforme*, and *S. hippocrepis* III is found with *H. natronense*.

The specimens representing each of these subspecies occur as dimorphic pairs.

DIMORPHISM IN AMMONITES

AMMONITES OTHER THAN SCAPHITES

Makowski (1962a, 1962b), Callomon (1957, 1963), and Westermann (1964a), have recently revived the arguments for the recognition of sexual dimorphism in ammonites. Makowski (1962a) and Callomon (1963) have presented excellent summaries of the literature concerning dimorphism in ammonites. They noted that as far back as 1840, European authors, chiefly French, had observed that many adult ammonites occurred as large and small forms in the same stratum. Both forms had identical early stages, but the adult whorls of the large form tended to be more inflated than those of the small form. Most of the ammonites reported on were Jurassic, and the small form of many of these was provided with lateral lappets, a feature absent from the large form. Several of the earlier authors suggested that these differences in size and form were due to sexual differences and, by analogy with most extant invertebrates, the large form was probably the female and the small one the male.

Callomon, Makowski, and Westermann verified many of the conclusions of earlier authors and, in addition, they described and illustrated numerous examples of dimorphism, especially among Jurassic ammonites. Makowski and Westermann agreed that the large form probably represented the female and the small form the male. In this respect, Makowski (1962a, p. 58) stated, "In the organic world, wherever sexual dimorphism becomes strong enough to be expressed by notably smaller dimensions of one sex (occasionally many tens of times smaller), the dwarfism invariably affects the male individuals. Not a single case of opposite morphological conditions has so far been reported * * * it is maintained that all these analogies in dimorphism within the living animal world supply conclusive evidence that small ammonite forms represent the males and that true gigantism occurs among the female forms only." On the other hand, Callomon (1963, p. 47) stated, "The question of which of a dimorphic pair should be identified with a particular sex received considerable attention in the past, but as the answer lies wholly with the unobservables it can never rise above speculation." Callomon (1955, p. 238; 1957, p. 62) earlier referred to the large forms as *macroconchs* and to the small forms as *microconchs*. Later (1963, p. 29), he used the letters "M" for macroconchs and "m" for microconchs. Westermann (1964a, p. 51) modified this usage a little by adding the zoological symbols for male (♂) and female (♀) to abbreviations for *Makrokonch* and *Mikrokonch* thus creating the signs Ma. ♀ and Mi. ♂. Makowski (1962a, p. 61) referred to the large forms as females and the small ones as males, and he applied the zoological symbols ♀ and ♂ to them as advocated earlier by Glangeaud (1897, p. 106).

Makowski considered a dimorphic pair to be a single species and, accordingly, he applied to the pair the oldest available specific name. As an example (Makowski, 1962a, p. 24), *Lissoceratoides erato* (d'Orbigny) [♀] and *Glochiceras cornutum* Ziegler [♂] were regarded as one species—*L. erato* (d'Orbigny). On the other hand, Callomon (1955, 1963), Arkell and Callogave the members of a dimorphic pair separate specific mon (1963), and Westermann (1964a, 1964b, 1966) rank and even separate subgeneric rank. A more recent trend in the study of Jurassic ammonites is to agree with Makowski and regard the members of a dimorphic pair as the same species (Howarth and Donovan, 1964, p. 286, 291–292; Lehmann, 1966; Palframan, 1966, p. 308–310; 1967, p. 84–87; Cope, 1967, p. 14–18, 24–63).

Two kinds of dimorphism were determined in the Mesozoic ammonites studied by Makowski (1962a, p. 16). One kind, which he called type A, consists of adults in which the small form (♂) has five to six whorls, whereas the large form (♀) has at least seven whorls. The other kind, which he termed type B, has seven to nine whorls in the small form and at least eight whorls in the large form. A morphological hiatus of one whorl separates the sexes.

Houša (1965), in a preliminary note, suggested a different classification. He recognized two kinds of dimorphism which he termed Type I and Type II. In Type I, which includes *Scaphites*, the sexes differ only in size, and the peristome is simple and is the same in both males and females. In Type II, the sexes differ not only in size, but the male has apertural outgrowths such as lateral lappets or a ventral rostrum.

SCAPHITES

Callomon, Makowski, Westermann, Palframan, and others dealt with dimorphism in Jurassic ammonites, but Makowski (1962) also presented observations on some Devonian goniatites and one Late Cretaceous ammonite. The Cretaceous ammonite investigated was *Scaphites constrictus* (Sowerby) from the Maestrichtian rocks near Kazimiez, Poland. Makowski had 22 large forms of this species which he considered to be females and 10 small forms which he believed to be males. He also reported on two adult scaphites, 62 and 68 mm (millimeters) in length, from the "Emscherian deposits of North Dakota" (presumably from the upper part of the Pierre Shale on the Cedar Creek anticline in the southwest corner of the State). These two specimens, identified as *S. nodosus* var. *plenus* Meek, were found to have seven whorls each and to fall in his type A.

The present study of *Scaphites hippocrepis* and closely related species revealed the presence of two forms in almost every collection. One form is larger and more involute than the other and usually has an umbilical swelling (fig. 2). Changes in size and ornamentation affect both forms simultaneously, that is, if one form becomes larger and finer ribbed in the younger rocks, the other form, likewise, becomes larger and finer ribbed. I see no way to interpret these forms other than as male and female, and in conformance with the interpretation of Makowski, the larger form is herein interpreted to be the female and the smaller more evolute form is assumed to be the male. The standard zoological symbols for male (♂) and female (♀) are used where applicable.

Possibly all species of scaphites occur in two forms, but these have received different treatment by different authors. Some authors, such as Wolansky (1932) and Müller and Wollemann (1906), placed both forms in the same species but considered the smaller forms as specimens less mature than the larger. Wolansky (1932, p. 10, pl. 1, figs. 10, 12) figured two specimens, a large adult and a small adult, which she assigned to *Hoploscaphites constrictus* (Sowerby). The small specimen is more evolute than the large one and has a more slender body chamber; it could be a male. The large specimen, which has a very small umbilicus, is probably a female. Müller and Wollemann (1906, pl. 9, figs. 4, 5; pl. 10, fig. 4) illustrated three specimens that they assigned to *Scaphites binodosus* Roemer. One is a large form that has a broad body chamber and an umbilical swelling at

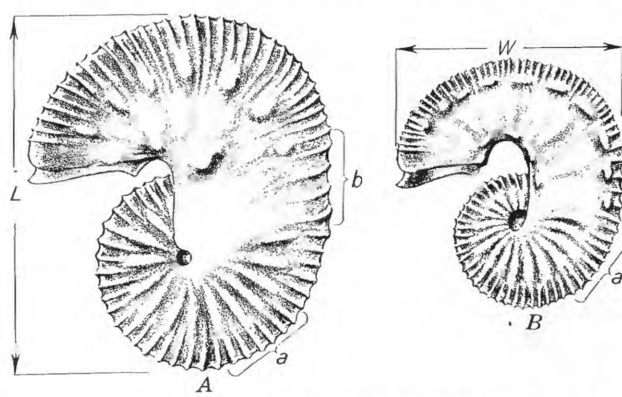

FIGURE 2.—Drawings of a female (*A*) and a male (*B*) based on *Scaphites hippocrepis* III from USGS Mesozoic loc. 21206 (fig. 1, loc. 17). *L*, length of shell; *W*, width of the shell as well as the width of the body chamber; *a*, area in which the body chamber begins; *b*, area of interruption in the spacing of the ventral ribs.

its base which nearly covers the umbilicus. This specimen, which was described by Müller and Wollemann as a "sehr alter Exemplar," is herein considered a female. The two smaller specimens could well be males inasmuch as they have a much wider umbilicus and narrower body chamber with concave umbilical wall.

Many authors also have treated both the large involute form and the smaller more evolute form as a single species without giving subspecific names to one or the other. This is especially well shown by the treatment of *Scaphites constrictus* (Sowerby) in the following publications (with my interpretation of males and females): Favre (1869, pl. 5, figs. 1 (♂), 2, 3 (♀♀), 4 (♂)), Binckhorst (1873, pl. Vd, figs. 6a, d (♂♂), 6b, c (♀♀)), Böhm (1891, pl. 1, figs. 10 (♂), 10a (♀)), Grossouvre (1893, pl. 31, figs. 1a–c (♀♀), 2a–c (♂♂), 7 (♀), 8a, b (♀♀)), Grossouvre (1908, pl. 11, figs. 3 (♀), 5–7 (♂♂)). Makowski (1962a, text pl. 4, figs. 3, 4) has also shown by sketches his interpretation of the male and female of this species.

Some authors have considered as one species both the large and the small forms of scaphites but have given formal varietal names to one or the other. A few examples of this treatment are shown in the following publications: Meek (1876, *Scaphites nodosus* var. *brevis*, pl. 25, figs. 1a–c (♀), *S. nodosus* var. *quadrangularis*, pl. 25, figs. 2–4 (♂♂)), Reeside (1927b, *S. leei*, pl. 21, figs. 1–7 (♀), *S. leei* var. *parvus*, pl. 21, figs. 8–16 (♂♂)), Cobban (1951, many examples but particularly *S. impendicostatus*, pl. 11, figs. 1–8 (♀), 11–13 (♀), *S. impendicostatus* var. *erucoides*, pl. 11, figs. 17–22 (♂), 23–24 (♂), 25–28 (♂)), and Mikhailov (1951, *S. constrictus*, pl. 17, figs. 77–80 (♀♀), *S. constrictus* var. *niedzwiedzkii*, pl. 15, fig. 65 (♂), pl. 17, figs. 81–82 (♂♂), pl. 18, fig. 85 (♂)).

Several authors either restricted the scope of the species to one or the other of the forms or had only one of the forms available for study. I interpret as females all six of the specimens of *Scaphites planus* illustrated by Yabe (1910, pl. 15, figs. 11–18) and all four of the specimens of *S. geinitzi* figured by Geinitz (1872, pl. 35, figs. 1–4). The inflated specimen described by Riedel (1931, p. 701, pl. 79, figs. 3, 4) as the new species *S. bärtlingi* is probably a female, whereas both slender specimens described by Riedel (1931, p. 704, pl. 79, figs. 5, 6) as the new species *S. fischeri* could be interpreted to be males of *S. bärtlingi*.

SCAPHITES LEEI AND *S. HIPPOCREPIS*

The early illustrations of *Scaphites hippocrepis* by DeKay (1827, pl. 5, fig. 5) and Morton (1829, pl. 7, fig. 1; 1834, pl. 7, fig. 1) were based on two stout adults which I interpret to be females. Nearly all specimens assigned to *S. hippocrepis* by authors later than DeKay and Morton applied the name to the feminine form. Noteworthy among these specimens are the two figured by Whitfield (1892, pl. 44, figs. 8–12), the two specimens figured by Schlüter (1876, pl. 42, figs. 1–3), the four specimens figured by Grossouvre (1893, pl. 32, figs. 2, 3a, b; pl. 35, figs. 6a–c; pl. 37, figs. 3a, b), the two specimens of Weller (1907, pl. 107, figs. 3–6), and the 19 specimens illustrated by Reeside (1927b, pls. 14–20; some specimens included under *S. stantoni* and *S. levis*).

I interpret as the male of *Scaphites hippocrepis* the following forms: *S. reniformis* Morton (1833, p. 291; 1834, p. 42, pl. 2, fig. 6), *S. aquisgranensis* Schlüter (1872, p. 81, pl. 24, figs. 7–9), *S. similis* Whitfield (1892, p. 267, pl. 44, figs. 1, 2), and *S. aquilaensis* Reeside (1927b, p. 25, pl. 18, figs. 15–27; pl. 19, figs. 1–21; pl. 20, figs. 1–6). Reeside's *S. aquilaensis* is associated with the larger and stouter feminine form of *S. hippocrepis*, has the same type of sculpture, and shows the same changes in size and sculpture according to locality and stratigraphic level. The type of Whitfield's *S. similis*, which seemingly is lost (Reeside, 1962, p. 126), consisted of the septate coil and the older part of the body chamber. It came from the Merchantville Formation of New Jersey. Complete specimens from the Merchantville associated with the large feminine *S. hippocrepis* (pl. 5, figs. 36–40) show that *S. similis* is the same as *S. aquilaensis*, and both are herein considered males of *S. hippocrepis*. The type of Morton's *S. reniformis* is a small distorted septate coil readily matched with phragmocones of similar size from the Merchantville. I regard the latter and Morton's specimen as males of *S. hippocrepis*. Whitfield (1892, p. 264) considered *S. reniformis* to be a valid species, and Gabb (1861, p. 88) and Reeside (1962, p. 125) regarded it to be a juvenile of *S. hippocrepis*.

SIZE

Each of the larger collections of adults shows a considerable range in size of the males and females. The range in size is such that the largest males are larger than the smallest females but not as large as the largest females. This overlap in the size range is shown in table 2, which summarizes data for the four largest collections.

TABLE 2.—*Range in length and number of measurable male and female scaphites*

Fossil	USGS Mesozoic fossil locality	Number of specimens	Sex	Length, in millimeters
Scaphites hippocrepis III	21206	15	♂	10.0–38.7
		9	♀	16.9–48.8
hippocrepis I	D4194, D4198, D4199	21	♂	15.7–35.1
		13	♀	20.4–52.2
hippocrepis I	D4181	16	♂	11.7–22.6
		16	♀	13.5–27.5
leei III	D4075	37	♂	12.5–21.8
		26	♀	18.2–28.9

The collection of *Scaphites hippocrepis* III (pl. 3, figs. 1–14) is from several limestone concretions (at the same stratigraphic level) distributed along half a mile of outcrop (fig. 1, loc. 17). One of the collections of *S. hippocrepis* I (pl. 2, figs. 1–17) is from many limestone concretions more or less from the same stratigraphic level but distributed along several miles of outcrop (fig. 1, locs. 27–29). The other collection of *S. hippocrepis* I (fig. 1, loc. 35; pl. 1, figs. 32–47) and the collection of *S. leei* III (fig. 1, loc. 79; pl. 1, figs. 19–31) are each from a single limestone concretion; the range in size of the adults from these two concretions is shown in figure 3.

Makowski (1962a, p. 31, 73) did not have this overlap in size of male and female in his collection of *Scaphites constrictus* (Sowerby) from the Maestrichtian rocks of Poland. His collection consisted of 22 females ranging in length from 47 to 68 mm and 10 males ranging in length from 22 to 35 mm. Makowski pointed out that the lack of overlap in size was also apparent from the Polish specimens of *S. constrictus* illustrated by Nowak (1912), which consisted of seven females, 47 to 53 mm long, and seven males, 22 to 34 mm long. Birkelund (1965, p. 141, text fig. 121) did not find this separation between the large and small forms in her scaphites from West Greenland. She noted, however, a tendency for some of her Campanian species to peak twice on histograms showing the range in size, and this led her to consider the cause to possibly be sexual differences.

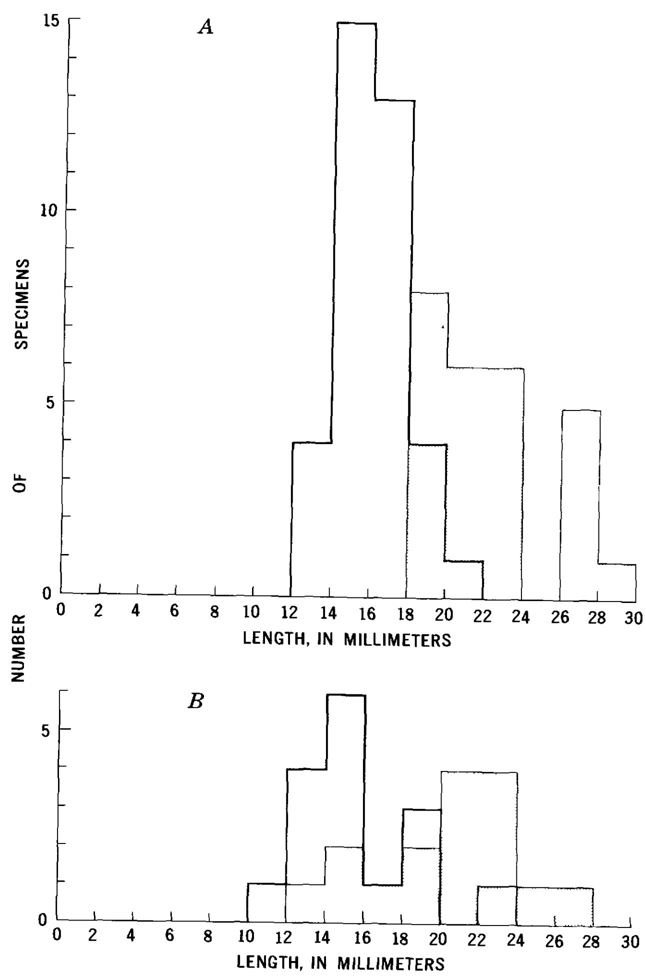

FIGURE 3.—Histograms showing the range in size of male (heavy line) and female (shaded) specimens of (*A*) *Scaphites leei* III from USGS Mesozoic locality D4075 (fig. 1, loc. 79) and (*B*) *S. hippocrepis* I from USGS Mesozoic locality D4181 (fig. 1, loc. 35).

