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THE ASCIDIAN FAUNA OF PORT ROYAL, JAMAICA I. HARBOR AND MANGROVE DWELLING SPECIES

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ABSTRACT

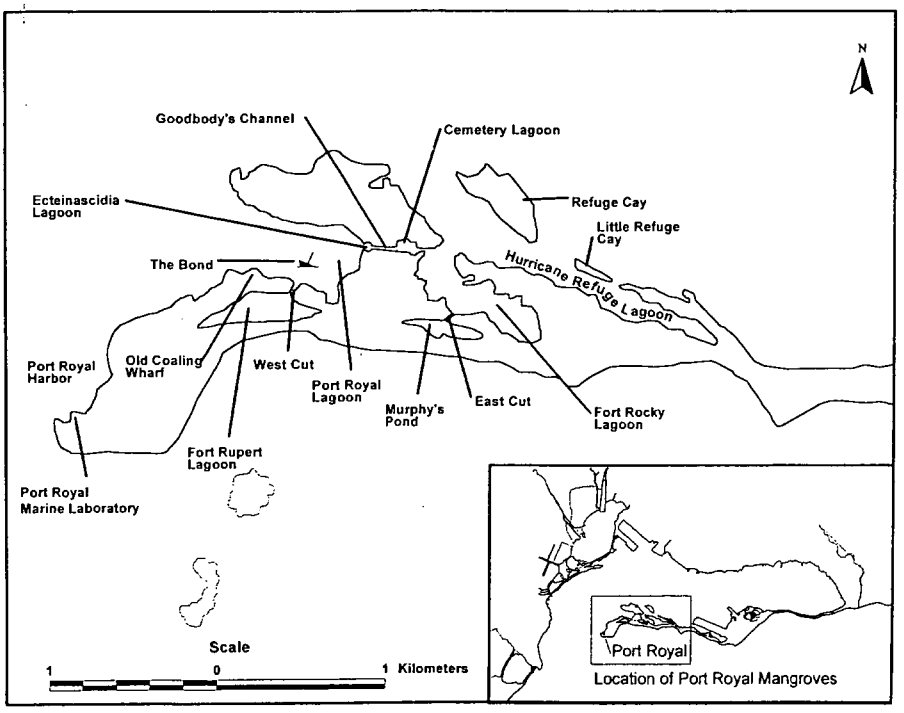
The near-shore environment of Port Royal, Jamaica and its adjacent mangrove ponds is described. Thirty-nine species of ascidian in 23 genera are listed as occurring in this area and brief notes and descriptions of their distribution and habitat preferences are provided. This fauna is compared with that occurring in other localities and it is concluded that the ascidian fauna of Port Royal is representative of faunal communities occurring in near-shore lagoonal environments in the Caribbean. The need to conserve Port Royal's biological heritage is addressed.

The diversity of West Indian ascidians is relatively well known as a result of studies carried out by a number of different workers, particularly Traustedt (1882,1883), Sluiter (1898), Herdman (1882,1886), Berrill (1932), C. Monniot (1983a, 1983b, 1983c,), F. Monniot (1983a,b,c), Monniot and Monniot (1984), Millar (1962), Millar and Goodbody (1974), Goodbody (1993,1995, 2000), van der Sloot (1969), Van Name (1921, 1924, 1945) and Verrill (1900, 1901). While most of these publications provide information, either directly or indirectly on the distribution and habitat requirements of different species, there are only a few publications which primarily address these issues in relation to Caribbean or other tropical communities (e.g., Kott, 1974; Goodbody, 1984a, 1984b, 1993, 2000).

HABITATS

The town of Port Royal lies at 17°56'N 76°50'W, at the entrance to Kingston Harbour, Jamaica (Fig. 1). Formerly the site of a British Naval Station, there is a sheltered deep water harbor on the northern side of the town between the town and a shallow bank of turtle grass (*Thalassia testudinum*). The foreshore of the town has an extensive array of piers, pilings etc., providing substrate for large communities of sessile organisms, notably ascidians, sponges, bivalves, barnacles and actinians, together with an associated infauna of annelids and crustaceans living in interstices between the larger elements of the biota. Mean tidal range is 23 cm (Wade, 1976) so that wave and wind action, as factors affecting sessile communities, are of more importance than tidal fluctuation. The bottom of the harbor (20–25 m) is covered by fine silts, while beneath are remnants of the sunken, seventeenth century city destroyed by an earthquake in 1692.

To the east of the town is an extensive system of mangroves and lagoons connected by narrow channels (Fig. 1). All of these lagoons and channels are fringed by red mangrove *Rhizophora mangle* L., the adventitious roots of which hang down into the water and provide substrate for sessile organisms. An important ecological feature of this area is that from time to time in the rainy season it may be inundated with freshwater, which floods into the harbor from rivers and gullies. Such flooding results in heavy mortality in sessile communities (Goodbody, 1961), giving rise to community instability. Recovery is usually rapid, after which the distribution of animals tends to return to the preceding



The Port Royal mangrove area of Kingston Harbour showing localities referred to in the text.

pattern. Nevertheless, the system is one of high biological diversity and is the type locality for several interesting animal species. General descriptions of this mangrove system have already been reported by Siung (1976), Warner (1967, 1969) and Alleng (1990). The principal components of the system relevant to this study of ascidians are as follows:

