

THE MARINE MOLLUSCA OF SURINAME (DUTCH GUIANA) HOLOCENE AND RECENT

PART 1. GENERAL INTRODUCTION

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I. SCOPE OF THIS WORK

More than ten years ago Dr. D. C. Geijskes, then Director of the Suriname Museum, Paramaribo, visited me and asked for my help. During the years (since 1938) Dr. Geijskes had stayed in Suriname, he had collected marine Mollusca in a great number of localities, in the Holocene so called shell-ridges, as well as on the coast and in the estuaries. He was sure that his collection contained a great number of species, and that their distribution over the localities was interesting. Geijskes is not a malacologist himself and he did not have at his disposal the literature and material for comparison necessary to identify his collection. Therefore he doubted if the list of names he had gradually drawn up from labels provided by malacologists to whom he had sent shells, and from information picked up during casual visits to

European museums when he was on leave, could be published. It was on this question that he asked my opinion.

A serious examination of this list showed that it needed considerable revision and addition. After thinking this over I answered Dr. Geijskes that I should like to help him, if he would not expect quick results, for it seemed worth while to study an extensive literature and other collections as well in order to publish eventually an annotated check list of the marine Mollusca of Suriname. With these conditions Dr. Geijskes agreed and at last the first definite results of my study, a general introduction to the subject, are published here. The second part, dealing with the bivalves, is partly ready for publication, while those treating of the other groups are in preparation.

2. ACKNOWLEDGEMENTS

I am deeply indebted to the former Netherlands Foundation for the Advancement of Research in Suriname and the Netherlands Antilles (WOSUNA) for enabling me to stay in Suriname during nearly three months in 1963 and to make the journey back via the United States of America. There I could verify my identifications by studying, during another two months, the collections in Washington, Philadelphia and Cambridge (Mass.).

Thanks are due to a great number of persons for helping me in various ways. Their kind co-operation has been indispensable for getting access to collections and finding satisfactory solutions to the great number of little problems which arise when one is making a check list. It is impossible to mention them all, but those who are not mentioned here may also be certain that their help has always been very much appreciated by me.

Throughout the course of this work Dr. D. C. Geijskes put at my disposal the vast material he had assembled and much of valuable information. In Paramaribo he and his staff, among whom Mr. P. Bolwerk should be especially mentioned, did all they could to make my stay as profitable as possible. As Geijskes has been working in the Department of Entomology of the Leiden Museum since his retirement as Director of the Suriname Museum in 1965, I have been regularly in touch with him these last years and he was so kind as to read the MS of this paper critically.

To Ir. H. E. Lionarons and captain Emanuels of the Suriname Fisheries Service I am indebted for material, information and for enabling me to be on board of the "Coquette" during one of her weekly trawling cruises. Ir. G. Doeve and his staff of the Geological and Mining Survey of Suriname

kindly allowed me to study samples from the deep boring Coronie-35. Ir. J. W. Gonggrijp provided useful information on the damage done by teredinids and was my guide on a trip to some jetties and the wreck of the "Goslar" in the Suriname River. Dr. L. J. Pons showed me a locality near Jarikaba where beds of Holocene clay yield marine shells. Further I wish to express my indebtedness to all those officials who enabled me to make a number of excursions in the coastal region of Suriname by providing means of transport and lodging.

In the United States National Museum at Washington, D. C., Dr. H. A. Rehder, Dr. J. P. E. Morrison and Dr. J. Rosewater allowed me to study the vast collections of Mollusca and gave much useful information. During a short stay at Philadelphia Dr. R. Tucker Abbott, Dr. R. Robertson and Miss Virginia Orr (now Mrs Maes) kindly helped me to find just those species which I was most anxious to examine in the collection of the Academy of Natural Sciences of Philadelphia. Dr. W. J. Clench and Dr. Ruth D. Turner were very helpful hosts to me in the Museum of Comparative Zoology at Cambridge, Mass., and with utter sadness I remember the kind help given to me in that institution by the late Dick Foster. During my stay in Cambridge Miss Turner was kind enough to check and supplement my identifications of Pholadidae and Teredinidae, while discussion of Suriname tellinids with Dr. K. Boss proved useful for my purpose.

Mr. Norman Tebble, Mr. S. P. Dance and Mr. J. Peake helped me to find my way in the large collection of Mollusca of the British Museum (Natural History) in London, where I could study several important type specimens. In the Institut Royal des Sciences Naturelles de Belgique Dr. W. Adam gave me access to the Dautzenberg collection, which contains the Mollusca collected during the Chazalie Expedition. Dr. H. Lemche and Mr. J. Knudsen allowed me to study some of Chemnitz's types in the Zoologisk Museum of Copenhagen.

To Dr. C. Beets and Miss Dr. G. de Groot of the Rijksmuseum van Geologie en Mineralogie, Leiden, I am indebted for putting at my disposal the Voltz collection of shells from the Suriname shell-ridges. Dr. J. H. van Voorthuysen of the Geologische Dienst, Haarlem, who co-ordinated the work of specialists on the cores of "boring Alliance-28", kindly put at my disposal the shells found in a number of samples of these cores. I am indebted to Mr. G. Spaink for sorting out these shells. Mrs. Dr. W. S. S. van der Feen-van Benthem Jutting and her successor, Drs. H. E. Coomans, repeatedly gave me access to the molluscan collection of the Zoologisch Museum of Amsterdam University.

The few shell-less opisthobranchs which my material contains were dealt

with recently by Mrs. J. Nijssen-Meyer (1965), while Dr. Gilbert L. Voss includes the cephalopods taken off the Suriname coast by the "Coquette" in a study of the species of this group occurring in a wider area.

Miss Dr. Marian H. Pettibone kindly identified a sample of polychaetes from station 197 of the "Coquette"; to the tubes of these specimens of *Diopatra cuprea* (Bosc) a number of interesting shells were attached.

3. HISTORY OF THE STUDY OF SURINAME MARINE MOLLUSCA

a. Recent

In the literature on the natural history of Suriname, Mollusca are scantily dealt with. Before 1850 oysters, mussels and shipworms were almost the only marine molluscs mentioned. Compilation of the older literature, which has hardly been considered by zoologists, was greatly facilitated by Holthuis's (1959: 4) account of the history of Suriname carcinology. For particulars on the early authors and on later editions and translations of their works, which have not been included in the bibliography of this paper, I refer to Holthuis's publication.

Ottho Keye (1659: 73) was the first to mention the occurrence of molluscs in Suriname. He states that delicious oysters grow on trees, and adds that this statement is just as incredible and just as true as the existence of flying fishes. Keye explains that such occurrence is possible because trees are growing in sea water along the coast and the banks of rivers. These oysters are good for consumption during almost the whole year; they may be eaten raw, but also stewed, fried in pastries, or cooked. By sailing up the river with the flood and returning again along the bank when tide goes out, the oysters are collected as they become exposed.

Similar accounts on Suriname oysters are found in other books dealing with the natural history of Suriname (Anonymus, 1676: 37, 40; Fermin, 1765: 84; Fermin, 1769: 279; Hartsinck, 1770: 78, 118; Stedman, 1796, 1: 378-379; Sack, 1810: 97; Teenstra, 1835: 443; Benoit, 1839: 39; Kappler, 1887: 205). Most of these authors agree that in Suriname the oysters remain much smaller than in Europe, but opinions appear to be divided about whether their taste is as good as that of European oysters.

Hartsinck and Stedman point out that it is not true that in Suriname oysters "grow on the trees" as the story goes, but that actually they attach themselves to the roots of trees standing in the water. According to Fermin (1769) different kinds of oysters occur in Suriname. Speaking first of the commonest kind he writes (p. 280): "... on les prend sur les Mangles. Elles sont fort petites, & leur écaille est, en partie, garnie de pointes, & de

l'autre toute graveleuse; mais elles sont très-déliques, tendres, & d'un fort bon goût.

Il y en a cependant de plus déliques encore que la précédente Espece; mais qui ne sont pas plus grosses, & qui s'attachent ordinairement aux écluses de pierre, desquelles on a beaucoup de peine à les détacher.

Il y en a encore une troisieme Espece, qui est celle que les Naturels du pays pêchent le long des rivières éloignées, & qui croissent contre des rochers, où elles sont si fortement collées, qu'ils sont obligés de se servir d'une serpe pour les en détacher: celles-ci sont beaucoup plus grandes; mais j'en (p. 281) ignore le goût, parce que je n'en ai jamais mangé."

Kappler also states that the oysters found on the walls of sluices are different from "*Ostrea parasitica*" occurring abundantly on mangrove trees. The former kind would also frequently cover the hulls of ships.

Presumably all these authors refer to *Crassostrea rhizophorae* (Guilding), Fermin and Kappler describing different forms occurring in different kinds of habitat. I can not judge, however, about Fermin's third kind of oysters, found on rocks, and consequently outside Suriname.

In her famous book on the insects of Suriname Maria Sybilla Merian (1705: pl. 69) depicts two gastropod shells, one of which is inhabited by a hermit-crab. In the accompanying text she writes: "I also had some shells fished for me from the sea, in order to find out what kind of animals inhabited them. I received many in which the animals were still alive. I pulled several out by force and found them to be a kind of lobster anteriorly, but posteriorly they were snails twisted into the shell. In the daytime they were quiet, but at night they made a soft noise with their legs and were very restless (translation by Holthuis, 1959: 146). Later Stedman (1796, 2: 186) confirms this observation by stating that near the fortress Amsterdam (the present Nieuw Amsterdam) sea-snails occur similar to those mentioned by Merian, and of which the anterior part exactly resembles that of a shrimp. Merian's shell with a pagurid might be *Thais coronata trinitatensis* (Guppy); without any doubt the other is *Pugilina morio* (L.). This figure of a shell which is certainly from Suriname is the first unambiguous record of a mollusc species from that country.

Herlein's (1718: 129, 189) references to the use of shells as money by the Indians and to the occurrence of a sepiid ("zeekat") with a cuttlebone in Suriname have never been confirmed. Holthuis (1959: 6) showed that Herlein's account of the Crustacea was actually not based on data about Suriname species, but had been borrowed from De Rochefort's book on the natural history of the Antilles. Therefore I did not trouble to try to

find the source of Herlein's certainly erroneous information on Suriname Mollusca.

Besides oysters Fermin (1767: 281, 336) mentions two other species of bivalves from Suriname. Mussels ("Mytilus parvus, totus niger") are very small in this country and are fished by the natives, but not very frequently. Fermin probably refers to *Mytella charruana* (d'Orb.) which is the only mytilid common on the Suriname coast, but the natives are taking also other bivalves, mainly to use them as a bait. The mussels "which are so small and of such insipid taste that they are hardly worth mentioning" referred to by Stedman (1796, 1: 379) are also probably *Mytella charruana*.

The other bivalve dealt with by Fermin is a shipworm of which he gives the following account. "Les *Vers Tarières* rongent ordinairement les vaisseaux, & le font avec tant de fureur & d'acharnement, que les poutres & les bois des bordages en sont criblés; ce qui met souvent le bâtiment en danger de faire eau & de périr. Ils ont jusqu'à un demi-pied de longueur. Tout leur corps est composé de différents anneaux. Ils ont, des deux côtés du ventre, une infinité de petites jambes, toutes armées de crochets. Leur tête est couverte de deux coquilles toutes pareilles, placées des deux côtés, pointues par le bout, comme le fer d'un vilebrequin, et qui peuvent jouer séparément & différemment l'une de l'autre. Cette espece de casque, qui enveloppe la tête du Ver, est très-dure, en comparaison du reste du corps, qui est fort molasse, se seche bientôt à l'air, & se réduit en poussiere; la tête seulement demeurant en son en- (p. 337) tier, par le moyen de son casque qui la préserve, & à l'aide duquel ce *Ver* fait tout son travail, & fournit à sa nourriture & à son logement. Il perce le bois avec ses deux coquilles, en les disposant comme l'outil dont je viens de parler; & comme ce casque rend la tête plus grosse que le reste du corps du *Ver*, le passage qu'il s'est fait par son moyen, lui suffit toujours pour se loger promptement.

Ces *Vers* sont si abondants à la Rade de *Surinam*, que les Capitaines craignent d'y faire un long séjour avec leurs vaisseaux, à moins qu'ils n'ayent un grand soin de les bien faire radoubler; comme il est arrivé de mon temps, qu'un bâtiment ayant séjourné environ dix mois dans la Rade, se trouva presque tout rongé de ces *Vers*, & que le Capitaine fut obligé de le faire entièrement radoubler, avant que de partir, parcequ'il faisait eau de tous côtés. Les Barques Angloises y sont encore plus exposées, parce qu'elles sont ancrées dans un endroit plus bourbeux, & où ces *Vers* se plaisent plus que dans l'eau courante."

Of course his description of the animal is a queer mixture of annelid (?) and teredinid morphology obviously borrowed from Deslandes (1722), but his statements as to the damage done by these animals in Suriname are

worth remembering. It seems most likely that Fermin is referring to *Neoteredo reynei* (Bartsch), which is a great pest in the brackish waters near Paramaribo.

Stedman (1796, 1: 37) also mentions the devastating effects of the activity of teredinids. As a remedy he says that "the coal-tar, invented by the Earl of Dundonald (for which a patent of twelve years was granted to him) is greatly preferable to any other material which can be applied for this use". Teenstra (1835: 481), another author dealing with this pest, says that it is already stated in charter dated The Hague, September 23, 1682, that ships fetching colonial products from Suriname are "eaten by the worms over there". According to Kappler (1887: 204) shipworms, like "*Teredo fatalis*", are a danger to ships both in salt and fresh water. Their burrows may reach a diameter of 1.5 cm and are found even in very hard wood. According to Turner (1966: 100) *Teredo fatalis* Quatrefages, 1849, is a synonym of *Nototeredo norvagica* (Spengler). However, the large boring holes mentioned by Kappler probably were those of *Neoteredo reynei* (Bartsch).

Bancroft (1769: 247) writes as follows on the occurrence of shells in Suriname: "Shells, which make a considerable part of the Natural History of some Countries, will have little share in that of *Guiana*, where the coast is low, and the shores muddy, the whole of their extent; so that whatever shells are thrown on shore are buried in the earth. Sometimes, indeed, a small patch of sand is found on the shore, with Shells, (p. 248) but these are not so considerable for their beauty, number, or variety, as to deserve a particular description." Such a remark might still be made nowadays by any collector of shells who is attracted by beautiful forms and colours. It shows that many fine shells labelled "Suriname" in eighteenth and early nineteenth century collections do not testify to changes in the fauna since those times, but are simply wrongly labelled.

In his *Fauna Surinamensis* Collin (1822: 8) mentions one mollusc only: *Patella surinamensis*. Holthuis (1958) showed that for all groups except insects Collin's dissertation was a list compiled from Gmelin's thirteenth edition of Linné's *Systema Naturae*. The species is dealt with hereafter (p. 15) in the section devoted to four Mollusca described from Suriname, but never found there again.

Kappler (1887: 203), who lived for many years in Albina near the mouth of the Marowijne, points out that circumstances on the Suriname coast do not favour the development of a rich fauna, because the bottom consists, of sand and mud, rocks are lacking, the water is turbid, and many rivers drain into the sea. This would explain why he never heard of cephalopods having

been caught here. The larger gastropod shells inhabited by pagurids appear to belong to species which do not live here and must have been washed ashore. On tree trunks in the jetsam on the beach a 3 to 4 cm high, thick shelled and nodulous "*Buccinum* sp." is found of which the Indians collect baskets full for consumption. This remark must refer to *Thais coronata trinitatensis* (Guppy), of which I found empty shells in the Indian village of Langamankondre, not far from Albina. According to Kappler "*Neritina zebra*" [*Neritina zebra* (Brug.)] is another species eaten by the Indians. It occurs by thousands on tree trunks and the walls of sluices in the brackish water of creeks. After having been cooked it is taken out of the shell with a pin and it has the finest taste of all gastropods. A bivalve eaten by the same people is referred to as "*Mya* sp." (Kappler, 1887: 204). It occurs plentifully in the sand bars in the mouth of the Marowijne, where it betrays its presence by two small holes which are 3-4 cm apart. The shell is greenish, white inside, oblong-oval, and measures $5 \times 3 \times 2$ cm. To me there is little doubt that *Iphigenia brasiliensis* (Lam.) is meant by this description.