The Jurassic ammonites investigated by Callomon, Makowski, and other authors show a much better separation into two size groups for each species. This is especially well shown by Callomon (1955, p. 225, figs. 3, 4) in his treatment of *Gulielmites* (♀) *and Gulielmiceras* (♂) and in a histogram by Palframan (1966, text fig. 6).

The ratio of the lengths of the largest and smallest adults of each sex in most collections of the *Scaphites leei-S. hippocrepis* group of ammonites is commonly from 1:1.5 to 1:2.5. However, rare individuals of extraordinary large or small size suggest that the maximum ratio is more like 1:4. The ratios of size for the largest collections are shown in table 3. Wherever the largest or smallest specimen was incomplete or damaged, an estimate was made of the original size.

TABLE 3.—*Ratios of lengths of largest and smallest male and female scaphites*

Fossil	USGS Mesozoic fossil locality	Size ratio of males	Size ratio of females
Scaphites hippocrepis III	21206	1:3.9	1:3.6
	D2413	1:1.4	1:2.5
hippocrepis II	D4185	1:1.5	1:1.9
hippocrepis I	D4194, D4198–99	1:2.3	1:2.5
	9625	1:2.2	1:3.2
	22822	1:2.3	1:2.7
	D4243	1:2.0	1:2.3
	D4181	1:2.0	1:2.8
leei III	D4075	1:1.7	1:1.6
leei II	D4280	1:1.3	1:1.5

Ratios of size of large and small adults of the same species have been recorded as ranging from 1:2 to 1:4 for scaphites of the Turonian, Coniacian, and Santonian (Cobban, 1951, p. 3) and from 1:4 to 1:6 for two late Campanian species (Birkelund, 1965, p. 140). Birkelund's figures are a little high compared to those for *Scaphites leei* and *S. hippocrepis* because the males and females are not differentiated.

Considerable variation occurs in the size of the whorls within the sexes (fig. 4). The protoconch and the first two whorls are nearly the same in size on all specimens on which they are preserved, but the subsequent whorls vary greatly in size. The larger specimens may even have one more whorl than the smaller (fig. 5).

FIGURE 4.—Cross sections, × 2½, at base of body chambers of a small (USNM 160319) and a large female (USNM 160320) of *Scaphites hippocrepis* III from USGS Mesozoic locality 21206 (fig. 1, loc. 17).

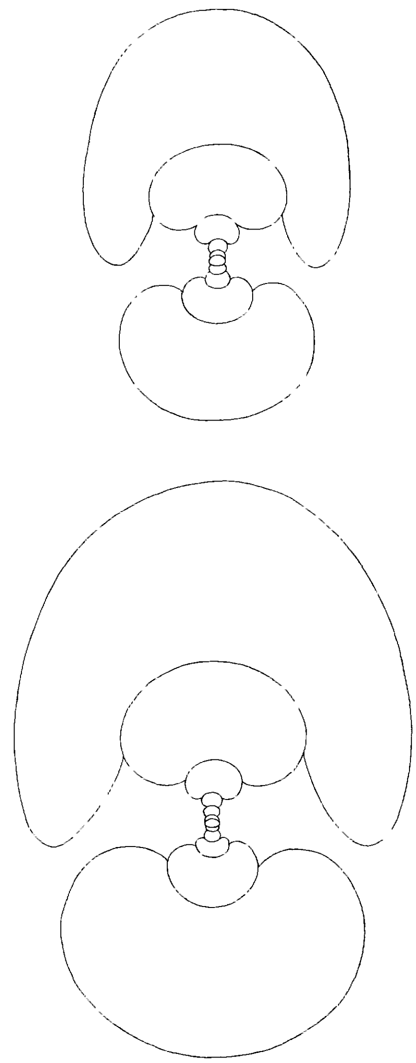

FIGURE 5.—Cross sections, × 5, at base of the body chamber of a small (USNM 160268) and a large female (USNM 160269) of *Scaphites hippocrepis* I from USGS Mesozoic locality D4181 (fig. 1, loc. 35).

FORM

The specimens herein assumed to be females visibly differ from those believed to be males in that they have a much smaller umbilicus in the adult growth stage. The females of *Scaphites leei* and *S. hippocrepis* have an umbilical swelling at the base of the body chamber, which causes the umbilicus to be much smaller than that of the preceding whorl (pl. 5, figs. 28, 29). According to the classification of Spath (1923, p. 8), the last whorl is perangustumbilicate, whereas the penultimate whorl is angustumbilicate.

The umbilical swelling is characteristic of many scaphites and reoccurs again and again in the Cretaceous. It is especially well shown in the following illustrations: late Albian, *Scaphites hilli* Adkins and Winton (1919, pl. 7, fig. 4; Adkins, 1918, pl. 2, figs. 4, 5, 7, 8, 12; Clark, 1965, pl. 21, fig. 4, pl. 22, figs. 6, 8), *S. bosquensis* Böse (Clark, 1965, pl. 4, fig. 2), *S. meriani* Pictet and Campiche (Wiedmann, 1965, pl. 54, fig. 6b; pl. 57, fig. 4), *S. obliquus* Sowerby (1813, pl. 18, fig. 5; Pervinquière, 1907, pl. 4, figs. 27a, c), *S. simplex* Jukes-Browne (Spath, 1937, pl. 57, fig. 16; Wiedmann, 1965, pl. 54, figs. 1, 7a; pl. 55, figs. 4c, 5b), *S. collignoni* Wiedmann (1965, pl. 57, fig. 5b); Cenomanian, *S. dailyi* Wright (1963, pl. 81, fig. 6a), *S. bassei* Collignon as figured by Sornay (1955, pl. 1, figs. 7, 11), and the species from the Malagasy Republic figured by Collignon (1928, pl. 19, figs. 9, 13, 14) as the new species *S. bassei*, *S. decaryi*, and *S. falloti*, as well as the specimens shown by Collignon (1928, pl. 19, figs. 1, 6, 12a) as *S. aequalis-obliquus* Sowerby and *S. hugardianus* d'Orbigny; Turonian, *S. aequalis* mut. *turonensis* Roman and Mazeran (1920, pl. 4, figs. 12, 13), *S. delicatulus* Warren (1930, pl. 4, fig. 7; Cobban and Gryc, 1961, pl. 37, figs. 18, 22, 23), *S. subdelicatulus* Cobban and Gryc (1961, pl. 37, figs. 3, 12, 14), *S. geinitzi* d'Orbigny (numerous illustrations but particularly those of Schlüter, 1872, pl. 23, figs. 17, 22; Geinitz, 1872, pl. 35, figs. 1–3; Fritsch and Schlönbach, 1872, pl. 13, figs. 10, 12a; Woods, 1896, pl. 3, fig. 6a), the specimens figured as *S. lamberti* Grossouvre by Leonhard (1897, pl. 6, fig. 7) and Frech (1915, text figs. 3a, b), the species described from Japan by Yabe (1910, pl. 15, figs. 9, 12a, 13a, 14a, 15a, 16) as *S. planus* and *S. gracilis*, and the species described from Oregon by Anderson (1902, pl. 2, figs. 58, 64, 67) as *S. condoni* and *S. roguensis;* Coniacian, *S. impendicostatus* Cobban (1951, pl. 11, figs. 1, 13); Santonian, *S. leei* Reeside (1927b, pl. 20, fig. 17; pl. 21, fig. 3), *Clioscaphites montanensis* Cobban (1951, pl. 16, figs. 1, 9, 12; pl. 17, fig. 1), and *C. novimexicanus* (Reeside) (Cobban, 1951, pl. 21, fig. 1); Campanian, *S. inflatus* Römer (Schlüter, 1872, pl. 24, fig. 1), and the new species described by Birkelund (1965, pl. 20, fig. 1a; pl. 21, figs. 2a, 3a; pl. 22, fig. 2a; pl. 23, figs. 1a, 2a, 3a; pl. 24, figs. 1a, 2a, 4a; pl. 25, fig. 2a; pl. 27, figs. 1a, 2b, 3a) as *S. cobbani*, *S. rosenkrantzi*, *S. ikorfatensis*, and *S. ravni;* Maestrichtian, *S. plenus* Meek and Hayden (Elias, 1933, pl. 37, fig. 1b; Coryell and Salmon, 1934, text fig. 10), *S. constrictus* (Sowerby) (numerous illustrations but especially those of Binckhorst, 1873, pl. Vd, fig. 6b; Grossouvre, 1893, pl. 31, fig. 7; 1908, pl. 11, fig. 3; Lopuski, 1911, pl. 2, figs. 3, 5; Nowak, 1912, pl. 33, figs. 8–11; Mikhailov, 1951, pl. 17, fig. 79; and Naidin and Shimanskii, 1959, pl. 6, figs. 5, 6, 12, 13), and *Discoscaphites iris* (Morton) (Stephenson, 1955, pl. 23, fig. 25).

The body chamber of the female scaphites is more inflated than that of the male, and it has a tendency to have an umbilical swelling. As a result the umbilical wall of the older half of the body chamber is ordinarily convex (pl. 2, figs. 11–17) in contrast to that of the male which is concave (pl. 2, figs. 1–10).

In addition to the presence of an umbilical swelling, the form of the female tends to be more robust than that of the male (fig. 6). All but the innermost whorls are commonly more depressed in the females (fig. 7).

SCULPTURE

The male and female specimens of *Scaphites leei* and *S. hippocrepis* have the same general sculptural features. All specimens are characterized by well-defined primary (umbilical) and secondary (ventral) ribs on the septate whorls, some sort of a weakening or interruption in the ribbing near the base of the older or straight part of the body chamber, and, on the younger or curved part, more or less uniformly spaced ventral ribs and a row of ventrolateral nodes separated from a row of umbilical nodes by a smooth or nearly smooth lateral area (fig. 2). The males differ from the females mainly in the number of nodes and ribs on the body chamber and the degree of interruption in ribbing near the base (fig. 2).

The adapical end of the area of ventral rib interruption begins either at the base of the body chamber or a little farther up, depending upon the length of the body chamber (for example, pl. 1, figs. 25–31). The adoral end of the interrupted area lies about half a whorl back from the aperture. The interrupted area assumes several forms. It may be smooth (pl. 4, figs. 20, 23, 41) and, on rare specimens, even slightly constricted (pl. 3, fig. 12). More commonly it is represented by ribs more widely spaced than those on the rest of the body chamber and septate coil (pl. 2, figs. 11, 14, 15); these ribs may be conspicuously stronger (pl. 5, figs. 36, 37) or irregular (pl. 4, fig. 48).

Interruption of the normal ventral ribbing at or near the base of the body chamber is present on many species other than *Scaphites leei* and *S. hippocrepis*. *S.*

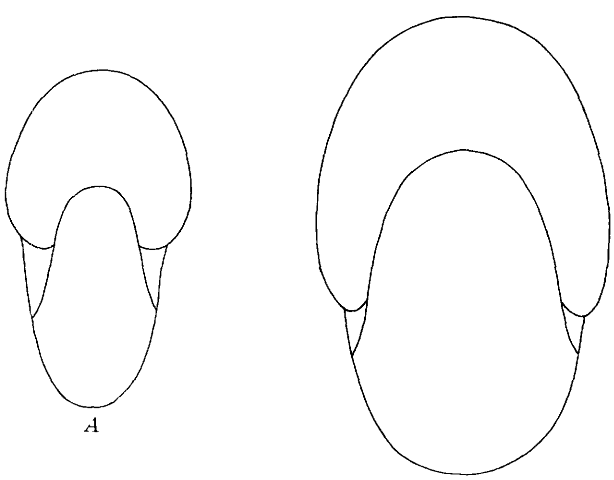

FIGURE 6.—Outline drawings, × 2, of the phragmocones of a male (*A*) (USNM 160288) and female (*B*) (USNM 160289) *Scaphites hippocrepis* I from USGS Mesozoic locality D4199 (fig. 1, loc. 29).

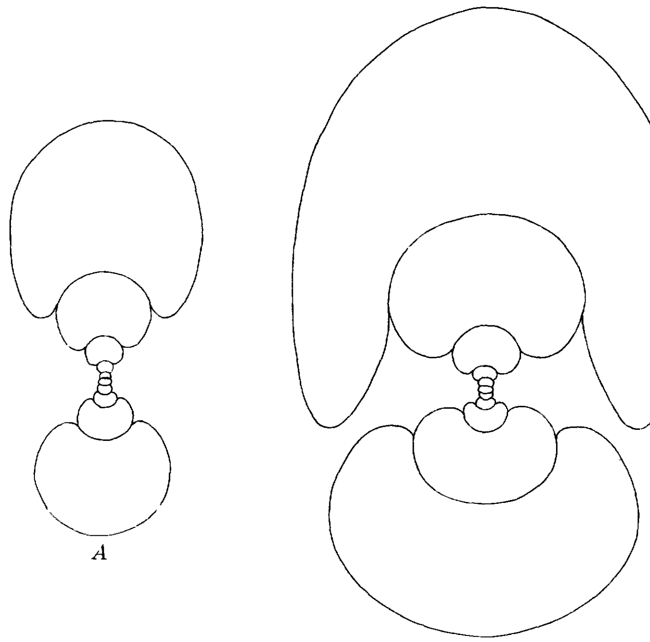

FIGURE 7.—Cross sections, × 4, at the base of the body chamber of a male (*A*) (USNM 160290) and female (*B*) (USNM 160291) *Scaphites hippocrepis* I from USGS Mesozoic locality D3312 (fig. 1, loc. 31).

equalis Sowerby of Cenomanian Age may show wider spacing of ribs (pl. 5, fig. 3) (Adkins, 1928, pl. 24, figs. 4, 5) or a smooth and somewhat constricted area as it is shown in the illustration by d'Orbigny (1840, pl. 129) and as it is reproduced in such standard work as that of Roman (1938, pl. 39, fig. 371), Basse (1952, pl. 24, fig. 4), and Wright (1957, text fig. 256.3a). These features are also apparent on the specimen figured by Cieśliński (1959, pl. 3, figs. 4a, b). *S. dailyi* Wright (1963, pl. 81, figs. 6a, b), also of Cenomanian Age, has a smooth venter but it is farther back and, according to Wright, it actually lies on the last part of the phragmocone. Ribbing seems to be lacking at the base of the body chamber of one of the Cenomanian specimens of *S. bassei* Collignon figured by Sornay (1955, pl. 1, fig. 7). Some specimens of the Turonian *S. geinitzi* d'Orbigny seem to be smooth near the base of the body chamber (Dacqué, 1939, pl. 14, fig. 30b) or weakly ribbed (Schlüter, 1872, pl. 23, figs. 12, 14, 21, 22). The Coniacian species described by Grossouvre (1893, pl. 32, figs. 8a, b) as *S. arnaudi* appears to be smooth near the base of the body chamber. Species that show a conspicuous increase in the spacing of the ventral ribs at or near the base of the body chamber include the following forms: Turonian, *S. warreni* Meek & Hayden (Cobban, 1951, pl. 3, figs. 16–18; pl. 4, figs. 1–15); Coniacian, *S. potieri* Grossouvre (1893, pl. 22, figs. 3a, b), *S. meslei* Grossouvre (1893, pl. 32, figs. 4a, b), *S. lamberti* Grossouvre as figured by Andert (1934, pl. 19, figs. 4a, b), *S. tetonensis* Cobban (1951, pl. 14, figs. 1–8), and *S. binneyi* Reeside (1927a, pl. 6, figs. 1–8); and Santonian, *Clioscaphites vermiformis* (Meek & Hayden) (Meek, 1876, pl. 6, fig. 4a) and *C. saxitonianus* (McLearn) (McLearn, 1929, pl. 18). Loss of ventral ribbing at or near the base of the body chamber is apparent on some examples of the Maestrichtian *S. constrictus* (Sowerby) figured by Schlüter (1872, pl. 28, figs. 5–7), Binckhorst (1873, pl. Vd, figs. 6e, f), Grossouvre (1893, pl. 31, figs. 1a, c, 8a, b), and Mikhailov (1951, pl. 17, figs. 77–80).

