Western Indian Ocean J. Mar. Sci. Vol. 12. No. 1, pp. 15-23, 2013

Distribution and Abundance of the Sponge *Spheciospongia vagabunda* (Ridley, 1884) (Phylum: Porifera, Class: Demospongiae) in a Shallow Mauritian Lagoon

Sandeep S. Beepat[1*], Chandani Appadoo[1], Daniel E.P. Marie[2], José Paula[3] and Kannan Sivakumar[4]

[1]*Department of Biosciences, Faculty of Science, University of Mauritius, Reduit 80837, Mauritius;* [2]*Mauritius Oceanography Institute, France Centre, Quatre Bornes, Mauritius;* [3]*Centro de Oceanografia, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal;* [4]*Center of Advanced study in Marine Biology, Annamalai University, Parangipettai-608 502, Tamil Nadu, India.*

Keywords: *Spheciospongia vagabunda*, distribution, abundance, habitat, Mauritius

Abstract—The distribution and abundance of the sponge *Spheciospongia vagabunda* (Ridley, 1884) was investigated in a shallow lagoon (Albion) of Mauritius (Western Indian Ocean). Sponge abundance and environmental parameters were assessed. Sponges in Albion lagoon were mostly distributed in the central part of the lagoon some distance from wave action. Two distinctive sponge patches were found, the largest patch being 15350 m^2 in area. Unlike most Porifera, *S. vagabunda* was mostly anchored in sand and not on hard substratum. A t-test revealed a significant difference in sponge size between sponge assemblages ($t = 3.01$; $p < 0.05$). One-way ANOVA indicated that environmental parameters did not influence sponge abundance within the lagoon ($p < 0.05$). This study provides a baseline for future monitoring of these benthic animals in the Albion lagoon.

INTRODUCTION

The Phylum Porifera is the oldest metazoan group found in our oceans (Müller, 1995). They have highly effective chemical defences to discourage predators, contributing to their evolutionary success (Finks, 1970; Randall & Hartman, 1968). Sponges are widely represented in freshwater (Cocchiglia *et al*., 2013) as well as in most marine ecosystems (Worheide *et al*., 2012).

Spheciospongia vagabunda (Ridley, 1884) is an Indo-Pacific sponge (Family Clionaidae) found in coastal lagoons (Levi,

Corresponding author: SSB
Email: sann_1205@hotmail.com

1998; Sutcliffe *et al*., 2010). Sponges of the genus *Spheciospongia* have been most documented in Singapore (Cheng *et al*., 2008; Lim *et al*., 2012). *Spheciospongia vagabunda* is very well adapted to shallow water environments Cheng *et al*., 2008) and has the ability to survive in the intertidal zone (Lim *et al*., 2012).

Sponges are of ecological and biopharmaceutical importance. Polychaetes, molluscs and crustaceans have been found associated with *Spheciospongia* spp. (Pearse, 1950; Westinga & Hoetjes, 1981) and bioactive compounds such as glycolipids (Costantino *et al*., 2008) and sterols (Arreguin-Espinosa *et al*. 1999) have been extracted from *Spheciospongia vesparium* (Lamarck, 1815). Two new O-glycosylated angucyclines were recently isolated from *S. vagabunda* from the Red Sea (Abdelmohsen *et al*., 2014).