Some species which occur mainly in estuaries and brackish waters were included by Vernhout (1914: 24, 25, 38, 39) in his check list of the non-marine Mollusca of Suriname. As the occurrence of these species depends to a greater or lesser extent of the influx of sea-water, they will also be dealt with in the following parts of this paper. They are *Ellobium pellucens* (Menke) ("*Auriculastra pellucens*"), *Melampus coffea* (L.), *Tralia ovula* (Brug.) ("*Melampus pusillus*"), *Blauneria heteroclita* (Mont.), *Neritina zebra* (Brug.), *Cyanocyclas rotunda* (Prime) ("*Corbicula surinamica*" and "*C. rotunda*"), *Polymesoda aequilatera* (Desh.) ("*Cyrena ordinaria*" and "*C. spec.*"), and *Crassostrea rhizophorae* (Guild.) ("*Ostrea parasitica*"). Only one of these species, viz., *Tralia ovula*, has never been found again in Suriname. Vernhout's record is based on two samples from anonymous old collections. It should be disregarded for the same reasons as explained below (p. 13) for almost all the Suriname records by Horst & Schepman (1894-1908).

The only general survey of the Mollusca of Suriname was compiled by Schepman (1917). It is part of the article "Mollusca" in an encyclopedia of the former Dutch West Indian colonies, which included the islands of Aruba, Curaçao, Bonaire, St. Martin, Saba and St. Eustatius, and Suriname. The information on marine and brackish water species from Suriname is based on the above mentioned publications by Kappler and Vernhout and on the catalogue of Prosobranchia and Polyplacophora of the Leyden Museum by Horst & Schepman (1894-1908). Hence it is necessary here to discuss the records from Suriname found in that catalogue.

For that purpose all the samples recorded from Suriname by Horst & Schepman have been examined again and arranged according to Thiele's system in the following revised list. After each name I added in brackets: (1) the name under which the species was referred to by Horst & Schepman when it differs from the name used here; (2) the collection or person from which the sample was received; (3) the page in the catalogue by Horst & Schepman. Unless otherwise stated no other records of the species from Suriname are known to me.

Diodora listeri (d'Orbigny, 1842) (*Glyphis listeri*, Ancien Cabinet: 491). This species is recorded from the Corantijn River, British Guiana by Farfante (1943b: 5).

Fissurella barbadensis (Gmelin, 1791) (with var., Ancien Cabinet: 489). This species is also recorded from the Corantijn River, British Guiana by Farfante (1943a: 7).

Tegula lividomaculata (C. B. Adams, 1845) (*Neomphalius scalaris*, Cabinet Trippenhuis à Amsterdam: 463).

Tegula maculostriata (C. B. Adams, 1845) (*Neomphalius maculostriatus*, Musée Trippenhuis à Amsterdam: 464).

Turbo castaneus Gmelin, 1791 (Collection Dalen: 441).

Astraca brevispina (Lamarck, 1822) (*Astralium brevispina*, Ancien Cabinet: 446).

Astraea caelata (Gmelin, 1791) (*Astralium coelatum*, Cabinet Trippenhuis à Amsterdam: 446).

Astraea phoebia Roeding, 1798 (*Astralium longispina*, ? : 445; *Astralium spinulosum*, Ancien Cabinet: 446).

Nerita atrata Gmelin, 1791 (*Nerita atrata* var. *largillerti*, Ancien Cabinet: 413). This is a species from tropical West Africa and Horst & Schepman already questioned the correctness of the locality.

Nerita tessellata Gmelin, 1791 (Ancien Cabinet: 406). There is another sample in our collection labelled "Paramaribo, 1911, leg. W. C. van Heurn".

Littorina meleagris Potiez & Michaud, 1838 (*Littorina guttata*, ? : 282).

Littorina nebulosa (Lamarck, 1822) (*Littorina columellaris*, le Dr. H. ten Kate: 280). This is a common species in the intertidal zone all along the coast of Suriname.

Tectarius muricatus (Linnaeus, 1758) (Cabinet Dalen: 286).

Turritella variegata (Linnaeus, 1758) (Cabinet Trippenhuis: 243). This species has been dredged off the Suriname coast by the "Coquette" in 1957. A few worn shells have been found washed ashore on the coast, and it is also rarely found in the shell-ridges.

Heliculus spec. (*Torinia perspectivumcula*, Ancien Cabinet: 289). These six specimens have later been recorded by Bayer (1948: 21, 22, 28) as *Torinia gyrus* forma *typica* (1 specimen), forma *areola* (3 specimens) and subsp. *variegata*. The Caribbean form is referred to by modern American authors as *Heliculus cylindricus* (Gmelin), or *H. cyclostomus* (Menke). The difference between this form and the related ones from the American west coast and the Indo-Westpacific area are, however, slight, and I would need series of specimens with reliable locality data for comparison to decide to which form or forms the specimens labelled "Suriname" belong.

Architectonica nobilis Roeding, 1798 (*Solarium granulatum*, Collection Dalen: 288). This sample has been referred to as *Solarium nobile* by Bayer (1940: 232). The species has been dredged off the Suriname coast by the "Coquette" in 1957.

Planaxis nucleus (Bruguière, 1789) (? : 238).

Crucibulum auricula (Gmelin, 1791) (*Crucibulum scutellatum* var. *auriculata*, ? : 366).

Calyptrea mamillaris Broderip, 1834 (? : 369). This is a West American species. The

two specimens are much larger and more solid than the Caribbean *C. centralis* Conrad, 1841, which occurs on the Suriname coast.

Strombus costatus Gmelin, 1791 (M. le Dr. Herklots: 211).

Strombus gallus Linnaeus, 1758 (Collection Trippenhuis: 216).

Strombus gigas Linnaeus, 1758 (Cabinet Trippenhuis: 211).

Strombus latus Gmelin, 1791 (*Strombus bubonius*, Cabinet Trippenhuis: 211). This is a West African species.

Strombus pugilis Linnaeus, 1758 (Cabinet Trippenhuis: 212).

Strombus raninus Gmelin, 1791 (*Strombus lobatus*, Cabinet Trippenhuis: 217).

Trivia pediculus Linnaeus, 1758 (? : 209).

Trivia quadripunctata Gray, 1827 (? : 210).

Trivia suffusa Gray, 1832 (? : 209).

Cyphoma gibbosum (Linnaeus, 1758) (*Ovula gibbosa*, ? : 189).

Cyphoma signatum Pilsbry & MacGinty, 1939 (*Ovula gibbosa* var., ? : 189).

Cypraea spurca acicularis Gmelin, 1791 (*Cypraea spurca*, ? : 205).

Cypraea cinerea Gmelin, 1791 (? : 192).

Phalium undulatum (Gmelin, 1791) (*Cassis sulcosa*, ? : 179). This is a mediterranean species. The three specimens have also been mentioned by Bayer (1935: 106).

Cassis tuberosa (Linnaeus, 1758) (? : 177). The sample has also been recorded by Bayer (1935: 95).

Murex margaritensis Abbott, 1958 (*Murex imperialis*, ? : 141). The correctness of the locality is questioned by Horst & Schepman.

Pisania pusio (Linnaeus, 1758) (? : 107). There is another specimen in our collection labelled "Suriname" and presented by J. Semmelink.

Melongena melongena (Linnaeus, 1758) (Ancien Cabinet et Collection Dalen: 97). This sample was also recorded by Bayer (1952: 270). The species is not rare on the Suriname coast.

Latirus infundibulum (Gmelin, 1791) (? : 93).

Fusinus spec. (*Fusus distans*, ? : 88). By their brownish-purple colour and details of their form these specimens differ from the shells of *Fusinus* dredged off the Suriname coast by the "Coquette" in 1957. The latter probably belong to one variable species which may be *F. closter* (Philippi, 1850).

Fasciolaria tulipa (Linnaeus, 1758) (with var. *concolor*, ? : 90). Several specimens of this species have been dredged off the Suriname coast by the "Coquette" in 1957. Moreover our museum possesses a somewhat worn shell washed ashore at the mouth of the Suriname River.

Ancilla balteata (Sowerby, 1823) (? : 58). Horst & Schepman give the locality with an interrogation mark.

Ancilla glabrata (Linnaeus, 1758). (? : 58)

Jaspidella jaspidea (Gmelin, 1791) (*Olivella jaspidea*, ? : 56).

Olivella verreauxi (Ducros, 1857) (*Olivella nitidula*, ? : 55). A slenderer form of *Olivella* (*Niteoliva*) is found washed ashore on the coast and in the shell-ridges. It may belong to the same species.

Olivella nivea (Gmelin, 1791) (? : 56).

Mitra barbadensis (Gmelin, 1791) (? : 72).

Voluta musica Linnaeus, 1758 (*Volutolyria musica* with vars. *thiarella*, *guinaica*, *carneolata*, and *sulcata*, all? except the last one, which is from "Collection Raye": 70). The species is recorded from the Corantijn River, British Guiana, by Clench & Turner (1964: 143).

Marginella irrorata Menke, 1828 (*Marginella glabella*, ? : 60). This is a West African species. The correctness of the locality is questioned by Horst & Schepman.

Conus daucus Hwass, 1792 (*Conus daucus* var. *pastinaca*, ? : 22).

Conus granulatus Linnaeus, 1758 (? *Conus verulosus*, ? : 31). This species is recorded from Suriname also by Lamarck (1822: 507).

Conus spec. (*Conus columba*, Collection Dalen: 27).

Of the 51 species recorded by Horst & Schepman from Suriname 43 (44?) have not been found there again. Among these are one West American, three West African and one Mediterranean species. The others are from the tropical western Atlantic and it seems likely that some of them will eventually be found to occur off the Suriname coast, because, e.g., three of them have already been recorded from the Corantijn River, British Guiana, just on the western border of Suriname. Nevertheless it is remarkable that most of the common larger prosobranchs found on the Suriname coast are not recorded in this catalogue and that of several genera (e.g., *Calyptraea*, *Cyphoma*, *Cypraea*, *Murex*, *Olivella*, *Marginella*, *Conus*) other species are recorded by Horst & Schepman than we certainly know to occur off the Suriname coast.

As far as the provenance of these samples is known most of them come from eighteenth or early nineteenth century collections, assembled when reliable locality data were not yet so much cared for. So "Ancien Cabinet" refers to the former "Cabinet" of Leiden University and "Cabinet Trippenhuys", or "Collection Trippenhuys", "Musée Trippenhuys" means the National Cabinet of Natural History in Amsterdam. From both these collections the zoological objects were transferred to the Rijksmuseum van Natuurlijke Historie at its foundation in 1820. Shells from the "Collection Raye" were bought at the sale of the collection of Joan Raye van Breukelerwaert in 1827, those from the "Collection Dalen" at the sale of the collection of C. Dalen, M. D., in 1854. Dr. J. A. Herklots was a curator at the museum from 1846 to 1872, but he never visited Suriname himself. Only Dr. H. ten Kate certainly collected himself the sample of *Littorina nebulosa*, the only one with an exact locality (mouth of the Marowijne River) (cf. Holthuis, 1956: 26). This sample is, therefore, the only one of which I think the locality to be reliable. All the others will be disregarded in the following parts of this paper, even when the species has later been found to occur on the Suriname coast.

The Leiden Museum possesses also samples of bivalves from old collections labelled 'Suriname', of which I do not trust the locality for the same reason. Fortunately these samples have not been recorded in literature and they will be ignored in the present paper. The reason why so many lots in old collections were wrongly labelled 'Suriname' may well be that sailing vessels often returned from Suriname via the Antilles. So persons returning from Suriname may easily have picked up or bought some

attractive shells on these islands their way back to the Netherlands, and collectors received these shells from persons coming from Suriname.

The publications by Reyne (1921?: 30), J. W. Gonggrijp (1921a, 1921b, 1923, 1924a, 1924b), Kempees & Gonggrijp (1922), L. Gonggrijp (1924) and Spoon & Loosjes (1946) on the damage done to wooden structures by boring bivalves and the resistance of different species of wood to their attacks contain particulars of some bivalves and will be referred to in the special part of this paper. Reyne's inquiries as to the identity of one of these borers lead to the description of "*Teredo (Neoteredo) reynei*" by Bartsch (1920).

Since the publication of Bullis's paper (1964) we are well informed on the Muricidae occurring off the coast of the Guianas. Preliminary results of the study of the material on which the present paper is based were published by Mrs. Nijssen-Meyer (1965) and Van Regteren Altena (1965, 1968).

Very recently Ranson (1967: 45, 51) included several samples of oysters from Suriname in his revision of the living Ostreidae of the world. In my preliminary paper (1968) I listed the Recent Suriname oysters as *Crassostrea rhizophorae* (Guild.) which I considered a variable species. In the present paper I have stuck to this identification, although I intend to reconsider the question. Ranson classes what I thought to be two not always separable forms of *Crassostrea rhizophorae* as *Cr. guyanensis* Ranson and *Cr. lacerata* (Hanley). It is embarrassing that both these names are invalid, because *Cr. guyanensis* is a nomen nudum, as Ranson does not describe this species but only gives a figure of the larval shell, and *Ostrea lacerata* Hanley, 1846, is preoccupied by *O. lacerata* Goldfuss, 1833.

A number of records of marine molluscs from Suriname are scattered throughout monographs, catalogues and other papers not dealing especially with the Suriname fauna. I tried to assemble these data as completely as possible and they will be referred to in the proper place in the following parts of this publication. Here, I want to mention only four nominal species of which the type locality is Suriname, but which have so far not been found again on the Guiana coast.

Conus ammiralis surinamensis Gmelin (1791: 3380) is based on "l'Amiral de Surinam" from the cabinet of Madame du Bois Jourdain (d'Argenville, 1757, 1: 387, (suppl.) pl. 1 (sometimes cited as pl. 10) fig. R, see Plate 1 Fig. 1 of this paper). The figure was copied by Martini (1773: 214 vign. 26 fig. 5, cf. p. 282). Chemnitz's figure (1788: pl. 139 fig. 1293), also cited by Gmelin, represents another species. As far as I know the material dredged by the "Coquette" in 1957 contains the first authentic cones collected off the Suriname coast. They belong to four species which are all certainly different

from the "subspecies" described by Gmelin. Kohn (1966: 321) considers *Conus ammiralis surinamensis* a nomen dubium and proposes its rejection, with which proposal I agree.

Conus cedo-nulli surinamensis Hwass, in Bruguière (1792: 603), is based on what de Favanne de Montcervelle Père & Fils (1780: 441, pl. 16 fig. D 3, see Pl. 1 Fig. 3 of this paper) call "l'Amiral de Surinam" in the third edition of d'Argenville's book mentioned above. This is certainly different from "l'Amiral de Surinam" of the second edition (*surinamensis* Gmelin) called in this third edition "Le Papier marbré à cordon" (1780, p. 443) and represented on the same plate, fig. E 5 (Plate 1 Fig. 2). It also differs from the four species now certainly known to live off the Suriname coast. Clench (1942: 6) puts the name in the synonymy of *C. dominicanus* Hwass, which may be correct. However, it seems very improbable to me that the type really came from Suriname.

Patella surinamensis Gmelin (1791: 3716) is based on a description and figure by Martini (1769: 107, pl. 7 fig. 50, see Pl. 1 Fig. 4 of this paper), who states that this species, "ex museo Vehriano", is common on the Suriname coast. No Patellacea, the superfamily to which this species must belong, have been recorded in later publications from the Guiana coast, nor is this superfamily represented in the material I examined. Pilsbry (1891: 161) lists *Patella surinamensis* under the "unidentified limpets". I have not been able to trace the museum Vehrianum.