The ribs on *Scaphites leei* and *S. hippocrepis* are rather straight. They are well differentiated into primaries and secondaries on the phragmocone in typical scaphitid manner, such as that of the genotype *S. equalis* Sowerby (pl. 5, fig. 1). The primary ribs are absent from the body chamber of *S. leei* and most specimens of *S. hippocrepis*. They are present sparingly on a few specimens of *S. hippocrepis* II (pl. 5, figs. 13, 22) and more commonly on *S. hippocrepis* III (pl. 3) where they grade into incipient nodes. The secondary or ventral ribs are conspicuous on the body chamber. They arise rather abruptly along the row of ventrolateral nodes and extend straight across the venter without forward arching. They are more numerous on *S. hippocrepis* III than on the older forms. Usually there are three or four more ribs on the male than on the female, but *S. hippocrepis* III reverses this trend (fig. 8).

Ribbing on the inner whorls was examined closely in only one collection (*Scaphites hippocrepis* I from USGS Mesozoic loc. D4181, fig. 1, loc. 35). Most of these specimens have the innermost whorls preserved. Sections cut through the plane of symmetry revealed a lack of ribs on the first four to 4½ whorls of both the males and the females. Inasmuch as the larger specimens have up to one whorl more than the smaller, the phragmocones of the larger have considerably more ribs than the smaller (fig. 9).

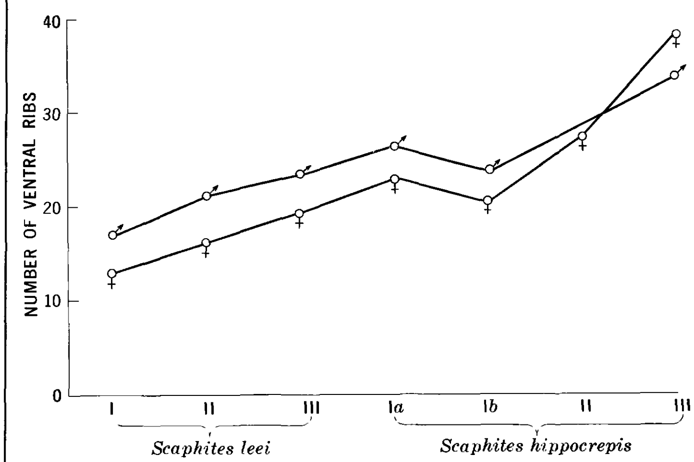

FIGURE 8.—Average number of ventral ribs of uniform height and spacing on the younger part of the body chambers of male (♂) and female (♀) specimens in the largest collection of each of the three forms of *Scaphites leei* (I, 21419; II, D4280; III, D4075) and in the largest collections of the three forms of *S. hippocrepis* (Ia, D4181; Ib, D4194, D4198, D4199; II, D4185; III, 21206).

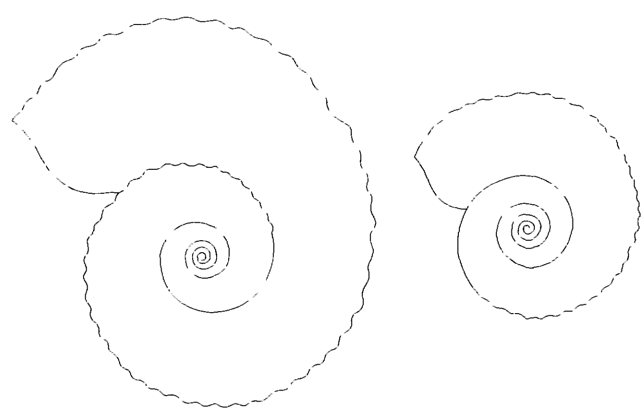

FIGURE 9.—Cross sections, × 2½, through the plane of symmetry of the entire phragmocones of a large (USNM 160266) and a small female (USNM 160267) of *Scaphites hippocrepis* I from USGS Mesozoic locality D4181 (fig. 1, loc. 35).

Umbilical and ventrolateral nodes are present on the younger half of the body chambers of nearly all specimens of *Scaphites leei* and *S. hippocrepis*; they are absent only from the smallest adults of both sexes (pl. 1, figs. 37, 47). The nodes may be bullate, as on most specimens of *S. hippocrepis* I (pl. 1, figs. 32–36, 38–46), or round, as on many specimens of *S. leei* (pl. 1, figs. 1–31). Clavate nodes are present on the males of *S. hippocrepis* III (pl. 3, figs. 1–6, 15–17; pl. 5, figs. 39, 40). An incipient row of bullate nodes is present between the umbilical and ventrolateral rows on most specimens of *S. hippocrepis* III (pl. 3).

Nodes are present on the end of the primary ribs on the phragmocone of the oldest form of *Scaphites leei* (I) (pl. 1, figs. 2, 4, 6). They are small, round, and number about 15 on the last septate whorl. Nodes are absent from the phragmocone of *S. leei* II and III and *S. hippocrepis* I and II, but they reappear on a few individuals of *S. hippocrepis* III, such as the splendid specimen figured by Morton (1834, pl. 7, fig. 1) and a few specimens from the western interior (this report, pl. 3, figs. 10, 14, 18).

Umbilical nodes are confined to the body chamber where they commonly number two or three, but they may be absent (pl. 1, figs. 45, 46) or they may number as many as five or six (pl. 2, figs. 2, 7). The male usually has about one more mode than the female. The umbilical nodes tend to be subequal in size on the males, whereas on many females one node may be much larger than the others (pl. 3).

Ventrolateral nodes are usually present only on the body chamber where they are largely confined to the younger half—the half that has the uniformly spaced ventral ribbing. The row of ventrolateral nodes may extend down past the area of ventral rib interruption to or beyond the base of the body chamber on some specimens of *Scaphites hippocrepis* III (pl. 3, figs. 5, 15–17, 19) and on most individuals of *S. leei* II (pl. 1, figs. 9, 10). The ventrolateral nodes tend to extend farther down toward the base of the body chamber on males than on females (compare figs. 19–24 on pl. 1 with figs. 25–31; also see pl. 3). The row of ventrolateral nodes on the body chamber represents the same line of nodes as those on the phragmocone of *S. leei* I (pl. 1, fig. 2) as well as those on the phragmocone of some individuals of *S. hippocrepis* III (pl. 3, fig. 14). The ventrolateral nodes on the body chamber usually number from five to seven, but there may be as many as 12.

On the three forms of *Scaphites leei* and on *S. hippocrepis* I and II, the distance separating the umbilical nodes from the ventrolateral nodes of both sexes is much less than the distance across the venter separating the opposite rows of ventrolateral nodes. On the males of *S. hippocrepis* III these distances become more equal (fig. 10).

The sutures of *Scaphites leei* and *S. hippocrepis* are rather simple and typical of the genus. Reeside (1927b, pls. 15–21) has shown many examples. The complete suture of an adult *S. hippocrepis* III is presented in figure 11.

The total number of chambers in the adult shell may be between 50 and 60, as indicated by the few sectioned specimens. The last chamber is usually crowded.

SYSTEMATIC DESCRIPTIONS

SCAPHITES LEEI REESIDE

Reeside (1927b, p. 26) characterized *Scaphites leei* by its stout whorls, convex umbilical shoulder, subquadrate cross section of the body chamber, coarse ribs, and conspicuous umbilical and ventrolateral nodes. He

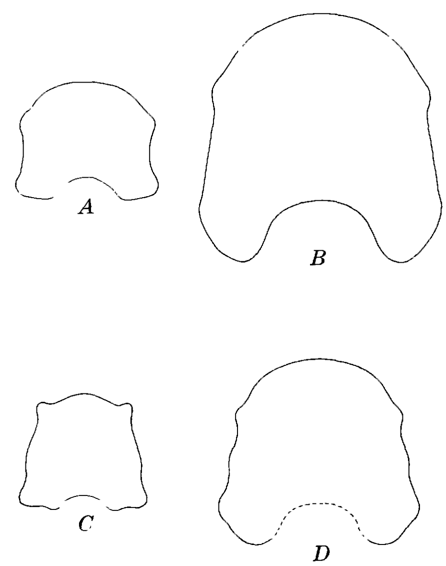

FIGURE 10.—Cross sections, × 2, through the body chambers of a male (*A*) (USNM 160275) and a female (*B*) (USNM 160289) of *Scaphites hippocrepis* I from USGS Mesozoic locality D4199 (fig. 1, loc. 29) and a male (*C*) (USNM 160309) and female (*D*) (USNM 160316) of *S. hippocrepis* III from USGS Mesozoic locality 21206 (fig. 1, loc. 17).

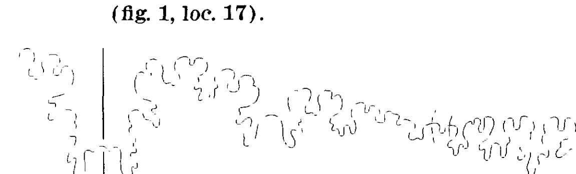

FIGURE 11.—Second from last suture, × 5, of an adult female *Scaphites hippocrepis* III from USGS Mesozoic locality 21206 (fig. 1, loc. 17). USNM 160321.

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observed that the ribbing was weak and widely spaced on the older part of the body chamber and strong on the younger part. He also noted that *S. leei* differed from *S. hippocrepis* in its sharpness of sculpture, its subquadrate cross section, and the presence of four subequal evenly spaced umbilical nodes. He figured two stout specimens as *S. leeli* and two smaller and more slender specimens as the variety *parvus*. The two larger specimens (holotype and paratype) came from the upper part of the Mancos Shale at different localities in Santa Fe County, N. Mex. I interpret these two specimens to be females. The holotype closely resembles the form herein referred to as *S. leei* II, whereas the paratype seems more assignable to *S. leei* I. The two smaller specimens (var. *parvus*) came from the lower part of the Mesaverde Formation at separate localities in Sandoval County, N. Mex. I consider these to be males of the youngest form of *S. leei* (III).

Scaphites leei Reeside I

Plate 1, figures 1–7; text figure 12

1927. *Scaphites leei* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 26, pl. 21, figs. 1–7 (♀).
?1929. *Scaphites hippocrepis* (DeKay). Dane, Arkansas Geol. Survey Bull. 1, p. 52, pl. 9, fig. 3 (♀).
1951. *Scaphites leei* Reeside. Cobban, U.S. Geol. Survey Prof. Paper 239, p. 34, pl. 21, figs. 24–26 (♂).
1955. *Scaphites leei* Reeside. Cobban, Billings Geol. Soc. Guidebook 6th Ann. Field Conf., p. 202, pl. 1, fig. 8 (♂).
1960. *Scaphites leei* Reeside var. *parvus* Reeside. Easton, Invertebrate Paleontology, text fig. 11.27–1b only (♀).

This form is characterized by the presence of nodes on the phragmocone and by coarse ribbing on the body chamber. It is the most coarsely ribbed scaphite in the *Scaphites leei-S. hippocrepis* group.

The specimen described by Reeside (1927b, p. 26, pl. 21, figs. 1–7) is a large female about 36 mm long that has a body chamber 26 mm wide and 19 mm thick. It has about 16 evenly spaced strong ventral ribs on the curved or younger part of the body chamber although an exact count cannot be made because the adapical part is incomplete. Four umbilical nodes are present, but the total number of ventrolateral nodes cannot be determined.

The largest collection, consisting of only four specimens, is from a bed of limestone concretions 10 feet below the top of the Marias River Shale at USGS Mesozoic locality 21419 near Shelby, Mont. (fig. 1, loc. 2). This bed of concretions produced the types of *Desmoscaphites erdmanni* Cobban (1951, p. 38, pl. 21, figs. 10–23), two plesiotypes of *Clioscaphites novimexicanus* (Reeside) (Cobban, 1951, pl. 21, figs. 4–7), two plesiotypes of *Scaphites leei* Reeside (Cobban, 1951, pl. 21, figs. 24–26; 1955, pl. 1, fig. 8), and a plesiotype of *Baculites thomi* Reeside (Cobban, 1955, pl. 2, fig. 4). Of the four specimens of *S. leei*, only two are complete body chambers. One, a female, is 19.5 mm wide and 12.8 mm thick. It has 13 evenly spaced ventral ribs on the younger part of the body chamber. The other, a male (Cobban, 1951, pl. 21, figs. 24–25), is 17.9 mm wide and 11.9 mm thick and has about 17 evenly spaced ventral ribs on the younger part of the body chamber. The published restoration (Cobban, 1955, pl. 1, fig. 8), based on this specimen, is incorrect in that it does not show the row of ventrolateral nodes continuing on to the phragmocone, and the umbilicus is drawn too small. The largest specimen, a female approximately 34 mm long with a body chamber 21.5 mm thick and possibly 31 mm wide (estimate), consists of part of the younger end of the body chamber and most of the phragmocone (pl. 1, figs. 4–7). This individual and another female (pl. 1, figs. 1, 2) from the same locality clearly show that the ventrolateral nodes extend entirely around the last septate whorl where they number about 15.

Umbilical node counts are not possible on any of the females, and the number of ventrolateral nodes can be determined on only one specimen which has about seven on the body chamber. The only complete body chamber of a male has four umbilical nodes and seven ventrolateral nodes. A small crushed incomplete male from 20 feet lower stratigraphically (fig. 1, loc. 1) is of interest in that the umbilical nodes probably number more than four and extend a little way down on the phragmocone (pl. 1, fig. 3). The primary ribs are unusually strong on this individual and seem to persist onto the older part of the body chamber.

Sutures of two females are shown in figure 12.

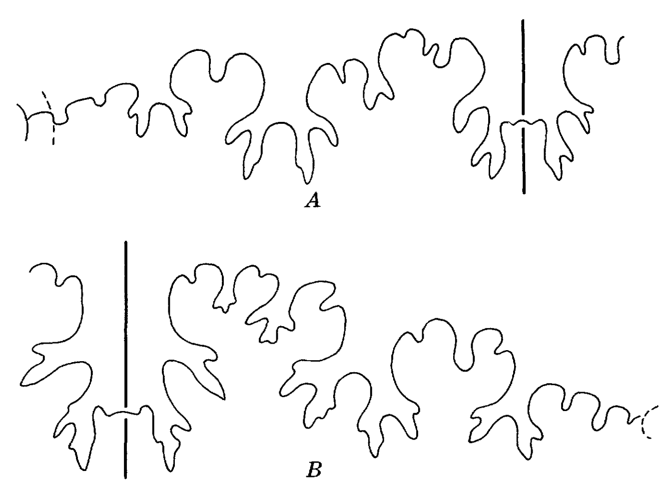

FIGURE 12.—Sutures of *Scaphites leei* I. *A*. Fourth from last suture (× 5) of a female (pl. 1, figs. 1, 2, USNM 160231) from USGS Mesozoic locality 21419 (fig. 1, loc. 2). *B*. Sixth from last suture (× 6) of a female (pl. 1, figs. 4–7, USNM 160232) from the same locality.

Scaphites leei I is easily distinguished from the younger forms of the species by the row of ventrolateral nodes on the phragmocone. In this respect, it resembles the female phragmocone from the Brownstown Marl of southwestern Arkansas illustrated by Stephenson (in Dane, 1929, p. 52, pl. 9, fig. 3) as *S. hippocrepis*.

Types.—Plesiotypes USNM 160231–160233.

Occurrences.—*Scaphites leei* I is known with certainty only from the uppermost part of the Marias River Shale in northwestern Montana (fig. 1, locs. 1–2), from the upper part of the Niobrara Shale Member of the Colorado Shale in east-central Montana (fig. 1, loc. 10), and from the uppermost part of the Mancos Shale in north-central New Mexico (fig. 1, loc. 85).

Scaphites leei Reeside II

Plate 1, figures 8–18

1927. *Scaphites leei* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 26, pl. 20, figs. 17–22 (♀).