(i) THE PORT ROYAL LAGOON.— This lagoon is fringed with mangroves on its eastern, northern and southern sides and opens directly to Port Royal Harbor at its western end; it is approximately two ha in area. At the western end of this lagoon, in shallow muddy water, lies the wreck of an old iron ship that now provides substrate for a variety of sessile organisms, particularly colonial species of ascidian. (This wreck is the remnants of the vessel BOND formerly used to carry water from Kingston to Port Royal. The site is referred to hereafter as the BOND and its co-ordinates are 17°56.'593N; 76°50.'132W). Close to the BOND on the southern shore of the lagoon, a gap in the mangroves gives access to a small tidal channel, West Cut, leading through the mangroves to Fort Rupert Lagoon on the south side of the Palisadoes tombolo. Like the East Cut arising from Fort Rocky Lagoon (see below), the constant flow of water through this channel encourages the growth of sessile organisms, including ascidians. In the northeastern corner of Port Royal Lagoon is a broad opening in the mangroves through which a channel provides access to other elements of the entire system.

(ii) THE *ECTEINASCIDIA* LAGOON.—This is a small circular lagoon connected on its western rim to Port Royal Lagoon through the channel referred to above. It has a uniform depth of 2–3 m with a soft sediment bottom and is completely fringed with mangrove. The name given to the lagoon reflects the abundance of species of *Ecteinascidia* found

around the rim on mangrove roots. Warner (1967, Fig. 4) referred to this lagoon as 'Small Pond.' Forty years ago it was an important habitat for the cubomedusan jellyfish (*Carybdea xaymacana*). The entrance to another channel, used by fishermen as a passageway through the mangroves to reach the main part of Kingston Harbour, is in the southeastern rim of this lagoon. This channel has often been referred to as the small boat channel, but more recently it has been named by University students in reports and theses as Goodbody's channel. Very few ascidians have been found in Goodbody's channel; this is probably related to the fact that water flow through the channel is sometimes very strong. The forces governing water flow through the channel have not been researched, but the fact that the current periodically reverses direction at relatively short intervals suggests that it is probably related not to tidal action, but to a wind enforced seiche in Kingston Harbour, which has an amplitude of 0.0635 m and a period of 45–60 min (Sherwin and Deeming, 1980; Wade, 1976).

(iii) The Cemetery Lagoon.—Goodbody's channel opens at its eastern end to another circular pond of similar size, which is being referred to now as Cemetery Lagoon. The name is derived from its proximity to the old military cemetery (Alleng, 1990). Historically, the military had a landing site there so that the dead could be transported by boat to their last resting place.

(iv) The Fort Rocky Lagoon.—On the eastern rim of Cemetery Lagoon there is a broad opening leading to the large and important Fort Rocky Lagoon, which is approximately 900 m in length, with an approximate area of 20 ha; this is the most productive and interesting of all the lagoons in the system. On the south side of Fort Rocky Lagoon a small gap in the mangroves provides access to a tidal channel, East Cut, connecting to Murphy's Pond on the south side of the Palisadoes tombolo. Constant flow of water through this channel encourages growth of several species of ascidian. Between 1960–1965, an attempt was made to clear the mangrove forest to the east of Fort Rocky lagoon as part of a planned development project. The development did not proceed and the peat floor of the swamp was left exposed to weathering and tidal erosion; as a result of these processes there has, in subsequent years, been considerable drainage of organic material from the swamp floor into the eastern end of the lagoon and this in turn may have affected the distribution and composition of sessile communities in this area e.g., *Polyclinum constellatum* (see below).

(v) Hurricane Refuge (Rosey Hole).—To the north of Fort Rocky Lagoon is the large, deep-water lagoon used as anchorage for small craft in hurricanes. This lagoon, named Hurricane Refuge, sometimes known as Rosey Hole, can be accessed by way of a broad, shallow opening through the mangroves in the north-west corner of Fort Rocky Lagoon. The refuge can also be entered at its western end, directly from Kingston Harbour. The eastern end of the Refuge is closely enveloped by mangrove and appears to be a stressed environment containing only small populations of sessile organisms; dominants in this environment include the cirripede *Balanus eburneus,* the bivalve *Crassostrea rhizophorae,* the ascidian, *Botrylloides nigrum* and various species of Bryozoa. On the northern shore of the Refuge are two small mangrove islands, Refuge Cay and Little Refuge Cay respectively, between which there is direct access to the waters of Kingston Harbour. Refuge Cay is a breeding site for Brown Pelicans (*Pelecanus occidentalis)* and several species of heron and egret whose droppings provide a constant source of nutrients for the lagoon waters below.

Although many researchers have worked in the Port Royal mangroves during the past 50 yrs, there has been no accepted nomenclature in use to describe the different ponds and lagoons found throughout the system. After consultation with colleagues currently working in the area it is recommended that the nomenclature used in this paper should now be adopted for future general use.

Methods

Observations on the sessile communities of piers, pilings and hanging mangrove (*Rhizophora*) roots were made on a casual basis between November 1955–1996. From March 1987 more frequent visits were made to all of the mangrove lagoons and the shorelines, and *Rhizophora* roots were inspected using a facemask and snorkel. Inspection of the shoreline was accomplished by swimming completely around each lagoon in a clockwise direction and recording all observations on an underwater slate.

