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FULL LENGTH ARTICLE

Aliens in Egyptian waters. A checklist of ascidians of the Suez Canal and the adjacent Mediterranean waters

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KEYWORDS

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Mediterranean Sea;
Erythrean non-indigenous species;
Suez Canal;
Polyclinum constellatum

Abstract Checklists of the alien ascidian fauna of Egyptian waters are provided covering the Suez Canal, the adjacent Mediterranean waters and the Gulf of Suez. Enrichment in ascidian species of the Suez Canal seems to have been on the increase since 1927. The distinctly uneven distribution pattern in the Canal appears to be directly related to the ship traffic system.

Earlier reports on alien ascidian species in the Mediterranean are compared and discussed. Of 65 species recorded from the Mediterranean waters of Egypt in all, four are Erythrean migrants and four potentially so. *Polyclinum constellatum* Savigny, 1816 is a new record for the Mediterranean Sea.

Introduction

Ascidians are receiving more and more attention because of the invasive ability of some species and the severe damage caused to aquaculture (reviewed in a special issue of *Aquatic Invasions*, January 2009: http://aquatic invasions.net/2009/index1.html). For example, two species, *Styela clava* Herdman, 1881 and *Ciona intestinalis* Linnaeus, 1767, have had an adverse effect on mussel culture along Canada's east coast (Lutz-Collins et al., 2009). In the last few years five International Conferences on Invasive Sea Squirts were held between 2005 and 2014 to deal with this issue and with other related problems.

Based on an analysis of the literature and on the on-line World Register of Marine Species (www.marinespecies.org/), Shenkar and Swalla (2011) assembled 2815 described ascidian species. The authors recognize that their inventory is certainly incomplete as the ascidian fauna in many parts of the world is relatively poorly known and many new species continue to be described each year. Species richness appears to be highest in tropical waters where colonial forms predominate, while solitary ascidians gradually increase in higher latitudes.

We owe the first inventory of the Mediterranean ascidian fauna to Peres (1958a) who compiled 136 taxa. The Peres inventory, however, leaves many problems open regarding the synonymy and the validity of some of the species or the biogeography of others (Koukouras et al., 1995). Numerous

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publications followed adding new records, either for non-indigenous species or from newly described ones.

According to Coll et al. (2010) the ascidian species now known from the Mediterranean number 229, so that about 8% of the global population are represented in this sea. They are, however, unequally distributed in its basin. Knowledge about the occurrence and distribution of ascidians in the Mediterranean and elsewhere is necessarily based on the availability of expertise and on the sampling effort. The Western basin has been studied in greater detail than the Eastern one and documented in numerous early and more recent publications. The species found to date in the Western basin number 165 (Koukouras et al., 1995), corresponding to 75% of the Mediterranean total.

A checklist was compiled by Koukouras et al. (1995) for the East Mediterranean basin (Aegean and Levantine Seas) and the Black Sea. Previously, forty-three species had been known from the Aegean Sea (including the Sea of Marmara) but with the additional records of Koukouras et al. (1995) their number increased to 67, about 28% of the Mediterranean records. The ascidian fauna of the Levantine basin (not including the Aegean Sea) has received much less attention than that of the West and Central basins and remains comparatively poorly known. Koukouras et al. (1995) report only ten publications, obviously overlooking the Egyptian waters as will be seen below.

It is to be noted that the earliest records of ascidian species from Egyptian waters do not concern the Mediterranean but only the Gulf of Suez with the work of Savigny (1816) describing several new ascidians from this Gulf. Savigny was followed one century later by Hartmeyer (1915) and Michaelsen (1918, 1919). With the additional contributions of Abdel Messeih (1994) we are now in possession of a list of 32 ascidian species from the Gulf of Suez and Port Tawfik harbour.

Ascidians from the fishing grounds of Alexandria collected by Steuer (1939) were examined and reported on by Harant (1939) in the "Notes et Mémoires" of the Institute of Hydrobiology and Fisheries of Alexandria. Other biological investigations were carried out on some Eastern Harbour ascidians by Sedra and Khalil (1971). Later, a survey of both Eastern and Western harbours and of the Alexandria coast yielded more ascidian species (Abdel Messeih, 1982 and published in Ghobashy and Abdel-Messeih, 1991). The latter was followed by a comprehensive investigation in 1987–88 (Abdel Messeih, 1994) encompassing the Egyptian waters, including the Gulf of Suez, the Suez Canal and the Mediterranean coast, which remained unpublished. Further published and unpublished records were made in the following years.

The Suez Canal ascidian fauna has been subjected to a detailed investigation twice at a time interval of about seventy years, first by Harant (1927) in the material collected by the Cambridge Expedition to the Suez Canal (Fox, 1926), and then by Abdel Messeih (1994). The results of the latter were briefly reported on by Halim et al. (1995). A small collection from the middle segment of the Canal was examined by Monniot and Monniot (1972).