This form of *Scaphites leei* is characterized by coarse ribbing and, on the female, by the presence of as many as four umbilical nodes and a tendency for the ventrolateral nodes to extend back as far as the base of the body chamber.

Scaphites leei II includes the holotype of the species (pl. 1, figs. 8, 9), a small female about 23.2 mm long, 19.3 mm wide, and 13 mm thick (measurements from a plaster cast). The body chamber has four umbilical nodes and nine ventrolateral nodes; each row extends down to the base of the body chamber. As observed by Reeside, the space on the flank between the rows of nodes is almost smooth, the two rows being connected by "obscure elevations." The older or straight part of the body chamber has weak irregularly spaced ventral ribs, whereas the younger or curved part has 18 strong evenly spaced ribs.

The largest collection of *Scaphites leei* II consists of nine adults (four males, five females) from the Telegraph Creek Formation at USGS Mesozoic locality D4280 in south-central Montana (fig. 1, loc. 15). The range in length of the males is 13.5 to 17.7 mm and that of the females is approximately 21 to 32 mm. The males have two to four umbilical nodes and five to seven ventrolateral nodes; the females have two to three umbilical nodes and five to eight ventrolateral nodes. The body chambers of the males have 24 to 30 ventral ribs of which 18 to 24 are on the part characterized by uniform ribbing. Rib counts can be made on only two of the female body chambers; the ribs number 19 of which 16 are evenly spaced on one chamber, and 17 are evenly spaced on the other.

Types.—Holotype, USNM 73354; plesiotypes, USNM 160234–160236.

Occurrences.—*Scaphites leei* II is known from only a few localities. The holotype is from the uppermost part of the Mancos Shale in north-central New Mexico (fig. 1, loc. 84). This form of the species has been found at only one locality in Wyoming on the north side of the Wind River Basin (fig. 1, loc. 54, 5 ♂ ♂, 1 ♀; Keefer and Troyer, 1964, p. 88). In Montana, this form has been found at three localities in the Telegraph Creek Formation (fig. 1, locs. 3, 1 ♀; 20, 1 ♀; 15, 4 ♂ ♂, 5 ♀ ♀) and questionably from the basal part of the Gammon Shale (fig. 1, loc. 9, 1 ♂, 3 ♀ ♀). The small female figured by Reeside (1927b, pl. 15, fig. 18) as *S. hippocrepis* from the Telegraph Creek Formation near map locality 15 is probably *S. leei* II. The specimens at map localities 3 and 15 in Montana and at map locality 54 in Wyoming are associated with *Desmoscaphites bassleri* Reeside. The scaphite recorded as *S. hippocrepis* by Pike (1947, p. 43) that is associated with *D. bassleri* in the Mancos Shale in southwestern Colorado is probably *S. leei* II.

Scaphites leei Reeside III

Plate 1, figures 19–31; text figure 15

1927. *Scaphites leei* Reeside var. *parvus* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 27, pl. 21, figs. 8–16 (♂ ♂).

1960. *Scaphites leei* Reeside var. *parvus* Reeside. Easton, Invertebrate Paleontology, text fig. 11.27–1a (♂).

Scaphites leei III differs from *S. leei* II in that it has denser ribbing on the body chamber and it rarely has more than two umbilical nodes on the female. The ventrolateral and umbilical nodes on the female are confined to the younger part that has the uniform ventral ribbing.

Reeside figured two males from separate localities in north-central New Mexico (fig. 1, locs. 81, 83). The slightly larger and better preserved specimen is the holotype of his variety *parvus*. This specimen is about 16.4 mm long, 14 mm wide, and 7.6 mm thick (measurements from a plaster cast). It has two umbilical nodes and six ventrolateral nodes. The uniform ventral ribs on the body chamber number 20, and the interruption in ribbing below them is very distinct (Reeside, 1927b, pl. 21, fig. 12).

An outstanding collection of *Scaphites leei* III consists of 75 adults from a single limestone concretion from the upper part of the Mancos Shale at USGS Mesozoic locality D4075 near Gallina, N. Mex. (fig. 1, loc. 79). Forty-five are males ranging in length from 12.5 to 21.8 mm (pl. 1, figs. 19–24), and 30 are females ranging in length from 18.2 to 28.9 mm (pl. 1, figs. 25–31). Most males have two to four umbilical nodes (average 3.2) on the body chamber and four to nine ventrolateral nodes (average 6.6). One female has a single umbilical node, another has three nodes, and the rest have two; the ventrolateral nodes number five to eight (average 6.2). Node counts are shown in figure 13.

All nodes are confined to the younger half of the body chamber—the part characterized by uniform ventral ribbing. The adapical umbilical node on the female is much larger than the adoral node. In the row of ventrolateral nodes, the second or third node from the adapical end is usually the largest, and the rest decrease progressively in size away from it. On males the nodes of both rows are more uniform in size. The evenly spaced ribs on the body chamber number 17 to 29 (average 23.5) on males and 15 to 25 (average 19.4) on females. Their distribution is shown in figure 14.

The collection from locality D4075 shows the greatest range in size for the females of *Scaphites leei* III (fig. 3), but a collection from the same locality (fig. 1, loc. 80) but 30 feet higher stratigraphically includes an adult male only 11.1 mm in length and another male as much as 26.9 mm in length.

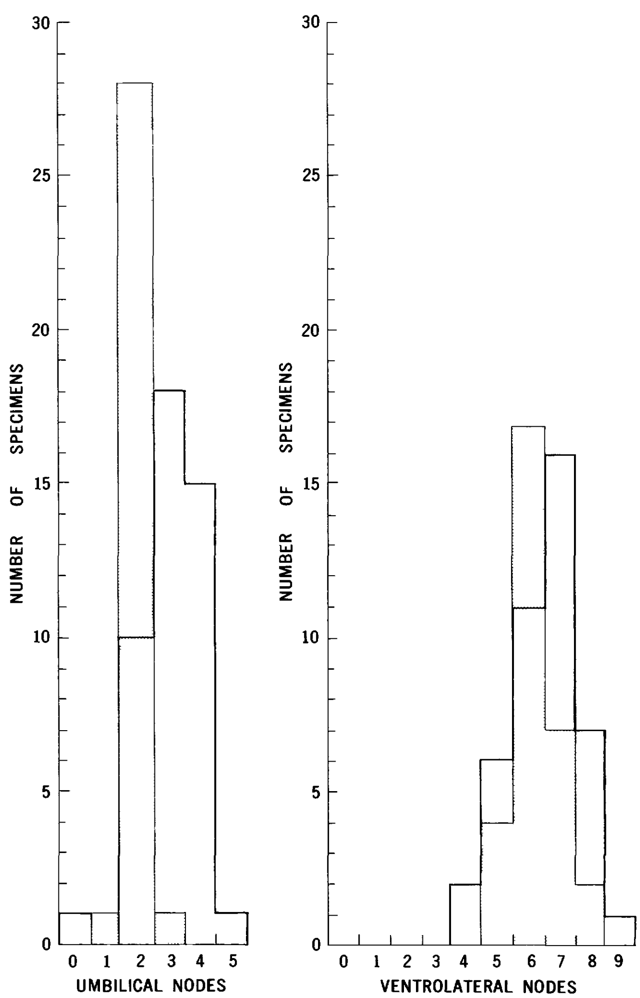

FIGURE 13.—Histograms showing node counts on the entire body chamber of male (heavy line) and female (shaded) specimens of *Scaphites leei* III from USGS Mesozoic locality D4075 (fig. 1, loc. 79).

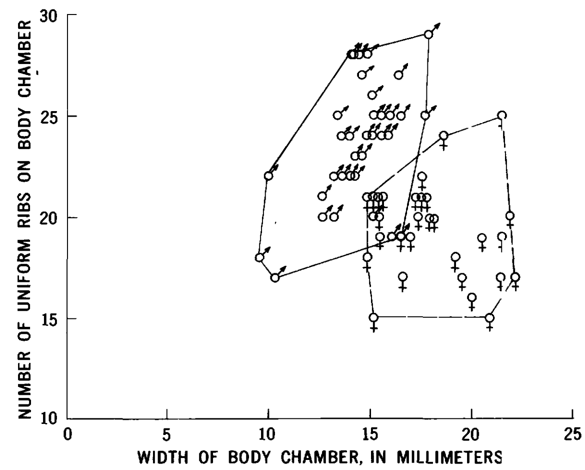

FIGURE 14.—Scatter diagram showing number of ventral ribs of uniform height and spacing on the younger part of the body chambers of male (♂) and female (♀) specimens of *Scaphites leei* III from USGS Mesozoic locality D4075 (fig. 1, loc. 79).

The external sutures of a male and a female from locality D4075 are shown in figure 15.

Most internal molds of either sex from locality D4075 have a small shallow pit on the umbilical wall at or very near the base of the body chamber (pl. 1, figs. 19–23). The pit is either circular or elliptical with the elongation in the direction of shell growth. The pits range in size from 1.0 by 1.5 mm to 2.0 by 2.0 mm. They are present on both sides of a scaphite. The pits reflect a localized thickening inward of the shell material; no thickening is visible on scaphites that retain their original shell.

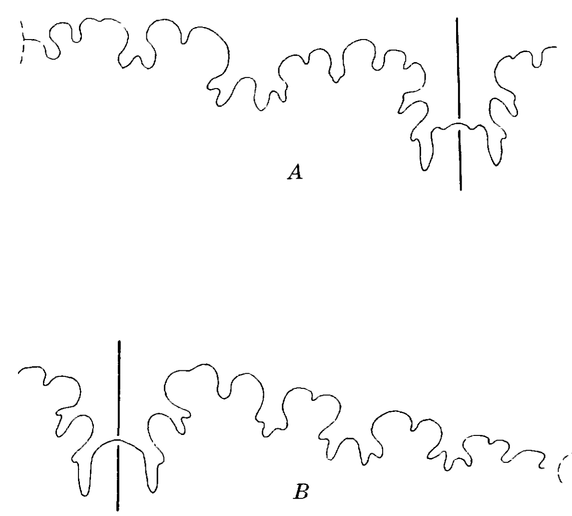

FIGURE 15.—Sutures of *Scaphites leei* III. *A*. Last suture (× 6) of a male (pl. 1, fig. 21, USNM 160239) from USGS Mesozoic locality D4075 (fig. 1, loc. 79). *B*. Penultimate suture (× 6) of a female (pl. 1, fig. 31, USNM 160249) from the same locality.

This local thickening of the shell was probably caused by a parasite.

Types.—Holotype, USNM 73356; paratype, USNM 73357; plesiotypes, USNM 160237–160249.

Occurrences.—*Scaphites leei* III has been found sparingly in Montana and Wyoming and more commonly in New Mexico. In Montana, it is known best from a collection of four females and two males from the lower part of the Gammon Shale on Porcupine dome (fig. 1, loc. 12) where the specimens were associated with an early form of *Haresiceras montanaense* (Reeside) (Cobban, 1964, p. I6). The body chamber of the male figured by Reeside (1927b, pl. 19, figs. 8, 9) as *S. aquilaensis* var. *costatus* from the Telegraph Creek Formation in south-central Montana (fig. 1, loc. 18) seems to be assignable to *S. leei* III. In Wyoming, *S. leei* III has been found associated with *H. montanaense* in the Cody Shale in the northern part of the Bighorn Basin (fig. 1, locs. 21, 1 ♂, 2 ♀ ♀; 26, 2 ♂ ♂, 2 ♀ ♀). In New Mexico, this scaphite has been found on the east side of the San Juan Basin (fig. 1, locs. 79, 45 ♂ ♂, 30 ♀ ♀; 80, 6 ♂ ♂, 5 ♀ ♀; 82, 3 ♂ ♂, 4 ♀ ♀; 81, 1 ♂) and in the Ortiz Mountains area between Santa Fe and Albuquerque (fig. 1, loc. 83, 1 ♂). The female from the Ortiz Mountains area (fig. 1, loc. 85) figured by Reeside (1927b, pl. 17, figs. 14, 15) as *S. hippocrepis* var. *crassus* is probably *S. leei* III.

Scaphites leei III may be present in the Austin Chalk of Texas. Two of the three females described by Young (1963, p. 48, pl. 2, figs. 1–4, 6–9; text fig. 7g) as *S. hippocrepis crassus* from his Dessau Limestone have well-defined ventrolateral nodes and a large umbilical node. A plaster cast of one of the specimens (Young, 1963, pl. 2, figs. 6–9) shows the presence of a much smaller umbilical node nearer the aperture. On this cast the ventrolateral nodes number five and the uniformly spaced ventral ribs on the body chamber number 15 or 16. The body chamber of a female described by Young (1963, p. 49, pl. 20, figs. 5, 6) as *S.* sp. cfr. *leei parvus* from his slightly younger Burditt Marl may also be *S. leei* III. It has six well-defined ventrolateral nodes, a large umbilical node, and a much smaller umbilical node nearer the aperture. About 16 or 17 evenly spaced ventral ribs are present on the body chamber.

SCAPHITES HIPPOCREPIS (DeKAY)

The holotype, part of an adult body chamber, is apparently lost (Reeside, 1962, p. 126). In the illustration by DeKay (1827, pl. 5, fig. 5), the specimen is oriented in such a manner that the viewer sees a cross section of the adapical end of the body chamber and little else. The stoutness of the specimen and the great involution of the base of the body chamber indicates a female. The conspicuous lunate cross section of the base of the body chamber suggests a horseshoe and, hence, the origin of the species name—hippo (Greek, "hippos," horse), crepis (Greek, "krepis," shoe). DeKay's description is as follows:

> Externally smooth, with slight transverse elevations, which in the smaller whirls are very distinct; each whirl envelopes one half of the internal contiguous whirl, and this gives to the septum a peculiar lunated appearance. This is supposed to be the last chamber, and a considerable prominence on each side near the outer lip, may be considered as analogous to corresponding parts in the Nautilus, where the lips fold round in order to be connected with the sides. The septum irregular, with tubercles on its surface, which towards its junction, with the sides of the shell, assume a branched appearance, similar to the divisions of the Baculite. The outline of the septum, as may be seen by reference to the figure, is semilunated, with the horns produced and somewhat approximated. Thickness one inch. Conjectured diameter of the whole shell two inches.

Morton (1829, p. 109, pl. 7, fig. 1) described a well-preserved complete female that he named *Scaphites cuvieri*, but he (1833, p. 290) later pointed out that his species was the same as DeKay's *Ammonites hippocrepis*. Morton's specimen, which is in the collections of the Academy of Natural Sciences in Philadelphia, has been illustrated by several authors (Whitfield, 1892, pl. 44, fig. 8; Richards, 1953, fig. 224 on p. 286; Reeside, 1962, pl. 71, figs. 1–5).

Reeside (1927b, p. 22) summarized *Scaphites hippocrepis* as follows: "The characteristic features of the species are the broad, stout whorls and the swollen living chamber with its flanks smooth except for the two prominent primary nodes and with its row of seven to nine low rounded nodes bordering the venter * * *. Variations from the typical form are common. The height of the tubercles and the distinctness of the obscure primary ribs on the living chamber, the relative coarseness of the ribs, the smaller details of the suture, and other characters vary with different individuals."

Reeside included in *Scaphites hippocrepis* only forms that I believe are females. Forms that I consider males were assigned to *S. aquilaensis* and *S. similis* by Reeside. With the inclusion of these in *S. hippocrepis*, the definition of *S. hippocrepis* has to be broadened. Accordingly, *S. hippocrepis* is herein considered as a rapidly evolving species that has bullate nodes in the older forms and more rounded nodes and denser ribbing in the later forms. The umbilical nodes ordinarily number one to three on females and one to four on males, and the ventrolateral nodes commonly number four to 10 on females and six to 10 on males. The species evolved from *S. leei* from which it differs chiefly by its having weaker ribbing and attaining a larger size. The three forms of *S. leei* are characterized by strong rounded ventrolateral nodes, whereas the oldest form of *S. hippocrepis* has weaker nodes that tend to be bullate.