The distribution of sponges usually depends on a number of physical and biological parameters (Knapp & Bell, 2010) such as depth (Nunez Flores *et al*., 2010), turbidity (Zea, 1994), salinity (Roberts *et al*., 2006), water flow (Bell & Barnes, 2003), nutrient concentration (Wilkinson & Cheshire, 1989), substratum type (Bell & Barnes, 2000a; Powell *et al*., 2010) and predation (Waddell & Pawlik, 2000). The abundance and diversity of most sponge species increase with depth (Sorokin & Currie, 2009). For example, Knapp & Bell (2010) have reported the influence of depth on sponge assemblages in lagoons in Palmyra Atoll. It is known that marine sponges avoid turbid waters since particulate matter in the water column often clogs their oscula, hindering respiration and feeding (Roberts *et al*., 2006). The influence of salinity and pH on sponges is less understood than depth and turbidity, and seems to be species-dependent. Hitherto, no studies have reported the effects of salinity or pH on *Spheciospongia* spp. but some studies have focused on the influence of the aforementioned parameters on *Cliona celata* Grant, 1826 (Family: Clionidae) (Emson, 1966; Miller *et al*., 2010; Duckworth & Peterson, 2012). Miller *et al*. (2010) reported that *C. celata* can withstand high salinity changes of up to 42 PSU but, in contrast, low pH values negatively affected it (Emson, 1966; Duckworth & Peterson, 2012).

Compared to other tropical ecosystems, such as those in the Caribbean (Pawlik, 2011) and Indonesia (Bell & Smith, 2004), few studies (e.g. Barnes & Bell, 2002) have focused on the distribution and abundance of sponges in the Mascarene region. Recent studies on Mauritian sponges have focused mainly on their biological activity in terms of marine natural products (Marie *et al*., 2013). This study constitutes the first investigation of *S. vagabunda* (Ridley, 1884) in the lagoon of Albion. The distribution of *S. vagabunda* was thus mapped in Albion and their abundance, size and preferred substrata were investigated. The influence of environmental parameters (water depth, turbidity, salinity and pH) on its abundance was also taken into consideration.

MATERIALS and METHODS

Study site

Albion lagoon is located at 20°12’29.11”S; 57°24’32.47”E on the west coast of Mauritius (Fig. 1). Its shoreline is 2 km long and is located between two small rocky points. The river ‘Belle Eau’ enters it in the south and introduces freshwater to its southern reaches. The Albion lagoon has fringing reefs with two passages and lie approximately 400-500 m offshore. Water flows southwards in the lagoon, irrespective of the tides. The water depth at low tide varies from 0.3 m in the northern part of the lagoon to 2.5 m towards the southern passage. Sand, seagrass (*Syringodium filiforme*) and coral rubble are the main constituents of the lagoon floor, followed by a few *Acropora* and *Porites* patches near the reef flat.

Survey methods

The study was carried out in May-October 2012. A preliminary survey was conducted by boat to identify areas of high *Spheciospongia vagabunda* abundance in the lagoon, followed by additional surveys by snorkel diving where *S. vagabunda* abundance was highest. A handheld GPS (Garmin 72) was used to record