Therefore, the objective of the present article is to update a checklist of the alien ascidian fauna of Egyptian waters covering the Suez Canal and the adjacent Mediterranean waters.

Material and methods

Samples for the present study were collected seasonally in 1987–88 along the Egyptian Mediterranean waters and harbours (Fig. 1) and fourteen Suez Canal pilotage stations (Fig. 2), as well as several sites in the northernmost ten kilometres of the Suez Gulf.

Following Cambridge Expedition to the Suez Canal (Fox, 1926), samples were obtained from rocks, submerged concrete blocks, metal structures and navigational buoys in the Suez Canal from depths of 2–4 m using a six-metre long dredge sampler. Moreover, metal chains attached to buoys provided samples from greater depths. By contrast, in Mediterranean stations, Ascidian specimens were sorted out from the catch of trawler nets from depths 60 to 70 m at stations west of Alexandria and 50–60 m east of the city. Checklists are given for the Suez Canal and for the Mediterranean waters (Table 1).

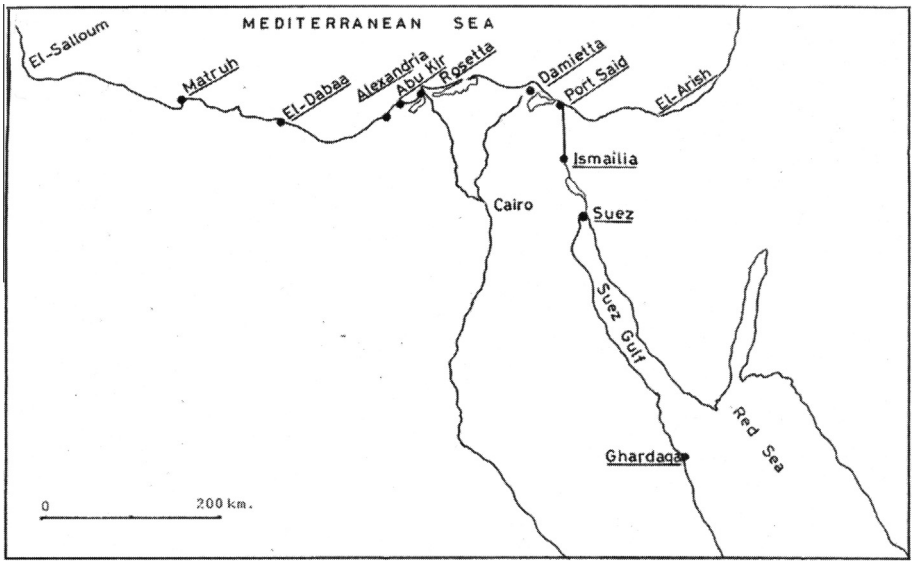

Figure 1 A map showing the sampling areas along the Mediterranean Sea.

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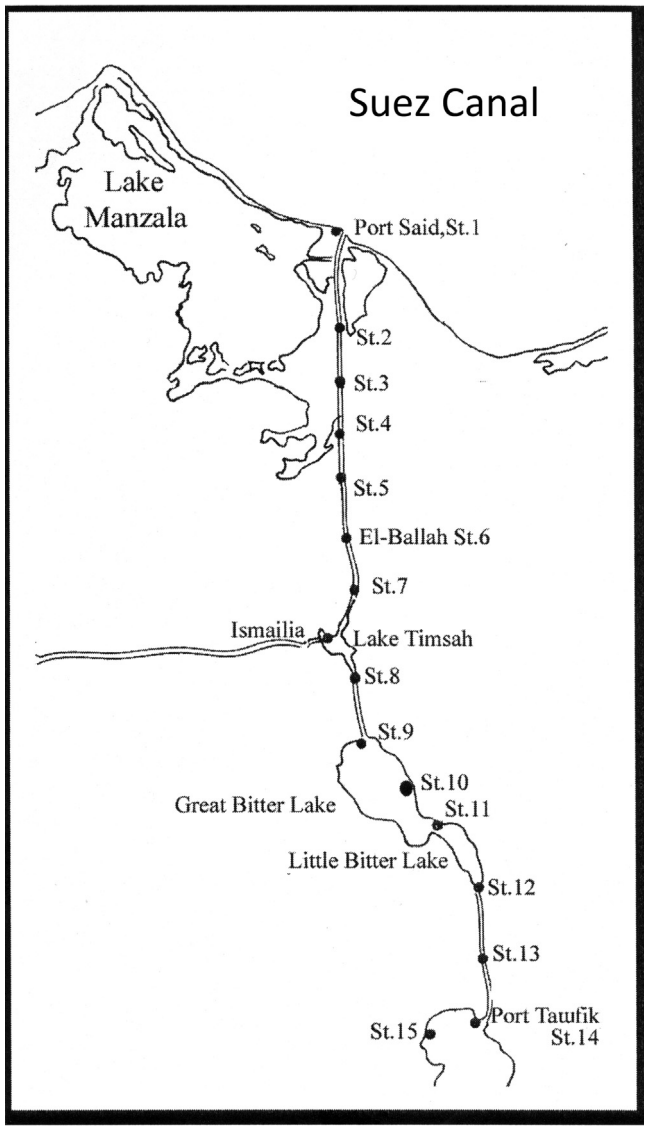

Figure 2 The Suez Canal and the sampling stations.