Cypraea surinamensis Perry (1811: pl. 20 no. 4, see Pl. 1 Fig. 5 of this paper) is said to be "a native of Surinam". In recent literature the name has been applied to a very rare cowry, formerly better known as *Cypraea bicallosa* Gray, for which Coomans (1963, as *Propustularia surinamensis*) lists the following localities (besides the type locality): Veracruz (Mexico), Hispaniola, St. Thomas, Guadeloupe, Marie Galante, Martinique, St. Vincent, Barbados, Curaçao, and Aruba. To these Emerson & Old (1965) added: off Punta Arenas (Mona I., Puerto Rico), off the Maticumba Keys (Florida), on Seramilla Bank (300 miles east of Honduras), and (1966) off Fortaleza (Ceará, Brazil). I found no indication that live specimens of this species have ever been collected; the Brazil shells were found in the gut of the bottom fish *Amphichthys cryptocentrotus*. The possibility that the type specimen really came from Suriname is also very improbable. The only authentic cypraeid I saw from Suriname is a specimen of *Cypraea zebra* (L.), dredged by the "Coquette" in 1957.

b. Holocene

The first author mentioning the occurrence of Holocene Mollusca in

Suriname was Blom (in Heshuysen, 1786: 12; Blom, 1787: 21). In his description of Suriname soil types he distinguishes three categories of unfertile land, of which the third is called "sand- and shell-ridges" ("Zand en Schulp-ritzen"). These are reefs of sand and shells in the lowlands, 6-9 feet high and 6-8 chains¹⁾ wide, lying at certain distances from each other along the whole coast and parallel to it. Quite correctly Blom concludes that these lowlands are marine deposits and are ancient coastal mud-flats which have been gradually heightened by the sea and eventually barred off by ridges of sand and shells. Ever since Blom's publication authors dealing with the geology, geomorphology and pedology of the coastal region of Suriname have discussed the origin, structure and composition of the sand- and shell-ridges, but little attention has been paid to their mollusc fauna.

An extensive collection of shells from the ridges was made by Voltz, who studied the geology of Suriname from 1853 to 1855. Voltz died from yellow fever in Paramaribo on August 6, 1855, and so he could not work out the results of his researches in Europe as he had the intention of doing. However, from his letters to Staring it appears that he was a keen observer and had already reached the important conclusion that the mollusc fauna of the ridges agrees with the recent mollusc fauna of the Suriname coast. The following is a translation of the relevant parts of Staring's paper.

"... he noticed species from the following genera which have been listed here as to their abundance: *Macra*, *Area* [*Arca*] three species, *Cardium*, *Ostrea*?, *Pecten*, two or three other species of bivalves, *Oliva*, *Fusus*, *Buccinum*, *Voluta*, *Natica* and *Scalaria*. Gastropods are much rarer than bivalves. However, all of them seem to be Recent and the same as occur in the neighbouring sea." (Letter of Dec. 21, 1853: Staring, 1854b: 110).

"The older as well as the younger shell-ridges contain numerous sea shells of species which occur living in the vicinity, in fact Mr. Voltz found them there with few exceptions. The *Macra* and the three species of *Arca* which occur abundantly in the shell ridges on the banks of the Saramacca are not found in this part of the colony along the Commewyne and Cottica, but all the other molluscs from the Saramacca are. The occurrence of *Pyrula metongena* [*melongena*] is remarkable, because it is not at home in South America, but in the East Indies, and the same holds for a *Donax* which fully agrees with *D. denticulatus* from the Mediterranean Sea. Up to now Mr. Voltz found ten species living on the coast and one in the East Indies of the 15 molluscs of the shell ridges, which means 73 % Recent, but he is convinced that a closer study than he was able to make will prove all these species to be still living on the coast, and that further and better identification of the

1) The Surinam chain was equal to 20.72 m.

species with better conchological aids, will bring forth important changes in his list." (Letter of Sep. 12, 1854: Staring, 1854b: 379-380, cf. also Anonymus, 1855: 148-149).

It is no use trying to find out which species Voltz exactly meant, although it seems clear that the "*Mactra*" must be *Mulinia cleryana* (d'Orb.), the three "*Arca*" *Anadara chemnitzii* (Phil.) and/or *A. brasiliana* (Lam.), *Lunarca ovalis* (Brug.) and *Noetia centrota* (Guppy), the "*Cardium*" *Trachycardium muricatum* (L.) etc. He can not be blamed for thinking that "*Pyrula melongena*" is an East Indian and "*Donax denticulatus*" a Mediterranean species, although both are inhabitants of the tropical western Atlantic, as he had no literature or collections at hand to check his identifications. On the contrary the correctness of his main conclusion and of most of his identifications (when the wider sense in which generic names were used in his time is taken into account) testify to his sound judgement and great knowledge.

Voltz's geological and palaeontological collections came to the Rijksmuseum van Geologie en Mineralogie in Leiden, where Martin (1888, part 2: 142) found them, poorly labelled and without Voltz's notes and maps. The shells from the ridges were studied by Schepman, who reported on them in 1887. He found almost all the species to be identical with such ones still living in the same general region, but he had considerable trouble in identifying them and, therefore, several of his identifications were tentative. Modern literature and examination of important collections enabled me to check Schepman's identifications and make the necessary emendations. So a revised list of the shells in the Voltz collection is given here. It contains the most common larger species from the shell-ridges; Recent specimens of all these species are found washed ashore on the beaches along the Suriname coast.

In the following list after each name I give the name under which the species was referred to by Schepman and the pages on which it is listed and discussed in his paper in brackets. Then, the localities from which samples are present are enumerated from east to west, using the following abbreviations:

M: at the river Marowijne, Marowijne district.

AC: Anna Catharina, a former plantation on the eastern bank of the Matapica Canal, Commewijne district (cf. the map of the eastern part of the Colony of Suriname published by Teenstra (1835, atlas), where it is no. 189).

J: Jewish cemetery near Paramaribo; this locality is now within the town, on the corner of Van Idsingastraat and Kwattaweg.

G: Post Groningen; at present the village of Groningen, Saramacca

district. This village is built on a shell-ridge, part of which is figured on Pl. 3 Fig. 13, 14.

C: Coronie; along the road which nowadays crosses the district of this name not far from the coast from east to west shell-ridges crop out in several places.

N: Nickerie; the westernmost district, where also several shell-ridges are found.

The non-marine species are given in parentheses.

- Anadara (Cunearca) brasiliana* (Lamarck, 1819) (*Arca Brasiliana*: 160) J, G.
Anadara (Cunearca) chemnitzii (Philippi, 1851) (*Arca Chemnitzii*: 160, 166) AC, J, G, N.
Lunarca ovalis (Bruguière, 1789) (*Arca Americana*: 160, 166) AC, J, G, C, N.
Noctia (Eontia) centrota (Guppy, 1867) (*Arca Martinii*: 161) AC, J, G, N.
Chlamys (Leptopecten) linki (Dall, 1926) (*Pecten Sowerbyi* aff.: 161, 167) AC, J, G.
Anomia simplex d'Orbigny, 1842 (*Anomia Humphreysiana*: 161, 168) AC, J, G.
Crassostrea rhizophorae (Guilding, 1828) (*Ostrea parasitica*: 161, 167) AC, J, G.
Cyrtopleura (Scobinopholas) costata (Linnaeus, 1758) (*Pholas costata*: 156, 164) AC.
Pholas campechiensis Gmelin, 1791 (idem: 156) AC.
Teredinidae, genus?, species? (? *Teredo* spec.: 162) AC.
Polymesoda aequilatera (Deshayes, 1855) (?*Cyrena ordinaria*: 159, 166, and *Cyrena* sp.: 160) M, G.
Tivela mactroides (Born, 1780) (*Cytheria (Tivela) mactroides*: 159, *Cythera mactroides*: 166) G, N.
Chione (Chione) subrostrata (Lamarck, 1818) (*Venus Portesiana*: 158, 165) AC, J, G, C, N.
Anomalocardia brasiliana (Gmelin, 1791) (*Cryptogramma flexuosa*: 159) J.
Protothaca (Nioche) pectorina (Lamarck, 1818) (*Venus cardioides*: 159) M?, AC, J, G, C, N.
Donax (Chion) denticulatus Linnaeus, 1758 (*Donax denticulatus*: 158) AC, J, G, N.
Donax (Chion) striatus Linnaeus, 1758 (*Donax striatus*: 158, 165) AC, J, G, N.
Iphigenia brasiliensis (Lamarck, 1818) (idem: 158) J.
Tagelus plebeius (Lightfoot, 1786) (*Tagelus caribaeus*: 157) AC.
Tellina (Eurytellina) trinitatis (Tomlin, 1929) (*Tellina punicea*: 158) AC.
Macoma constricta (Bruguière, 1792) (*Tellina constricta*: 157) G, C.
Mulinia cleryana (d'Orbigny, 1846) (*Mactra Portoricensis*: 157, 164) J, G, C, N.
Spisula subtruncata (Da Costa, 1778) (*Mactra (Spisula) tellinoides*: 157, 165) AC.
No sample labelled "*Mactra (Spisula) tellinoides*" was found in the Voltz collection, but Schepman's record must be based on a sample of mactrids labelled "Anna Catharina" bearing the number St. 31297. This appears from the presence of a sample labelled *Mactra tellinoides* from Anna Catharina among the duplicates which Schepman kept for his own collection, now in the Zoological Museum of Amsterdam University. This sample contains 13 valves, which agree perfectly with those in sample St. 31297. Both series consist of young valves of the European *Spisula subtruncata*, which certainly do not come from Suriname. This is proved by the fact that on close examination the large sample appears to contain also a few young valves of *Spisula solida* (L.), two young valves of *Macoma balthica* (L.) and a young valve of *Donax vittatus* (Da C.). All these are European species, lacking in the tropical western Atlantic, but common on the Dutch coast. Hence there can be no doubt that the locality on the labels of these two samples is erroneous.

- Trachycardium (Dallocardia) muricatum* (Linnaeus, 1758) (*Cardium muricatum*: 160) AC, J, G.
Littorina nebulosa (Lamarck, 1822) (*Littorina columellaris*: 155) AC, G.
 [Doryssa devians Brot, 1874 (idem: 155, 164) M.].
Natica cayennensis Recluz, 1850 (*Natica pennata*: 154, 163) AC, J, G, C, N.
Natica marochiensis (Gmelin, 1791) (*Natica maroccana*: 155, 163) AC, J, G.
Bursa spadicea (Montfort, 1810) (*Ranella crassa*: 154, 163) M, AC, J.
Tonna galea (Linnaeus, 1758) (*Dolium Antillarum*: 154, 163) G.
Thais (Thaisella) coronata coronata (Lamarck, 1816) (*Purpura coronata*: 152 p.p.) M.
Thais (Thaisella) coronata trinitatis (Guppy, 1869) (*Purpura coronata*: 152 p.p.) M, J, G, C.
Thais (Stramonita) haemastoma floridana (Conrad, 1837) (*Purpura floridana*: 152, 162) AC, J, G, C.
Melongena melongena (Linnaeus, 1758) (*Pyrula (Cassidulus) melongena*: 153) N.
Pugilina morio (Linnaeus, 1758) (*Pyrula (Pugilina) morio*: 153) AC, J, C.
Nassarius vibex (Say, 1822) (*Nassa antillarum*: 153, 162) AC, G, C.
Marginella prunum (Gmelin, 1791) (idem: 153) AC, J, G, C, N.
Ellobium pellucens (Menke, 1830) (*Auricula pellucens*: 156, 164) N.
Melampus coffea (Linnaeus, 1758) (idem: 156, 164) AC, G.
 [Eudolichotis aurissciuri (Guppy, 1866) (*Bulinus distortus* var.: 155, 164; cf. v. R. Altana, 1964: 140) M.]

Schepman's list was cited by Martin (1888, part 2: 200) and it was used by Schepman himself (1917: 481) for a discussion of the Quaternary Mollusca of Suriname.

IJzerman (1931: 36-37) listed what he considered the most frequent species of molluscs in the shell-ridges. According to personal communication his list is based partly on the Voltz collection, partly on material collected by himself which has not been preserved. With a few corrections and the nomenclature brought up to date his list, with the names he used in brackets when necessary, runs as follows.

- Nuculana concentrica* (Say, 1824) (*Leda* spec.)
Anadara brasiliiana (Lamarck, 1819)¹⁾
Lunarca ovalis (Bruguière, 1789) (*Arca campechiensis*)
Noetia centrota (Guppy, 1867) (*Arca Martinii*)
Chlamys linki (Dall, 1926) (*Pecten* spec.)
Anomia simplex d'Orbigny, 1842 (*A. Humphreysiana*)
Crassostrea rhizophorae (Guilding, 1828) (*Ostrea* cf. *frons*)
Mytella charruana (d'Orbigny, 1846) (*Modiola* spec.)
Corbula caribaea d'Orbigny, 1842 (C. cf. *biradiata*)
Tivcla mactroides (Born, 1780)
Chione subrostrata (Lamarck, 1818) (*Venus Portesiana*)
Protothaca pectorina (Lamarck, 1818) (*Venus cardioides*)
Donax denticulatus Linnaeus, 1758
Donax striatus Linnaeus, 1758
Tagelus plebeius (Lightfoot, 1786) (*T. gibbus*)

¹⁾ Possibly IJzerman's *Arca brasiliiana* also includes *Anadara chemnitzii* (Philippi, 1851).

Mulinia cleryana (d'Orbigny, 1846) (*Mactra guadelupensis*)
Trachycardium muricatum (Linnaeus, 1758)
Littorina nebulosa (Lamarck, 1822)
Calyptraea centralis Conrad, 1841 (*C. cf. mamillaris*)
Natica cayennensis Recluz, 1850 (*N. canrena*)
Natica marochiensis (Gmelin, 1791)
Bursa spadicea (Montfort, 1810) (*B. crassa*)
 ? (*Murex salleanus*)
Thais coronata trinitatis (Guppy, 1869)
Thais haemastoma floridana (Conrad, 1837)
Nassarius vibex (Say, 1822) (*N. antillarum*)
Olivella spec.
Marginella prunum (Gmelin, 1791)

No species of *Murex* is frequent in the shell-ridges, but I saw a few specimens of *M. brevifrons* Lamarck, a species nearly related to *M. salleanus* A. Adams. Clench & Farfante (1945: 32) consider *M. salleanus* a synonym of *Murex florifer* Reeve.

IJzerman was the first to mention Holocene (and? Pleistocene, cf. p. 32) molluscs from borings in Paramaribo and Nickerie. His records are compiled in the following table in which the figures indicate the depths in metres at which shells have been found.

	Combé, Paramaribo	Vaillant square, Paramaribo	Nickerie
<i>Anadara brasiliiana</i> (Lam.) ¹⁾	2.70-4.50		
<i>Lunarca ovalis</i> (Brug.)		12.00-13.50	
<i>Noetia centrota</i> (Guppy)		12.00-13.50	
<i>Anomia simplex</i> d'Orb.	14.00-15.50		
<i>Corbula caribaea</i> d'Orb.			12.00-27.00 54.00-54.50 89.60-90.00 90.00-100.50
<i>Chione subrostrata</i> (Lam.)		12.00-13.50	84.80-89.60 90.00-100.50
<i>Trachycardium muricatum</i> (L.)		12.00-13.50	
<i>Natica marochiensis</i> (Gm.)			12.00-27.00
<i>Olivella</i> spec.			57.00-60.20

More molluscs from borings in the neighbourhood of Paramaribo were mentioned by d'Audretsch (1953); they had been identified by Geijskes. Mr. L. O'Herne of the Geological Survey of Surinam was so kind as to inform me that the samples on which these records are based are no longer available. Hence it is no longer possible to check the identifications, but as I know what Geijskes meant by most of the names listed by d'Audretsch (1953: 239), I am pretty sure that the following species were found in the blue clays belonging to the Demerara formation (when necessary the name in the d'Audretsch list is given in brackets):

¹⁾ See note p. 19.