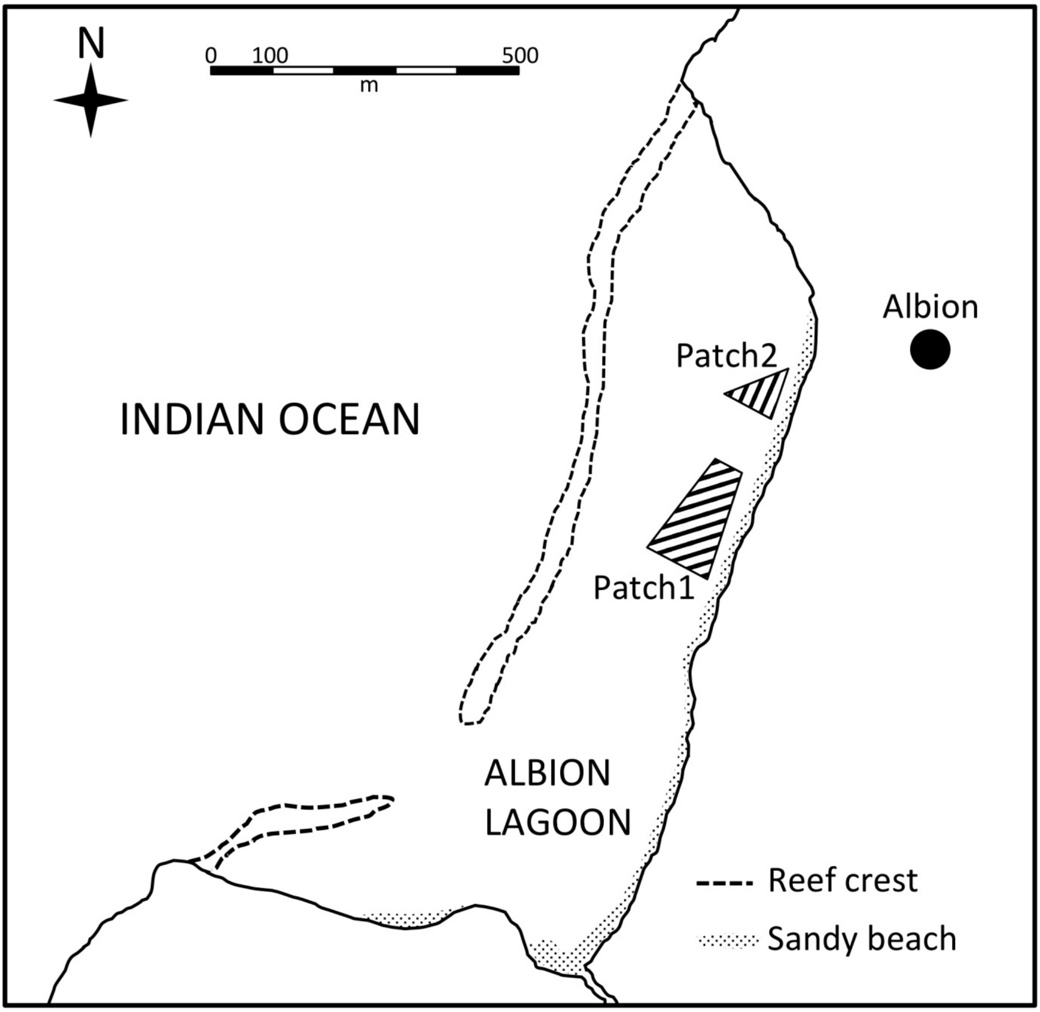

Figure 1. Map of *Spheciospongia vagabunda* assemblages in Albion lagoon, Mauritius.

coordinates along the borders of each sponge assemblage (patch). Sponge abundance was assessed in each sponge patch in randomly placed 1 x 1 m quadrats (n = 30). Three sponge samples were collected, one being lodged at the Institut Mediterraneen de Biodiversite et d'Ecology Marine et Continentale (Marseille, France) for taxonomic confirmation. The sponge habitat (sand, rock, coral rubble, live coral, seagrass and algae) was determined in randomly placed 30 x 30 cm (0.09 m^2) quadrats (n = 15) in the vicinity of the sponges. Sponge sizes were recorded (n = 30) in each assemblage with a measuring tape to the nearest centimetre. The longest horizontal axis (top view) of *S. vagabunda* was used as a measure of sponge size. Water depth was measured at 5 m intervals in the middle of the lagoon, irrespective of the presence/absence of *S. vagabunda*. Water samples (n = 20) were collected in 200 ml plastic bottles. Samples were stored in a cooler box at -20^{o}C for laboratory analysis. Turbidity, salinity and pH were measured in the laboratory. Salinity was measured by using a Captive Purity Refractometer (Model: CP2111, Ade Advanced Optics) and a pH-meter (Oakton, Eutech Instruments) was used to measure pH. The turbidity of the water samples was measured with a Hach 2100 Turbidimeter (Hach Company).

Data analysis

A spatial distribution map was drawn using Google Earth software (Version 7.0) showing the different assemblages of *S. vagabunda* within the lagoon. The approximate area of each sponge patch was assessed using the Google Maps Area Calculator Tool (Version 6.0; www.Draftlogic.com). Statistical analyses were performed with Minitab software (Version 14). A Kolmogorov-Smirnov test was applied to sponge abundance and size data to test for normality prior to parametric tests. Independent sample T-tests were performed to define statistical differences between sponge abundance and sponge size (H_o = means are equal) in the sponge patches. One-way ANOVA was conducted to determine the influence of environmental parameters on sponge abundance.