The specimens collected were first narcotized by adding crystals of magnesium sulphate before being preserved in 10% neutral formalin solution. Specimens from each species were carefully examined and dissected; line drawings were made of whole specimens and of the internal organs. Several authors were consulted for species identification: Carlisle (1954a,b), Eldredge (1966), Herdman (1882, 1886), Sluiter (1905), Tokioka (1967), and Van Name (1902, 1921, 1945). WoRMS, the World Register for Marine Species (2014, online), was consulted for the biogeographic distribution of the species and the synonymy.

The classification followed for higher taxa is that of Berrill (1950) and Millar (1970). All samples are deposited in the reference collection of the Institute of Oceanography and Fisheries in Alexandria.

In addition to the present study data, the new checklists are based primarily on the work of Harant (1927, 1939) and Abdel Messeih (1982, 1994), together with information compiled from further published (Emara and Belal, 2004; Gab-Alla, 2008; Sedra and Khalil, 1971) (Table 1).

Results

The Suez Canal ascidians

The species distribution along the Canal is far from being homogenous as it seems to follow a distinct pattern in species richness and abundance (Table 2). Growth and diversity are most intensive in the middle (Sts. 6–10) and the northernmost (Sts. 1 and 2) segments of the Canal. The middle segment encompasses the hypersaline northern Bitter Lake and Lake Timsah (Fig. 2). The northernmost segment (Sts.1 and 2), is nearer to the Mediterranean in salinity. In contrast, the southernmost segment, south of the Bitter Lakes to Port Tawfik (Sts. 11–14), is extremely poor in diversity. This distribution appears to be unrelated to salinity (Table 2).

It is to be noted that the inhospitality of the southernmost segment did not prevent the enrichment of the upper segments by Erythrean ascidians. The number of species increased from 3 to 29, two-thirds of which consist of Erythrean species. It can be inferred therefore that the more intensive colonization of the middle and northern segments is not due to larval transport by currents. Both the configuration of the Canal and the traffic system seem to be involved in causing this distribution pattern. The Canal extends for 163 km in length, crossing two lakes: Lake Timsah which extends for 4 km and the Great Bitter Lakes which make about 30 km of its length. There is only one traffic lane along most of the Canal but there are two main anchorage and waiting stations to allow for the south bound and the north bound ship convoys to cross, plus an emergency station in Lake Timsah. The two stations are located at El Ballah and at the northern Bitter Lake, between St. 6 and St. 10. It is likely that while ships are waiting, release and settlement on neighbouring solid structures of tadpole larvae from fouling ascidians takes place. This is a case of *contamination*, therefore, rather than of immigration. The same can be expected to happen at the northern entrance, the approaches to Port Said harbour (Sts.1 and 2), but not for the southern terminal, Port Tawfik, which remains poor in species. This is a typical case of ship-mediated introductions of non-indigenous species. Their success is obviously due to the semi-confined condition of the Canal and its lakes. For the Mediterranean as a whole, ship-mediated introduction of alien species relative to other vectors remains difficult to assess (Zirbrowius, 2002). Although the Gulf fauna is out of the scope of this review, a list is given below (Table 3).

Amongst the recorded species five are pervasive in the Canal, namely, *Didemnum candidum* Savigny, 1816, *Polyclinum constellatum*, *Phallusia nigra* Savigny, 1816, *Styela canopus* Savigny, 1816 and *Symplegma brakenhielmi* Michaelsen, 1904.

Ascidians of the Egyptian Mediterranean waters

Harant (1939), examining samples from the area off Alexandria, recorded 25 species. The present work adds 40 species compiled from more recent, published and unpublished (*) records (Table 1).

The ascidian species recorded from the Egyptian Mediterranean (the Suez Canal not included) therefore now number 65 (Table 1). According to Koukouras et al. (1995), the species recorded from the Levantine basin as a whole come to 45. The difference is understandably due to the fact that the sampling

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Table 1 Ascidians of the Suez Canal and coastal Mediterranean waters of Egypt during the present study.