Annotated Species List

In this section (see also Table 1) notes are provided on the occurrence and habitat preferences of each species recorded. Also in the text, three species (*Lissoclinum abdominale, Diplosoma glandulosum* and *Pyura munita*) are included that, surprisingly, have not been recorded although there is suitable habitat available. The taxonomic arrangement is based on that used by Kott (1985, 1990, 1992). Voucher specimens of all species recorded are deposited and documented in the reference collections of the Department of Life Sciences at the University of the West Indies in Jamaica. The ascidian fauna of the reef area outside the harbor just south of Port Royal will be documented in a subsequent paper.

Suborder Aplousobranchia

Family Polyclinidae

Aplidium antillense (Gravier, 1955)

The species usually forms flattened encrusting colonies easily recognized by their translucent lattice-like appearance created by the distribution of zooids in the test. It is relatively common on piers and boats in the vicinity of the town and is sometimes fairly abundant on the iron framework of the old wrecked boat, the Bond, at the entrance to the Port Royal Lagoon. It was abundant on the undersurface of the hull of a boat, which had been moored at the University marine laboratory, when this boat was beached on May 17,1984. It is seldom found on mangrove roots in the lagoons.

Aplidium lobatum Savigny, 1816

The species forms flattened gelatinous colonies inhabiting benthic communities, often attached to bivalve shells (*Arca*) or lying in sediments around seagrass (*Thalassia*) plants. It does not normally occur in sessile communities on pilings or on *Rhizophora* roots.

Table 1. The Ascidian fauna of Port Royal.

Sub-order Aplousobranchia
Aplidium antillense (Gravier, 1955)
Aplidium lobatum Savigny, 1816
Polyclinum constellatum Savigny, 1816
Tridemnum hians Monniot F., 1983
Didemnum cineraceum (Sluiter, 1898)
Didemnum conchyliatum (Sluiter, 1898)
Didemnum duplicatum Monniot F., 1993
Didemnum halimedae Monniot F., 1983
Didemnum psammatodes (Sluiter, 1895)
Lissoclinum fragile (Van Name, 1902)
Diplosoma listerianum (Milne-Edwards, 1841)
Distaplia bermudensis Van Name, 1902
Eudistoma hepaticum (Van Name, 1921)
Eudistoma olivaceum (Van Name, 1902)
Clavelina oblonga Herdman, 1880
Sub-order Phlebobranchia
Rhodosoma turcicum (Savigny, 1816)
Perophora bermudensis Berrill, 1932
Perophora carpenteria Goodbody, 1994
Perophora multiclathrata (Sluiter, 1904)
Perophora viridis Verrill, 1871
Ecteinascidia minuta (Berrill, 1932)
Ecteinascidia styeloides (Traustedt, 1882)
Ecteinascidia turbinata Herdman, 1880
Ascidia curvata (Traustedt, 1882)
Ascidia interrupta Heller, 1878
Phallusia caguayensis Millar & Goodbody, 1974
Phallusia nigra Savigny, 1816
Sub-order Stolidobranchia
Botrylloides nigrum Herdman, 1886
Symplegma brakenhielmi (Michaelsen, 1904)
Symplegma rubra Monniot C., 1972
Polyandrocarpa tincta VanName, 1902
Polycarpa spongiabilis Traustedt, 1883
Styela canopus Savigny, 1816
Styela plicata (Lesueur,1823)
Herdmania momus (Savigny, 1816)
Pyura vittata (Stimpson, 1852)
Microcosmus exasperatus Heller, 1878
Microcosmus helleri Herdman, 1881
Molgula occcidentalis Traustedt, 1883

Polyclinum constellatum Savigny, 1816

Colonies develop as large balloon-like gelatinous cushions usually red, or greenish in color, and young colonies form button-like growths with similar coloration. Apart from its size and gelatinous consistency, colonies are easily recognized by the groups of zooids associated with radiating systems of cloacal canals easily discernible with the naked eye. This is one of the most common ascidians in sessile communities in the Port Royal area. It occurs in all of the mangrove lagoons on *Rhizophora* roots and was particularly common on some occasions in the southwest corner of Fort Rocky Lagoon between the mouth of East Cut and the entrance to Cemetery Lagoon. In a survey of Fort Rocky Lagoon in March 1984 the species was found to decline in numbers as one proceeded east along the north shore, suggesting that *P. constellatum* may be sensitive to some unusual environmental situation in this sheltered, least disturbed portion of the lagoon; drainage of large amounts of organic matter from the swamp floor (*vide supra)* might be a controlling factor affecting many sessile organisms including *P. constellatum.* The species is common on piers and pilings at the town and is an early colonist on settling panels.

Family Didemnidae

Trididemnum hians Monniot F., 1983

The species is easily confused in the field with *Diplosoma listerianum* and may have been overlooked in early surveys. Colonies are a non-descript gray in color and lack the surface layer of spicules, which gives rise to a conspicuous white color in many other members of the family. The first confirmed record at Port Royal is of a colony collected on the BOND in Port Royal lagoon on June 12, 1992.

Didemnum cineraceum (Sluiter, 1898)

The species forms flat, encrusting blue-gray colonies and is occasionally found on the old iron wreck- the BOND and on piers and pilings around the town. At Port Royal it is not normally found on mangrove roots. Forty years ago it was abundant in the mangroves at Bogue in Montego Bay, but these swamps have now been reclaimed as part of a development program.