Nuculana concentrica (Say, 1824) (*Leda eburnea*)
Anadara brasiliensis (Lamarck, 1819) (*Arca br.*)
Lunarcia ovalis (Bruguière, 1789) (*Arca campechiensis*)
Noetia centrota (Guppy, 1867) (*Arca martini*)
Anomia simplex d'Orbigny, 1842. (*A. humphreysiana*)
Mytella charruana (d'Orbigny, 1846) (*Mytilus falcatus*)
Corbula caribaea d'Orbigny, 1842 (*C. obesa*)
Chione subrostrata (Lamarck, 1818) (*Venus portesiana*)
Mulinia cleryana (d'Orbigny, 1846) (*Mactra portoricensis*)
Dentalium spec.
Epitonium cf. *albidum* (d'Orbigny, 1842) (*Scala modesta*)
Natica cayennensis Recluz, 1850 (*N. canrena*)
Natica marochiensis (Gmelin, 1791)
Thais haemastoma floridana (Conrad, 1837)
Anachis spec.
Olivella spec. (*Olivella mutica*)
Cylichna (*Cylichnella*) spec. (*Atys* spec.)

In a boring at Zorg en Hoop d'Audretsch (1953: 241) found shells also at somewhat greater depths in brown stained clays and underlying sandy clays. These beds may be of Pleistocene age (cf. p. 32); the following molluscs, all of them species belonging to the Recent Suriname fauna, are recorded from these clays:

	36 m	75 m
<i>Anadara chemnitzii</i> (Philippi, 1851) (<i>Arca ch.</i>)	+	—
<i>Lunarcia ovalis</i> (Bruguière, 1789)	+	—
<i>Noetia centrota</i> (Guppy, 1867)	—	+
<i>Plicatula gibbosa</i> Lamarck, 1801 (<i>Pl. cristata</i>)	+	—
Pectinidae, gen. spec. (non <i>Chlamys linki</i> (Dall))		
(non <i>Pecten sowerbyi</i>)	—	+
<i>Anomia simplex</i> d'Orbigny, 1842	+	+
<i>Chione subrostrata</i> (Lamarck, 1818)	—	+
<i>Natica marochiensis</i> (Gmelin, 1791)	+	—
<i>Thais haemastoma floridana</i> (Conrad, 1837)	+	—

At still greater depth d'Audretsch (1953: 242) found a bed of green clay which in a boring at Nieuw Amsterdam contained small fragments of marine shells at a depth of 167 m. These shells were partly tentatively identified with species Geijskes knew to occur on the Suriname coast, but partly they appeared to belong to species which had not yet been found Recent in Suriname. I regret not to have seen this material; a renewed study of this fauna, which seems older than Holocene, would be interesting.

Some preliminary results of my studies of the Holocene Mollusca of Suriname have already been published (v. R. Altena, 1966, 1968 and in press).

4. THE SURINAME COASTAL WATERS AND ESTUARIES AS AN ENVIRONMENT FOR MOLLUSCA

a. General remarks

The coast of Suriname is that part of the north coast of South America which is situated between the estuaries of the rivers Marowijne ($53^{\circ} 58'$ W) and Corantijn ($57^{\circ} 6'$ W). The coast line is practically directed from east to west, the southernmost point (Galibi, Marowijne district) being at $5^{\circ} 44'$ N, while near the Warappa Creek, Commewijne District, and at the Turtle Bank, Nickerie district, the coast just reaches 6° N. Between the rivers just mentioned, which form the natural boundaries between Suriname and French and British Guiana, there are two other large estuaries: that of the Suriname and Commewijne Rivers (at about $55^{\circ} 11'$ W), and that of the Coppename and Saramacca Rivers (at about $55^{\circ} 54'$ W). Another large river, the Nickerie River, debouches at the north-easternmost point of the Corantijn estuary.

The coastal region of Suriname consists of Holocene marine deposits: the clay soil of large plains mostly covered by swamps alternates with narrower and slightly higher sand reefs of which the general direction is from east to west. The greater part of the intertidal zone along the coast is occupied by often extensive mud flats, while sand banks occur locally (Plate 2 Fig. 6, 8). No hard rock is found anywhere along this whole coast. The higher part of the intertidal zone bears a rich mangrove vegetation, in which *Avicennia* is dominant along the coast (Plate 2 Fig. 9) and replaced by *Rhizophora* in the estuaries.

Because of the interaction of tidal movements and the prevailing westward current sand and mud banks are always on the move and the details of coastal topography are, therefore, constantly changing. The Suriname coast belongs to the section of the coast of South America between Amazon and Orinoco where in general the sea is regressing (Choubert, 1948, e.g. 10 to 15 km since the end of the 19th century at Pointe Isère, French Guiana). Locally and temporarily, however, transgressions occur. So in the Nickerie district the town of Nieuw Rotterdam was swallowed by the sea in the second half of the 19th century. A new town, Nieuw Nickerie, was founded more to the south and to the west of this town a 3400 m long sea dike had to be constructed in order to protect the hinterland (Plate 2 Fig. 10). January 27, 1963, during an excursion to the coast near the mouth of Matapica Canal, Commewijne district, Geijskes called my attention to the traces of man made ditches through the mud flats exposed at low tide, while some graves of negro slaves and old pottery proved that in the 18th century plantations existed here below the present shore line (Plate 2 Fig. 6).

b. The intertidal zone and shallow coastal waters.

The molluscan fauna of the intertidal zone and the shallow coastal waters of Suriname is not rich in species as compared with, e.g., that of the Antilles. Apparently this difference is caused by the great quantities of fresh water emptied into this part of the sea by the large rivers debouching rather close to each other, by the considerable turbidity of the water, by the continuous shifting of the sand and mud banks, and by the scarcity of hard substratum.

Wherever not silted hard substratum occurs in the intertidal zone, it provides a suitable habitat for a small number of species, some of which may occur in great quantities. The hard substrata available are: the roots, stems and branches of mangrove trees, greater and smaller logs washed ashore, the stone covered seaward slope of the dike west of Nieuw Nickerie, and, mainly in the estuaries, wooden wharfs and jetties. On these substrata one finds the bivalves *Crassostrea rhizophorae* (Guild.) and *Mytella charruana* (d'Orb.), and the gastropods *Littorina nebulosa* (Lam.) (Plate 2 fig. 7, 11), *L. angulifera* (Lam.), *Thais coronata trinitatensis* (Guppy) and *Th. haemastoma floridana* (Conr.). The *Littorina* live above high water level, *L. angulata* still somewhat higher up than *L. nebulosa*. *Neoteredo reynei* (Bartsch) bores in dead wood, while *Assiminea succinea* (Pf.) and *Blaumeria heteroclita* (Mont.) are found in crevices and empty boring holes. Under and between the matter washed ashore at high water mark the ellobiids *Auriculastra pellucida* (Menke) and *Melampus coffea* (L.) are found. They also occur at the roots of plants in lagoons and along ditches just behind the shore.

On the jetties near Paramaribo the zonation in the intertidal zone can be roughly described as follows. At high water level there is a narrow zone of brown algae. Between this and low level the wood is covered by a more or less dense growth of balanids. In this zone *Neritina zebra*, *Thais coronata trinitatensis* and *Crassostrea rhizophorae* are found, while *Mytella charruana* occurs from slightly above low water level downward.

Crassostrea rhizophorae and *Mytella charruana* were also found in material scraped from a buoy which had been floating off Nieuw Nickerie, near the remains of the former jetty of Nieuw Rotterdam and from the hull of the lightship lying off the mouth of the Suriname River. On the latter moreover *Sphenia antillensis* Dall & Simpson appeared to live between the barnacles.

Great quantities of shells washed ashore testify to a number of species, mainly bivalves, living near the Suriname coast. With *Crassostrea rhizopho-*

rae¹) the dominating species are *Chione subrostrata* (Lam.) and *Mulinia cleryana* (d'Orb.), while at least a dozen other species are not rare at all. Large numbers of these shells collected on the beach enabled the writer to make a census of this shallow water fauna which may be nearly complete. Although it seems likely that a great part of these species, especially those of which the shells are found more or less frequently and locally in very fresh condition, live not far beyond low tide level, the following few data are the only information which the writer could assemble as to exactly where these species live.

When exploring the mud flats on the coast near the end of the Fernandez road (Suriname district) by means of a mud sledge²) in March 1963, Dr. L. J. Pons took hold of two living specimens of *Polymesoda aequivalvis* (Desh.) and one of *Macoma constricta* (Brug.) by reaching down with his hand into the soft mud.

Kappler (1847: 204) writes that on the sand banks in the mouth of the Marowijne River "*Mya* sp." (from his description and measurements it is evident that *Iphigenia brasiliensis* (Lam.) is meant) is not rare at all. It burrows in the sand to a depth of 5-6 cm and betrays its presence by two little holes, 3-4 cm apart.

When collecting at low tide on the mud flats near the mouth of the Matapica Canal on January 27, 1963, we found a bed of *Cyrtopleura costata* (L.) and a few *Protothaca pectorina* (Lam.), all dead shells in situ.

It is technically difficult to explore the bottom fauna of the shallow waters just along the coast of Suriname, but by using mud sledges and small boats it will probably be possible to fill this gap in our knowledge of the distribution of marine molluscs.

c. The estuary and lower course of the Suriname River.

Marine and brackish water molluscs occur in the Suriname River at least up to Jodensavanne, i.e., about 60 km from the mouth of the river as the crow flies, and about 100 km when measured along the winding river bed. The localities from which I could examine molluscs are plotted on a map (textfig. 1) and the records which I could assemble are compiled in table 1. They give a rough impression of the distribution of the 13 species involved, but far more data would be necessary for establishing exactly the limits of the distribution of each of them. All the records are from before the building

1) In British Guiana this species "forms the greater part of the shell sand" according to Graham (1955: 27, pl. 3 fig. 3, 4, as Rock Oyster, *Ostrea* sp.).

2) The so called fisherman's horse, hassi or toko toko ars of the Suriname fishermen, who use such sledges for checking their nets.

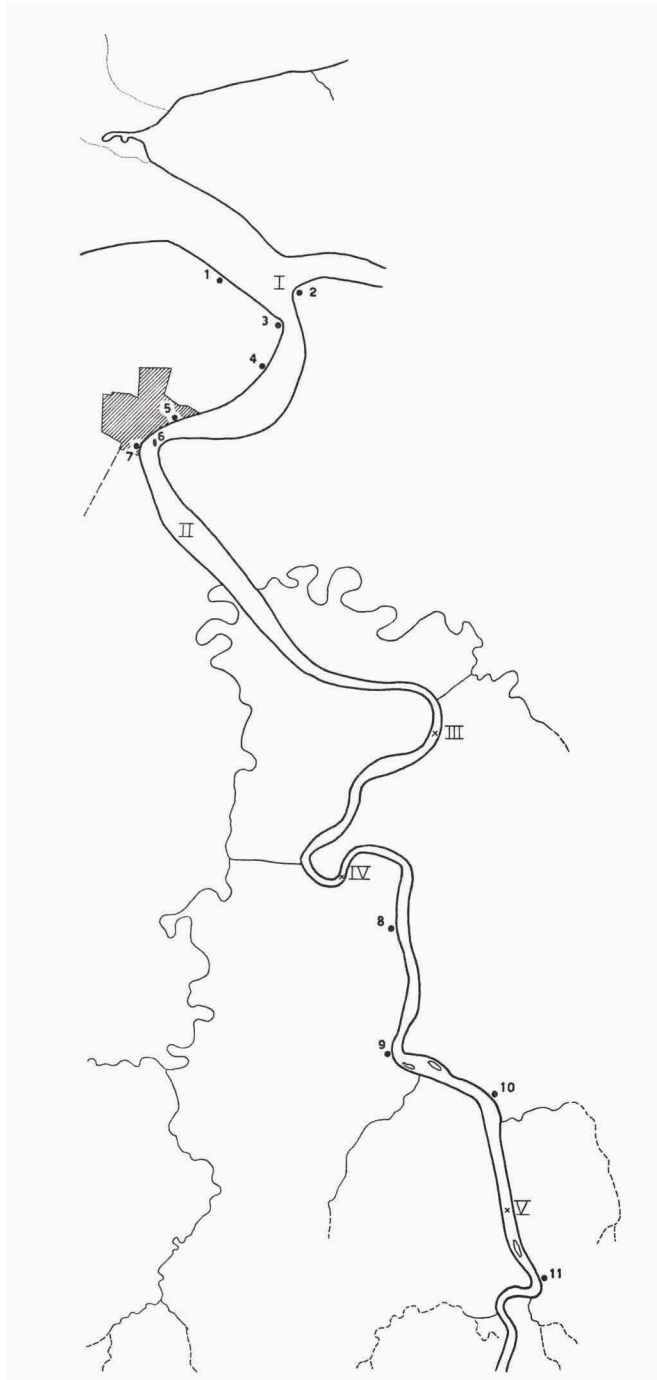


Fig. 1

Table 1. Occurrence of 13 species of Mollusca in 11 localities along the Suriname River.

<i>Littorina angulifera</i> (Lam.)	1	.	.	.	.	.	.	.	.	.	.	.
<i>Ellobium pellucens</i> (Menke)	1	2	.	.	.	.	.	.	.	.	.	.
<i>Thais coronata trinitatensis</i> (Guppy)	1	.	3	4	.	.	.	.	.	.	.	.
<i>Melampus coffea</i> (L.)	1	.	.	.	5	.	.	.	.	.	.	.
<i>Detracia parana</i> Morr.	1	2	.	.	5	.	.	.	.	.	.	.
<i>Neritina zebra</i> (Brug.)	1	.	.	.	5	6	.	.	.	.	.	.
<i>Mytella charruana</i> (d'Orb.)	1	.	3	4	5	6	7	.	.	.	.	.
<i>Crassostrea rhizophorae</i> (Guild.)	1	.	3	.	5	.	.	8	.	.	.	.
<i>Neoteredo reynei</i> (Bartsch)	.	.	.	.	.	6	7	.	.	.	.	.
<i>Lignopholas clappi</i> Turner	.	.	.	.	.	.	7	.	.	.	.	.
<i>Anticorbula sinuosa</i> (Morr.)	.	.	.	.	.	.	7	8	9	.	11	.
<i>Cyanocyclas rotunda</i> (Prime)	.	.	.	.	.	.	.	8	9	10	11	.
<i>Psiloterdo healdi</i> (Bartsch)	.	.	.	.	.	.	.	8	.	.	11	.

of the dam in the Suriname River at Afobakka, which may have changed this distribution pattern drastically.

The records from Purmerend are based on samples collected at that locality by Dr. P. W. Hummelinck in March 1965. The specimens from the Saramacca Canal near Beekhuizen mentioned as *Martesia cuneata* by J. W. Gonggrijp (1923: 13/14) and those listed as *Martesia* spec. by Spoon & Loosjes (1946: 5) were found to belong to *Lignopholas clappi* by Dr. Ruth D. Turner, while *Modiolus* sp. and *Saxicava* sp. recorded by Spoon & Loosjes (l. c.) from the same locality appeared to be *Mytella charruana* and *Anticorbula sinuosa* respectively. Data from all the other localities are based on the collection I made from the beginning of January to the end of March 1963.

The monthly means of salinity of five localities (textfig. 2, I-V) during 1939 and 1940 and the means of rainfall in Paramaribo during the same period are plotted in textfigure 2.