SPECIES	Invasive status	FIRST RECORD	OCCURRENCE
Phylum: Chordata			
Sub-phylum: Tunicata			
Class Ascidiacea			
Order: Aplousobranchia			
Family: Polycitoridae			
Eudistoma angolanum (Michaelsen, 1915)	Exotic	ABDEL MESSEIH 1994	MED:Alx.
Eudistoma Paesslerioides (Michaelsen, 1914)	Native	ABDEL MESSEIH 1994	SC:3,5,6,8,9.
Cystodytes dellechiajei (Della Valle, 1877)	Native	HARANT 1939	MED: Alx,A.Q.,M.M.,S.K.
Family: Clavelinidae			
Pycnoclavella nana (Lahille, 1890)	Native	HARANT 1939	MED: Alx.
Family: Holozoidae			
Distaplia magnilarva (Della Valle, 1881)	Native	HARANT 1927	SC:1,2, .MED: Alx
Distaplia rosea (Della Valle, 1881)	Native	GHOBASHY & ABDEL MESSEIH 1991	MED: Alx.
Family: Polyclinidae			
Aplidium accarense (Millar, 1953)	Exotic	GHOBASHY & ABDEL MESSEIH 1991	MED: Alx.
Aplidium conicum (Olivi, 1792)	Native	HARANT 1939	MED: Alx.
Aplidium griseum (Kott, 1992)	Native	HARANT 1939	MED: Alx.
Aplidium pallidum (Verrill, 1871)	Exotic	Present	MED: S.B.
Aplidium proliferum (Milne Edwards, 1841)	Exotic	ABDEL MESSEIH 1994	MED: M.M.
Aplidium retiforme (Herdman, 1886)	Exotic	ABDEL MESSEIH 1994	MED: Alx.
Polyclinum aurantium (Milne Edwards, 1841)	Native	GHOBASHY&ABDELMESSEIH 1991	MED: widespread
Polyclinum constellatum (Savigny, 1816) Widespread	Native	MONNIOT & MONNIOT 1972	MED: PtS., Dam.SC:3,14
Polyclinum saturnium (Savigny, 1816)	Native	HARANT 1927	MED: Alx.,SC:7
Morchellium argus (Milne Edwards, 1841)	Exotic	EMARA & BELAL 2004	SC:7
Synoicum Duboscqui (Harant, 1927)	Exotic	ABDEL MESSEIH 1994	Med: SC:1,14.
Synoicum intercedens (Sluiter, 1909)	Native	HARANT 1927	SC:7
Family: Didemnidae			
Polysyncraton lacazei (Giard, 1872)	Exotic	ABDEL MESSEIH 1994	SC:6.
Polysyncraton amethysteum (Van Name, 1902)	Exotic	ABDEL MESSEIH 1994	MED: PtS.
Didemnum candidum (Savigny, 1816)	Native	HARANT 1927	MED: widespread. SC:PtS to PtT.
Didemnum edmondsoni (Eldredge, 1966)	Exotic	ABDEL MESSEIH 1994	SC:7
Didemnum moseleyi (Herdman, 1886)	Exotic	ABDEL MESSEIH 1994	SC:PtS To 9
Didemnum maculosum (Milne Edwards, 1841)	Exotic	GHOBASHY & ABDEL MESSEIH 1991	MED: Alx.
Didemnum psammatodes (Sluiter, 1895)	Exotic	HARANT 1927	SC:7
Lissoclinum perforatum (Giard, 1872)	Native	HARANT 1939	MED: Alx.
Tridemnum cereum (Giard, 1872)	Native	HARANT 1939	MED: Alx.
Tridemnum tenerum (Verrill,1871)	Native	HARANT 1927	MED: Alx.A.Q,.SC:9
Tridemnum savignii (Herdman, 1886)	Native	HARANT 1927	SC:2,6.
Leptoclinides faeroensis (Bjerkan, 1905)	Exotic	ABDEL MESSEIH 1994	MED:Dab.
Diplosoma listerianum (Milne Edwards, 1841)	Native	HARANT 1927	MED: widespread. SC:PtS. to7
Order: Phebobranchia			
Family: Cionidae			
Ciona intestinalis (Linnaeus, 1767)	Native	SEDRA and KHALIL 1971	MED: Alx.
Family: Diazonidae			
Rhopalaea neapolitana (Philippi, 1843)	Native	GHOBASHY & ABDELMESSEIH 1991	MED: Alx.
Family: Perophoridae			
Perophora listeri (Wiegman, 1835)	Native	HARANT 1939	MED: Alx.SC:1,3,6.
Perophora viridis (Verrill, 1871)	Exotic	ABDEL MESSEIH 1994	SC:8.
Ecteinascidia imperfecta (Tokioka, 1950)	Exotic	ABDEL MESSEIH 1994	SC:3,6,8.
Ecteinascidia turbinata (Herdman,1880)	Native	HARANT 1927	SC:7,9,10.
Ecteinascidia Thurstoni (Herdman, 1890)	Exotic	GAB-ALLA 2008	MED: PtS. SC:widespread.