Scaphites hippocrepis (DeKay) I

Plate 1, figures 32–47; plate 2, figures 1–17; plate 4, figures 13–34; plate 5, figures 28–32; text figures 5–7, 9, 10, 17

1927. *Scaphites hippocrepis* (DeKay). Reeside, U.S. Geol. Survey Prof. Paper 151, p. 22 [part], pl. 14, figs. 17, 19, 20 (♀♀); pl. 15, figs. 1–17 (♀♀); pl. 16, figs. 5–9 (♀).
1927. *Scaphites hippocrepis* (DeKay) var. *pusillus* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 23, pl. 17, figs. 1–5 (♀).
1927. *Scaphites hippocrepis* (DeKay) var. *crassus* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 23, pl. 17, figs. 6–13 (♀♀).
1927. *Scaphites aquilaensis* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 25 [part], pl. 18, figs. 15–23, 26, 27 (♂♂); pl. 19, figs. 6, 7 (♂).
1927. *Scaphites aquilaensis* Reeside var. *costatus* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 25, pl. 19, figs. 10–13 (♂).
1927. *Scaphites aquilaensis* Reeside var. *nanus* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 26, pl. 19, figs. 14–21 (♂♂); pl. 20, figs. 1–6 (♂).
1927. *Scaphites levis* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 26, pl. 20, figs. 7–16 (♀♀).
1927. *Scaphites similis* Whitfield. Reeside, U.S. Geol. Survey Prof. Paper 151, p. 24 [part], pl. 18, fig. 11 (♂).
1944. *Scaphites hippocrepis* (DeKay). Shimer and Shrock, Index fossils of North America, p. 591, pl. 244, figs. 4, 5 (♀).
1952. *Scaphites hippocrepis* (DeKay). Basse, *in* Piveteau, Traité de Paléontologie, v. 2, fig. 16 on p. 539 (♀).
1960. *Scaphites hippocrepis* (DeKay). Easton, Invertebrate Paleontology, text fig. 11.27–4b only (♀).
1964. *Scaphites* cf. *S. hippocrepis* (DeKay). Cobban, U.S. Geol. Survey Prof. Paper 454–I, p. I8, pl. 1, figs. 28–30 (♀).
1965. *Scaphites* (*Scaphites*) *hippocrepis* (DeKay). Wiedmann, Palaeontology, v. 8, pt. 3, text fig. 15 on p. 447 (♀).

Scaphites hippocrepis I is characterized by weak bullate ventrolateral nodes on almost all females and on most males. The umbilical nodes number two to four on most of the males and one to two on most of the females. Most of the males have five to 10 ventrolateral nodes, and most of the females have five to eight. The interruption in the uniformity of the ventral ribs on the older part of the body chamber is poorly defined on the males and on many of the females. The evenly spaced ribs on the younger part of the body chamber average about 25 for the males and about 22 for the females.

This form differs from its immediate ancestor *S. leei* III in that it has denser ribbing and weaker nodes which tend to be elongated. (Contrast pl. 1, figs. 19–31 with pl. 1, figs. 32–47.)

Scaphites hippocrepis I is represented by several collections of very well preserved specimens. One of the best collections is from a silty limestone concretion in the Cody Shale at USGS Mesozoic locality D4181 near Manderson, Wyo. (fig. 1, loc. 35). The collection contains 38 adults suitable for measurements. Twenty are males 11.7 to 22.6 mm in length (pl. 1, figs. 32–37), and 18 are females 13.5 to more than 27.5 mm in length (pl. 1, figs. 38–47). The larger males have two to four umbilical nodes, whereas the smaller males commonly have none. The larger females have one or two umbilical nodes, and the smaller females may have none. The ventrolateral nodes number five to 10 on the larger specimens, but they may be absent from some of the smaller specimens. The number of ventrolateral nodes ranges from four to seven on the females. The evenly spaced ventral ribs on the curved part of the body chamber ranges from 20 to 34 on the males and from 17 to 26 on the females (fig. 16).

The specimens from locality D4181 near Manderson are associated with a late form of *Haresiceras montanaense* (Reeside). Another large lot of scaphites that seems best assigned to *Scaphites hippocrepis* I was collected from a zone of sandy limestone concretions in the Cody Shale along several miles of outcrop near Lovell, Wyo. (fig. 1, locs. 27–29; pl. 2, figs. 1–17; pl. 4, figs. 25–34). Associated fossils include *H. placentiforme* Reeside, a younger species than *H. montanaense*. The Lovell collection contains 38 scaphites suitable for measurements; 25 are males 15.7 to 35.1 mm long and 13 are females 20.4 to 52.2 mm long. The larger size of the specimens makes comparisons with the scaphites from locality D4181 difficult. All but one of the females have two or three umbilical nodes, whereas those from locality D4181 have one or two nodes or none. Ventrolateral

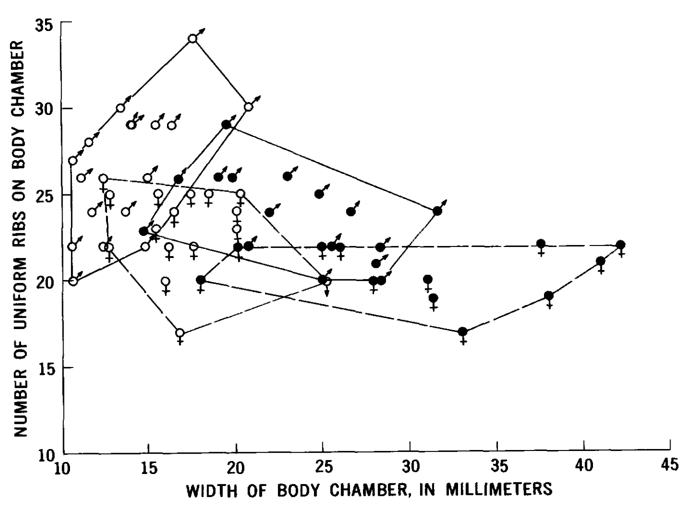

FIGURE 16.—Scatter diagram showing number of ventral ribs of uniform height and spacing on the younger part of the body chambers of male (open ♂) and female (open ♀) specimens of *Scaphites hippocrepis* I from USGS Mesozoic locality D4181 (fig. 1, loc. 35) and on male (solid symbol) and female (solid symbol) specimens of *S. hippocrepis* I from localities D4194, D4198, and D4199 (figs. 1, locs. 27–29).

nodes on the females number five to nine compared to four to seven on those from loc. D4181. The males have two to six umbilical nodes compared to four to nine on those from the Manderson locality. The ventrolateral nodes on the males seem to be more rounded although they number about the same (five to 10). The uniform ribs on the body chamber number 17 to 22 on the females and 20 to 29 on the males which is fewer than those on the scaphites from the Manderson locality (fig. 16). These differences are probably due in part to the younger age of the Lovell locality and in part to the larger size of the Lovell specimens.

The external sutures of four males and four females are shown in figure 17.

A shallow pit on the umbilical wall at the base of the body chamber like that on specimens of *Scaphites leei* III is present on a few individuals of *S. hippocrepis* I (pl. 2, fig. 4).

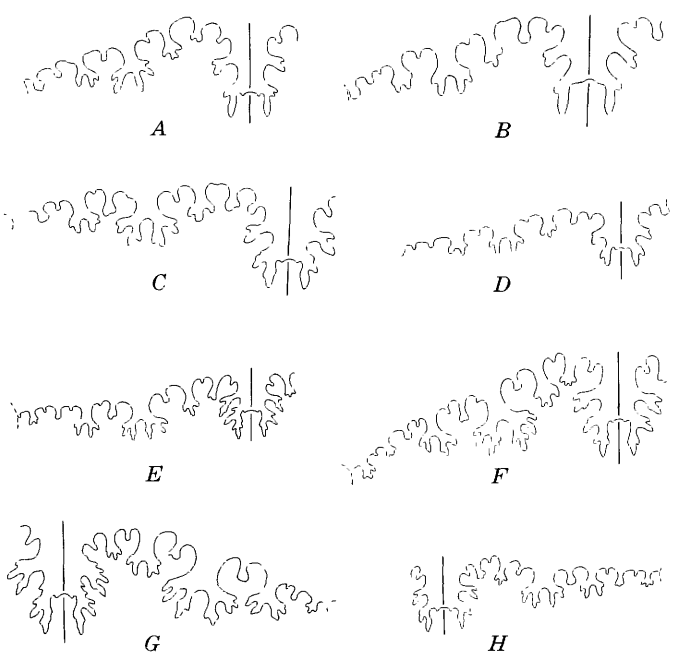

FIGURE 17.—Sutures of *Scaphites hippocrepis* I. *A*. Penultimate suture (× 3) of a male (pl. 1, fig. 32, USNM 160250) from USGS Mesozoic locality D4181 (fig. 1, loc. 35). *B*. Second from the last suture (× 6) of a male (pl. 1, fig. 34, USNM 160252) from the same locality. *C*. Second from the last suture (× 3) of a female (pl. 1, fig. 40, USNM 160258) from the same locality. *D*. Second from the last suture (× 3) of a smaller female (pl. 1, fig. 43, USNM 160261) from the same locality. *E*. Penultimate suture (× 2) of a male (pl. 2, fig. 1, USNM 160270) from USGS Mesozoic locality D4194 (fig. 1, loc. 27). *F*. Fourth from last suture (× 2) of a large female (pl. 5, fig. 28, USNM 160287) from USGS Mesozoic locality D4198 (fig. 1, loc. 28). *G*. Sixth from last suture (× 2) of another large female (pl. 2, fig. 11, USNM 160280) from the same locality. *H*. Second from the last suture (× 2) of a male (pl. 2, fig. 2, USNM 160271) from the same locality.

Types.—Plesiotypes, USNM 160250–160291.

Occurrences.—*Scaphites hippocrepis* I is known from many localities in Wyoming and from a very few localities in Montana, Utah, and New Mexico. In the Bighorn Basin of Wyoming, several large collections have been made from the Cody Shale in the northern part (fig. 1, locs. 35, 30 ♂ ♂, 83 ♀ ♀; 36, 4 ♂ ♂, 26 ♀ ♀; 27, 5 ♂ ♂, 2 ♀ ♀; 28, 21 ♂ ♂, 22 ♀ ♀; 29, 8 ♂ ♂, 8 ♀ ♀) and from the Elk Basin Sandstone Member of the Telegraph Creek Formation (fig. 1, locs. 22, 8 ♂ ♂, 8 ♀ ♀; 24, 1 ♂, 4 ♀ ♀; 25, 6 ♀ ♀; 23, 1 ♂, 2 ♀ ♀). In the southern part of the Bighorn Basin, this scaphite has been collected east of Thermopolis (fig. 1, locs. 43, 2 ♂ ♂, 5 ♀ ♀; 44, 6 ♀ ♀; 45, 2 ♂ ♂, 1 ♀). On the west side of the Powder River Basin, several collections have been made in addition to those listed by Reeside (1927b, p. 4, locs. 108–115). The best collections are from Elgin Creek, south of Buffalo (fig. 1, loc. 39, 15 ♂ ♂, 7 ♀ ♀; Hose, 1955, p. 96), and from the Kaycee area (fig. 1, loc. 46, 8 ♂ ♂, 8 ♀ ♀). In the Wind River Basin of Wyoming, *S. hippocrepis* I has been found in the Cody Shale near Lander (fig. 1, loc. 56, 5 ♂ ♂, 5 ♀ ♀) and in the Shotgun Butte area (fig. 1, loc. 55, 1 ♂, 5 ♀ ♀; Keefer and Troyer, 1964, p. 114). Two poorly preserved collections from the Steele Shale in south-central Wyoming suggest the presence of the species there (fig. 1, locs. 68, 4 ♂ ♂, 3 ♀ ♀; 67, 1 ♂, 5 ♀ ♀).

The record for this form of *Scaphites hippocrepis* outside of Wyoming is rather poor. A single large female from near Warren, Mont., reveals the presence of this scaphite in the Montana part of the Bighorn Basin (fig. 1, loc. 19). In east-central Montana this scaphite has been found in the lowest sandstone unit of the Eagle Sandstone near Winnett (fig. 1, loc. 4, 7 ♂ ♂, 10 ♀ ♀) and below the lowest sandstone farther east near Cat Creek (fig. 1, locs. 5, 4 ♂ ♂, 1 ♀; 6, 1 ♂, 1 ♀). Specimens from Utah are rare and not well preserved in thin-bedded sandy strata. The scaphite has been found on the north side of the Uinta Mountains (fig. 1, locs. 72, 1 ♀; 73, 2 ♀ ♀) and near Green River (fig. 1, loc. 76, 4 ♂ ♂, 2 ♀ ♀). In New Mexico, the scaphite has been found near the top of the Mancos Shale on the west side of the San Juan Basin (fig. 1, loc. 78, 2 ♂ ♂, 2 ♀ ♀).

Scaphites hippocrepis (DeKay) II

Plate 2, figures 18–37; plate 5, figures 5–18, 24–27, 33–35; text figure 18

1927. *Scaphites stantoni* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 23, pl. 17, figs. 16–21 (♀); pl. 18, figs. 1–4 (♀).

1927. *Scaphites aquilaensis* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 25, pl. 19, figs. 1–5 (♂).

1927. *Scaphites hippocrepis* (DeKay) var. *tenuis* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 23 [part], pl. 16 figs. 14, 15 (♀), 17–19 (♀).

This form of *Scaphites hippocrepis* ordinarily has well-defined ventrolateral nodes and rather dense ribbing. The ventral ribbing on the body chamber of small adults tends to be very weak or absent. The form differs from its immediate ancestor *S. hippocrepis* I by most specimens having round ventrolateral nodes instead of bullate nodes and by having denser ribbing. Most males have only two umbilical nodes, whereas most of those of *S. hippocrepis* I have three to five.

Scaphites hippocrepis II is not common, and none of the collections is large. One of the largest lots consists of three males and seven females from a limestone concretion in the Cody Shale at USGS Mesozoic locality D3244 near the Salt Creek oil field in east-central Wyoming (fig. 1, loc. 49). Four of the specimens are shown on plate 2, figures 18–30. The males have two or three umbilical nodes and about seven ventrolateral nodes. The females have seven to 10 ventrolateral nodes and two umbilical nodes of which the adapical one is much the larger. With one exception, ventral ribbing on the younger part of the body chamber is moderately dense and weak or even lacking from the internal molds. The exception is the largest individual, a female that has a body chamber 37 mm wide crossed by 23 evenly spaced ribs (pl. 2, figs. 28–30). A smaller female, 21 mm wide, has 35 evenly spaced ribs, and two incomplete female body chambers of about this size have similar dense ribbing. Ventral ribbing is lacking from the body chamber of the male shown on plate 2, figures 18–21. An incomplete body chamber of a slightly larger male has very weak dense ribbing.

Another of the larger collections from the zone of *Scaphites hippocrepis* II consists of five males and 15 females from the Cody Shale at USGS Mesozoic locality D4185 near Manderson, Wyo. (fig. 1, loc. 37). (See pl. 2, figs. 31–37; pl. 5, figs. 19–21.) An unusual specimen in this lot is a male (pl. 5, figs. 19–21) that has a coarsely ribbed venter and nodelike ribs between the umbilical and ventrolateral nodes. The flank is wider than that of the associated males, and the ventrolateral nodes are elongated parallel to the direction of coiling of the body chamber. A similar specimen (pl. 5, figs. 22, 23) was collected from the upper part of the Mancos Shale at Vermilion Creek in northwestern Colorado (fig. 1, loc. 75). The wide flank, midflank nodelike ribs, and clavate ventrolateral nodes are features found on the males of *S. hippocrepis* III, but the coarse ventral ribbing is unusual. The presence of this advanced type of scaphite at the Manderson and Vermilion Creek localities suggests that these localities lie high in the zone of *S. hippocrepis* II. Another of these peculiar coarse-ribbed scaphites was collected near Lamont, Wyo. (fig. 1, loc. 60), possibly in the zone of *S. hippocrepis* III.

A collection that should be considered here consists of nine males and three females from the Cody Shale at USGS Mesozoic locality D4243 near Kaycee on the west flank of the Powder River Basin in Wyoming (fig. 1, loc. 46). Three males and one female from this locality are shown on plate 5, figures 5–18. The largest male (pl. 5, figs. 13, 14) has distinct ventral ribs on the body chamber and a few primary ribs as well, but most of the other males either lack ribs or have very faint ribs. The males have two to four umbilical nodes and five to nine ventrolateral nodes. The only female with a complete body chamber has two umbilical nodes and six ventrolateral nodes (pl. 5, figs. 5–8). The smoothness of the venter on many of the specimens recalls similar individuals in the Manderson and Salt Creek collections. The presence, however, of as many as four umbilical nodes on a male is a character more like that of *S. hippocrepis* I. The collection from locality D4243 probably occupies a position low in the zone of *S. hippocrepis* II. Similar scaphites were also collected at a locality in the Wind River Basin (fig. 1, loc. 53).