The species appears to be synonymous with *D. vanderhorsti* described by Van Name (1924), although this synonymy is not recognized by F. Monniot (1983a) or Rodrigues et al. (1998). *Didemnum cineraceum* is well described by F. Monniot (1983a) and *D. cineraceum* and *D. vanderhorsti* are described by Rodrigues et al. (1998). The difference between the two species must hinge mainly on the characters of the larva. Further research is needed to establish the true taxonomic difference between these species.

Didemnum conchyliatum (Sluiter, 1898)

This is one of the most common colonial ascidians in the West Indies. It occurs throughout the Port Royal area on piers, pilings and mangrove roots and often as an epibiont on

the test of large stolidobranch species such as *Microcosmus exasperatus*. In the serial succession of developing sessile communities it tends to be a primary colonizer quickly overgrowing any available bare space or adjacent barnacles. In earlier publications there has been some confusion between this species and the Old World species *D. candidum* Savigny, 1816. The taxonomy of western Atlantic species is unduly confused by Van Name's (1945) description of several varieties of *D. candidum*, some of which may in fact belong to *D. conchyliatum*. The latter species is well described by F. Monniot (1983) and for a description of *D. candidum* the reader is referred to LaFargue's (1974) description of a neotype from The Red Sea. Most colonies of *D. conchyliatum* in inshore habitats at Port Royal usually have a smooth surface and are dirty white in color; occasionally orange colored colonies occur, but this color morph is more common in offshore habitats. Occasionally colonies have epibiont algae living on the test surface, but I have never recorded colonies with symbiotic algae in the atrial chambers or cloacal canals.

Didemnum duplicatum Monniot F., 1983

Colonies are usually pure white and sometimes have a pinkish tinge (Goodbody, 2000). *Didemnum duplicatum* is not common, appears to be confined to piers and boat hulls and is not recorded from mangrove roots at Port Royal, though it is common on roots in Belize.

Although first described as an independent species by F. Monniot in 1983, recognition of the salient characters were reported earlier by Millar (1962), who first observed that this species was distinct from *D. candidum* and *D. Conchyliatum* in specimens from his Station 1028A in Curacao. In the material he examined, he recognized that there was another species characterized by the presence of two testis follicles instead of the single one present in the two other species.

Didemnum halimedae Monniot F., 1983

This small and rather insignificant-looking white didemnid is fairly commonly found close to the water surface on piers and particularly on the framework of the old iron wreck, the BOND, at the entrance to the Port Royal lagoon. This is an environment where there is often significant agitation of the water and in this respect is comparable to shallow reef-flat localities where the species is also common.

Didemnum psammatodes (Sluiter, 1895)

The species is easily recognized by its muddy-brown appearance due to the accumulation of fecal pellets in the test. It is commonly found in only a few places particularly on mangrove roots in the northwest corner of Fort Rocky Lagoon where it opens out into the Hurricane Refuge. It also occurs along the south shore of Hurricane Refuge where the water is shallow and sediments are easily disturbed by land breezes, or the wash from passing boats. It is not often found on piers or pilings and appears to be a species associated with shallow environments with heavy sediment loading. *Didemnum psammatodes* is one of a number of Caribbean species that have a cosmopolitan distribution and is recorded from a number of localities in the Indo-Pacific region (cf. Kott, 2001).

Lissoclinum abdominale Monniot F., 1983

Although this species occurs elsewhere in Jamaica (e.g., Bowden, St. Thomas), I have never recorded it from anywhere in the Port Royal area. At Bowden it has been found overgrowing the shells of *Crassostrea rhizphorae* in the oyster farm. The cloacal cavities of *L. abdominale* are lined by symbiotic algae giving the colony a greenish tinge (cf. Goodbody, 2000).

Lissoclinum fragile (Van Name, 1902)

Colonies are flat and encrusting and as the name implies are fragile and the test is easily torn in which case identification is easily confirmed by the bright yellow coloration of the abdominal region of individual zooids. It is common in some parts of the mangrove area especially at the junction between Goodbody's channel and Cemetery Lagoon; at this point colonies are usually abundant on *Rhizophora* roots at the lagoon margin, but not in the channel itself.

Diplosoma glandulosum (Monniot F., 1983)

This species appears to be totally absent from the mangrove area of Port Royal, although it is an abundant component of sessile communities in mangrove lagoons elsewhere e.g., Belize (Goodbody, 2000) and in Jamaica at Salt Marsh, Trelawny (unpubl. data). It also occurs rarely on the Port Royal Cays outside Kingston Harbour.

Diplosoma listerianum Milne-Edwards, 1841

The species forms flattened gelatinous gray colonies often with yellow spots indicating the position of the stomach of individual zooids. It is abundant in all the sessile communities on mangrove roots, piers, pilings and boat hulls and is frequently to be found filling the interstices between larger elements of the community. It is often found encircling the top of a mangrove root at water surface level; this is a disturbed environment with frequent agitation. The species also often occurs growing over the test surface of large stolidobranch ascidians and on the test of *Ecteinascidia turbinata*. F. Monniot (1983a) and Goodbody (2000) report on a green color morph occurring elsewhere in the Caribbean, but this morph has not been recorded from anywhere in Jamaica. *Diplosoma listerianum* is widely distributed in tropical and temperate latitudes including western Europe, the Mediterranean, Indo-Pacific, Australia and north and south America (Rowe, 1966).