Of the 13 species listed I consider six, viz., *Littorina angulata*, *Ellobium pellucidum* (Pl. 3 Fig. 12), *Thais coronata trinitatensis*, *Melampus coffea*, *Mytella charruana*, and *Crassostrea rhizophorae* to be euryhaline marine species, as they also occur along the coast outside the estuaries. I admit that probably the surface water just along the shore may have a lower salinity than pure seawater most of the time, because of the great quantities of fresh water, drained into the sea by the large rivers, flowing westward along the coast with the prevailing current. On the other hand, however, it seems likely that evaporation often leads to hypersalinity in the intertidal zone. These six euryhaline species appear to penetrate into the river more or less far according to their specific tolerance of lowered salinity.

The seven other species appear not to occur outside the estuaries and

TABLE 2

general region	cruise no.	station no.	date	locality	depth in fathoms	bottom	remarks	Bivalvia	Scaphopoda	Gastropoda	Cephalopoda
off Coronie District	1	A1	1-4.IV.1957	?, or NNW Coppename	8-17½			21	-	11	-
do.	1	A2	do.	NNW Coppename, 20 miles off the coast	15			3	-	9	-
do.	1	A3	do.	20 miles NNW of Coppename River	17			-	-	2	-
off Marowijne District	2	B1	8-12.IV.1957	NW of mouth Marowijne River	20			4	-	13	-
off Coronie and Nickerie District	3	C1	16-19.IV.1957	NNW Coppename	5-23			4	-	1	-
do.	3	C2	do.	N of Coppename-Nickerie	15			-	-	1	-
do.	3	C3	do.	N of Coppename-Nickerie, 20 miles off the coast	15			-	-	1	-
off Commewijne District	?	D1	1V.1957	NE of Lightship	28		Lijding leg.	4	-	2	-
off Marowijne District	5	E1	30.IV-2.V.1957	?	16-31			-	-	3	-
do.	5	E2	do.	RNW of Marowijne River, 30 miles off the coast	20			11	-	16	-
do.	5	E3	do.	NNW of Marowijne River, ca. 30 miles off the coast	20 and less			15	-	24	2
off Suriname District	5a	E4	3.V.1957	near Lightship	4			-	-	1	-
do.	5a	E5	do.	15 miles N of Lightship	10			-	-	1	-
do.	5a	E6	do.	N of Suriname River, 20 miles off the coast	15			19	-	9	1
do.	6	F1	6-9.V.1957	N of Suriname River, 20 miles off the coast	15 and less			5	-	8	2
off Commewijne District	7	1	11.V.1957	6°22' N, 55°06' W	14	mud	material in USNM	4	-	-	-
do.	7	2	do.	6°23' N, 55°05.5' W	15	mud	bivalves in USNM	7	-	4	-
do.	7	15	do.	6°24.5' N, 54°59.5' W	16	mud, shells	material in USNM	2	-	-	-
do.	7	20	do.	6°28' N, 54°57.5' W	17	shells	material in USNM	1	-	-	-
do.	7	23	12.V.1957	6°24' N, 54°59.5' W	15	shells		-	-	4	-
do.	7	27	do.	6°45' N, 54°58' W	23	hard mud, shells	material in USNM	1	-	-	-
do.	7	28	do.	6°48' N, 54°54' W	25	shells		-	-	4	-
do.	7	29	do.	6°49' N, 54°54' W	26	hard mud, shells		-	-	7	-
do.	7	30	do.	6°49.5' N, 54°54' W	26	hard mud, shells		-	-	2	-
do.	7	32	do.	6°51' N, 54°53.5' W	28	mud, shells	material in USNM	3	-	-	-
do.	7	34	do.	6°53' N, 54°53' W	28	mud, shells	material in USNM	2	-	-	-
do.	7	44	13.V.1957	6°18.5' N, 54°51' W	10	mud	material in USNM	1	-	-	-
do.	7	49	do.	6°04' N, 54°51' W	3	mud	material in USNM	1	-	-	-
off French Guiana	8	89	22.V.1957	5°50.5' N, 53°03' W	17	shells, rock		-	-	1	-
do.	11	157	4.VI.1957	6°22' N, 55°03.5' W	13	mud		1	1	3	-
do.	11	159	do.	6°22' N, 55°02.5' W	14	mud		3	-	1	-
off Saramacca District	11	167	6.VI.1957	6°18.5' N, 55°28' W	10	mud, shells	material in USNM	1	-	-	-
do.	11	178	do.	6°19' N, 55°50.5' W	15	mud, shells		-	-	1	-
do.	11	179	do.	6°18.5' N, 55°51.5' W	14	mud, shells	material in USNM	1	-	-	-
off Commewijne District	12	184	10.VI.1957	6°21' N, 54°59' W	12	mud		4	-	3	-
do.	12	197	do.	6°22.5' N, 55°10' W	11	mud, shells	from tubes of Diopatra cuprea (Bosc)	22	-	3	-
do.	12	206	11.VI.1957	6°22' N, 55°01' W	13	mud		-	-	2	-
off Marowijne District	13	209	14.VI.1957	6°41' N, 54°33' W	22	mud, shells	material partly in USNM	5	-	2	-
do.	13	210	do.	6°43' N, 54°32' W	23	mud, shells	material in USNM	1	-	-	-
do.	13	211	do.	6°44' N, 54°31' W	23	mud		-	-	3	-
do.	13	212	do.	6°45' N, 54°30' W	24	mud	material in USNM	1	-	-	-
do.	13	214	14.VI.1957	6°47' N, 54°29' W	24	mud, fine shells	bivalves in USNM	1	-	1	-
do.	13	215	do.	6°41' N, 54°17' W	25	mud		-	-	5	-
do.	13	216	do.	6°41.5' N, 54°16' W	24	mud		-	-	6	-
do.	13	220	do.	6°42.5' N, 54°11' W	23	mud		2	-	1	-
do.	13	226	15.VI.1957	6°55' N, 54°10' W	30	mud		-	-	1	-
off Saramacca District	14	250-256	19.VI.1957	6°41' N, 55°26.5'-55°43' W	23-24	mud, shells		-	-	11	-
do.	14	260	20.VI.1957	6°40'-6°41.5' N, 55°26'-55°41' W	23	mud, shells, coral	material in USNM	1	-	-	-
do.	14	267	do.	6°42'-6°41' N, 55°43'-55°45' W	24	mud, fine shells	material in USNM	1	-	-	-
do.	14	270	do.	6°42' N, 55°50' W	24	mud, fine shells		-	-	1	-
do.	15	275	25.VI.1957	6°41' N, 55°29' W	23	shells, coral	material in USNM	1	-	-	-
do.	15	277	26.VI.1957	6°42.5' N, 55°31.5' W	24	mud, shells, coral		2	-	10	-
do.	15	279	do.	6°44' N, 55°33' W	25	mud, fine shells		-	-	1	-
do.	15	280	do.	6°45' N, 55°35' W	26	mud, fine shells		-	-	1	-
do.	15	281-282	do.	6°46'-6°46.5' N, 55°36.5'-55°38' W	25	mud, fine shells	material in USNM	4	-	-	-
do.	15	283	do.	6°47' N, 55°40' W	25	mud, fine shells		-	-	7	-
do.	15	284	do.	6°49' N, 55°42' W	25	mud, fine shells	material in USNM	-	-	-	1
do.	15	285	do.	6°50' N, 55°45' W	25	mud, fine shells	material in USNM	1	-	-	-
do.	15	286	do.	6°51' N, 55°49' W	26	mud, sponges, shells		2	-	9	-
do.	15	287	do.	6°52' N, 55°50' W	26	mud, shells, coral	material in USNM	6	-	-	-
do.	15	289	27.VI.1957	6°52.5' N, 55°53' W	27	mud, fine shells		-	-	9	-
off Commewijne and Suriname District	15	293	28.VI.1957	6°27'-6°25' N, 55°05'-55°10' W	14	mud, shells		-	-	-	1
off Saramacca District	15	302	28.VI.1957	6°49' N, 55°25' W	24	mud, fine shells	material in USNM	2	-	-	-
off Coronie District	16	304	7.VII.1957	6°57' N, 56°18' W	29	mud, shells	material in USNM	1	-	-	-
do.	16	306	7.VII.1957	6°54' N, 56°14' W	27	shells, coral	bivalves in USNM	1	-	2	-
off Saramacca District	17	318	20.VII.1957	6°42' N, 55°38' W	24	mud, fine shells		-	-	1	-
do.	17	320	do.	6°47' N, 55°36' W	26	shells, coral, sponges	material in USNM	3	-	-	-
do.	17	332	do.	6°50' N, 55°24' W	29	mud, shells	material in USNM	1	-	-	-
do.	17	337	21.VII.1957	6°49'-6°47' N, 55°21'-55°18' W	27-29	mud, fine shells	material in USNM	1	-	-	-
off Suriname District	17	360	22.VII.1957	6°19'-6°20' N, 55°15'-55°14' W	14	mud, shells	material in USNM	2	-	-	-
off Saramacca and Suriname District	17	309-360	19-22.VII.1957	6°19'-6°55' N, 55°13'-55°40' W	14-29			2	-	11	-

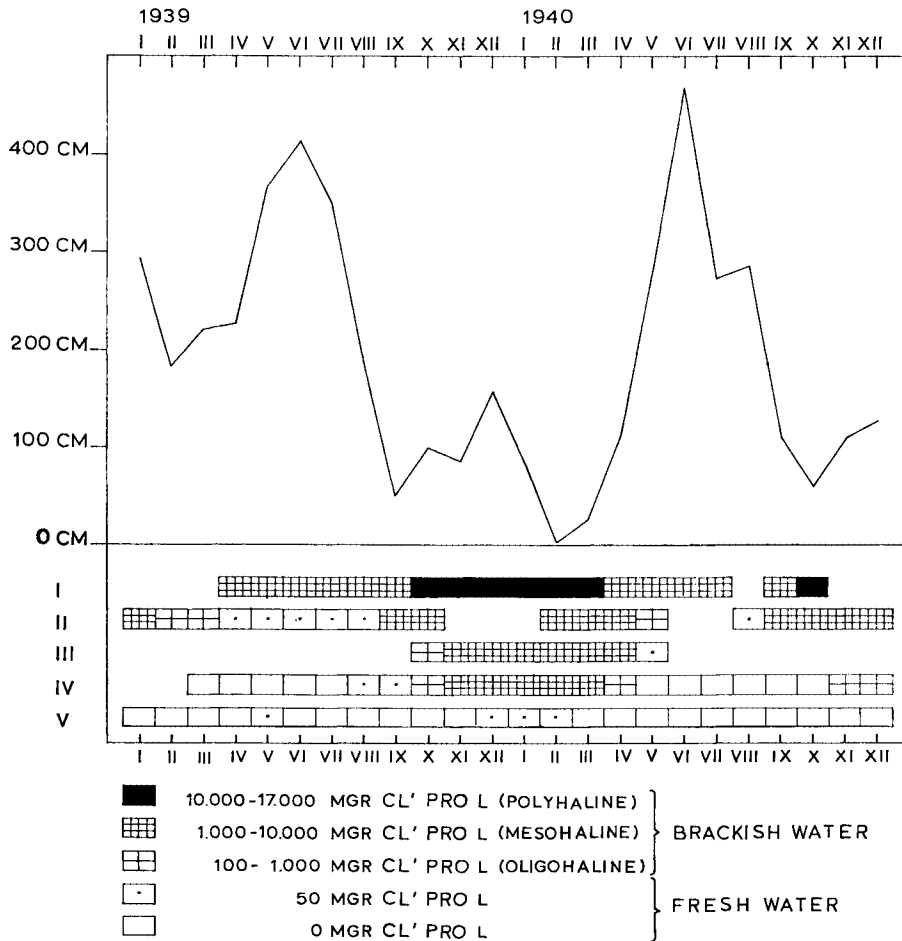


Fig. 2

lower rivers and, therefore, I consider them true brackish water species. It seems reasonable to suppose that their distribution in the river is largely controlled by the salinity, and they seem to fall into two groups of which the first, comprising *Detracia parana* (Pl. 3 fig. 12), *Neritina zebra*, *Neoteredo reynei* and *Lignopholas clappi*, requires a higher salinity than the second, consisting of *Anticorbula sinuosa*, *Cyanocyclus rotunda* and *Psiloteredo healdi*. When more data are available the overlap of the distribution of these two groups may appear to be greater than the present data would seem to indicate. Nevertheless the first group must be considered especially characteristic of the Suriname River near Paramaribo, the second of the same river between the plantation "Toevlucht" and Jodensavanne.

In the localities 1-7, where the species of the first group are living, the water appears to be mesohaline during the greater part of the year. In the localities 8-11, however, it is fresh for most of the time and the surface water of the southernmost of the localities from which salinity data are available appears not even to have attained a monthly mean of more than 50 gr Cl' pro L in the years the salinity was measured. Hence we might consider the three species of the second group freshwater molluscs which can tolerate low salinities, not with-standing their close affinity to true marine species, but then the question arises why they do not penetrate farther up the river. Evidently they are in some way restricted to waters connected with the sea.

The following hypothesis is here advanced to explain this distribution. The larvae of these species might require at least oligohaline water and consequently the adults would be able to settle only so far up the river as oligohaline water occurs at some time or other.

The incidental presence of oligohaline water in the southernmost locality, Carolina, for which monthly means are indicated in textfigure 2 does not appear from that figure. However, daily measurements of the salinity during high and low water at Carolina in December 1958 and January 1959 kindly provided by F. A. del Prado, M. Sc., Director of the Agricultural Experiment Station at Paramaribo, include the following figures.

date	water level	mg Cl' pro L
30 XII 1958	high water	101
7 I 1959	idem	124
8 I 1959	idem	132
9 I 1959	idem	116
10 I 1959	idem	129
15 I 1959	idem	137

In deeper parts of the river the water has a higher salinity, so the larvae may have developed there. But the openings of the boreholes of the Tere-

dinids are visible at low water in the jetty of the Jodensavanne, and it seems more probable that the larvae have been brought there by the surface water. *Anticorbula sinuosa* (Morr.) I have more than once found in the old borings of Teredinids.

A similar hypothesis, in which the eggs may take the place of the larvae when no free swimming larvae occur, may explain the distribution of many Ellobiidae and Assimineidae of which the adults seem quite emancipated from the marine environment, but which are nevertheless bound to the neighbourhood of the sea.

Far less data are available about the occurrence of molluscs in the other estuaries and lower rivers. In the Marowijne, which has a stronger current than the Suriname River, the brackish water species occur farther downstream than in the Suriname River.

d. The coastal waters within the 30 fathom line

The results of the exploration of the bottom fauna off the Suriname coast inside the 40 fathom line led Higman (1959) to distinguish four zones of different bottom types along the Suriname coast:

1. *The inshore zone* from 0 to 5 fathoms. Here the waters "are irregularly obstructed by extensive soft "sling" mud banks which extend from 2 to 12 miles offshore (Hydrographic Office 1935). These banks are subject to frequent shifting by tides and strong westerly currents. . . . The water in the inshore zone is the color of creamed coffee due to considerable material in suspension".

2. *The intermediate zone* from 5 to 19 fathoms, where the bottom largely consists of soft, sticky gray mud. "The water color in the intermediate zone changes from brown on the inshore side to milky green offshore".

3. *The shell ridge zone* from 19 to 23 fathoms, where "a zone of rough bottom apparently parallels most of the Surinam coast. . . . Although the ridge is narrow along the eastern and central Surinam coast, exploratory operations indicate a widening in the vicinity of the Coppename River and disruption of the ridge in the vicinity of the Maroni (= Marowijne) River. Try-net catches included dead encrusted shells, dead coral, gorgonids, and sponge".

4. *The offshore zone*. "In water deeper than 23 fathoms hard trawlable bottom, consisting predominantly of gray mud and fine shell, extends to at least the 40 fathom depth curve - the limit of the trawling gear. Scattered through this zone extensive patches of soft blue and black mud. Large expanses of gray mud bottom are covered with a fine moss-like gorgonids

growth which clogged the trawl meshes... The water color in this zone is the deep blue that is characteristic of the open ocean".