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Table 1 (*continued*)

SPECIES	Invasive status	FIRST RECORD	OCCURRENCE
Family: Corellidae			
Corella parallelogramma (Müller, 1776)	Native	HARANT 1939	MED: Alx. S.Bar.
Family: Ascidiidae			
Ascidiella aspersa (Müller, 1776)	Native	HARANT 1927	MED: Alx. Ham.,Fou.SC:1,2. Widespread
Ascidia virginea (Müller, 1776)	Exotic	GHOBASHY & ABDELMESSEIH 1991	MED:Alx.
Ascidia cannelata (Oken, 1820)	Native	HARANT 1927	SC:1,2.
Ascidia conchilega (Müller, 1776)	Native	HARANT 1939	MED: Alx. Dam. SC:PtS. to South, Widespread
Ascidia melanostoma (Sluiter, 1885)	Exotic	EMARA & BELAL 2004	SC:7.
Ascidia mentula (Müller, 1776)	Native	HARANT 1939	SC:1,7.MED:Alx.
Ascidia obliqua (Alder, 1863)	Exotic	ABDEL MESSEIH 1994	MED: PtS.
v***Ascidia prunum*** (Müller, 1776)	Exotic	ABDEL MESSEIH 1994	SC:7.
Phallusia arabica (Savigny, 1816)	Native	HARANT 1927	SC:7,8,11.
Phallusia fumigata (Grube, 1864)	Native	HARANT 1939	MED:Alx. Ham., Rash.
Phallusia mammillata (Cuvier, 1815)	Native	GHOBASHY&ABDELMESSEIH 1991	MED:Alx.
Phallusia nigra (Savigny, 1816) Widespread	Native	HARANT 1927	MED:Alx, SC:3 to 14
Order: Stolidobranchia			
Family: Styelidae			
Styela canopus (Savigny1816)	Native	HARANT 1927	MED:Alx.A.Q. SC:5,11,13. Widespread
Styela plicata (Lesueur, 1823)	Native	HARANT 1939	MED:Alx.A.Q.,Dam., widespread,SC:5,6
Cnemidocarpa margaritifera (Michaelsen, 1919)	Native	HARANT 1927	SC:1,2,6,14.
Cnemidocarpa mollis (Stimpson, 1852)	Exotic	GHOBASHY&ABDELMESSEIH 1991	MED:Alx.
Polycarpa gracilis (Heller, 1877)	Native	GHOBASHY&ABDELMESSEIH 1991	MED:Alx.
Polycarpa pomaria (Savigny, 1816)	Native	GHOBASHY&ABDELMESSEIH 1991	MED:Alx.
Eusynstyela hartmeyeri (Michaelsen, 1904)	Native	HARANT 1927	SC:5,7,11,14.
Distomus variolosus (Gaertner, 1774)	Exotic	Present	MED:PtS,Ghard.
Symplegma brakenhielmi (Michaelsen, 1904)	Native	HARANT 1927	MED:Alx. Dam,widespread,SC:1to12
Botryllus rosaceus (Savigny, 1816)	Native	HARANT 1927	SC:11,14
Botryllus schlosseri (Pallas, 1766) Widespread	Native	HARANT 1939	MED:Alx.AQ,SC:2,3,7,9,10
Botrylloides nigrum (Herdman, 1886)	Native	HARANT 1927	SC:4,6,9 to 14
Botrylloides leachii (Savigny, 1816)	Native	HARANT 1939	MED:PtS.SC:7
Family: Pyuridae			
Pyura gangelion (Savigny, 1816)	Native	HARANT 1927	SC:7,11.
Pyura microcosmus (Savigny, 1816)	Native	HARANT 1939	MED:Alx.
Pyura squamulosa (Alder, 1863)	Native	GHOBASHY&ABDEL MESSEIH1991	MED:Alx.
Pyura tessellata (Forbes, 1848)	Native	GHOBASHY&ABDEL MESSEIH 1991	MED:Alx.
Herdmania momus (Savigny, 1816)	Native	HARANT 1927	SC:1,4,6to9.
Halocynthia papillosa (Linnaeus, 1767)	Native	HARANT 1939	MED:Alx, A.G.
Halocynthia spinosa (Sluiter, 1905)	Native	HARANT 1927	SC:2,9,10
Microcosmus pupa (Savigny, 1816)	Native	HARANT 1927	SC;4
Microcosmus exasperatus (Heller, 1878)	Exotic	ABDEL MESSEIH 1994	SC:4,6,9
Microcosmus Vulgaris (Heller, 1877)	Native	HARANT 1939	MED:Alx. AQ.,A.G.
Family: Molgulidae			
Molgula appendiculata (Heller, 1877)	Native	GHOBASHY&ABDEL MESSEIH1991	MED:Alx.
Molgula dione (Savigny, 1816)	Native	HARANT 1927	SC:7
Molgula helleri (Drasche, 1884)	Native	HARANT 1939	MED:Alx.
Molgula impura (Heller, 1877)	Native	HARANT 1939	MED:Alx.

