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Beiträge zur Kenntnis tropisch-amerikanischer Tertiärmollusken.

III. Nuculid Pelecypods of the genus Acila in the Tertiary of Venezuela, Northern Colombia, and Trinidad.[1])

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Introduction.

The presence of *Acila* in the Cretaceous system of Venezuela was announced in print in 1922, and *Acila (Acila) isthmica* (Brown & Pilsbry) was recorded in 1928 by Liddle[2]) from a Miocene formation in the state of Falcón, Venezuela. This species has been known for several years from Tertiary strata near Puerto Colombia, Colombia. The best material reported upon here is from beds of Miocene age, in the sense that they are thought to be younger than the Aquitanian age and older than the Pontian age of the European time-scale. Less well preserved fossils come from strata called Oligocene. No *Acila* is known from the tropical Americas or from the West Indies from formations definitely dated as Eocene, despite the often-repeated assertion that *Acila schomburgki* (Forbes), described from Trinidad, is from the Eocene.

Basis of report.

A. A. Olsson in 1931 generously turned over to me specimens of *Acila isthmica* that he had collected from Puerto Colombia. In 1934 I collected from the same region. Olsson also gave me representatives of his *Acila paita* and *piura* from Peru. G. D. Harris has permitted me to study a suite of Cretaceous specimens from Venezuela. In 1935 I received for study from R. Rutsch numerous specimens of *Acila* from the Tertiary of Venezuela and one from Trinidad, and I wish to thank Dr. H. G. Kugler of the North Vene-

[1]) Nr. II see: Eclogae geol. Helv. *27* (p. 299) 1934.

[2]) As " *Nucula isthmica* Brown and Pilsbry ", by R. A. Liddle, The Geology of Venezuela and Trinidad, p. 296, 1928.

zuelan Petroleum Co. and Dr. RUTSCH for permitting me to report upon these fossils, deposited in the Natural History Museum in Basel, Switzerland. I have also examined the fossil identified as *Acila schomburgki* and catalogued as No. 115560 in the United States National Museum. Specimens collected by geologists of the Standard Oil Company of California were placed at my disposal by J. O. NOMLAND. I wish also to acknowledge the cooperation of KATHERINE VAN WINKLE PALMER, P. BARTSCH, R. A. LIDDLE, F. EARL TURNER, and others mentioned in the following pages. H. D. HEDBERG, H. G. KUGLER and A. SENN kindly criticized the typescript of this note.

Acila (Truncacila?) schomburgki (FORBES), 1846.

1846. *Nucula schomburgki* FORBES, in SCHOMBURGK, History of the Barbadoes, p. 565. (Not available to the writer.)
1867. *Nucula schomburgki* FORBES. GUPPY, Geol. Mag., n. s., vol. 4, pp. 497, 498, 500, fig. 5.
1867. *Nucula schomburgki* FORBES. GUPPY, Proc. Sci. Assoc. Trinidad, pt. 3, p. 163. Harris' Reprint, 1921, Bulls. Amer. Paleo., no. 35, p. 42.
1874. *Nucula schomburgki* FORBES. GUPPY, Geol. Mag., n.s., Dec. 11, vol. 1, p. 442.
1878. *Nucula schomburgki* FORBES. GUPPY, Proc. Sci. Assoc. Trinidad, vol. 2, p. 170, pl. 7, fig. 10; Harris' Reprint, 1921, Bulls. Amer. Paleo., no. 35, p. 91, pl. 5, fig. 10.
1898. *Nucula schomburgki* FORBES. DALL, Trans. Wag. Free Inst. Sci., vol. 3, pt. 4, p. 573.
1925. *Nucula (Acila) schomburgki* FORBES. MAURY, Bulls. Amer. Paleo., vol. 10, pp. 171—172, with synonymy.