Sutures of two females and a male are shown in figure 18.

The holotypes of *Scaphites stantoni* Reeside (1927b, p. 23, pl. 17, figs. 16–21) and *S. aquilaensis* Reeside (1927b, p. 25, pl. 19, figs. 1–5) seem to be *S. hippocrepis* II. Reeside's types were collected by T. W. Stanton in 1903 and were said to have come from near the base of the Eagle Sandstone along "Willow Creek, 6 miles above old Fort Maginnis-Junction City road, Fergus County, Mont." (fig. 1, loc. 11). This road is shown on the U.S. Post Office Department's "Post Route map of the States of Montana, Idaho, and Wyoming" (June 1906). The Eagle Sandstone crops out along Willow Creek on Big Wall dome (Dobbin and Erdmann, 1955) about 10 miles upstream from the crossing of the old Fort Maginnis-Junction City road, and, presumably, that is where the types were collected.

Reeside's *Scaphites stantoni* is a female that has a large umbilical node and a much smaller one nearer the aperture. The smaller one is not shown on Reeside's illustration. The seven ventrolateral nodes are round and moderately conspicuous. The evenly spaced ventral ribs on the body chamber are very weak and number about 30.

Reeside's *Scaphites aquilaensis* is a male that is missing the adoral end of the body chamber. The venter of the body chamber is almost smooth; traces of closely spaced very weak ventral ribs indicate a fairly high rib count. The side view presented by Reeside has been retouched incorrectly. Two umbilical nodes should be

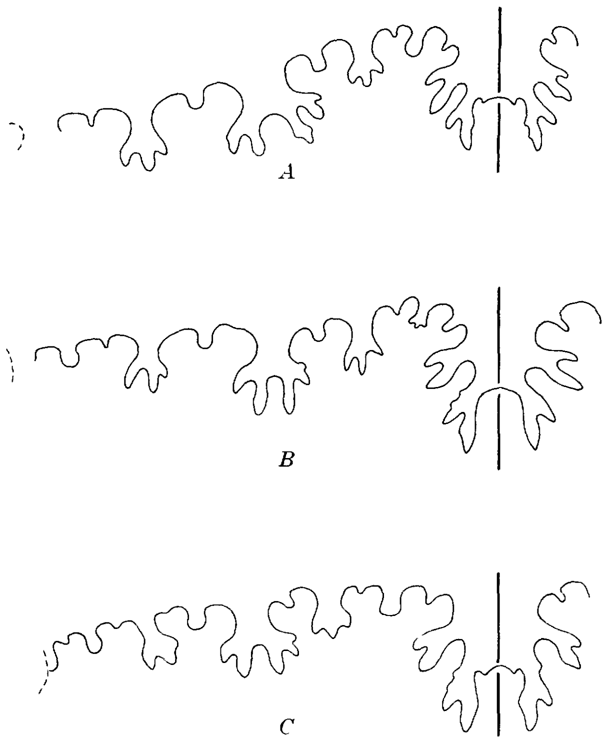

FIGURE 18.—Sutures *Scaphites hippocrepis* II. *A*. *Second* from the last suture (× 4) of a large female (pl. 2, figs. 34–37, USNM 160297) from USGS Mesozoic locality D4185 (fig. 1, loc. 37). *B*. Penultimate suture (× 6) of a small female (pl. 5, figs. 5–8, USNM 160298) from USGS Mesozoic locality D4243 (fig. 1, loc. 46). *C*. Second from last suture (× 6) of a male (pl. 5, figs. 9–12, USNM 160299) from the same locality.

shown instead of three, and six weak ventrolateral nodes should be indicated instead of four, and they should be more circular.

Types.—Plesiotypes, USNM 160292–160301, 160304–160305.

Occurrences.—*Scaphites hippocrepis* II is known from Montana, Wyoming, and Colorado. Aside from Stanton's locality (fig. 1, loc. 11), the scaphite has been found in Montana in the Eagle Sandstone near Billings (fig. 1, locs. 13, 1 ♂, 6 ♀ ♀; 14, 5 ♀ ♀) and near Cat Creek (fig. 1, locs. 7, 3 ♀ ♀; 8, 19 ♂ ♂, 24 ♀ ♀). In addition to the localities near Manderson (fig. 1, loc. 37) and near the Salt Creek oil field (fig. 1, loc. 49), the scaphite seems to be represented in Wyoming by only a few specimens from the Cody Shale on the west side of the Powder River Basin (fig. 1, locs. 38, 1 ♀; 30, 3 ♀ ♀) and near Rawlins (fig. 1, locs. 64, 1 ♀; 63, 2 ♀ ♀). In Colorado, the scaphite has been found only in the northwestern corner of the State (fig. 1, locs. 75, 2 ♂ ♂, 4 ♀ ♀; 74, 3 ♂ ♂, 4 ♀ ♀; Reeside, 1955, p. 86).

Scaphites hippocrepis (DeKay) III

Plate 3, figures 1–25; plate 4, figures 35–49; plate 5, figures 36–40; text figures 2, 4, 10, 11

1827. *Ammonites hippocrepis* DeKay, Lyceum Nat. History New York Annals, v. 2, p. 273, pl. 5, fig. 5 (♀).
1829. *Ammonites hippocripes* DeKay. Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., v. 6, p. 88, pl. 7, fig. 1 (♀).
1829. *Scaphites cuvieri* Morton, Acad. Nat. Sci. Philadelphia Jour., 1st ser., v. 6, p. 109, pl. 7, fig. 1 (♀).
1830. *Scaphites cuvieri* Morton. Morton, Am. Jour. Sci., 1st ser., v. 17, p. 280 (♀).
1834. *Scaphites hippocrepis* (DeKay). Morton, Synopsis of the organic remains of the Cretaceous group of the United States, p. 41, pl. 7, fig. 1 (♀).
1834. *Scaphites reniformis* Morton, Synopsis of the organic remains of the Cretaceous group of the United States, p. 42, pl. 2, fig. 6 (♂).
1872. *Scaphites aquisgranensis* Schlüter, Palaeontographica, v. 21, p. 81, pl. 24, figs. 7–9 (♂).
1876. *Scaphites cuvieri* Morton. Schlüter, Palaeontographica, v. 24, p. 162, pl. 42, figs. 1–3 (♀ ♀).
?1885. *Scaphites* cfr. *aquisgranensis* Schlüter. Moberg, Sveriges geol. undersökning, ser. C, no. 73, pt. 2, p. 26, pl. 3, figs. 2a, b (♂).
1888. *Scaphites aquisgranensis* Schlüter. Holzapfel, Paleontographica, v. 34, pt. 1, p. 62, pl. 5, figs. 3a, b (♀).
1888. *Scaphites aquisgranensis Schlüter*. Holzapfel, Paleontographica, v. 34, pt. 1, p. 61, pl. 5, figs. 2a, b (♂).
1889. *Scaphites cuvieri* Morton. Griepenkerl, Palaeont. Abh., v. 4, no. 5, p. 103 (405).
1892. *Scaphites hippocrepis* (DeKay). Whitfield, U.S. Geol. Survey Mon. 18, p. 262, pl. 44, figs. 8–12 (♀ ♀).
1892. *Scaphites reniformis* Morton. Whitfield, U.S. Geol. Survey Mon. 18, p. 264, pl. 44, fig. 3 (♂).
1892. *Scaphites similis* Whitfield, U.S. Geol. Survey Mon. 18, p. 267, pl. 44, figs. 1–2 (♂).
1894. *Scaphites hippocrepis* (DeKay). Grossouvre, Recherches craie supérieure, pt. 2, p. 244, pl. 32, figs. 2, 3a, b (♀ ♀); pl. 35, figs. 6a–c (♀); pl. 37, figs. 3a, b (♀).
1894. *Scaphites aquisgranensis* Schlüter. Grossouvre, Recherches craie supérieure, pt. 2, p. 246, pl. 31, figs. 3, 4a, b, 6a, b (♂ ♂).
1907. *Scaphites hippocrepis* (DeKay). Weller, New Jersey Geol. Survey, Paleontology ser., v. 4, p. 826, pl. 107, figs. 3–6 (♀ ♀).
1910. *Scaphites hippocrepis* (DeKay). Grabau and Shimer, North American index fossils, v. 2, p. 178, fig. 1431 (♀).
1916. *Scaphites hippocrepis* (DeKay). Gardner, Maryland Geol. Survey, Upper Cretaceous, p. 382 (♀).
1927. *Scaphites hippocrepis* [part] (DeKay). Reeside, U.S. Geol. Survey Prof. Paper 151, p. 22, pl. 14, fig. 18 (♀); pl. 16, figs. 1–4 (♀).
1927. *Scaphites hippocrepis* [part] (DeKay) var. *tenuis* Reeside, U.S. Geol. Survey Prof. Paper 151, p. 23, pl. 16, figs. 11–13, 16 (♀ ♀).
1927. *Scaphites similis* [part] Whitfield. Reeside, U.S. Geol. Survey Prof. Paper 151, p. 24, pl. 18, figs. 8–10 (♂).
1931. *Scaphites aquisgranensis* Schlüter. Riedel, Preuss. Geol. Landesanstalt Jahrb., v. 51, pt. 2, p. 703 (♂).
1943. *Scaphites hippocrepis* (DeKay). Van der Weijden, Geol. Stichting Med., ser. C–IV–2, no. 1, p. 124, pl. 13, fig. 8 (♀).

1943. *Scaphites aquisgranensis* Schlüter. Van der Weijden, Geol. Stichting Med., ser. C–IV–2, no. 1, p. 124, pl. 13, figs. 6–7 (♂♂).
1953. *Scaphites hippocrepis* (DeKay). Richards, Record of the Rocks, fig. 224 (♀).
1960. *Scaphites hippocrepis* (DeKay). Easton, Invertebrate Paleontology, fig. 11.27–4a (♀).
1962. *Scaphites hippocrepis* (DeKay). Reeside, New Jersey Geol. Survey Bull. 61, pt. 2, p. 124, pl. 70, figs. 11–12 (♂); pl. 71, figs. 1–7 (♀♀).
1962. *Scaphites similis* Whitfield. Reeside, New Jersey Geol. Survey Bull. 61, pt. 2, p. 126, pl. 70, fig. 7 (♂).
1963. *Scaphites* sp. cfr. *S. aquisgranensis* Schlüter. Young, Texas Univ. Pub. 6304, p. 49, pl. 80, figs. 3–4 (♂).
1964. *Scaphites hippocrepis* (DeKay). Cobban, U.S. Geol. Survey Prof. Paper 454–I, p. I8, pl. 1, figs. 33–36 (♀).

Scaphites hippocrepis III is featured by numerous ventral ribs on the body chamber and by the presence of weak nodelike ribs on the middle of the flank between the umbilical and ventrolateral rows of nodes. On some individuals the ventrolateral nodes extend onto the phragmocone. The males have flattened flanks and clavate ventrolateral nodes.

Cross sections through the body chambers of males and females are quite different. Those of the male are rather squarish whereas those of the female are more rounded. On the male the distance between the umbilical and ventrolateral rows of nodes is nearly equal to the distance between the rows of ventrolateral nodes (fig. 10*C*). On the female the ventrolateral rows of nodes are more widely separated than the rows of umbilical and ventrolated nodes (fig. 10*D*; also fig. 19).

Two large collections have been made. One, at USGS Mesozoic locality 21206 (fig. 1, loc. 17) from the Gammon Ferruginous Member of the Cody Shale of south-central Montana (Richards, 1955, p. 60), contains 16 males and 12 females suitable for measurement (pl. 3, figs. 1–14). These specimens were collected from several limestone concretions at the same stratigraphic level along about a quarter of a mile of outcrop. The other collection (pl. 3, figs. 15–25), containing four males and 11 females suitable for measurement, is from a bed of sandstone in the Blair Formation near Rock Springs, Wyo. (fig. 1, loc. 70) at USGS Mesozoic locality D2413 (Smith, 1961, p. 107, loc. D2341 [D2413]).

The smallest male in the Montana collection (USGS Mesozoic loc. 21206) lacks nodes; the other males in this lot have two to four (average 2.9) umbilical nodes on the body chamber and five to ten (average 8.2) ventrolateral nodes. The umbilical nodes on the males are ordinarily circular, but one or more may be somewhat clavate on a few individuals. On specimens that have two or three umbilical nodes, the adapical node is generally the largest, but the second one from the adapical end may be the largest on specimens having four nodes.

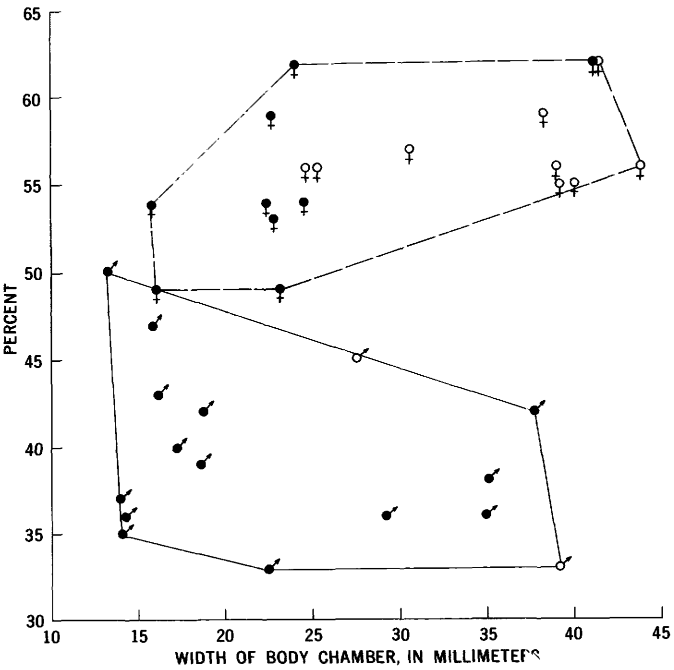

FIGURE 19.—Scatter diagram showing ratios in percent of the surface distance between opposite ventrolateral nodes and the surface distance (across both flanks and the venter) between opposite umbilical nodes on male (open ♂) and female (open ♀) specimens of *Scaphites hippocrepis* III from USGS Mesozoic locality D2413 (fig. 1, loc. 70) and male (solid symbol) and female (solid symbol) specimens from USGS Mesozoic locality 21206 (fig. 1, loc. 17).

In the row of ventrolateral nodes, the largest nodes are clavate and located near the adapical end of the row. Away from the largest one or two nodes, the rest of the nodes become progressively smaller and circular in outline. Between the two rows of nodes an incipient third row is ordinarily present. It consists of weak bullate nodes on some specimens and weak nodelike ribs on others. One node or rib is present for each ventrolateral node. The females from locality 21206 have one to three (average 2.0) umbilical nodes which are commonly bullate. The adapical one is the largest. The ventrolateral nodes are small, number five to 10 (average 7.7), and are mostly bullate. Like those on the male, the largest ventrolateral nodes are near the adapical end of the row, and away from them, the nodes become progressively smaller. A midflank row of very weak bullate nodes or ribs is present as on the flank of the male. The evenly spaced ventral ribs on the body chambers of the males and females are numerous on most specimens. They number 22 to 45 (average 33.6) on the males and 22 to 52 (average 38.2) on the females. In general, the larger specimens have the most ribs. Differences between the number of ribs on a male and a female are not obvious (fig. 20).