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Table 1 (*continued*)

SPECIES	Invasive status	FIRST RECORD	OCCURRENCE
Molgula occidentalis (Traustedt, 1883)	Exotic	ABDEL MESSEIH 1994	MED: Alx.
Molgula occulta (Kuppfer, 1875)	Native	HARANT 1939	MED:Alx.
Molgula oculata (Forbes, 1848)	Native	GHOBASHY&ABDEL MESSEIH 1991	MED:Alx.
Molgula siphonalis (Kiaer, 1896)	Exotic	ABDEL MESSEIH 1994	MED:Alx.
Eugyra arenosa (Alder & Hancock, 1848)	Exotic	Present	MED:Alx.,S.Bar.

Abbreviations: **MED**: Mediterranean Sea, A.G.: The Arabs' Gulf, Alx: Alexandria, A.Q.: Abu Qir, Dab.: Dabaa, Dam: Damietta, Fou.: Fouka, Ghard.: Ghardaqa, Ham.: Hammam, M.M.: Mersa Matrouh, PtS.: Port Said, PtT.: Port Tawfik, Rash.: Rosetta, S.Bar.: Sidi Barrani, S.K.: Sidi Kreir. (See Fig. 1). **SC**: Suez Canal (see Fig. 2 for station numbers). Species in bold: recorded from Suez Canal only.
* Unpublished.

Table 2 Salinity, temperature and ascidian fauna in the Suez Canal. Species richness and abundance.

Station	Salinity range (%)	Temp range (°C)	Number of species	Abundance
1–2	41.2–38.0	28–16	10–17	Relatively rich
3–5	43.6–40.0	28–16	6–11	Relatively poor
6–10	45.9–40.4	29–17	29	Richest
11–13	45.4–42.02	29.8–17.8	3	Poorest

Table 3 Ascidians recorded from the Gulf of Suez (Savigny, 1816; Hartmeyer, 1915; Michaelsen, 1918; Abdel Messeih, 1994).

Aplidium lobatum (Savigny, 1816)	*Polycarpa ehrenbergi* (Hartmeyer, 1916)
Ascidia cannelata (Oken, 1820)	*Polycarpa mytiligera* (Savigny, 1816)
Ascidia savignyi (Hartmeyer, 1915)	*Polycitor torensis* (Michaelsen, 1920)
Botrylloides nigrum (Herdman, 1886)	*Polyclinum constellatum* (Savigny, 1816)
Botryllus rosaceus (Savigny, 1816)	*Polyclinum saturnium* (Savigny, 1816)
Cnemidocarpa hemprichi (Hartmeyer, 1916)	*Polyandrocarpa anguinea* (Sluiter, 1878)
Didemnum moseleyi (Herdman, 1886)	*Pyura gangelion* (Savigny, 1816)
Eudistoma paesslerioides (Michaelsen, 1914)	*Herdmania momus* (Savigny, 1816)
Eusynstyela hartmeyeri (Michaelsen, 1904)	*Pyura pantex* (Savigny, 1816)
Halocynthia spinosa (Sluiter, 1905)	*Rhodosoma callense* (Lacaze-Duthiers, 1865)
Microcosmus vulgaris (Heller, 1877)	*Styela magalhaensis* (Michaelsen, 1898)
Microcosmus exasperatus (Heller, 1878)	*Symplegma brakenhielmi* (Michaelsen, 1904)
Microcosmus pupa (Savigny, 1816)	*Synoicum intercedens* (Sluiter, 1909)
Phallusia nigra (Savigny, 1816)	*Synoicum duboscqui* (Harant, 1927)
Phallusia arabica (Savigny, 1816)	

covered a more extensive area and a variety of sites. The authors also appear to have compiled their information from only two sources, Harant (1939) for the coast of Alexandria and Peres (1958a,b) for Israel. The Koukouras et al. (1995) list for the Levantine basin is assumed by Shenkar (2008) to represent the ascidian fauna of the Mediterranean coast of Israel, with but the addition of twelve species.

The majority of the species are Atlanto-Mediterranean, six are cosmopolitan and some appear to be derived from the Red Sea. Forty species are in common with the Aegean Sea. *P. constellatum,* a circumtropical species, is a new record tor the Mediterranean Sea (Fig. 3) (http://www.sealifebase.fisheries.ubc.ca). Some fifteen species appear to be more abundant and widespread in the intertidal and the subtidal zones. Ten of them are colonial.

The present work reports the first documented southward migration of Mediterranean ascidian species. Three Mediterranean ascidians were collected from the Red Sea, namely, *Synoicum* cf *duboscqui*, *Distomus* cf *variolosus* and *Microcosmus* cf *vulgaris*. They were identified in samples from El Ghardaqa (Horghada) collected by the second author in 1988 (Abdel Messeih, 1994). It is to be noted that neither of these species was encountered by earlier authors who surveyed the northern Gulf of Suez (Savigny, 1816; Hartmeyer, 1915; Michaelsen, 1918, 1919).