This species, although named in 1846, was not figured until 1867, when GUPPY presented a poor figure of what he called the species, stating that it came from the " lower Miocene " of Trinidad. In 1874 he affirmed that it was from the San Fernando formation, supposedly Eocene. In 1878 he figured the species from the " Eocene " of Barbados, Trinidad, and compared it to *Acila bivirgata*, *ornatissima*, *cobboldiae*, *castrensis*, and *divaricata*. MAURY, in 1925, asserted that *schomburgki is* " entirely unlike in both form and sculpture GABB's *Acila tuberculata* from the Dominican Miocene "[3]). TRECHMANN[4]), HARRIS[5]), and other writers failed to throw light on this *Acila*. A. A. OLSSON, C. MAURY, W. P. WOODRING, L. R. COX, and several others with whom I have communicated were unable to give me

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[3]) *Nucula tuberculata* GABB is not an *Acila*. Consult HUBERT G. SCHENCK, Classification of Nuculid Pelecypods, Bull. Mus. roy. Hist. Nat. Belgique, t. X, no. 20 (1934), p. 45.

[4]) TRECHMANN, C.T., The Scotland beds of Barbados, Geol. Mag., vol. 62 (1925), pp. 481—504. His other papers in later volumes of this magazine also have been consulted.

[5]) HARRIS, G. D., in GERALD A. WARING, The Geology of the Island of Trinidad, B.W.I. The Johns Hopkins Univ. Studies in Geology, no. 7 (1926).

any satisfactory information concerning either the age or the repository of the holotype. In short, what biologic unit is to be given the name *schomburgki* is an unsettled problem and the age of the beds carrying this type specimen is uncertain.

Dr. E. LEHNER of Pointe-à-Pierre, Trinidad, informed me[6]) that the probable age of *Acila schomburgki* is Oligocene. He stated in the same letter:

> "FORBES' specimens came from Springfield in Barbados, but SCHOMBURGK definitely states that they were collected from blocks and I do not recollect having met a similar rock in situ. How GUPPY came to claim an Eocene age, I do not know."

I have before me a specimen tentatively identified as this species, collected by Dr. E. LEHNER from "Cipero-Küste ca. 150 m SW vom Ende der Mauer, Trinidad, B.W.I.". This single left valve is No. 2358 in the collection of the Naturhistorisches Museum, Basel, and may be described as follows:

Shell small, trigonal; anterior dorsal margin sloping; anterior extremity bluntly rounded; ventral margin convex; posterior side straight, giving truncate appearance to shell; umbones high; beak strongly inturned; escutcheonal area defined by a depressed, narrow area; primary bifurcation only; ribs high, narrow, separated by wider interspaces; concentric lines indistinct; interior filled with matrix, but enough has been removed to disclose taxodont dentition; no rostral sinus. Length, 6.0 mm., height, 5.0 mm.; semi-thickness, ca. 2.0 mm.

This is unlike any species I have seen, but I hesitate to express an opinion of relationships, since the specimen is doubtless immature and the adult may have an entirely different appearance. It does not agree with Specimen No. 115560 in the U.S. National Museum identified as this species.

Acila (Acila) isthmica (BROWN & PILSBRY), 1911.

1911. *Nucula (Acila) isthmica* BROWN & PILSBRY, Proc. Acad. Nat. Sci., Phila., vol. 63, pp. 361—362, pl. 27, figs. 11, 12. Gatun formation, locks at Gatun, Isthmus of Panama.
1928. ? *Acila isthmica* (BROWN & PILSBRY). WOODRING, Carnegie Inst. Wash. Publ. 385, p. 78. Panama formation near Paraiso, Panama Canal Zone.
1928. *Nucula isthmica* BROWN & PILSBRY. LIDDLE, The Geology of Venezuela and Trinidad, p. 296. Damsite formation, Miocene.
1934. *Acila (Acila) isthmica* (BROWN & PILSBRY). SCHENCK, Bull. Mus. roy. Hist. Nat. Belgique, t. X, no. 20, p. 42.