Famliy Polycitoridae

Distaplia bermudensis Van Name, 1902

Colonies usually grow as small, rounded, or oval cushions with zooids arranged around a central cloacal aperture. The color is very variable, but colonies are often flecked with

white, brown or pinkish pigment visible through the test substance. The species was widespread, but nowhere common in the Fort Rocky Lagoon in April 1966, and has occasionally been found in East and West Cuts. In 1962, it was frequently found in West Cut, but in March 1987, it was not recorded at all from the Fort Rocky Lagoon, and now seems to be of uncommon occurrence in that lagoon. It is not otherwise a regular inhabitant of the mangrove area and is seldom recorded from anywhere else within the harbor. However, it has been found on pilings at the Port Royal Marine Laboratory and on one occasion, on the carapace of a dromiid crab; the species is a common element of reef flats and is found on the reefs and cays outside Kingston Harbour.

Eudistoma hepaticum (Van Name, 1921)

As the name implies, the colonies are ovoid and resemble liver lobes. Up to 1964, it was common in the Port Royal area sometimes attached to boat hulls or piers, other times lying on the bottom amongst sea grasses (*Thalassia*). I have no recent information of its occurrence in the area.

Eudistoma olivaceum (Van Name, 1902)

The species forms groups of zooids embedded in a gelatinous cushion of test and an entire colony will usually consist of a cluster of these cushions or heads joined together at the base. Colonies are usually olive green in color, sometimes tinged with red at the basal stalk; this turns deep blue on death. The species is abundant throughout the mangrove area and is often particularly common at the back of the root system where it hangs close to the peat bank. It is often common on the northern fringe of Fort Rocky Lagoon and the north shore of the Port Royal Lagoon close to the boat channel entrance. Population numbers seem to fluctuate between surveys of Fort Rocky Lagoon but this has never been quantified and probably reflects changes in environmental conditions in the lagoon.

Clavelina oblonga Herdman, 1880

The species forms clusters of very transparent zooids usually with white flecks in the test material. It was at one time (1963–1966) common in the Fort Rocky Lagoon and occasionally in parts of the Port Royal Lagoon, as well as along the south side of Refuge Cay; it also flourished in May 1963 on the hull of a wrecked boat on the south side of the Hurricane Refuge. Observations of this species suggest that it is a shade lover, flourishing in places where overhanging mangroves shade the water below. In Fort Rocky it was widely distributed along the eastern and southern shorelines, but was generally absent from the exposed northern shore or in other disturbed locations. Its absence from the north shore might also be associated with exposure to bright sunlight or drainage of sediments from this swamp in this location. In 1973, a very large colony (# CL20-JA in the UWI collection) was brought into the laboratory with no precise details of when or where in the mangroves it was collected. It probably was collected from the Port Royal lagoon. The species had disappeared entirely from most of the mangrove area by March 1984 and March 1987. It has not been found elsewhere in the vicinity of Port Royal or elsewhere in Jamaica. Like *Ecteinascidia turbinata, C. oblonga* is very sensitive to lowered salinity (Goodbody, 1961).

Suborder Phlebobranchia

Family Corellidae

Rhodosoma turcicum (Savigny, 1816)

This is a small solitary ascidian usually only 3–4 cm in length. It is characterized by a protective lid or valve at the anterior end, which can be pulled down over the siphons when they retract. The species is common throughout the mangrove area but is never found in abundance. It is usually found as solitary individuals growing on *Rhizophora* roots, but also occurs occasionally on piers and pilings at Port Royal town; on one occasion several specimens were collected from the interior walls of the seawater reservoir at the marine laboratory. The species has a wide pan-tropical range (Kott, 1985).

Family Perophoridae

Species in this Family are difficult to identify in the field and it is often necessary to confirm identifications by laboratory inspection of collected samples. The characteristics of the Caribbean species have been reviewed by Goodbody (1994).

Perophora bermudensis Berrill, 1932

The species is widely distributed throughout the Port Royal mangrove area, but is seldom common. An exception is that it is often abundant on mangrove roots hanging in the water current flowing through the boat channel entrance at the junction between Port Royal Lagoon and *Ecteinascidia* Lagoon; large colonies develop in this current and hang down in festoons attached to the *Rhizophora* roots. The species has been recorded living in similar festoons in a water current at Twin Cays, Belize (Unpub. Data).

Perophora carpenteria Goodbody, 1994

This species, like many other species of *Perophora*, forms creeping colonies with zooids arising on long pedicel like stolons from the main creeping stolon. The species has no distinctive characters that can permit ready identification in the field; however, after identification in the laboratory and observations on the growth form and habitat specimens may be recognized in the field. It is of frequent occurrence on mangrove roots, on the upper surface of *Thalassia* leaves or on the peat bank itself.

Perophora multiclathrata (Sluiter, 1904)

The species is closely related to *P. carpenteria* (for comparison of the two species see Goodbody, 1994). However, *P. multiclathrata* is uncommon in mangrove environments and has seldom been recorded from Port Royal except in *Ecteinascidia* Lagoon.