Discussion

There appears to be some uncertainty--and even disagreement – in the literature concerning the alien ascidian species in the East Mediterranean (Table 4). From a critical review of the candidate species, Koukouras et al. (1995) retained only two for the Levantine basin: *Ascidia cannelata* Oken, 1820 and

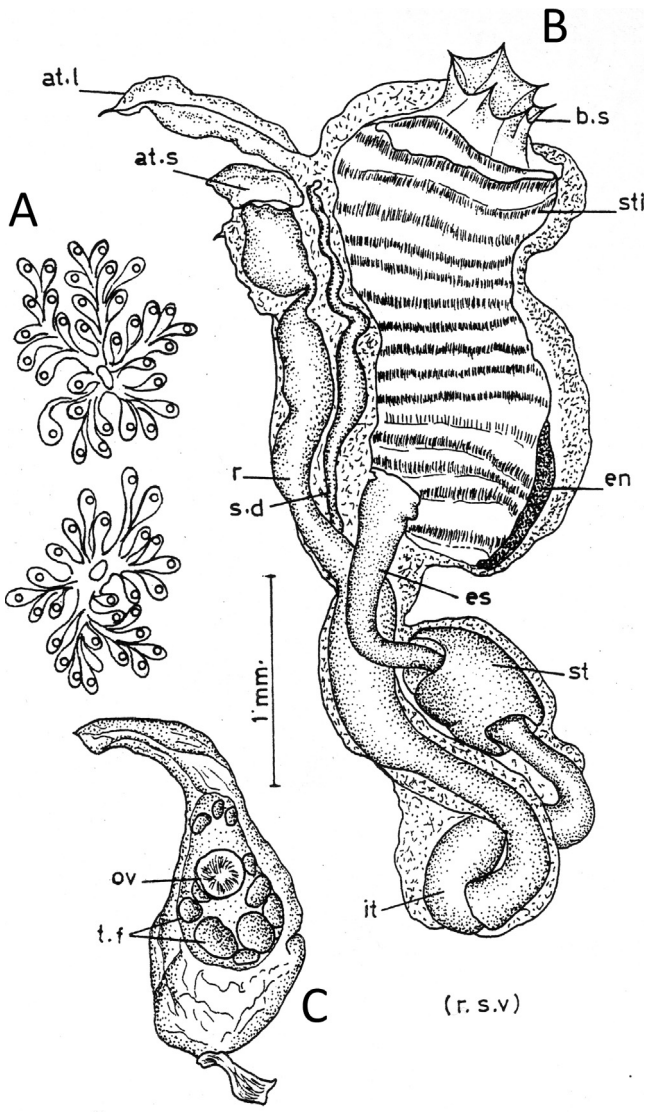

Figure 3 *Polyclinum constellatum*. Drawing from living material collected from the Suez Canal (Abdel Messeih, 1994). A: Arrangement of the zooids in the colony. B: Zooid. C: postabdomen. *Abbreviations: at.l.: atrial languet, at.s.: atrial siphon, b.s.: buccal siphon, en.: endostyle, it.: intestine, ov.: ovary, s.d.: sperm duct, st.: stigma, t.f.: testicular follicle.*

E. hartmeyeri Michaelsen, 1904. Galil (2007), in her checklist of alien species along the coast of Israel, recognized two different species, *Herdmania momus* Savigny, 1816 and *P. nigra* Savigny, 1816. In a "first" attempt to up-date the list of non-indigenous ascidian species for the same coast, Shenkar and Loya (2009) listed seven species. The authors stated that the list corresponds to studies of non-indigenous ascidians elsewhere in the Mediterranean Sea. Zenetos et al. (2010), in their checklist of Mediterranean non-indigenous species, adopted the list of Shenkar and Loya (2009) for the Levantine basin amongst 16 alien ascidians for the Mediterranean as a whole. In their review of recent non-indigenous ascidians in the Mediterranean at large Izquierdo-Munoz et al. (2009) list fourteen species, seven of which are given as possible Red Sea migrants. Their list agrees with the above except for the absence of *Ecteinascidia thurstoni* Herdman, 1890 and the addition of *Microcosmus squamiger* Michaelsen, 1927. In the present work we adopt the rigorous approach of Koukouras et al. (1995) taking into consideration the biogeographic record of the species. Only the species known to be restricted to the Red Sea and the Indo-Pacific waters can be safely received as Erythrean migrants when recorded from the Mediterranean. With reference to this criterion, the widely distributed pan-tropical or cosmopolitan species are excluded from the list of Erythrean aliens. Four Erythrean species are retained, namely, *A. cannelata*, *E. thurstoni*, *Eusynstyela hartmeyeri* and *P. constellatum*.