The bottom zones distinguished off the coast of French Guiana by Durand (1960: 15, fig. p. 16) do not quite agree with Higman's zones as appears from the following table.

off Suriname (Higman)		off French Guiana (Durand)	
depth	bottom	depth	bottom
0-5 fms.	with soft "sling" mud banks	0-11 fms.	mud
5-19 fms.	soft, sticky gray mud	11-22 fms.	sandy mud
19-23 fms.	shell ridge	22-25 fms.	shells
23-40 fms.	hard gray mud and fine shells	more than 25 fms.	sand

Presumably these differences are partly due to gradual change along the coast, partly to different appreciation of the bottom characters.

The dredged material which I could examine probably gives a fairly complete census of the larger species of Mollusca occurring within the 30 fathom line. Small and minute species are scantily represented; most of them were found in or on shells and concretions. The samples I studied are, however, far too incomplete to establish exactly the bathymetrical distribution of the species collected. Nevertheless there are some indications that particular species may be characteristic for the zones distinguished by Higman.

Hardly any dredging has been done in the inshore zone within the 5 fathoms line. However, it appears that several species of which the shells are common and often found in fresh condition on the beach, are altogether lacking or very scarce in the dredged samples. It seems, therefore, likely that these species are members of the inshore fauna. Some examples of the first category (species not represented in the dredged samples) are: *Lunarca ovalis* (Brug.), *Tivela mactroides* (Born), *Protothaca pectorina* (Lam.), *Donax denticulatus* L., *D. striatus* L., *Iphigenia brasiliensis* (Lam.), *Tagelus plebeius* (Lightf.), *Macoma constricta* (Brug.), *Pugilina morio* (L.) and *Nassarius vibex* (Say), while the following species are hardly found in the dredged material, but common or locally common on the beach: *Chione subrostrata* (Lam.), *Tellina trinitatis* (Toml.), *T. diantha* (Boss), *Mulinia cleryana* (d'Orb.), *Natica marochiensis* (Gm.), *Marginella prunum* (Gm.) and *Melongena melongena* (L.). Part of the fauna of this zone has a large bathymetrical range. This appears from the maximum depth at which some species have been found which belong certainly (*Crassostrea*

rhizophorae (Guild.): 28 fms.) or most probably (*Anadara chemnitzii* (Phil.): 28 fms., *Noetia centrota* (Guppy): 30 fms.) to the inshore fauna. These species may even occur in deeper water, as no samples dredged beyond the 30 fathoms are at my disposition.

As to the intermediate zone (5-19 fms.) I have the impression that some thin-shelled bivalves, like *Yoldia crosbyana* (Guppy) and *Macra iheringi* (Dall) may prove to be characteristic of this zone. Several species are common in the shell-ridge zone and the offshore zone, but have not been found on the shore, make their first appearance in the intermediate zone, e. g., *Glycymeris pectinata* (Gm.), *Amusium papyraceum* (Gabb), *Distorsio clathrata* (Lam.), *Fusinus* sp., *Conus austini* Rehder & Abbott and *C. ranunculus* Hwass.

The fauna of the shell-ridge zone (19-23 fms.) appears to have many elements in common with that of the offshore zone (more than 23 fms.). Taken together these zones are characterized by a great number of species not found on the coast and not or rarely in the intermediate zone. In these zones the gastropod species outnumber the bivalves, while on the coast only ca. 45% of the species belong to the Gastropoda. Species characteristic of these two deeper zones are: *Glycymeris pectinata* (Gm.), *Amusium papyraceum* (Gabb), *Turritella exoleta* (L.), *Crucibulum striatum* (Say), *Cymatium gemmatum* (Rve), *Conus austini* Rehder & Abbott, *C. ranunculus* Hwass and *C. verrucosus* Hwass.

No species have been dredged exclusively in the shell-ridge zone, but two species, *Aequipecten lineolaris* (Lam.) and *Conus sozoni* Bartsch, were only collected in the offshore zone, respectively at five and three stations.

As to the mollusc fauna of depths greater than 30 fathoms, the only information available is that about the Muricidae dredged by the "Oregon", for which I refer to Bullis's paper (Bullis, 1964).

5. THE OCCURRENCE OF HOLOCENE MARINE MOLLUSCA IN SURINAME

Holocene marine deposits yielding a rich molluscan fauna cover the northern part of the coastal region of Suriname. They are the Fluvio-marine Deposits of IJzerman (1931), now generally known as Demerara formation or Demerara series. These deposits stretch from the coast to only a few km inland at the Marowijne River on the eastern border, but become gradually broader to the west and are found up to some 35 km from the coast in the Nickerie district in western Suriname. They are the upper and most northern strata of a complex of unconsolidated sediments found in a narrow zone along the coast of Suriname and British Guiana. "This zone penetrating the Guiana shield at an obtuse angle along an axis between the

Berbice and Corantyne Rivers, shows very distinct indications of subsidence. In the central part, near New Amsterdam in British Guiana, the total thickness of all "young" sediments on top of the weathered basement rocks exceeds 2000 m. Further to the east, this maximum thickness decreases to about 300 m around Paramaribo" (Montagne, 1964: 500-501). The thickness of the Holocene beds forming the upper and northern part of this complex is known more or less exactly from a number of borings. In Suriname they are presumably thickest in the northwest, where according to IJzerman (1931: 51) undoubtedly the upper dozens of metres of the boring section near Nickerie belong to the "Fluvio-marine Deposits", the thickness of which might even be about 100 m.

The most exact data about the lower limit of the Demerara series are from the neighbourhood of Paramaribo. D'Audretsch (1953: 239) found this limit at a depth of 16.50 m at Nieuw Amsterdam, 24.00 and 28.50 m at Zorg en Hoop and 10.00 m at Livorno. Montagne (1964: 501) states that in the more southward Onverdacht area "shell remnants (*Ostrea* sp.)" occurring at about 6-10 m below the surface prove the existence of marine to brackish water deposits of the Demerara series at that level.

In the boring Alliance-28 in the Commewijne district Holocene beds were found to a depth of 23.50 m. In this well-studied boring no marine molluscs were found between the Holocene beds and those of Palaeocene age at a depth of more than 200 m (v. R. Altena, in press).

D'Audretsch (1953: 241) found shells of marine molluscs all belonging to the Recent fauna of Suriname (cf. p. 20) in brown stained clays and underlying sandy clays at depths of 36 and ca. 75 m at Zorg en Hoop. These beds probably belong to the Coropina series to which a Pleistocene age is assigned by Montagne (1964: 500). Moreover fragments of shells partly not belonging to species known from the Recent fauna of Suriname were found in green clay at a depth of 167 m at Nieuw Amsterdam (d'Audretsch, 1953: 242). These are the only indications of marine molluscs younger than Palaeocene and older than Holocene occurring in Suriname which I could find. It should, however, be borne in mind that the shells recorded by IJzerman (1931: 48) from greater depths, especially from 84.80-100.50 m, near Nickerie may very well be older than Holocene (cf. p. 20).

At the surface the deposits belonging to the Demerara series consist of sand reefs more or less parallel to the coast alternating with slightly lower plains of clay which are for a great part covered by swamps. The sand reefs contain the so-called shell-ridges: beds of shells which were washed ashore when these reefs formed the beach of the regressing sea. Locally the shells in the ridges are cemented together and form beds of coquina, e.g. in the ridge

behind the football grounds at Groningen (Pl. 3 Fig. 13, 14). Martin (1888: 199) mentions such a coquina from the bank of the Suriname River opposite the "Gouvernementsplein", the central square of Paramaribo. IJzerman records "shell-breccias . . . formed by recrystallization of calcite" i. a. from "the landing-place at Groningen on the Saramacca". For an account of the morphology of the sand- and shell-ridges I refer to the paper by Geijskes (1952).

Collecting in the shell-ridges is easy and, therefore, I can dispose of a large collection from many localities in the ridges. No shells from the ridges in the Marowijne District are available. Here the sand reefs seem to contain hardly any or no molluscs. Not a single shell was found during the crossing of the eastern coastal plain made by the 1948-1949 expedition, although many pits were dug (Brouwer, 1953: 228). I doubt whether the samples by Schepman (1887) from "at the Marowijne" really are from shell-ridges.

All the bivalves found in the shell-ridges belong to Recent species, but among the gastropods at least three species are unknown in a living state. They belong to the Vitrinellidae, a family of minute forms hardly studied in this region and therefore it seems likely that eventually these three species will appear to be still living in this area (v. R. Altena, 1966). On the whole the fauna of the shell-ridges is very much the same as that found washed ashore on the Suriname coast at present. Bivalves outnumber gastropods as to species and still more so as to specimens. The commonest large species are the bivalves *Crassostrea rhizophorae* (Guild.), *Chione subrostrata* (Lam.) and *Mulinia cleryana* (d'Orb.), and the gastropods *Natica cayennensis* Recl., *N. marochiensis* (Gm.) and *Marginella prunum* (Gm.).

A number of species have been found in the ridges which are not known to occur on the coast. Some of these are rare and may have been overlooked, but others presumably indicate that minor changes occurred in the composition of the Suriname marine mollusc fauna since the shell-ridges were deposited. So the large bivalves *Lucina pectinata* (L.) and *Sanguinolaria operculata* (Gm.) are known from two localities in the ridges but not from the coast; the smaller *Strigilla pisiformis* (L.), *Eulima* sp. and *Terebra* sp. have been found in several localities in the ridges but not on the coast, while *Tivela geijskesi* v. R. Altena is locally abundant in the ridges but has hardly been found on the coast.

The beds of clay in between the ridges also contain shells, as sometimes appears when ditches or canals are dug. So in March 1963 Dr. L. J. Pons showed me a locality at Jarikaba near Uitkijk where we found the following species in the clay dug out of a newly made canal:

<i>Protothaca pectorina</i> (Lam.):	several entire shells,
<i>Tagelus plebeius</i> (Lightf.):	several entire shells,
<i>Tellina diantha</i> (Boss):	a few entire shells and odd valves,
<i>Macoma constricta</i> (Brug.):	several entire shells and odd valves,
<i>Mulinia cleryana</i> (d'Orb.):	some entire shells and several odd valves,
<i>Nassarius vibex</i> (Say):	some shells.

The great number of entire shells of bivalves makes it probable that they had been embedded in situ or very near the place where they had lived. Locally the clay was more sandy and contained moreover odd valves of *Anadara brasiliensis* (Lam.), *Lunarcia ovalis* (Brug.) and *Anomia simplex* d'Orb. This whole fauna certainly lived in shallow water.

The shells and shell fragments from boring cores which I could examine form a much smaller collection than that from the shell ridges. The greater part of the samples are from boring Coronie-35: 16 species of bivalves and 2 of gastropods from depths between 6.30 and 21.70 m, and from boring Alliance-28: 18 species of bivalves and 14 of gastropods from depths of 12.25 to 16.25 m. The fauna met within the latter boring certainly lived at some distance off the coast at a depth which was estimated ca. 10 fathoms (v. R. Altena, in press), but at present I would rather say 5-10 fathoms. Roughly similar ecological conditions may be assumed for the fauna (13 species) found at a depth of 15.75 to 18.70 m in boring Coronie-35.

6. THE ECONOMIC IMPORTANCE OF SURINAME MARINE MOLLUSCA

From the literature it would appear that oysters were frequently eaten by Europeans living in Suriname in previous centuries (for references see p. 6). During my stay in Paramaribo in 1963, however, I never heard of oysters being eaten and Geijskes informed me that in all the years he lived in Suriname no instance of oysters being used for food had ever come to his attention. Probably the easier importation of food from elsewhere has emancipated at least the population of Paramaribo from this autochthonous source of food.

Kappler (1887: 203-204) mentions some species of molluscs which were eaten by the Indians on the Marowijne (see p. 10). I do not know if molluscs are still of importance as part of their food. Geijskes does not think so, but he told me that molluscs are often collected by the Indians to be used as bait for fishes.

Marine molluscs may have an indirect importance for the economy of Suriname as they presumably are a part of the food of bottom fishes. Mrs

Lowe (1962) states that bottom invertebrates are an important component of the food of fishes off the coast of British Guiana. Although annelids dominate among these invertebrates, molluscs are certainly part of them. Trawl fisheries have started in Suriname since the second world war and may be a source of food of gradually increasing importance for the country.

Ever since the time of Columbus the West Indies have been notorious for the damage done to wooden ships by shipworms. In Suriname also these boring bivalves were a dreaded pest, as appears from the accounts of several authors referred to on p. 8. At present the main problem posed by teredinids is how to protect wooden structures like jetties and the doors of locks against their attacks. *Neoteredo reynei* (Bartsch) is the species which has done much damage in the neighbourhood of Paramaribo. Reyne (1921?) states that the doors of the sluice in the Saramacca Canal at Beekhuizen were destroyed in a few years, notwithstanding the fact that they had been made of "Demerara Greenheart" (*Nectandra rodioei* Schomb.). By long experience this kind of wood had proved to be resistant against *Teredo navalis* L. in England and the Netherlands. A fresh piece of "Demerara Greenheart" sunk into the just mentioned sluice in February 1920 appeared to have been already seriously attacked in June of the same year. The larger burrows had then reached a diameter of 9 mm and the animals had penetrated 10 cm into the wood.

The devastating powers of *Neoteredo reynei* make it a very useful species for checking the resistance of kinds of wood against the attacks of borers. It was used for this purpose by J. W. Gonggrijp (e.g. 1923, sep.: 18) in a series of experiments with Suriname kinds of wood and by Spoon & Loosjes (1946) in a test of eight kinds of wood of various origins. Gonggrijp (e.g. 1924: 24-25) found the presence of silica particles in the wood to be an important indication of its resistance, kinds of wood containing more than 0.5 % their weight of these particles proving to be resistant against teredinids.

The damage done by *Lignopholas clappi* Turner, a pholad mentioned as *Martesia cuneiformis* by J. W. Gonggrijp (1923, sep.: 13-14) and as *Martesia* spec. by Spoon & Loosjes (1946, sep.: 5) is unimportant, as these animals do not penetrate far into the wood.

Dr. Geijskes told me that the Suriname Water Company uses shell beds in the pumping-station at Republiek to increase the pH of the ground water to 7 in order to counteract the erosion of the water-pipes to Parbo.

The Holocene shells of the shell-ridges are used in the construction of roads which preferably follow the sand reefs (Pl. 3 Fig. 13-16). I saw blocks

of coquina used for sheet piling the bank of a ditch near the jetty of the ferry on the Saramacca opposite Uitsicht in March 1963.

7. ORIGIN OF THE MATERIAL STUDIED

a. Collections and collectors

The Mollusca from Suriname which I could study belong to the following five museums.

Rijksmuseum van Geologie en Mineralogie, Leiden. — This museum owns the collection of shells from the shell-ridges which F. Voltz brought together in 1853-1855 and on which Schepman reported in 1887. For particulars about Voltz see the next section.

Rijksmuseum van Natuurlijke Historie, Leiden. — Marine Mollusca from Surinam collected by several persons found their way to this museum. Disregarding the old collections dealt with in chapter 3, as well as some more recent acquisitions of which the labels appear to be unreliable, the following is a list of these collectors.

H. H. Dieperink (1794-1842) was a military apothecary in Paramaribo from about 1816 to 1836, who sent at least 13 consignments of preserved and living animals to the Leiden Museum between June 1824 and April 1836 (Holthuis, 1959: 21). In the extensive lists of these consignments still preserved in the archives of the Museum, Mollusca are mentioned in two places. The translation of one entry in the list of the fourth consignment runs as follows. "Some tree oysters, *Ostrea edulis*. Houttuin (sic) vol. 1, part 7, p. 314, describes very well how these grow fixed to trees called Mangrove". Houttuyn is the author of an illustrated Natural History according to the system of Linnaeus which appeared from 1761 to 1785 in 37 parts; the reference should be to vol. 1, part 15, p. 314 (Houttuyn, 1771). Dieperink's ninth consignment includes "a small cuttlefish, *Sepia marina*". The oysters are still in the Museum's collection, partly preserved in alcohol, but the cephalopod could no longer be traced.