RESULTS

The study sites

Spheciospongia vagabunda in Albion were confined to two assemblages distributed in the northern section of the lagoon as shown in Figure 1. No *S. vagabunda* were observed elsewhere in the lagoon. The two sponge patches occurred at slightly different depths and were referred to as Patch 1 and Patch 2.

Patch 1 was situated in the central part of the lagoon (20°12'34.64" S, 57°24'10.17" E) and was approximately 205 m long and 108 m wide, whereas Patch 2 was located in the northern section of the lagoon (20°12'27.48" S, 57°24'13.78" E) and was approximately 90 m long and wide.

The abundance of *S. vagabunda* within both assemblages was not uniform (Table 1). In situ observations clearly indicated that Patch 2 had the lower abundance and the difference between the two patches proved significant ($t = 2.39$, $p = 0.022$). While the mean sponge abundance in Patch 1 was 3.3 ± 0.46 sponges.m^{-2}, that in Patch 2 was 1.8 ± 0.42 sponges.m^{-2}. Measurement of individual sponges in the two assemblages indicated that they differed significantly ($t = 3.01$, $p = 0.004$), those in Patch 1 being larger (mean=15.53 ± 1.5 cm) than those in Patch 2 (mean=10.26 ± 0.9 cm).

Observations indicated that 46.6% and 40.0% of the *S. vagabunda* were anchored in sand in Patches 1 and 2 respectively (Figure 2). This was followed by dead coral (37.3% in Patch 1 and 26.6% in Patch 2). Some *S. vagabunda* colonies were also observed adjacent to the seagrass *Syringodium filiforme* (14% in Patch 1; 33.3% in Patch 2 with a few next to the alga, *Turbinaria* sp.

One-way ANOVA indicated that none of the physical or chemical parameters (depth, salinity, turbidity, pH) that were measured (Table 2) influenced *S. vagabunda* abundance within the Albion lagoon.

Table 1.Locations of *Spheciospongia vagabunda* assemblages in Albion lagoon, Mauritius, with their approximate area, sponge abundance and size (±SE).

Patch	GPS location	Approximate patch area (m^2)	Mean abundance (sponges/m^2)	Mean sponge size (cm)
Patch 1	20°12'34.64" S, 57°24'10.17" E	15350	3.3 ± 0.46	15.53 ± 1.5
Patch 2	20°12'27.48" S, 57°24'13.78" E	5875	1.8 ± 0.42	10.26 ± 0.9