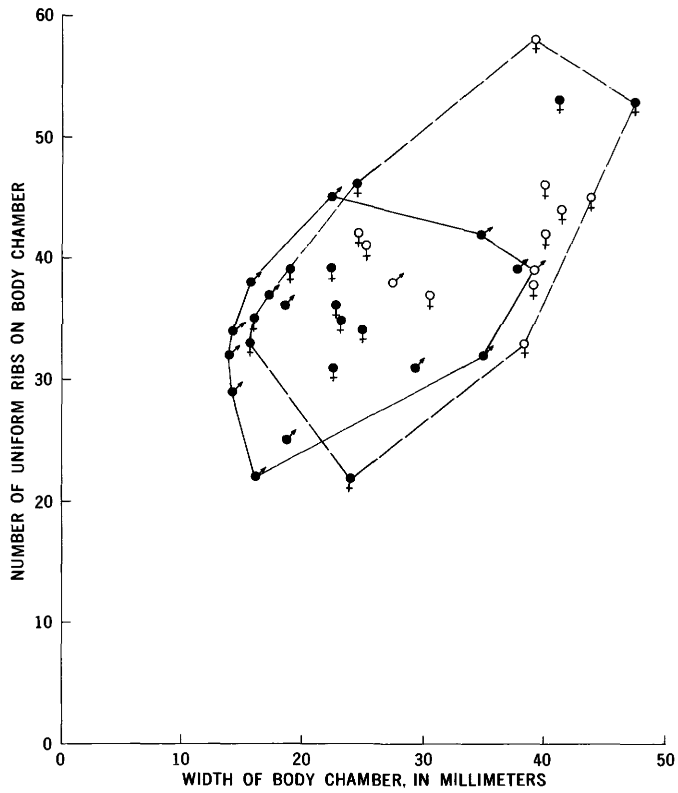

FIGURE 20.—Scatter diagram showing number of ventral ribs of uniform height and spacing on the younger part of the body chambers of male (open ♂) and female (open ♀) specimens of *Scaphites hippocrepis* III from USGS Mesozoic locality D2413 (fig. 1, loc. 70) and male (solid symbol) and female (solid symbol) specimens from USGS Mesozoic locality 21206 (fig. 1, loc. 17).

The large collection from Wyoming (USGS Mesozoic loc. D 2413) differs from the one from Montana by having more large specimens and fewer small specimens. The larger specimens have rib counts as high as 58 (pl. 3, fig. 22). One unusual male has a very sparsely ribbed phragmocone (pl. 3, fig. 17).

The entire suture is shown in figure 11. External sutures of several males and a female are shown in figure 21.

Types.—Plesiotypes, USNM 131465, 160306–160334.

Occurrences.—*Scaphites hippocrepis* III is widely distributed in North America and Europe. In the western interior region, the scaphite has been found in Montana, Wyoming, South Dakota, Utah, and New Mexico. The Montana occurrences are in the southern part of the State (fig. 1, locs. 17, 20 ♂ ♂, 27 ♀ ♀; 16, 1 ♂, 2 ♀ ♀; 32, 1 ♂; 33, 1 ♀). In Wyoming, the scaphite has been found in the Cody Shale in the Powder River Basin (fig. 1, locs. 40, 1 ♀; 41, 1 ♀; 42, 2 ♀ ♀; 47, 1 ♂; 48, 1 ♀; 50, 5 ♂ ♂, 10 ♀ ♀; 51, 1 ♀; 52, 1 ♂, 5 ♀ ♀), in the Cody Shale in the Wind River Basin (fig. 1, locs. 57, 1 ♂; 58, 1 ♀), in the Cody Shale in the Rawlins-Lamont

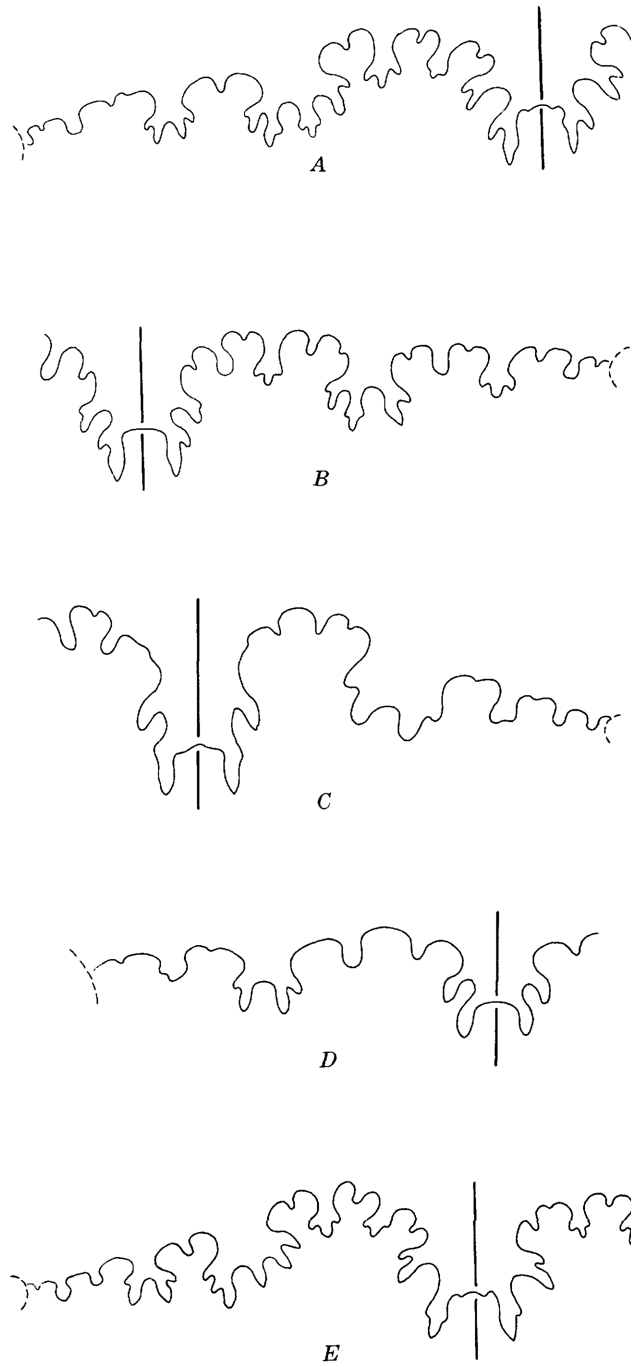

FIGURE 21.—External sutures of *Scaphites hippocrepis* III. All specimens from USGS Mesozoic locality 21206 (fig. 1, loc. 17). *A*. Third from last suture (× 4) of a large male (pl. 3, fig. 1, USNM 160306). *B*. Last suture (× 8) of a smaller male (pl. 3, fig. 4, USNM 160309). *C*. Third from last suture (× 12) of a still smaller male (pl. 3, fig. 6, USNM 160311). *D*. Last suture (× 12) of a very small male (pl. 3, fig. 7, USNM 160312). *E*. Fourth from last suture (× 6) of a medium-sized female (pl. 3, fig. 12, USNM 160316).

area (fig. 1, locs. 61, 1 ♀ ; 62, 1 ♀ ; 59, 1 ♂ ; 65, 6 ♂ ♂, 7 ♀ ♀ ; 66, 4 ♂ ♂, 5 ♀ ♀ ; 60, 1 ♂, 1 ♀), and in the Blair Formation near Rock Springs (fig. 1, locs. 70, 4 ♂ ♂, 16 ♀ ♀ ; 71, 2 ♂ ♂, 1 ♀ ; 69, 1 ♀). The scaphite may be in some of the collections from the Gammon Ferruginous Member of the Pierre Shale on the west flank of the Black Hills uplift in eastern Wyoming (Robinson and others, 1964, p. 78–79). It has been found in this member at one locality on the east flank of the Black Hills uplift in South Dakota (fig. 1, loc. 34, 2 ♂ ♂, 2 ♀ ♀ ; Cobban and others, 1962, p. B59). In Utah, the scaphite has been found in the upper part of the Mancos Shale along the Book Cliffs (fig. 1, loc. 77, 3 ♀ ♀). In New Mexico, it has been found in the lower part of the Pierre Shale near Raton (fig. 1, locs. 86, 1 ♀ ; 87, 2 ♂ ♂ ; 88, 1 ♂, 3 ♀ ♀).

Outside the western interior region, *Scaphites hippocrepis* III has been found in the United States in the Atlantic and Gulf Coastal Plains. The specimen from the Austin Chalk near Austin, Tex., described by Young (1963, p. 49, pl. 80, figs. 3–4) as *Scaphites* sp. cfr. *S. aquisgranensis*, is herein interpreted as a large male of *S. hippocrepis* III. The midflank row of nodelike ribs is clearly visible in one of Young's photographs. A very fine collection of *S. hippocrepis* III has recently been made by Mr. James P. Conlin, Fort Worth, Tex., from just above the Gober Tongue of the Austin Chalk in Lamar County, Tex. This collection includes several complete uncrushed male and female adults. All show the obscure midflank elevations, and all have the ventrolateral nodes continued on to the phragmocone. They differ, however, from most specimens from the western interior region by having fewer and coarser ribs and more conspicuous ventrolateral nodes on the phragmocone.

A single crushed female suggests the presence of *Scaphites hippocrepis* III in the Blufftown Formation in Russell County, Ala. (USGS Mesozoic loc. 27893). Two crushed females from the Blufftown Formation of Chattahoochee County, Ga. (USGS Mesozoic loc. 28443) may represent either *S. hippocrepis* III or *S. hippocrepis* II.

Scaphites hippocrepis III is represented in the Atlantic Coastal Plain by well-preserved specimens from the Merchantville Formation of New Jersey and Delaware. The specimens are dominantly fine ribbed as in the western interior region (pl. 5, figs. 36–40).

Several good illustrations clearly show the presence of *Scaphites hippocrepis* III in Europe. *S. aquisgranensis* Schlüter (1872, p. 81, pl. 24, figs. 7–9), the type of which was apparently lost during World War II (Dr. Hans Mensink, Geologisch-palaeontologisches Institut und Museum, Bonn, written commun. 1958), is herein interpreted as a fairly large male from West Germany. Schlüter's lateral view shows a densely ribbed scaphite with obscure riblike elevations on the flank of the body chamber between the rows of umbilical and ventrolateral nodes. His drawing shows three umbilical nodes and eight more or less clavate ventrolateral nodes. The two specimens described and illustrated as *S. cuvieri* Morton by Schlüter (1876, p. 162, pl. 42, figs. 1–3) are herein interpreted as females of *S. hippocrepis* III. Both specimens have umbilical swellings, dense ribbing, and noding as in American examples. Other specimens from West Germany which I consider to be *S. hippocrepis* III have been described and illustrated by Holzapfel (1888, p. 61–62, pl. 5, figs. 2a, b, 3a, b).

The presence of *Scaphites hippocrepis* III in France is revealed by the excellent illustrations of Grossouvre (1893), especially his figures 3a and 3b on plate 37. The specimen illustrated is a large densely ribbed female that clearly shows the incipient third row of nodes. Three other large females illustrated by Grossouvre (1893, pl. 32, figs. 2, 3a, b; pl. 35, figs. 6a–c) are more coarsely ribbed than American examples, but the presence of ventrolateral nodes on the phragmocones is a *S. hippocrepis* III character. The three males, illustrated by Grossouvre (1893, pl. 31, figs. 3, 4a, b, 6a, b) as examples of *S. aquisgranensis* Schlüter, likewise, are very coarsely ribbed and recall rare coarse-ribbed individuals from the zones of *S. hippocrepis* III and *S. hippocrepis* II (pl. 5, figs. 19–23).

The presence of *Scaphites hippocrepis* III in the Netherlands is shown by the illustrations of van der Weijden (1943, pl. 13, figs. 6–8) of fine-ribbed specimens that he assigned to *S. hippocrepis* and *S. aquisgranensis*. The species may also be present in Sweden (Moberg, 1885, p. 26, pl. 3, figs. 2a, b).

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PLATES 1–5

PLATE 1

[All figures natural size. Arrows point to base of body chambers]

FIGURES 1–7. *Scaphites leei* Reeside I (p. 14).

1, 2. Rear and side views of a female from 10 ft below top of Marias River Shale at USGS Mesozoic loc. 21419, 8 miles west of Shelby, Toole County, Mont. (fig. 1, loc. 2). USNM 160231.

3. Side view of a small crushed male from 29.5 ft below top of Marias River Shale at USGS Mesozoic loc. D692, 9 miles west of Shelby, Mont. (fig. 1, loc. 1). USNM 160233.

4–7. Side and top views of a large incomplete female, and side and rear views of the phragmocone. From the same locality as figs. 1, 2. USNM 160232.

8–18. *Scaphites leei* Reeside II (p. 15).

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17, 18. Side and top views of part of the body chamber of a large female from the same locality as figs. 10–13. USNM 160236.

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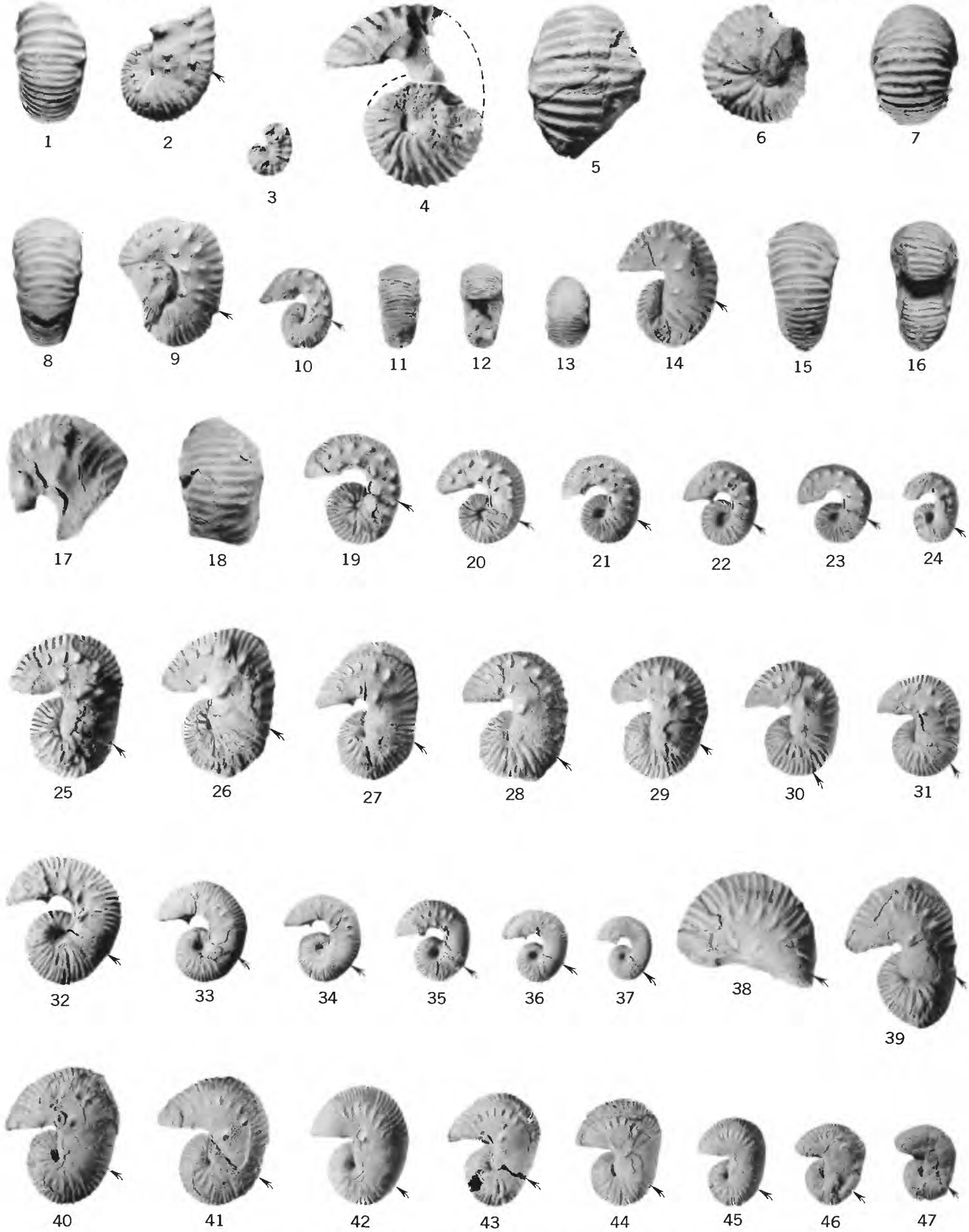
38–47. Side views of 10 females. USNM 160256–160265. See pl. 4, figs. 16–24, for other views of figs. 42, 44, 45.



SCAPHITES LEEI AND *SCAPHITES HIPPOCREPIS*

PLATE 2

[All figures natural size. Arrows point to base of body chambers]

FIGURES 1–17. *Scaphites hippocrepis* (DeKay) I (p. 18).

From limestone concretions in the upper part of Cody Shale at Alkali anticline 8–12.5 miles southeast of Lovell, Big Horn County, Wyo. (fig. 1, locs. 27–29). Figs. 1 and 5 from USGS Mesozoic loc. D4194; figs. 14–16 from loc. D4199; rest from loc. D4198.