F. Voltz, (1828-1855), a geologist, was a member of a German commission invited by the Dutch government to study the geological, medical and agricultural conditions in Suriname in view of the possibility of founding a colony for convicts from the German countries. The preliminary results of his studies are known from letters to Sandberger (Sandberger, 1853, see also Staring, 1854a) and to the Dutch geologist W. C. H. Staring (Staring, 1854b, 1855, also translated in German: Anon., 1855). Voltz died from yellow fever in Paramaribo one day before his intended return to Europe (Sijpesteijn, 1856; Sandberger, 1856). Some Recent shells collected

by Voltz, labelled "Nickerie", are in the Rijksmuseum van Natuurlijke Historie.

C. J. Hering (1829-1907) was born and lived in Suriname where he was mainly occupied in agriculture (Holthuis, 1959: 25). Among the many zoological specimens he sent to the Leiden Museum there is one mollusc, a specimen of *Acanthopleura granulata* (Gm.) labelled "Suriname". This species has never been found again in Suriname and, as it is an inhabitant of rocky shores, I do not trust the locality label.

H. F. C. ten Kate (1858-1931) was an ethnologist and anthropologist who visited Suriname in 1885-1886, making several trips in the coastal region (Holthuis, 1959: 26). The zoological material he collected was donated to the Leiden Museum and contains marine Mollusca in alcohol and dry shells from localities on the coast as well as from the shell-ridges.

J. Semmelink (1837-1912) was a military surgeon in the Netherlands East Indies from 1859 to 1882, who afterwards settled in the Hague as a civil physician (van Benthem Jutting, 1939: 177). Among the Mollusca he presented to the Rijksmuseum van Natuurlijke Historie in 1909 and 1910 were some shells from Suriname, presumably duplicates from his own collection. There is no indication that he visited Suriname himself and we do not know who collected these shells for him.

D. G. J. Bolten (1871-1960) was a military apothecary in Suriname from 1902 to 1910, whose zoological collections presented to the Leiden Museum (Holthuis, 1959: 27) include some samples of shells labelled "Suriname".

A. J. Schimmelpenninck van der Oye (1872-1945) when administrator of the Finance Department of Suriname (Holthuis, 1959: 29) sent lots of molluscs to the Leiden Museum in 1913 and 1914. Most of these are shells collected at Braampunt at the mouth of the Suriname River.

M. D. Horst (1879-1958) visited Suriname in 1907 when he was ship's surgeon (Holthuis, 1959: 28). The zoological material he collected for the Leiden Museum contains a few Mollusca.

W. C. van Heurn (born 1887), a biologist, visited Suriname in 1911 and made extensive zoological collections for the Rijksmuseum van Natuurlijke Historie (Holthuis, 1959: 29). Shells, both from the coast and the ridges, were collected by him in large series. Unfortunately the greater part of his samples is labelled "Suriname" or "Paramaribo" only and so we are not even sure if they are from the ridges or from the beach. Nevertheless this is one of the main contributions to our Suriname collection of Mollusca.

W. A. Collier (1896-1960) was Head of the laboratory for bacteriology of the Government Hospital in Paramaribo from 1950 to 1957 (Wolff, 1961). During these years he made extensive collections of shells, both from

some localities along the coast and from the shell-ridges in the neighbourhood of Paramaribo. After his death his collection was acquired by the Leiden Museum.

R. IJzerman (born 1901), a geologist, wrote a thesis entitled "Outline of the geology and petrology of Surinam" (Utrecht, 1931). He participated in the expedition to the Wilhelmina Range under the leadership of Dr. G. Stahel in 1926 (Holthuis, 1959: 38). Some shells he presented to the Leiden Museum were collected during his stay in Suriname in 1926.

H. W. Lijding (born 1903) was Head of the Suriname Fisheries Service when in 1957 the American trawler "Coquette" was used for exploring the sea off the Suriname coast. He did part of the collecting of fish and marine invertebrates during the first six cruises of the "Coquette" (Holthuis, 1959: 33, 41).

P. Wagenaar Hummelinck (born 1907), a biologist, visited Suriname several times (Holthuis, 1959: 33). The Rijksmuseum van Natuurlijke Historie received some samples of marine molluscs which he collected at Purmerend in 1965.

D. C. Geijskes (born 1907) was the Entomologist of the Agricultural Experiment Station of Suriname from 1938 to 1952, Government Biologist of Suriname from 1952 to 1954 and Director of the Suriname Museum from 1954 to 1965 (Holthuis, 1959: 31). During all these years he collected Mollusca in the neighbourhood of Paramaribo as well as on his numerous shorter and longer trips in all parts of the country. He also did part of the collecting during the first six cruises of the "Coquette" (Holthuis, 1959: 41). The greater part of his collection is in the Leiden Museum and it is the most important part of the material I studied, as no other collector found so many species or visited so many localities.

C. O. van Regteren Altena (born 1907), Curator of Mollusca at the Rijksmuseum van Natuurlijke Historie, visited Suriname in 1963 and collected Mollusca in several localities along the coast and in the shell-ridges. A few samples were collected by him when on board of the "Coquette" during one of her weekly trips.

H. W. C. Cossee (born 1914), taxidermist in the ornithological department of the Leiden Museum, visited Suriname during a collecting trip in 1939 (Holthuis, 1959: 39). The collections he made include a few Mollusca.

J. van der Drift (born 1917), a biologist, studied the fauna of the sandy soils in Suriname in 1959 (Van der Drift, 1963). Among the land molluscs from Tambaredjo and Sidoredjo he sent for identification to the Leiden Museum were a few shells of Holocene marine gastropods.

L. B. Holthuis (born 1921), curator of Crustacea at the Rijksmuseum van

Natuurlijke Historie, visited Suriname in 1957 (Holthuis, 1959: 34). He enriched our molluscan collection mainly with shells of gastropods which had been inhabited by pagurids.

A. C. J. Burgers (born 1925), a biologist, visited Suriname in 1957 to study the eyestalk hormones of Crustacea (Holthuis, 1959: 34). He collected some shells at the mouth of the Matapica Canal for the Leiden Museum.

Moreover some molluscs collected during the 1948-1949 Suriname Expedition by D. C. Geijskes and P. H. Creutzberg (Holthuis, 1959: 39) and a great part of the Mollusca dredged off the Suriname coast in 1957 by the trawler "Coquette" (Holthuis, 1959: 41) are in the Rijksmuseum van Natuurlijke Historie.

Surinaams Museum, Paramaribo. — Most of the Mollusca in this museum were collected by D. C. Geijskes from 1938 to 1965. Part of the material dredged off the Suriname coast by the "Coquette" in 1957 is kept here.

United States National Museum, Washington, D. C. — Another part of the Mollusca dredged off the Suriname coast by the "Coquette" in 1957 belongs to this museum. The bivalves could be studied by the author, but the gastropods will be dealt by H. R. Bullis. Shells collected along the Suriname coast by P. J. V. Delaney in 1955 were presented to the U. S. National Museum and could be studied by the author in 1963.

Zoölogisch Museum van de Gemeentelijke Universiteit, Amsterdam. — Duplicates retained by Schepman from the Voltz collection of shells from the shell-ridges are kept in this museum.

b. Localities.

In the map on plate 4 most of the localities from which I have examined marine Mollusca are indicated. The localities where Holocene shells were collected from outcrops, except the numbers 3, 5, 16 and 19 all in the shell-ridges, are numbered from 1 to 34 according to the following list.

Nickerie District: 1. Stalweide. — 2. Van Drimmelpolder. — 3. Clay dug from a canal near Hertenrits. — 4. Cupido on the Maratakka.

Coronie District: 5. Dike of clay south of the main road at Totness. — 6. Indjikondre, kilometre-stone 134. — 7. Kilometre-stone 117-118. — 8. Picket 216, 217 and other localities of the 1948-1949 Suriname Expedition.

Saramacca District: 9. Kilometre-stone 79. — 10. Carl François, Kilometre-stone 76. — 11. Kilometre-stone 72½. — 12. Sidoredjo. — 13. Tambarédjo. — 14. Kilometre-stone 50. — 15. Groningen, Kilometre-stone 45-46. — 16. Near the jetty of the ferry to Uitkijk. — 17. Garnizoenspad at ca. kilometre-stone 25. — 18. Baboen Creek, ca. kilometre-stone 15.

Suriname District: 19. Clay dug from a canal near Jarikaba. — 20. Vierde Rijweg. — 21. Derde rijweg. — 22. Ridge crossing the Fernandez Road, including the localities Tingiholo and Sniphout. — 23. Jodenkerkhof, at the northwest side of Paramaribo. — 24. Ridges just north of Paramaribo, including the localities Munderweg, Cultuurtuin, Charlesburgerweg and Krepi. 25. Paramaribo, including the localities Gravenstraat, Noorderkerkstraat, Herenstraat and Kerkplein in the centre, and Zorg en Hoop in the southwest. — 26. Blauwgrond.

Commewijne District: 27. Meerzorg. — 28. Jagtlust. — 29. Lust en Rust. — 30. Belwaarde. — 31. Klein Voorburg. — 32. Constantia. — 33. Tapoeripa. — 34. Anna Catharina.

The situation of well borings from which material was examined is marked by the numbers 41 to 44.

Coronie District: 41. Coronie-35.

Suriname District: 42. Region between Onoribo and Paranam, including the borings Onoribo III, La Vigilantie, Hole V6-312 and Paranam.

Commewijne District: 43. Nieuw Amsterdam. — 44. Alliance-38.

The localities on the coast and in brackish water are numbered from 51 to 97 as listed below.

Nickerie District: 51. Beach of eastern bank of Corantijn River. — 52. Sea-dike of Nieuw Nickerie. — 53. Bank of Nickerie River south of Nieuw Nickerie. — 54. Beach of eastern bank of Nickerie River. — 55. Coast east of mouth of Nickerie River. — 56. Coast near mouth of Kweriman Creek. — 57. Coast near mouth of Box Creek.

Coronie District: 58. Coast near mouth of Tweeling Creek. — 59. Coast near Totness. 60. Jetty of ferry on Coppename River.

Saramacca District: 61. Jetty of ferry on Coppename River. — 62. Coast at Coppename Point. — 63. Hermina flat. — 64. Camping site 11/12.VI.1959 D. C. Geijskes. — 65. Coast near mouth of Popogaimama Creek. — 66. Coast near mouth of Toeholi Creek. — 67. Coast at Toniholo. — 68. Coast near mouth of Gandoe Creek.

Suriname District: 69. Coast at end of Fernandez road. — 70. Bank of Suriname River at Purmerend. — 71. Jetty at Leonsberg. — 72. Jetty of Plantation Geysersvliet. — 73. Bank of Suriname River at Combe. — 74. Bank of Suriname River at Plantation Toevlucht. — 75. Bank of Suriname River at Torarica. — 76. Bank of Suriname River between Palmaneribo Creek and Makanai Creek.

Commewijne District: 77. Ditches of fortress of Nieuw Amsterdam. — 78. Bank of Suriname River at Plantation Resolutie. — 79. Bank of Suri-

name River at Post Leiden. — 80. Braampunt. — 81. Warappa Coast. — 82. Coast near mouth of Kat Creek. — 83. Coast near mouth of Warappa Creek. — 84. Coast near mouth of Matapica Canal. — 85. Halet. — 86. Krofajapassie. — 87. Coast near mouth of Mot Creek.

Marowijne District: 88. Bigisanti. — 89. Wiawia coast. — 90. Godoholo. — 91. Lubin Bank. — 92. Tijger Bank. — 93. Bank of Marowijne River at Galibi. — 94. Bank of Marowijne River at Christiaankondre. — 95. Bank of Marowijne River at Langamankondre. — 96. Bank of Marowijne River at mouth of Wane Creek. — 97. Bank of Marowijne River at Albina.

The localities off the coast are listed in the Tables 2-4; they all refer to dredgings by the trawler "Coquette". The labels of the material from the cruises 1-6 do not refer to single dredge hauls and consequently the letters A-F only indicate general regions where dredging was done during these cruises. Two other letters, viz., L and R, refer to the light-ship off the mouth of the Suriname River and the buoy near the remains of the jetty of Nieuw Rotterdam, a town swallowed by the sea about 1870.

The localities where the "Coquette" operated during her 7th to 17th cruise are exactly indicated on the map. Some samples, however, were labelled "9 VII 1957", which must be a lapsus for 19-22 VII 1957, as no dredging was done between 9 and 19 July of that year. The samples thus labelled must be from the localities 309-359 and 360. The region including the localities 309-359 is, therefore, marked as a whole. Locality no. 89, situated off the coast of French Guiana, has been included in Table 2, because Mrs Nijssen-Meyer (1965: 146) recorded *Bornella calcarata* Mörch from that station. When she prepared her paper we did not realise that this locality was not off the Suriname coast. The *Bornella* is the only specimen from off the coast of French Guiana which I found in the "Coquette" material.

Part of the material from the 1957 cruises was labelled by a locality number and the depth in feet only. These depths do not agree with those of the localities bearing the same numbers on the "official" list of localities from which the data in table 2 were compiled. This series of samples can, therefore, not exactly be located, but they are of some value, because they prove the occurrence of certain species at a certain depth off the Suriname coast. These localities are found in table 3. To distinguish them from those of table 2 they will be cited between quotation marks throughout this paper.

Table 4 contains the localities from which I received material from the Suriname Fisheries Service in 1963 and at which I was enabled to do some collecting myself. These "VRA" numbers are encircled in the map.

In the Tables 2-4 for every locality the approximate number of species

TABLE 3

station no.	date	depth on label	depth reduced to fathoms	Bivalvia	Scaphopoda	Gastropoda
"1"	1.IV-31.VII.1957	14'-147'	2-24	3	-	11
"2"	do.	138'-139'	23	17	2	10
"6"	do.	141'-143', or 140'-147'	24	2	-	11
"7"	do.	144'	24	1	-	10
"8"	do.	145'	24	1	-	7
"11"	do.	144'-142'	24	2	-	12
"14"	do.	140'-141'	23	6	-	16
?	do.	138'-139'	23	-	-	1

that could be studied are given in the last three columns. This is the number which was retained and may be much lower than the number which was dredged.

8. THE MARINE MOLLUSCA OF FRENCH AND BRITISH GUIANA

Although the Suriname marine molluscan fauna includes species which are spread as far north as the coast of Massachusetts and others occurring on the Brazilian coast as far as Rio de Janeiro, its closest affinities are, of course, to the fauna of the neighbouring Guianas. Therefore I have paid special attention to the fauna of French and British Guiana.

Records of species occurring on and off the coast of these countries are scattered in the literature. For instance Cayenne or "la Guyane" is the type locality of several species described by Lamarck, Deshayes and Recluz. As to the Muricidae occurring off the Guianas we are well informed by Bullis's paper (1964). For the rest, however, very few publications devoted especially to the marine molluscs of these countries appear to exist.