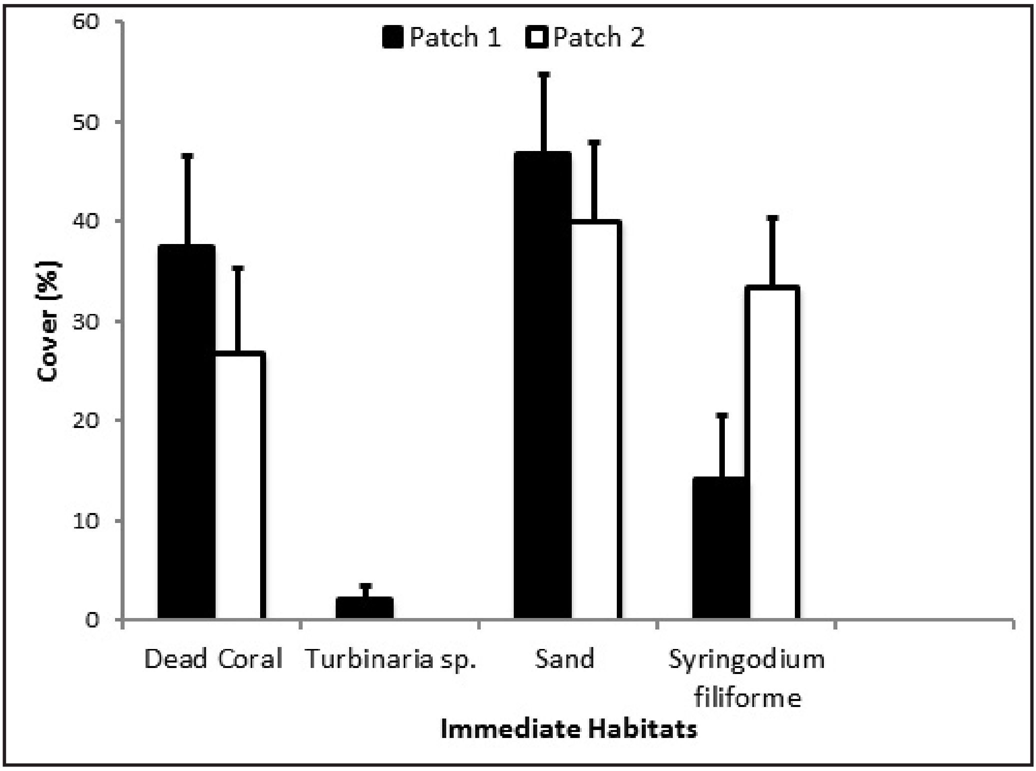

Figure 2. Habitat type in *Spheciospongia vagabunda* assemblages in Albion lagoon, Mauritius.

Table 2. Mean physical and chemical parameters (±SE) recorded within each *Spheciospongia vagabunda* assemblage in Albion lagoon, Mauritius.

Patch	Depth (m)	pH	Salinity (PSU)	Turbidity (NTU)
Patch 1	1.18 ± 0.12	8.32 ± 0.01	36.25 ± 0.25	0.73 ± 0.15
Patch 2	0.70 ± 0.10	8.43 ± 0.01	35.50 ± 0.29	0.60 ± 0.15

DISCUSSION

Aggregation of sponges in assemblages or patches has been reported in Indonesia (Bell & Smith, 2004), Singapore (de Voogd & Cleary, 2009) and Mauritius (Appadoo *et al*., 2011) and is common among *Spheciospongia* spp. The latter have been recorded in Mexico (Erdman & Blake, 1987) and Singapore (de Voogd & Cleary, 2009). Aggregation in sponges is often attributed to low turbulence at such locations which enables recruits to settle amongst conspecifics (Bell and Barnes, 2000b).

Spheciospongia vagabunda was most abundant in shallower water in the middle of the lagoon. The shoreline and reef flats in Mauritian lagoons are subjected to high wave action which appears detrimental to benthic communities, including sponges (Monteiro & Muricy, 2004). We suggest that *S. vagabunda* preferred this habitat as it was unaffected by wave action. Similar observations were also reported for the sponge *Neopetrosia exigua* (Kirkpatrik, 1900) in another Mauritian lagoon with a profile similar to that of Albion (Appadoo *et al*., 2011).

The abundance of *S. vagabunda* was higher in Patch 1 than Patch 2. The average depth in the former (1.18 m) seemed to provide habitat more conducive for the growth of this sponge compared to the latter (0.70 m). *S. vagabunda* has previously been recorded in a depth range of only 1-2 m (Barruca *et al*., 2007) and this may explain the significant difference in sponge size between the Albion patches. Moreover, the physical effects of wave action were reduced at the depth of Patch 1 (pers. obs), allowing the sponges in this assemblage to grow larger.