The colonization of the Suez Canal by ascidians appears to have slowly accelerated since Harant (1927) who recorded only 24 species. Seventeen new records were added by Abdel Messeih (1994), two by Emara and Belal (2004) and one by Gab-Alla (2008), bringing the total to 44 species (Table 1). This continuous enrichment in ascidian biodiversity in the Suez Canal does not support the assumption expressed by Por (1978) that the process of immigration into the Canal has reached a plateau.

Ascidia cannellata is recorded from the Gulf of Suez (Hartmeyer, 1915; Michaelsen, 1918), from Lake Timsah and Tossoun (Harant, 1927), from the great Bitter Lake (Monniot and Monniot, 1972) in the Suez Canal, and from Port Said, growing on the hull of a permanently anchored ship, on manila ropes, on concrete blocks and on buoys (Abdel Messeih, 1994). The species is reported from the coast of Israel by Shenkar and Loya (2009) following Peres (1958b, 1958c). *E. thurstoni,* an Indo-West Pacific species, is reported by Gab-Alla (2008) from several sites along the Egyptian Red Sea coast, the Gulf of Suez, the Bitter Lakes and Lake Timsah in the Suez Canal and from Port Said. It is reported from the Mediterranean coast of Israel by Shenkar and Loya (2009). *E. hartmeyeri* is known from the Gulf of Suez (Michaelsen, 1919), the Suez Canal (Harant, 1927) and Port Said harbour. It occurs in the Mediterranean coast of Israel (Shenkar and Loya, 2009). *E. hartmeyeri* was reported from Somalia by Sluiter (1905). *P. constellatum* was absent from the records of Harant (1927) for the Suez Canal and referred to as very rare by Monniot and Monniot (1972). It is now very widespread in the Canal, showing a progressive northward extension to the Mediterranean Sea. In the present work *P. constellatum* is recorded from Port Said and Damietta harbours (Abdel Messeih, 1994). *P. constellatum* is known from the East and South African coasts.

In addition to the above four species, four other species are potential Red Sea migrants, *Polyclinum saturnium* Savigny, 1816, *H. momus* Savigny, 1816, *P. nigra*, and *S. brakenhielmi*. They are circumtropical species (WoRMS, 2014) occurring in the Red Sea (Hartmeyer, 1915; Michaelsen, 1918) and the Suez Canal (Abdel Messeih, 1994), but in the Mediterranean they remain so far restricted to the Levantine Basin adjacent to the Suez Canal (Kondilatos et al., 2010; Cinar et al., 2006; Koukouras et al., 1995). They are "high probability Lessepsian migrants."

The present review brings together scattered information and new data from one of the less well-known sectors of the Mediterranean as well as from the man-made Suez Canal environment. At least two conclusions come out: first, that the diversity of the ascidian fauna in Egyptian Mediterranean waters is much greater than previously thought, and second,

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Table 4 Literature review of Erythrean ascidians in the East Mediterranean Sea.

Species	Author					
	Shenkar and Loya (2009)	Zenetos et al. (2010)	Galil (2007)	Izquierdo-Munoz et al. (2009)	Koukouras et al. (1995)	Present Study
Ascidia cannelata	+	+	–	+	+	+
Ecteinascidia thurstoni	+	+	–	–	–	+
Herdmania momus	+	+	+	+	–	–
Microcosmus exasperatus	+	+	–	+	–	–
Microcosmus squamiger	–	–	–	+	–	–
Phallusia nigra	+	+	+	+	–	–
Symplegma brakenhielmi	+	+	–	+	–	–
Eusynstyela hartmeyeri	–	–	–	–	+	+
Rhodosoma turcicum	+	+	–	+	–	–
Polyclinum constellatum	–	–	–	–	–	+

that the rate of introduction and settlement of non-indigenous ascidian species through the Suez Canal and other vectors is considerably smaller than for other taxa, either benthic or pelagic. For instance, forty-two Erythrean fish species are documented from the Egyptian waters alone (Halim and Rizkalla, 2011). The checklist of Zenetos et al. (2010) for non-indigenous species brings together 45 copepods, 93 polychaetes and 70 molluscs (bivalvia) for the Mediterranean as a whole. From a review of the literature, Shenkar and Swalla (2011) recognize 64 non-indigenous ascidian species in the world oceans. In striking contrast to their global diversity, therefore, the occurrence of non-indigenous ascidian species is much reduced compared to that of other taxa, but the records are increasing with the recent discovery of *S. clava* in the French Etang de Thau (Davis and Davis, 2008).

A better insight into this discrepancy might be obtained in the future through further study of their life-history, their larval ecology and the type of vectors.

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Some revisions were made to this article after the passing of Professor Youssef Halim (1925–2015). These revisions were undertaken by Professors Michael Abdel Messeih, Magdy T. Khalil (Ain Shams University) and Amany Ismael.

Conflict of interest

The authors have no conflict of interest.

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