Perophora viridis Verrill, 1871

It is difficult to recognize this species in the field because of its size and its similarity to other small species of *Perophora* (i.e., *P. carpenteria* and *P. multiclathrata*). It appears to occur commonly throughout the mangrove area and the collection contains specimens from the Port Royal, Cemetery and Fort Rocky Lagoons.

Ecteinascidia minuta (Berrill, 1932)

The species forms colonies of flattened greenish-yellow zooids connected by creeping stolons. The species is common throughout the Port Royal mangrove area, colonies growing on all forms of available hard substrate such as *Rhizophora* roots, oyster shells, floating timber and the test of large stolidobranch ascidians.

Ecteinascidia styeloides (Traustedt, 1882)

This is a very common species found throughout the mangrove area, but not elsewhere. Many authors have confused this species with *E. conklini* (see Goodbody, 2000) a species that does not occur in Jamaica. *Ecteinascidia styeloides* is particularly common in the more sheltered parts of the Port Royal mangroves such as *Ecteinascidia* Lagoon, a small recess in the center of the south shore of Fort Rocky lagoon and in another recess on the north shore of the same lagoon; it is also often abundant among hanging roots on the western shore of Cemetery Lagoon. Colonies form clusters of small erect greenish-colored zooids.

Ecteinascidia turbinata Herdman, 1880

This is one of the most common and abundant animals in sessile communities in the mangrove lagoons, but is seldom recorded elsewhere. It grows in the form of bushy colonies of finger-shaped bright orange zooids. Colonies thrive especially well on mangrove roots that hang well clear of the peat bank over relatively deep water; normally colonies are not found growing directly on the peat bank or on the sea floor, and zooids are sometimes partially overgrown by small colonies of *Diplosoma listerianum* and *Botrylloides nigrum*. The large polyclad Turbellarian *Pseudoceros crozieri* is frequently found associated with colonies of *E. turbinata*; it is likely that it is grazing on epibionts rather than actively preying on the ascidian. The populations of *E. turbinata* in the lagoons are sufficiently large for it to be possible to harvest the species on a sustainable basis for pharmaceutical research; this has been achieved by University staff under license from the Government Environmental Authority. Nevertheless, the populations are decimated from time to time by the activities of an artisanal oyster fishery. Oyster pickers strip all organisms off the mangrove roots and discard everything other than the oysters. This activity may not be entirely harmful because the action of squeezing the ascidiozooids may force viable larvae out of the atrial chamber and these larvae may successfully re-colonize some of the bare space left on roots by the pickers. *Ecteinascidia turbinata* is particularly sensitive to changes in water salinity and heavy mortality occurs in conditions of lowered salinity (Goodbody, 1961).

Family Ascididae

Ascidia curvata (Traustedt, 1882)

This is a medium-sized species growing to a length of 5 cm and more and with a colorless test usually relatively free of epibionts. The species first appeared in the mangrove area, attached to *Rhizophora* roots some time around 1980 (Goodbody, 1993). It is now an abundant component of sessile communities on mangrove roots apparently living preferentially near to the water surface, and often associated with clusters of *Balanus eburneus* that provide a hard substrate for larval settlement. It is often found aggregated in dense populations. There are no records of this species occurring commonly anywhere else in the harbor other than in the mangroves. For comment on the nomenclature of this species see C. Monniot (1983a).

Ascidia interrupta Heller, 1878

This is a large species growing up to 10 cm in length; the test is grey-green in color often coated with thin filaments of epiphytic algae. The species is common throughout the mangroves and as recorded elsewhere (Goodbody, 1966, 1993, 2000) has a preference for living partially buried in the peat bank. Sometimes it is also found attached to bottom rubble (Goodbody, 2000) and on occasions has been found in abundance amongst old coal rubble and *Thalassia* plants in the Port Royal lagoon just east of the old coaling wharf.

Phallusia caguayensis Millar and Goodbody, 1974

The type locality for this species is the sea water reservoir of the marine laboratory at Port Royal. The holotype and seven paratypes are the only specimens on record and the species has never again been seen in the area.

Phallusia nigra Savigny, 1816

This is another large species, fully expanded specimens sometimes attaining a length of 15 cm; it is recognized by the deep blue-black coloration of the test which is usually free of epibionts. Occasionally, small specimens of the platyctenid Ctenophore *Vallicula multiformis* may be found crawling or resting on the test, an association also noted by Rankin (1956) in her original description of this Ctenophore. The small pea crab *Pinnotheres moseri* is frequently found as a commensal in the atrial cavity of this species (Goodbody, 1960). *Phallusia nigra* is abundant throughout the Port Royal area growing on pier pilings, mangrove roots and any other structure that keeps the animal well above bottom sediments (Goodbody, 1966). The life, history and biology of the species have been studied by Goodbody (1962, 1963, 1965), Goodbody and Fisher (1974) and Goodbody and Gibson (1974). Rocha et al. (1999) have conducted additional studies in Brazil.

Although the species properly belongs in the genus *Phallusia* and was originally named *Phallusia nigra* by Savigny, both Lesueur (1823) and Herdman (1882) assigned it to the genus *Ascidia* and the name *Ascidia nigra* subsequently came into common usage throughout the Caribbean. For a further discussion see Van Name (1945). Outside the Caribbean *P. nigra* has also been recorded from the Red Sea (Savigny, 1816), Brazil (Rodrigues et. al., 1998), South Africa (Herdman, 1882) and West Africa (Millar, 1965), but there are no records from Australia, Kott having mistakenly assigned specimens of *P. obesa* to *P. nigra* and *P. barbarica* respectively (see Kott, 1985).