The holotype of this species has not been available to me for examination; however, the original description gives a fair characteri-

[6]) Written communication dated 8 January, 1935.

zation of the species. The authors compared it to "*Nucula decisa* CONRAD" and "*Nucula cordata* DALL", to neither of which it is related, whereas it is allied to *Acila (Acila) gettysburgensis* (REAGAN), *Acila (Acila) divaricata* (HINDS), *Acila (Acila) fultoni* (SMITH) and other representatives of the genus *Acila, sensu stricto*. The age of the Gatun formation carrying the holotype has been called Oligocene (BROWN & PILSBRY, p. 337), upper lower Miocene (OLSSON, 1922), and perhaps Helvetian (VAUGHAN, Bull. Geol. Soc. Amer., vol. 35, p. 737, 1924).

Table I.

Dimensions*) of Specimens of *Acila (Acila) isthmica* (BROWN & PILSBRY) from the Las Perdices "Group" of the Puerto Colombia District, South America.

Specimen (Stanford University)	Locality	Length in mm.	Height in mm.	Thickness (2 valves) in mm.	Umbonal angle in degrees	Ratio of height to length in per cent
454 (Schenck Coll.)	Shales just east of Morro Hermosa	18.5**)	13.8	10.9	111	75±
453 (Schenck Coll.)	¾ mile west of pier, Puerto Colombia	19.4**)	16.7	—	—	86±
5762	Cliffs west of pier at Puerto Colombia	25.2	18.8	14.9	105	75
5761	Same as 5762	28.5	22.6	17.3	115	79

*) All measurements are made with the dorsal margin horizontal.
**) Broken specimen.

The species is represented by specimens (Table I) from the cliffs at Puerto Colombia, northern Colombia. The beds carrying the specimens at Puerto Colombia are referrable to the "Las Perdices Group" of ANDERSON[7]). JORGEN O. NOMLAND has informed me[8]) that evidence available to him suggests a Miocene age for the Las Perdices "shale", which is unconformable upon thin-bedded sandstones and shales believed to be Oligocene. H. D. HEDBERG[9]) states

[7]) ANDERSON, F. M., Marine Miocene and related deposits of North Colombia, Proc. Calif. Acad. Sci., 4 ser., vol. 18, no. 4 (1929), p. 89.
[8]) Oral communication dated July 6, 1932.
[9]) Oral communication dated May 2, 1935.
Since writing this paper, Hedberg has studied Foraminifera from the Las Perdices shale associated with *Acila isthmica* at Puerto Colombia, comparing the species with types in the Cushman Laboratory for Foraminiferal Research. He

that, in his opinion, the foraminiferal fauna of the Las Perdices "shale" indicates that it is younger than beds commonly correlated with the Aquitanian stage of southern France and that it is perhaps the correlative of the Gatun formation of the Panama Canal Zone. The Gatun has been synchronized with various Miocene stages of Europe.

In collections deposited in the Museum of Paleontology of the University of California by the Standard Oil Company of California is one specimen (Locality S—8025)[10]) of *isthmica* from 1½ km. S 70° E of the village of Rotinet, in the southern part of the Department of Altantico, northern Colombia, associated with a faunule that appears to be Lower Gatun, according to RICHARD BRAMKAMP[11]).

In Venezuela, *Acila isthmica* was reported by LIDDLE *(supra cit.)* from the Damsite formation in the La Vela region, Falcón. Table II records the species from the Miocene Damsite and La Vela formations collected at different localities in the districts Silva, Acosta and Zamora of the State of Falcón.

Acila isthmica, in conclusion, occurs in beds treated as younger than the Aquitanian stage of southern France and older than the Pontian of Italy. Somewhat older formations may also carry the species. The acme of development would seem to come during the Gatun age, which perhaps corresponds approximately to the Helvetian of the European time-scale. The *isthmica* biochron may prove to be from Oligocene to late Miocene.

The original figure and description of *isthmica* set forth clearly the generic characters, in the sense that *Acila* is a genus of the family *Nuculidae*[12]). BROWN & PILSBRY's figure 12 shows clearly the rostral sinus extending from the umbonal area to the posterior ventral margin, a character that I take to aid in the characterization of *Acila, sensu stricto.* Both original figures give a good idea of the distinctive trigonal profile of the species. The original description does not, however, state the character of the ornamentation of the escutcheonal area, but judging from representatives of the species from Colombia and Venezuela, the ribs cross that part of the shell

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reports (letter dated September 21, 1935): The sample yielded *Bolivina plicatella* Cushman, *Siphogenerina lamellata* Cushman, *Cibicides floridana* Cushman, *Cibicides pseudo-ungerianus* Cushman, and *Globorotalia menardii* (d'Orbigny). The assemblage indicates a Miocene age but it is probably somewhat older than the type Gatun.