For the sea within a depth of about 60 fathoms off the coast of French Guiana Durand (1960) mentions some 35 species of Mollusca, of which at least the following are also found off the Suriname coast (the page of the record preceded, when necessary, by the name used by Durand is added in brackets):

- Anadara brasiliiana* (Lam.) (34)
- Glycymeris pectinata* (Gmel.) (*Gl. tessellata*, 34)
- Atrina serrata* (Sow.) (*Pinna s.*, 34, 37)
- Plicatula gibbosa* Lam. (34, 37)
- Amusium papyraceum* (Gabb) (34, 36-40, photo 18)
- Aequipecten gibba* (L.) (*Pecten nucleus*, 34, 35)
- Lyropecten nodosus* (L.) (*Pecten n.*, 34, 35)
- Crassostrea rhizophorae* (Guild.) (*Ostraea brasiliiana*, 35)
- Arcinella arcinella* (L.) (*Chama a.*, 34, 35)
- Dosinia concentrica* (Born) (35)

TABLE 4

general region	station no.	date	locality	depth in fathoms	donor	remarks	Bivalvia	Scaphopoda	Gastropoda	Cephalopoda
off Suriname District off Suriname	VRA 4 VRA 5	I.1963 do.	N of Lightship ?	30 ?	Surinam Fisheries Service do.	mainly small species from <u>Murex</u> and oyster shells	1 14	- -	2 2	1 1
off Coronie District off Suriname District off Marowijne District	VRA 6 VRA 11 VRA 11a	do. do. do.	N of Coppename off 3 miles E to 6 miles W of Lightship off 30-45 miles E of Lightship	ca. 18 17-18 6-8	do. do. do.	mainly small species from concretions and old shells	1 15 3	- - -	- 2 7	- - -
off Suriname District off Saramacca District off Coronie District off Suriname District do.	VRA 17 VRA 18 VRA 18a VRA 20 VRA 62	II.1963 do. do. 19.II.1963 26-29.III.1963	N of Lightship N of Lightship to N of Coppename N of mouth of Coppename River off ca. 5 miles NW of Lightship off 10-12 miles NW of Lightship, end of mud zone	17 25-30 ? 17 12-13	do. do. do. author Surinam Fisheries Service do.	from concretions	14 9 1 1 -	- - - - -	7 3 2 1 1	- - - - -
do.	VRA 63	III.1963	off 10 miles NW of Lightship	13	do.		-	-	1	-

- Chione subrostrata* (Lam.) (*Venus s.*, 35)
 ?*Chione latilirata* (Conr.) (*Venus (Lirophora)* sp., 35)
 ?*Tagelus plebeius* (Lightf.) (*Tagelus* sp., 35)
Macoma constricta (Brug.) (35)
 ?*Macoma tageliformis* Dall or *cleryana* (d'Orb.) (*Macoma (Psammocoma)* sp., 35)
Trachycardium isocardia (L.) (*Laevicardium i.*, 35)
Neritina zebra (Brug.) (35)
Littorina nebulosa (Lam.) (34, 35)
Architectonica nobilis Roed. (*Solarium granulatum*, 34, 37)
Natica marochiensis (Gm.) (34, 37)
Natica cayennensis Recl. (*N. affinis*, 34)
Bursa spadicea (Montf.) (34, 37, photo 16)
Tonna galca (L.) (*Dolium g.*, 34, 36, 38, photo 17)
Murex brevifrons Lam. (34, 37)
 ?*Murex donmoorci* Bullis (*M. cabriti*, 34)
Thais coronata (Lam.) (an subsp. *trinitatensis* (Guppy)?) (34, 35)
Pugilina morio (L.) (*Semifusus m.*, 34, 35)
Fasciolaria tulipa (L.) (34, 37)
Fusinus sp. (*Fusus turris*, 34, 37)
Polystira albida (Perry) (34, 35)

Faunistic data about British Guiana were published by Schomburgk (1847, 1848), Morrison (1943) and Graham (1955).

"*Teredo navalis* Lin." is the only marine mollusc which Schomburgk said to have found living in British Guiana. He considered *Neritina zebra* (Brug.) collected at the mouth of the rivers Essequibo and Demerara a freshwater snail transported by the current from the upper rivers (Schomburgk, 1848: 545). The same author describes a large accumulation of shells at the mouth of the Waini which seems comparable with the Surinam shell-ridges. My interpretation of his list of species (1847: 107; 1848: 545), with the names used by Schomburgk added in brackets when necessary, is as follows:

- ?*Nuculana concentrica* (Say) (*Nucula rostrata*)
Tagelus plebeius (Lightf.) (*Solen caribaeus*)
Natica marochiensis (Gm.)
Tonna galea (L.) (*Dolium fasciatum*)
Thais haestoma floridana (Conr.) (*Purpura cataracta*)
Nassarius vibex (Say) (*Buccinum miga*)
Melongena melongena (L.) (*Pyrula m.*)
Pugilina morio (L.) (*Fusus m.*)
Marginella prunum (Gm.) (*M. coerulescens*)

Morrison (1943), described "a new type of fresh water clam", *Guianadesma sinuosum*, from the Cuyuni River opposite Kartabo Point. *Guianadesma* Morrison, 1943, has appeared to be a synonym of *Anticorbula* Dall, 1898. As explained in chapter 4c I consider *Anticorbula sinuosa* a brackish water species as its distribution in the Suriname River seems to be con-

trolled by the influx of seawater. In British Guiana Morrison found it associated with *Littoridina* spec.

Graham's popular booklet "Sea shore life of British Guiana" contains two plates with figures of shells. Although these figures are not very elaborate, most of them struck me as characteristic of shells commonly washed ashore on the Suriname coast. Hence I am almost sure that Graham found the following species of marine molluscs washed ashore in British Guiana.

- Anadara brasiliana* (Lam.) (*Arca* sp., pl. III fig. 21)
Lunarca ovalis (Brug.) (*Acra* (sic) *transversa*, pl. III fig. 16)
Chlamys linki (Dall) (*Pecten* sp., pl. III fig. 20)
Anomia simplex d'Orb. (Mother of Pearl Shell, pl. III fig. 15)
Crassostrea rhizophorae (Guild.) (*Ostrea* sp., pl. III fig. 3, 4; ? *Ostrea* sp., pl. III fig. 2)
Mytella charruana (d'Orb.) (*Modiolus arborescens*, pl. III fig. 12)
Cyrtopleura costata (L.) (*Pholas* sp., pl. III fig. 6)
Pholas campechiensis Gm. (*Pholas* sp., pl. III fig. 7)
Teredinidae, gen. spec. (*Teredo* sp., pl. III fig. 19)
Corbula caribaea d'Orb. (*Corbula contracta*, pl. III fig. 17)
Polymesoda aequilatera (Desh.) (*Lucina* sp., pl. III fig. 11)
Chione subrostrata (Lam.) (*Venus* sp., pl. III fig. 18)
Protothaca pectorina (Lam.) (*Chione staminea*, pl. III fig. 1)
? (*Lucina* sp., pl. III fig. 13)
Donax spec. (*Donax lamarckii*, pl. III fig. 8)
Tagelus plebeius (Lightf.) (*Tagelus* shell, pl. III fig. 14)
Tellina diantha (Boss) (*Tellina* sp., pl. III fig. 9)
Macoma constricta (Brug.) (Large Tellen, pl. III fig. 10)
Mulinia cleryana (d'Orb.) (*Spisula truncata*, pl. III fig. 5)
Neritina zebra (Brug.) (*Nerita viginea* (sic), pl. II fig. 8)
Littorina nebulosa (Lam.) (*Littorina scalra* (sic), pl. II fig. 20)
**Ianthina* spec. (*Ianthina* (sic) sp., pl. II fig. 12)
**Strombus gigas* L. (pl. II fig. 15)
Natica marochiensis (Gm.) (*Natica maroccana*, pl. II fig. 9)
**Cypraea* spec. (pl. II fig. 18)
Toma galea (L.) (pl. II fig. 13)
Thais haemastoma floridana (Conr.) (pl. II fig. 21; ? Furrowed Whelk, pl. II fig. 16)
Thais coronata trinitatensis (Guppy) (*Thais haemastoma*, pl. II fig. 1, 2)
Melongena melongena (L.) (*Thais* sp., pl. II fig. 2, 3)
Nassarius vibex (Say) (*Nassa pauperata*, pl. II fig. 6)
Marginella prunum (Gm.) (*Marginella* sp., pl. II fig. 7)
*Bulla spec. (*Bulla striata*, pl. II fig. 10)
Ellobium pellucens (Menke) (*Auricularia gangetica*, pl. II fig. 19)
Melampus coffea (L.) (Salt Marsh Snail, pl. II fig. 14)

The species marked by an asterisk have not been found in Suriname.

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Plate 1

1, "l'Amiral de Surinam" of d'Argenville, 1757, Fig. R; 2, "Le Papier marbré à cordon" of Favanne de Montcervelle, 1780, Fig. E5; 3, "l'Amiral de Surinam" of Favanne de Montcervelle, 1780, Fig. D3; 4, "Die braungestrahlte dickschaalige Napfschnecke von Surinam" of Martini, 1790, Fig. 50; 5, *Cypraea surinamensis* Perry, 1811, Pl. 20 No. 4.

Plate 2

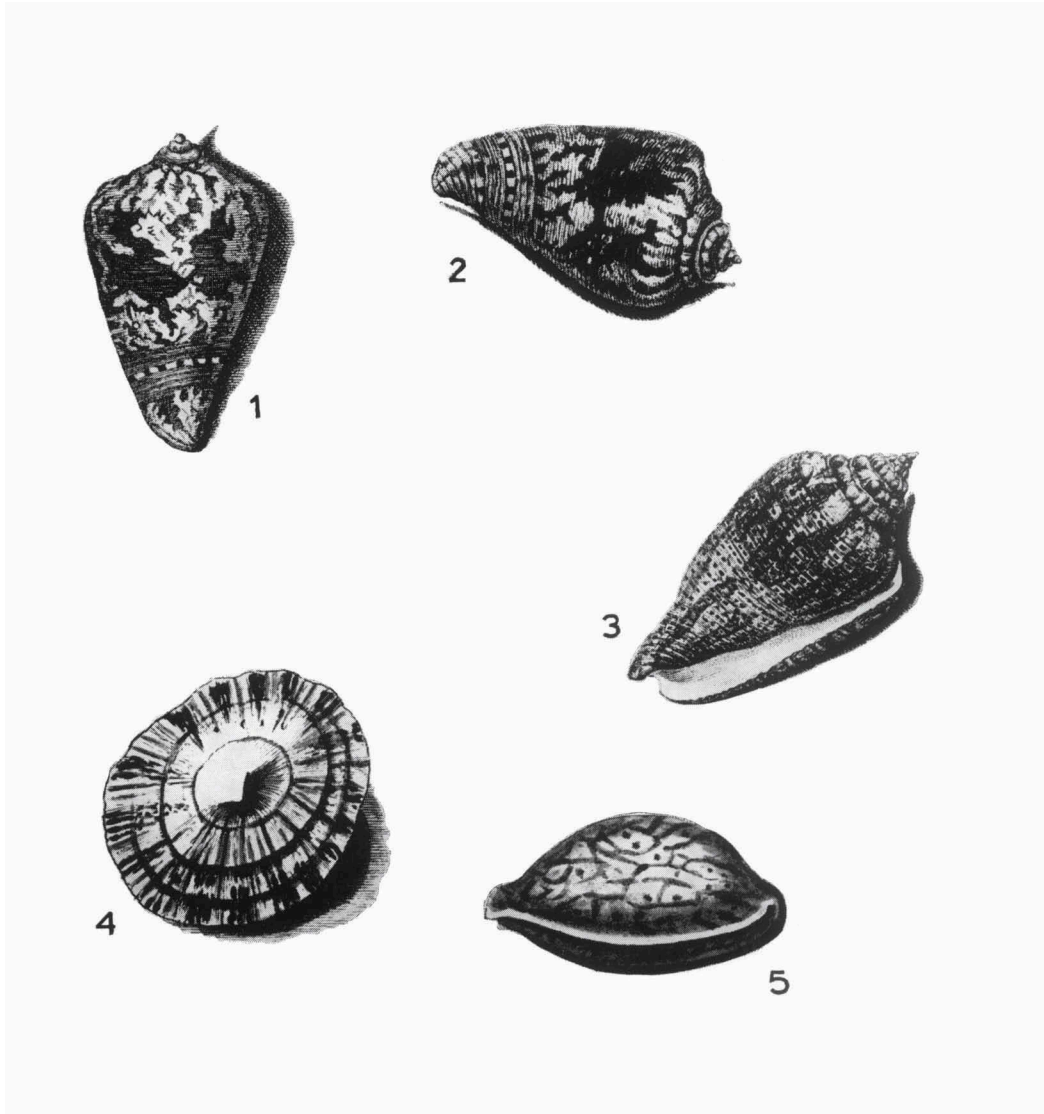
6, beach near the mouth of the Matapica Canal, with traces of man-made ditches; 7, *Littorina nebulosa* on branches of *Avicennia*; 8, beach at the west end of the dike west of Nickerie; 9, beach along the mouth of the Corantijn River; 10, dike west of Nickerie; 11, *Littorina nebulosa* on the dike west of Nickerie.

Plate 3

12, Suriname River and ditch of old fortress Nieuw Amsterdam, where *Ellobium pellucens* and *Detracia parana* are living; 13, Groningen, shell ridge; 14, Groningen, detail of shell ridge with blocks of coquina; 15, near Charlesburgweg, excavations of shell ridge; 16, Kwattaweg, excavation of shell ridge.

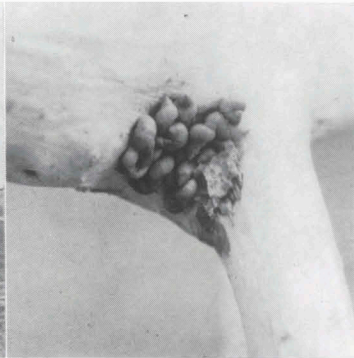
Plate 4

Map of the localities on the shell ridges, along the coast and off the coast to 30 fathoms in Suriname (see chapter 7b).





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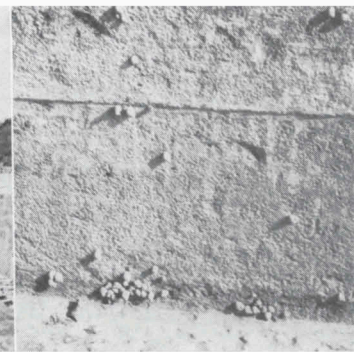
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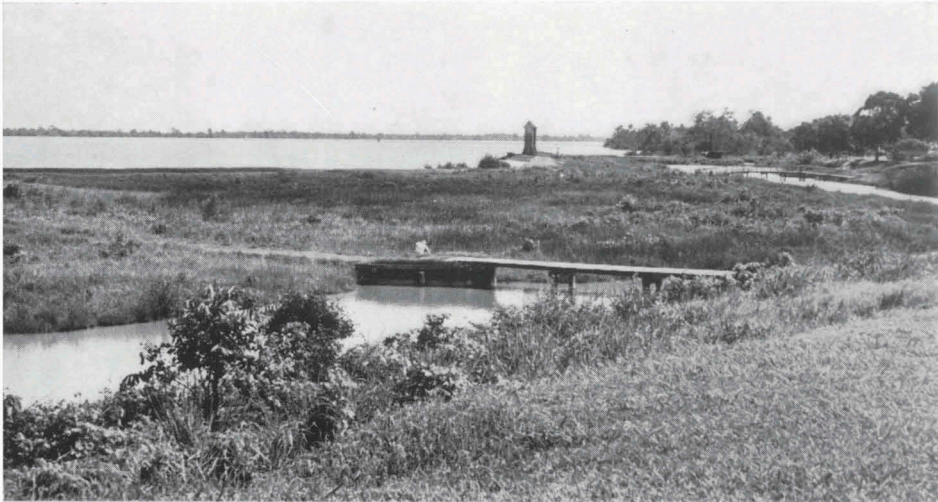
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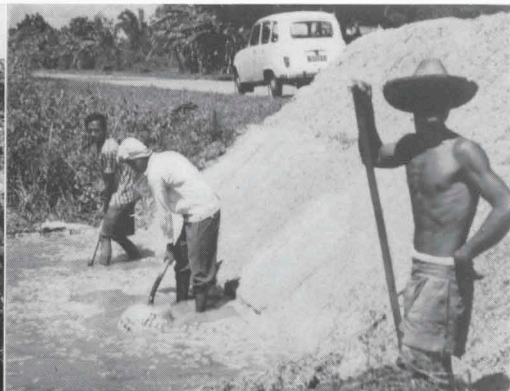
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