Suborder Stolidobranchia

Family Styelidae

Botrylloides nigrum Herdman, 1886

The flattened, encrusting, orange–red colonies of this species are abundant throughout the mangrove area overgrowing mangrove roots, oyster shells and other hard substrates. Colonies are less common on piers and other structures outside the mangrove area. The species seems to be fairly tolerant of stress and is sometimes quite abundant in shallow water along the south side of Hurricane Refuge where fine silts are constantly thrown into suspension by wave action.

Symplegma brakenhielmi (Michaelsen, 1904)

The species forms flattened, encrusting colonies, gray–green in color; it is seldom seen in the harbor area and only became common in the mangrove area after 1966 following which it became increasingly abundant gradually replacing *S. rubra* (Goodbody, 1993). It grows freely over any hard substrate (oyster shells, mangrove roots, the test of larger ascidians etc.) and frequently is found at the tip of mangrove roots.

Symplegma rubra Monniot C., 1972

The species forms spreading, flattened colonies of dome shaped zooids with two color morphs, pink and yellow. In the mangroves it occurred sparsely until 1963 after which it declined in numbers but remains common in parts of the harbor area, particularly on pier pilings (Goodbody, 1993).

Polyandrocarpa tincta Van Name, 1902

Colonies grow in spreading sheets and are usually maroon-red in color with dome-shaped zooids scattered throughout a leathery test. Small colonies are common in the reef area outside Kingston Harbour and although large colonies have occasionally been found on floating timber in the lagoons or surrounding mangrove roots, it does not seem to be a successful colonist in this area.

Polycarpa spongiabilis Traustedt, 1883

This large solitary ascidian is one of the most common species in the mangrove area attached to *Rhizophora* roots or more often embedded in bottom sediments where usually it is attached to a broken shell fragment or other hard substrate (cf. Goodbody, 2000). It is frequently found on the sea floor in shallow water at the eastern end of both the Port Royal Lagoon and Fort Rocky Lagoon. When swimming over these shallows, individuals are easily recognized by the wide open branchial siphon with a conspicuous ring of white tentacles inside the aperture. It is less common in the harbor area.

Styela canopus Savigny, 1816

The test of this species is soft and thin and it is easily recognized in the field by alternate dark and light stripes on the inside of the siphons. Zooids may grow singly or in aggregations with each individual seldom exceeding a length of 1.5–2.0 cm. This small solitary ascidian is common throughout the mangrove area where it grows amongst other organisms in the *Rhizophora* root communities. It occurs less commonly on piers and pilings in the harbor area. In much of the literature the species is known by its synonym *Styela partita* (Stimpson, 1852). *Styela canopus* has a wide distribution throughout tropical and temperate waters (cf. Kott, 1985).

Styela plicata (Lesueur, 1823)

This is a medium sized, solitary ascidian with a milky-white test often thrown into deep folds or covered by bulbous excrescences. Prior to 1963 it was found rarely in different parts of Kingston Harbour, particularly on piers and pilings of the old Yacht Club near Rockfort and occasional specimens were also recorded from pilings and settlement panels in Port Royal. In 1963 the species was recorded from the mangrove area for the first time and specimens were found in Fort Rocky Lagoon, from the north shore of Port Royal Lagoon, and were abundant in parts of the Hurricane Refuge, particularly on mangrove roots on the north shore (i.e., on Refuge Island and Little Refuge Island). The species subsequently declined in numbers and has not been found commonly anywhere in the mangroves since August 1975, when it was quite common along the eastern shore of the Port Royal Lagoon. Marlon Hibbert collected six specimens in December 1999 from the surface of a current meter suspended between 5–6 m in the water column close to Pickering Beacon in the western part of the harbor.

Family Pyuridae

Herdmania momus (Savigny, 1816)

The species is readily recognized in the field by the iridescent red and green lining of the interior of the siphons. Internally the tissues of the mantle and branchial sac contain numerous needle-like spicules; under the microscope it may be seen that each spicule is adorned along its length with minute adpressed spines. This is a common and widespread species throughout the mangroves; it tends to be more common on the sea floor of la-

goons or amongst *Thalassia* plants in sea-grass beds and less common on mangrove roots. *Herdmania momus* has a broad pan-tropical distribution and in Australia and South Africa extends into temperate waters (Kott, 1985).

Pyura munita (Van Name, 1902)

This is a small pyurid frequently found in sand or muddy bottoms elsewhere in the Caribbean (Goodbody, 2000). It has never been found in the Port Royal area, in spite of the presence of suitable habitat. It is common in shallow water at Negril in western Jamaica. The species is well described by Monniot (1983c).

Pyura vittata (Stimpson, 1852)

This is a large species of solitary ascidian in which fully grown individuals may reach lengths of 8–10 cm. It is a widely distributed, common species throughout the Port Royal area and occurs on mangrove roots, piers, and pilings. Occasionally specimens of *P. vittata* are found growing on the lagoon bottom and close examination reveals that as with other species (e.g., *Polycarpa spongiabilis*) the animal is attached to a shell fragment in the sediment that has apparently provided the hard surface necessary for larval settlement.