Despite being an uncommon substratum for sponges, many *S. vagabunda* colonies were found attached to sand, an observation common to both assemblages. This seems to be a common characteristic in this species as it has been previously described as a burrowing sponge (Barruca *et al*., 2007). Moreover, the low turbulence in Albion would have favoured growth on the soft substratum and *S. vagabunda* has been reported to incorporate sand and coral rubble in its base, enhancing its burrowing ability while acting as an anchoring mechanism (Levi, 1998). The second most common habitat for *S. vagabunda* in Albion was dead coral which was common in Patch 1 (Fig. 2); coral rubble is a good anchoring base for many sponge species (Duckworth & Wolff, 2011). This provided a suitable settlement substratum for many juvenile sponges in Patch 1 and may be another factor that contributed to its larger sponges. In addition, sponges and algae are known competitors for space (Preciado & Maldonado, 2005). While Patch 1, in particular, had little seagrass (*Syringodium filiforme*), providing less competition for the sponges, very few sponges were observed near the alga *Turbinaria* sp. in either aggregation.

Sedimentation has been reported to influence the distribution of temperate sponges but, in contrast, less information is available on the influence of sedimentation on tropical sponges (Bell & Smith, 2004). Generally, sedimentation and its associated turbidity are known to have a negative effect on sponge abundance (Powell *et al*., 2014) but had no significant influence on *S. vagabunda* abundance in Albion lagoon. Some sponge species thrive in turbid environments (Bell & Smith, 2004; Powell *et al*., 2014) and variable morphology in osculum length in *S. vagabunda* (Levi, 1998) may enable it to grow in turbid conditions. Elevated oscula may enable it to maintain a constant water supply and minimise particle deposition within its orifices (Bell *et al*., 2002). Similar observations have been reported for other clionaid sponges (Bell *et al*., 2002), some of which have fewer oscula, which increases the exhalent water flow, inhibiting particle settlement (Bell *et al*., 2002).

Clionaidae have previously been reported to be tolerant of a wide range of salinities (Miller *et al*., 2010) suggesting that *S. vagabunda* may cope with salinity changes in Albion lagoon. In contrast, a low water pH (<7.8) has been reported to negatively affect clionaid sponges (Emson, 1966; Duckworth & Peterson, 2012). However, the pH levels recorded in Albion were >8 (Table 2) and variations in pH were inconsequential in the *S. vagabunda* assemblages. Sponges of this species have recently been recorded in a sewage outfall in Australia (Padovan *et al*., 2012), indicating that this species may be adapted to adverse environmental conditions. However, the results of the present study must be viewed with caution as the full seasonal cycle was not covered, and seasonal variation in the environmental parameters we measured may be higher.

Acknowledgements–We wish to thank the University of Mauritius (UOM) and the Mauritius Oceanography Institute (MOI) for logistical and technical assistance. Sincere thanks are due to Dr Jean Vacelet (Institut Mediterraneen de Biodiversite et d'Ecology marine et continentale) for taxonomic confirmation of the sponge samples. The authors are also grateful to two anonymous reviewers for their critical review of this paper.

References

Abdelmohsen UR, Cheng C, Viegelmann C, Zhang T, Grkovic T, Ahmed S, Quinn RJ, Hentschel U, Edrada-Ebel R (2014) Dereplication strategies for targeted isolation of new antitrypanosomal actinosporins A and B from a marine sponge associated-Actinokineospora sp. EG49. Marine Drugs 12: 1220-1244

Appadoo C, Beepat SS, Marie D (2011) Study of physico-chemical parameters affecting the distribution of the sponge *Xestospongia exigua* (Phylum Porifera, Class Demospongiae) in a northern lagoon of Mauritius. Journal of Environmental Research and Development 5: 741-748

Arreguin-Espinoza R, Arreguin B, Hernandez-Santoya A, Rodriguez-Romero A (1999) Sterol composition and biosynthesis in the sponge *Spheciospongia vesparia*. Journal of Chemical Technology and Biotechnology 72: 245-248

Barnes DKA, Bell JJ (2002) Coastal sponge communities of the West Indian Ocean: taxonomic affinities, richness and diversity. African Journal of Ecology 40:337–349

Barruca M, Azzini F, Bavestrello G, Biscotti M, Calcinai B, Canapa A, Cerrano C, Olmo E (2007) The systematics position of some boring sponges (Demospongiae, Hadromerida) studied by molecular analysis. Marine Biology 151: 529-535