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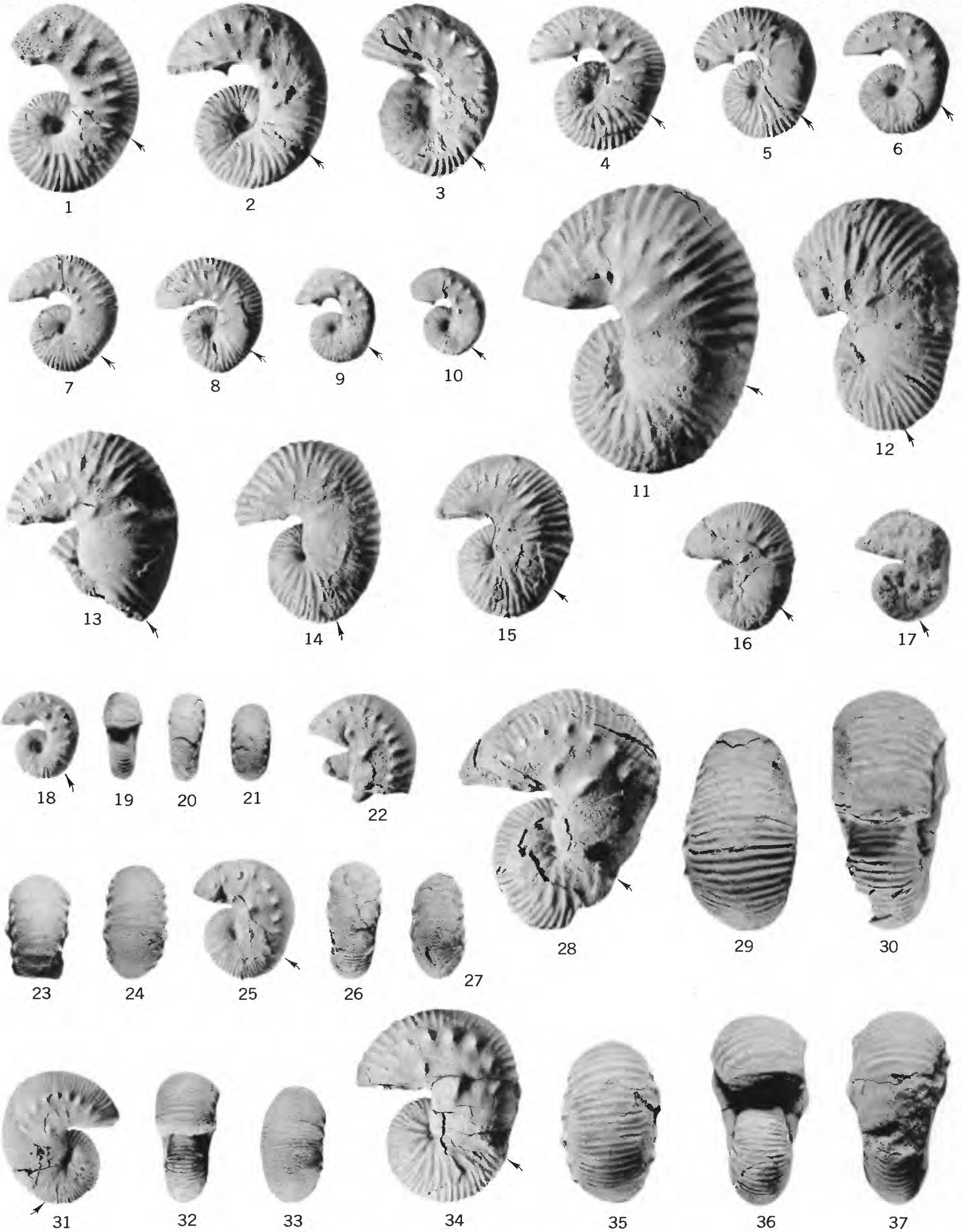
28–30. Side, top, and front views of a large female from the same locality as figs. 18–21. USNM 160295.

31–33. Side, front, and top views of a small female from a sandstone bed in the Cody Shale 665 ft above top of Niobrara Shale Member at USGS Mesozoic loc. D4185, 9 miles southeast of Manderson, Big Horn County, Wyo. (fig. 1, loc. 37). USNM 160296.

34–37. Side, top, front, and rear views of a large female from the same locality as figs. 31–33. USNM 160297.



SCAPHITES HIPPOCREPIS

PLATE 3

[All figures natural size. Arrows point to base of body chambers]

FIGURES 1–25. *Scaphites hippocrepis* (DeKay) III (p. 21).

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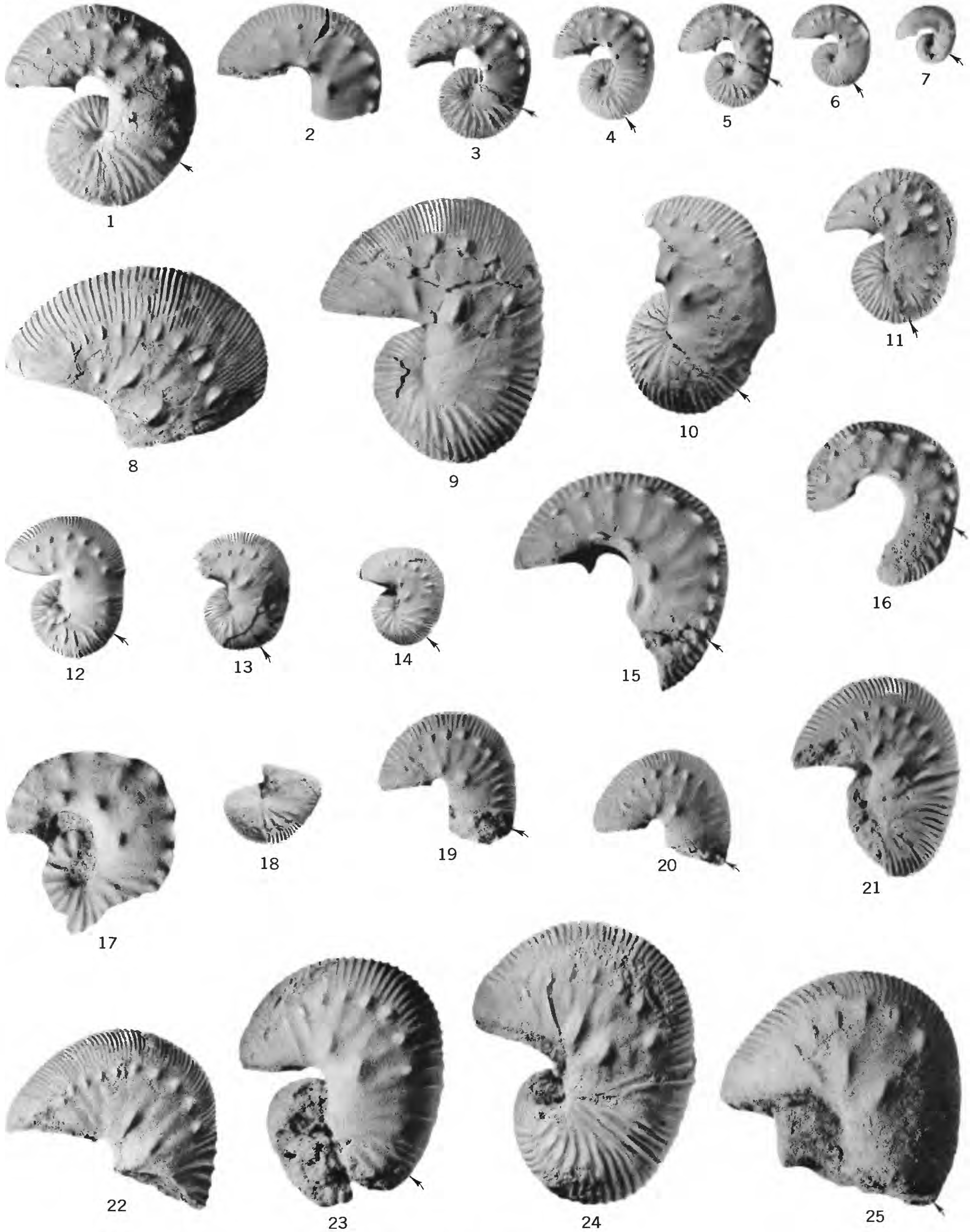

SCAPHITES HIPPOCREPIS

PLATE 4

[All figures natural size. Arrows point to base of body chambers]

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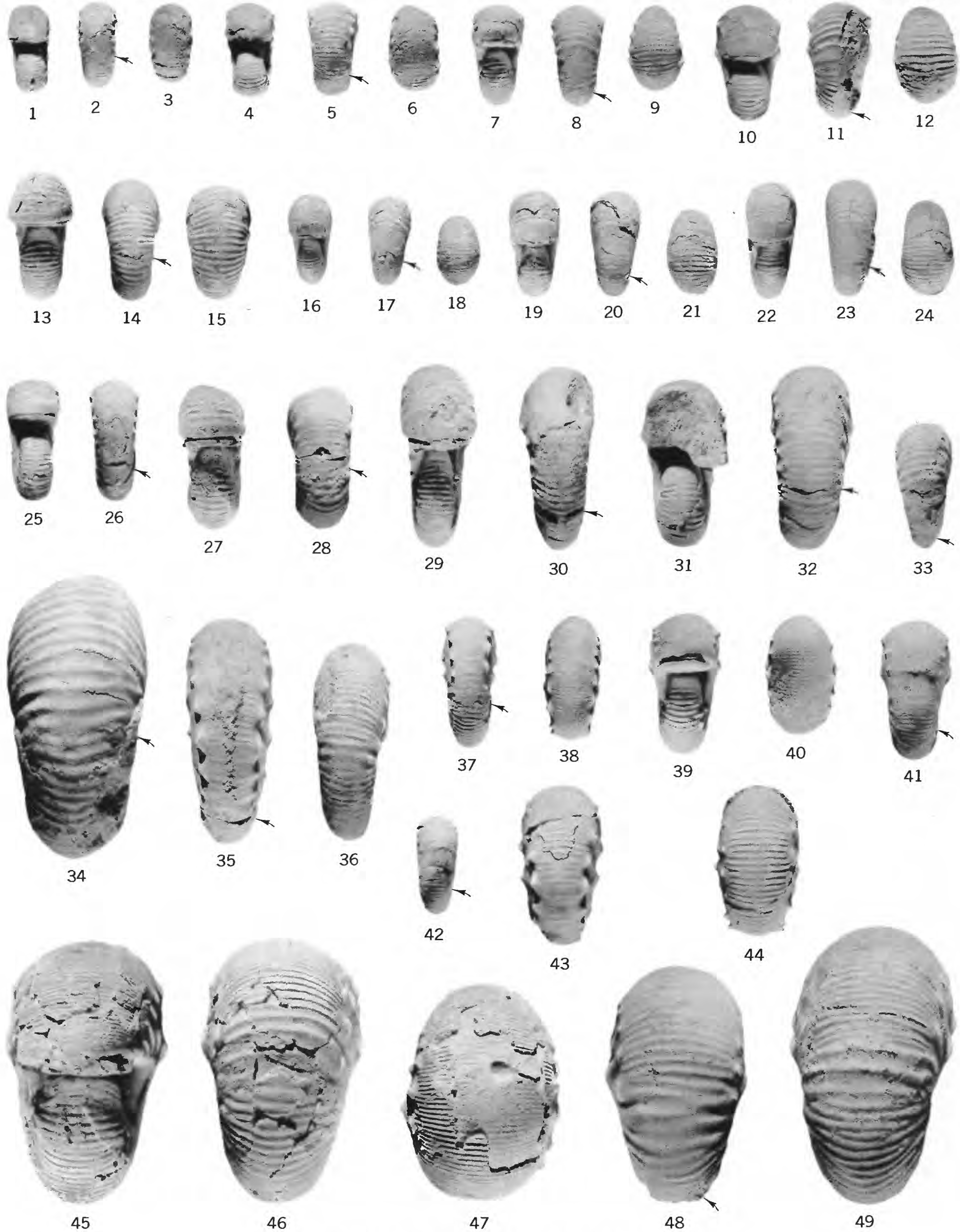

SCAPHITES LEEI AND *SCAPHITES HIPPOCREPIS*

PLATE 5

[All figures natural size. Arrows point to base of body chambers]

FIGURES

1–4. *Scaphites equalis* J. Sowerby (p. 12).
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28–32. *Scaphites hippocrepis* (DeKay) I (p. 18).
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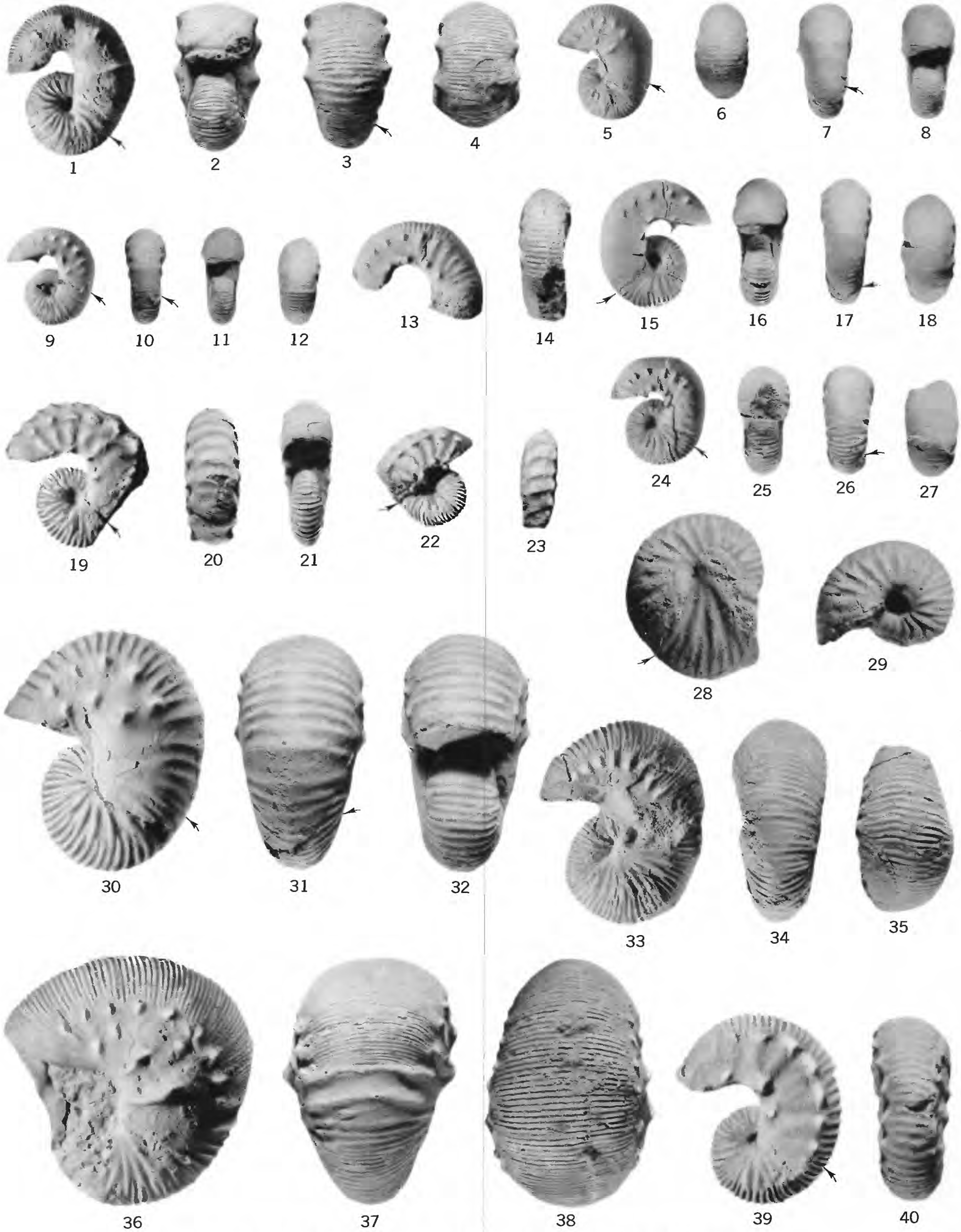

SCAPHITES EQUALIS AND *SCAPHITES HIPPOCREPIS*

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