[10]) The following information is supplied by J. O. NOMLAND (letter dated June 3, 1935): S—8025. This locality is in a small area (surrounded by alluvium) of what we have given a local formational name. It may be equivalent to what Mr. BECK (Economic Geology, vol. 16, p. 463) has called San Antonio formation, and is also probably at least in part the equivalent of what Dr. ANDERSON later described as the Tubera formation.

[11]) Written communication May 14, 1935.

[12]) SCHENCK, Bull. Mus. roy. Hist. nat. Belgique, t. X, no. 20, 1934.

without leaving a ribless grooved area, so conspicuous in the case of *Acila (Acila) divaricata* HINDS, *sensu stricto*, and its synonym *Acila mirabilis* (ADAMS & REEVE). The umbones are situated rather high above the hinge and the lunular area is outlined by a shallow groove and low, though on some specimens almost imperceptible, ridge. The radial ribs, on the specimens from Puerto Colombia, attain a width of as much as 530 microns; the interspaces are appreciably narrower. At some places on the disk, both interspaces and ribs are crossed by relatively high concentric ridges, thereby producing the "tuberculiferous" appearance noted by BROWN & PILSBRY. Primary bifurcation is generally central. Secondary bifurcation and other divarications are present on some specimens. Most of the larger shells have a narrow area of obsolete radial ribbing; i.e., at the ventral margin the radial threads "break up" and are not as conspicuous as the concentric growth rings. One specimen (2263) from Venezuela has as wide an area of obsolete radial ribbing as one sees frequently in the case of *Acila (Acila) fultoni* (SMITH). One well-preserved Venezuelan right valve (4334) shows a crenulate ventral margin, nuculid dentition, simple pallial line, two subequal adductor muscle scars, anterior (long) row of about 25 teeth, posterior (short) row of about 10 teeth, and about 12 concentric growth rings. The beaks are opisthogyrate. The largest specimen that has come into my hands is 28.5 mm. in length.

Acila, sp. A.

The specimen given this designation is in the Standard Oil Company of California collections now deposited in the Museum of Paleontology at the University of California, Berkeley. The fossil comes from Locality S—8068[13]); shales underlying marly limestone 500 meters west of Puerto Colombia, District of Atlantico, northern Colombia. The specimen has the following dimensions: length, 19.2 mm.; height, 12.5 mm., and thickness, 10.5. It has coarse ribbing and the general profile of *Acila (Truncacila) paita* OLSSON, 1931. Poor preservation prevents a more precise identification. *Acila isthmica* may be present in the same faunule, which includes several of the species of mollusks listed and named by F. M. ANDERSON (1929).

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[13]) The following information is supplied by J. O. NOMLAND (letter dated June 3, 1935): S—8068. Located about 500 m W of Puerto Colombia and has been referred to by us as Usiacuri shale, probably of lower Miocene or possibly upper Oligocene age. There seems little doubt but that this formation is the equivalent of the Bombo shale of BECK in his publication of 1921. The formation is very widespread in northern Colombia and is of very uniform lithologic character. What has been described by F. M. ANDERSON in 1926 (Bull. Amer. Assoc. Pet. Geol., vol. 10, no. 4 (1926), p. 387) and later papers as the San Juan group can be traced by continuous outcrop to the general area of the original description of the Bombo shale by BECK.

Table II.

Dimensions of Specimens of *Acila (Acila) isthmica* (BROWN & PILSBRY) from the Miocene, State of Falcón, Venezuela.