Bell JJ, Barnes DKA (2000a) The distribution and prevalence of sponges in relation to environmental gradients within a temperate sea lough: inclined cliff surfaces. Diversity and Distribution 6: 305-323

Bell JJ, Barnes DKA (2000b) The influences of bathymetry and flow regime upon the morphology of sublittoral sponge communities. Journal of the Marine Biological Association of the UK 80: 707-718

Bell JJ, Barnes DKA (2000c) A sponge diversity centre within a marine island. Hydrobiologia 440: 55-64

Bell JJ, Barnes D, Turner J (2002) The importance of micro and macro variation in the adaptation of a sublittoral demosponge to current extremes. Marine Biology 140: 75-81

Bell JJ, Barnes DKA (2003) Effect of disturbance on assemblages: an example using Porifera. The Biological Bulletin 205: 144-159

Bell JJ, Smith D (2004) Ecology of sponge assemblages (Porifera) in the Wakatobi region, south-east Sulawesi, Indonesia: Richness and abundance. Journal of the Marine Biological Association of the United Kingdom 84: 581-591

Cheng LS, de Voogd N, Siang TK (2008) A guide to sponges of Singapore. Science Centre Singapore, 173 pp

Cocchiglia L, Kelly-Quinn M, Lucey J (2013) Small Scale Study: Classification of freshwater sponges in Ireland, EPA Report. (Available at: http://www.epa.ie/pubs/reports/research/sss/Classification%20of%20freshwater%20sponges.pdf) [Date Accessed: 20 October 2013]

Costantino V, Fattorusso E, Imperatore C, Mangoni A (2008) Glycolipids from sponges. 20. J-Coupling analysis for stereochemical assignments in furanosides: Structure elucidation of vesparioside B, a glycosphingolipid from the marine sponge *Spheciospongia vesparia*. The Journal of Organic Chemistry 73: 6158-6165

de Voogd NJ, Cleary DFR (2009) Variation in sponge composition among Singapore reefs. The Raffles Bulletin of Zoology suppl. 22: 59-67

Duckworth AR, Wolff CW (2011) Population dynamics and growth of two coral reef sponges on rock and rubble substrates. Journal of experimental Marine Biology and Ecology 402: 40-55

Duckworth AR, Peterson BJ (2012) Effects of seawater temperature and pH on the boring rates of the sponge *Cliona celata* in scallop shells. Marine Biology 160: 27-35

Emson RH (1966) The reactions of the sponge *Cliona celata* to applied stimuli. Comparative Biochemistry and Physiology 18: 805-827

Erdman RB, Blake NJ (1987) Population dynamics of the sponge-dwelling alpheid *Synalpheus longicarpus*, with observations on *S. brooksi* and *S. pectiniger* in shallow water assemblages of the eastern Gulf of Mexico. Journal of Crustacean Biology 7: 328-337

Finks RM (1970) The evolution and ecologic history of sponges during Palaeozoic times. Symposia of the Zoological Society of London 25: 3-22

Knapp I, Bell JJ (2010) Effect of depth on sponge assemblage structure at Palmyra Atoll, Central Pacific. Open Marine Biology Journal 4: 26-30

Levi C (1998) Sponges of the New Caledonian Lagoon. Editions de l'Orstom, Paris. 93 pp

Lim SW, de Voogd NJ, Tan KS (2012) Biodiversity of shallow-water sponges (Porifera) in Singapore and description of a new species of *Forcepia* (Poecilosclerida: Coelosphaeridae). Contributions to Zoology 81: 55-71

Marie DEP, Ramanjooloo A, Beedessee G, Arya D, Van Soest RWM, Cresteil T (2013) The apoptic activity of one VLC fraction of the sponge *Petrosia tuberosa* on human cervical cells and the subsequent isolation of bioactive polyacetylene. Natural Product Communications 8: 635-638