Microcosmus exasperatus Heller, 1878

This species has siphons that are usually pinkish-brown with paler markings internally and some zooids have bright orange siphons. Often the test is overgrown by small epibionts (including small colonial species of ascidian), it is firm and leathery and high internal branchial pressure gives the whole body great rigidity. It is abundant throughout the Port Royal area, growing on piers, pilings and mangrove roots and less often attached to a shell fragment or other hard substrate on the sea floor. The species is particularly abundant in the Fort Rocky Lagoon. The abundance of this species in mangrove lagoons is in striking contrast to its relative absence from reef environments; it is a large species reaching a length of 5.0–5.5 cm and probably has high nutritional requirements that can be easily met in the detritus-laden waters of mangrove lagoons. *Microcosumus exasperatus* is a pan-tropical species and in south Australia extends into temperate waters (Kott, 1985).

Microcosmus helleri Herdman, 1881

This is uncommon in the Port Royal area and the species normally lives on the sea floor in soft sediments or in sea-grass beds; nevertheless, two small specimens were collected from the sea wall at the Old Naval Dockyard in Port Royal on August 5,1961; elsewhere around the coast of Jamaica other specimens have been recorded from Negril in the west, Portland Bight on the south coast and seven specimens were recovered from coral rubble collected in a dredge at about 20 m depth at 17° 56.8'N 77° 55.3'W on March 21,1967.

Family Molgulidae

Molgula occidentalis Trausted 1883

The species has been recorded on several occasions living in seagrass (*Thalassia*) beds in the Port Royal lagoon. Further research will probably reveal it to be more widely distributed in soft sediment habitats in the Port Royal area. It appears to be generally distributed around the coast of Jamaica and is recorded from Negril and Discovery Bay and in both localities was found in *Thalassia* beds.

Discussion

The diversity of ascidian species in harbor and mangrove environments at Port Royal is representative of near shore lagoonal environments in the Caribbean where mildly eutrophic conditions prevail. The fauna of similar environments in Curaçao, Bonaire and Belize has been documented by Goodbody (1984a,b, 2000). Dominant solitary species in these locations tend to be *P. nigra, A. interrupta, M. exasperatus, P. spongiabilis, P. vittata* and S. *canopus. Pyura lignosa,* which is abundant in certain lagoons in Belize appears to be totally absent from Port Royal.

There is less uniformity in the distribution of colonial species. *Polyclinum constellatum, D. conchyliatum* and *E. olivaceum* are widely distributed in the region as are most members of the Family Perophoridae; note, however, that *P. regina* has never been reported outside the type locality in Belize and *E. conklini* has a narrow distribution in Belize and Bermuda. *Distaplia corolla,* found commonly in lagoons in Belize is elsewhere probably confined to reefal environments. *Diplosoma listerianum* and *B. nigrum,* and possibly also *S. brakenhielmi,* are other colonial species that appear to have a pan-Caribbean distribution in mangrove lagoons. All three species seem to have similar ecological requirements, overgrowing any available hard substratum, including the test of other ascidians, and all are characteristic of relatively calm conditions. *Diplosoma listerianum* grows close to the water surface more often than *B. nigrum,* while *S. brakenhielmi* is distributed more widely than either of the other species.

The distribution of the species of *Clavelina* in the Caribbean is interesting. *Clavelina oblonga* was at one time common in Port Royal and disappeared some time around 1966 (*vide supra*). It is not recorded from Piscadera Baai in Curaçao or Lac of Bonaire (Goodbody 1984a,b), but is recorded from lagoons in Aruba and Isla da Margarita. F. Monniot (1972) reports that in Bermuda it is found in deep, sheltered (*tres abritées*) water and is intolerant of polluted water. This might explain its disappearance from Port Royal at a time when Kingston Harbour was suffering from increasing organic pollution (Wade et al., 1972). In Belize it is absent from lagoons, but lives under stones on reef ridges at Pelican Cays, a habitat it also occupies in Trinidad (pers. obs.) and Bermuda (Van Name, 1945). *C. picta* and *C. puertosecensis* are abundant elements of the lagoonal fauna at Pelican Cays, Belize (Goodbody, loc. cit), but do not occur in lagoons in Port Royal and there are no other records of their occurrence in mangrove lagoons.

Finally, it is pertinent to restate the fact that the entire Port Royal area and in particular the mangrove system is an area of high biological diversity. For this reason and because it is the type locality for several interesting species of marine invertebrate and the area is

the subject of a redevelopment plan for tourism, urgent measures are needed to ensure conservation of the biological heritage while acknowledging the benefits of historical restoration and tourism development. Providing that the mangrove area can be preserved, the Port Royal environment offers a unique opportunity for future research on the ecology of the Ascidiacea. For instance, students might be encouraged to address questions about why so many species co-exist and how they share the resources of the environment between them. Autecological studies of key species could be addressed first, and as a starting point, a detailed study of the ecology and physiology of *Microcosmus exasperatus* might prove rewarding, particularly if conducted in comparison to similar studies of other large Stolidobranchs inhabiting the mangroves, such as *Polycarpa spongiabilis* or *P. aurita* (from the Belize mangroves).

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