(All specimens in the Museum of Natural History, Basel, Switzerland)

Specimen Number (Basel)	Length in mm.	Height in mm.	Semi-Thickness in mm.	Thickness (2 valves) in mm.	Umbonal angle in degrees	Ratio of height to length in per cent	Locality**)	Formation
2263	19.0	12.8	—	10.6	106	67	Region southeast of junction Quebrada Charal, Rio Tocuyo, District of Silva.	La Vela
2263	22.1	17.2	—	12.7	104	78		
2263	23.2	19.2	—	15.0	106	83		
2263	29±*)	19.7±	—	14.2	—	68±		
4860	21+*)	19±	—	—	—	90±	Quebrada San Fernando on northern slope of Cerro Misión, District of Silva.	La Vela
4334	19.4	13.0	6.0	—	100	67	Cumarebo anticline, south of Puerto Cumarebo, District of Zamora.	Upper Damsite
25 C	22.3+*)	20±	6±	—	—	90±	Coast near Montaña de Gueque.	Probably Damsite
3350	18+	15±	—	—	—	83±	Region of Riecito, south, District of Acosta.	La Vela

*) Imperfect specimens.

**) All locality and stratigraphic data recorded here supplied by Drs. H. G. Kugler and A. Senn.

Acila, sp. indet.

The specimens indeterminate specifically are listed in Table III. Several are from the El Mene formation (named from El Mene de Acosta)[14]) referred to the Aguaclara stage[15]). The Agua Clara shale, according to LIDDLE (p. 260) has as its type locality the region near Agua Clara, State of Falcón[16]). It lies above the San Luis formation, with numerous species of *Lepidocyclina*, and below the Cerro Pelado formation. The *Acila*-bearing beds of the El Mene sandstone are probably older than Aquitanian, which I regard as upper Oligocene[17]).

Two imperfect specimens are from beds assigned to the Damsite stage, which, as mentioned above, would probably be of about Gatun age.

One broken valve comes from " zone A_1 or A_2 " of the Aguasalada clays, which H. D. HEDBERG informs me[18]) might mean either lower Damsite or upper Socorro; that is, according to current views, Miocene.

One imperfect specimen comes from shales said to belong to the La Vela stage. These shales are situated between the correlative of the Gatun below and the Punta Gavilan[19]) above and might, therefore, be classed as upper Miocene.

Time Range of Acila in South America and the West Indies.

Acila (Truncacila) bivirgata (J. DE C. SOWERBY) was first recorded from the Cretaceous of Venezuela by COLLET (Soc. Phys. et Hist. nat. Genève, C.R. des Séances, v. 39, no. 1 (1922), pp. 16—17) and later by LIDDLE (1928, pp. 128—129, 131—132) from the El Cantil formation. The age of the fossils is claimed by COLLET to be " Aptian-Albian ".

Acila (Truncacila ?) schomburgki (FORBES) is from Tertiary beds of uncertain age, presumably early Tertiary and perhaps Oligocene. Convincing proof that the species is Eocene has yet to be adduced.

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[14]) Not to be confused with the " El Mene sands " of LIDDLE (1928), El Mene de Buchivacoa.

[15]) Note by Dr. A. SENN: "Concerning the stratigraphical position, the Orbitoid-Fauna and the correlation of the El Mene formation of East Falcón with the Aguaclara formation of Central Falcón, I refer to Eclogae geol. Helv. 28, p. 75—78 and plate VIII ".

[16]) Consult also S. H. WILLISTON and C. R. NICHOLS, a review of LIDDLE's book, in Bull. Amer. Assoc. Pet. Geol., vol. 12 (1928), pp. 445—451. The Agua Clara shale is called Upper Oligocene.

[17]) SCHENCK, HUBERT G., What is the Vaqueros formation of California and is it Oligocene ?. Bull. Amer. Assoc. Pet. Geol., vol. 19, no. 4 (April, 1935), pp. 532—533.

[18]) Oral communication, May 2, 1935.

[19]) The age of the Punta Gavilan beds has been discussed by R. RUTSCH, Die Gastropoden aus dem Neogen der Punta Gavilan in Nord-Venezuela. Abh. Schweiz. Pal. Ges., Bd. LIV u. LV (1934), pp. 115—145.

Table III.

Indeterminate Specimens of *Acila* from the Tertiary*) of Venezuela in the Natural History Museum, Basel.