Miller AN, Strychar KB, Shirley TC, Rützler, K (2010) Effects of heat and salinity stress on the sponge *Cliona celata.* International Journal of Biology 2: 3-16

Monteiro LC, Muricy G (2004) Patterns of sponge distribution in Cagarras Archipelago, Rio de Janeiro, Brazil. Journal of the Marine Biological Association of the UK 84: 681-687

Müller WEG (1995) Molecular phylogeny of Metazoa (animals): Monophyletic origin. Naturwiss 82: 321-329

Nunez Flores M, Rodriguez-Quintal JG, Diaz CM (2010) Sponge (Porifera) distribution along a depth gradient in a coral reef, parquet Nacional San Esteban, Carabobo, Venezuela. Revista de Biologia Tropical 58 (Suppl. 3): 175-187

Padovan AC, Munksgaard NC, Alvarez B, McGuinness KA, Parry DL, Gibb KS (2012) Trace metal concentrations in the tropical sponge *Spheciospongia vagabunda* at a sewage outfall: Synchrotron X-ray imaging reveals the micron-scale distribution of accumulated metals. Hydrobiologia 687: 275-288

Pawlik JR (2011) The chemical ecology of sponges on Caribbean Reefs: Natural Products shape systems. Proceedings of the National Academy of Science of the USA 111: 4151-4156

Pearse AS (1932) Inhabitans of certain sponges at dry Tortugas. Papers of the Tortugas Laboratory 28: 1117-124

Powell AL, Hepburn LJ, Smith DJ, Bell JJ (2010) Patterns of sponge abundance across a gradient of habitat quality in the Wakatobi Marine National Park, Indonesia. The Open Marine Biology Journal 4: 31-38

Powell A, Smith DJ, Hepburn LJ, Jones T, Berman J, Jompa J, Bell JJ (2014) Reduced diversity and high sponge abundance on a sedimented Indo-Pacific reef system: Implications for future changes in environmental quality. Plos One 9: 1-14

Preciado I, Maldonado M (2005) Reassessing the spatial relationship between sponges and macroalgae in sublittoral rocky bottoms: A descriptive approach. Helgoland Marine Research 59: 141-150

Randall JE, Hartman WD (1968) Sponge-feeding fishes of the West Indies. Marine Biology 1: 216-225

Roberts DE, Davis AR, Cummings SP (2006) Experimental manipulation of shade, silt, nutrients and salinity on the temperate reef sponge *Cymbastela concentrica*. Marine Ecology Progress Series 307: 143-154

Sorokin SJ, Currie DR (2009) The distribution and diversity of sponges in Spencer Gulf. Report to Nature Foundation SA Inc. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 9 pp

Sutcliffe PR, Hooper JNA, Pitcher CR (2010) The most common sponges on the Great Barrier Reef seabed, Australia, including species new to science (Phylum Porifera). Zootaxa 2616: 1-30

Wadell B, Pawlik JR (2000) Defences of Caribbean sponges against invertebrate predators. I. Assays with hermit crabs. Marine Ecology Progress Series 195: 125-132

Westinga EPHC, Hoetjes PC (1981) The intrasponge fauna of Spheciospongia vesparia (Porifera, Demospongiae) at Curacao and Bonaire. Marine Biology 62: 139-150

Wilkinson CR, Cheshire AC (1989) Patterns in the distribution of sponge populations across the Central Great Barrier Reef. Coral Reefs 8: 127-134

Worheide G, Dohrmann, M, Erpenbeck, D, Larroux C, Maldonado M, Voigt O, Borchiellini C, Lavrov DV (2012) Deep phylogeny and evolution of sponges (Phylum Porifera). Abstracts in Marine Biology 61: 1-60

Zea S (1994) Patterns of coral and sponge abundance in stressed coral reefs at Santa Marta, Colombian Caribbean. In: Van Soest RWM, Van Kempen TMG, Braekman JC (eds) Sponges in time and space. AA Balkema, Rotterdam, Netherlands, pp 257-264