Specimen Number (Basel)	Locality	Formation	Stage	Age	Remarks
419	Slope of "Yarayaca" in the upper part of the Rio Capadare, District of Acosta, State of Falcón. Glauconitic marly limestone at the base of the Capadare limestone.	Capadare limestone	Damsite (uppermost part)	Miocene	Mold of broken valve
2255	Region of Quebrada Quaca on the northern slope of Cerro Misión, District of Silva, State of Falcón.	"San Fernando shales"	La Vela	Miocene	Interior cast of left valve. May be *isthmica*
2447	El Mene de Acosta, Well No. 13, core 871′—889′, District of Acosta, State of Falcón.	Upper part of El Mene formation	Aguaclara	Oligocene	Imperfect right valve
2531	Repelon between El Mene de Acosta and Pozon, District of Acosta, State of Falcón.	Red-weathering gray clays	Damsite	Miocene	Mold of broken left valve
2767	El Mene de Acosta, Well No. 16, core 868′—904′, District of Acosta, State of Falcón.	Upper part of El Mene formation	Aguaclara	Oligocene	Numerous fragments; all small. One shows trace of rostral sinus
2768	El Mene de Acosta, Well No. 16, core 920′, District of Acosta, State of Falcón.	Upper part of El Mene formation	Aguaclara	Oligocene	Fragments; similar sculpture to *isthmica*
2769	El Mene de Acosta, Well No. 16, core 949′—960′, District of Acosta, State of Falcón.	Upper part of El Mene formation	Aguaclara	Oligocene	Small, imperfectly preserved right valve
2773	El Mene de Acosta, Well No. 16, core 1083′, District of Acosta, State of Falcón.	El Mene formation	Aguaclara	Oligocene	Imperfectly preserved right valve
4259	El Mene de Acosta, Well No. 23, District of Acosta, State of Falcón.	Aguasalada clays (zone A_1 or A_2)	Lower Damsite or Upper Socorro	Miocene	Broken right valve; sculpture as in *isthmica*
4260	El Mene de Acosta, Well No. 25, District of Acosta, State of Falcón.	El Mene formation	Aguaclara	Oligocene	Two fragments; may prove to be related to *isthmica*

*) All locality and stratigraphic data supplied by Drs. H. G. Kugler and A. Senn.

Acila (Truncacila) paita and its variety *piura* were described by OLSSON (Bulls. Amer. Paleo., vol. 17, no. 63 (1931), pp. 130—131) from the Heath formation of Peru. This formation is believed to be Oligocene because it is overlain unconformably by the Zorritos (so-called lower Miocene) and is underlain by beds of late Eocene and early Oligocene age[20]).

Acila isthmica (BROWN & PILSBRY) ranges from Las Perdices and Damsite ages into what is believed to be La Vela age. It is possibly present in rocks of late Oligocene age. As far as definitely recorded, the species would seem to range throughout most of the Miocene.

Indeterminate species of *Acila* in the Tertiary of Venezuela offer fairly conclusive evidence that the genus lived in that part of the South American region during the whole or at least a part of what is believed to be Oligocene time.

In summary, nuculid pelecypods of the genus *Acila*, today restricted to Indo-Pacific waters, inhabited Cretaceous, Oligocene, and Miocene seas of the Antillean region, and if their presence in Eocene rocks is proven by future investigations, then the genus must have had a life-span of Cretaceous to late Miocene in that part of the world. Perhaps it will prove to be significant that the first appearance of *Acila, sensu stricto*, in the tropical Americas was at approximately the same time as its first appearance on the Pacific Slope of North America and in the Japanese Empire.

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[20]) The Heath formation may be Oligocene, but not necessarily for the reasons given by OLSSON. The argument of stratigraphic position is conclusive only when the adjacent beds are definitely synchronized with strata of established age. OLSSON (Bulls. Amer. Paleo., vol. XIX (June, 30 1932), p. 39) calls the Lower Zorritos Aquitanian. On that basis, the Lower Zorritos should be classed as Upper Oligocene.

Manuscript received June 24, 1935.