تريبيلوس

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مجلة جمعية الامارات للتاريخ الطبيعي

TRIBULUS

Volume 26 - 2018

Journal of the Emirates Natural History Group

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TRIBULUS

Notes for Contributors

TRIBULUS is published by the Environment Agency – Abu Dhabi, EAD, in association with the Emirates Natural History Group, ENHG, and was launched in 1991.

EAD, established in 1996 as the Environmental Research and Wildlife Development Agency, ERWDA, is an agency of the Government of the Emirate of Abu Dhabi, responsible for conservation and protection of the Emirate's environmental resources and natural history.

The ENHG, based in Abu Dhabi, founded in 1976, is the UAE's oldest environmental non-governmental organisation. It has sister groups in Al Ain, Dubai and Ra's al-Khaimah. Between 1976 and 1990, the Group published 42 issues of a thrice-yearly **Bulletin**.

Copies of **TRIBULUS** and of the **Bulletin** are on the website of the Al Ain ENHG, at www.enhg.org

Between 1991 and 2006, **TRIBULUS** was published twice-yearly, becoming annual from Volume 17 (2007). From Volume 26 (2018), the journal is published as a collaborative venture between the Environment Agency – Abu Dhabi and the Emirates Natural History Group.

The publication seeks to create a collection of articles and papers on topics related to the natural history, heritage, geology, palaeontology, archaeology and history of the United Arab Emirates and adjacent areas. Papers, short notes and other contributions are welcomed but should not have previously been published elsewhere. All manuscripts are reviewed by Editorial Board members and appropriate Advisory Panel members and, as appropriate, other referees. Information contained in papers is as accurate as can be determined but opinions expressed are, however, those of the authors alone.

Submission of Manuscripts

Manuscripts and illustrations, including photographs, should be submitted in electronic format, to the Managing Editor (*address below*). Guidelines on request.

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Or by e-mail to: peterhellyer@yahoo.co.uk

تريبيلوس

ملاحظات إلى المساهمين

تنشر تريبيلوس من قبل هيئة البيئة - أبوظبي بالتعاون مع جمعية الإمارات للتاريخ الطبيعي وتصدر منذ عام 1991.

أنشئت هيئة البيئة - أبوظبي في عام 1996 كهيئة لبحوث البيئة والحياة الفطرية وتنميتها، وهي وكالة تابعة لحكومة إمارة أبوظبي وتعد مسؤولة عن الحفاظ على الموارد البيئية للإمارة والتاريخ الطبيعي وصونه.

تأسست جمعية الإمارات للتاريخ الطبيعي، التي تأسست في أبو ظبي في عام 1976، وهي أقدم منظمة بيئية غير حكومية في دولة الإمارات العربية المتحدة. ويتبع لها جمعيات مماثلة في العين ودبي ورأس الخيمة. وبين عامي 1976 و1990، قامت الجمعية بإصدار 42 عددا وذلك بمعدل ثلاثة أعداد سنويا.

تتوفر أعداد تريبيلوس والنشرات على الموقع الالكتروني التابع لجمعية الإمارات للتاريخ الطبيعي: www.enhg.org

وبين عامي 1991 و2006، أصبحت TRIBULUS تصدر مرتين سنويا، لتصبح سنوية من العدد 17 (2007).
ومن العدد (2018) ، يتم نشر المجلة كمشروع تعاوني بين هيئة البيئة - أبوظبي وجمعية الإمارات للتاريخ الطبيعي.

وتهدف المجلة إلى إنشاء مجموعة من أوراق العمل والمقالات حول مواضيع تتعلق بالتاريخ الطبيعي والتراث والجيولوجيا وعلم الحفريات وعلم الآثار وتاريخ دولة الإمارات العربية المتحدة والمناطق المجاورة.
ويتم الترحيب بالأوراق والملاحظات القصيرة والمساهمات الأخرى، على ألا يكون قد تم نشرها من قبل في مكان آخر.
وتتم مراجعة جميع المخطوطات من قبل أعضاء هيئة التحرير وأعضاء اللجنة الاستشارية ومختصين آخرين حسب ما هو ملائم.
إن المعلومات الواردة في المجلة دقيقة بقدر ما يمكن تحديده ولا تعبر الآراء الواردة فيها إلا عن رأي مؤلفيها فقط.

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يجب تقديم نسخة إلكترونية من المخطوطات والرسوم التوضيحية، بما في ذلك الصور الفوتوغرافية إلى مدير التحرير (على العنوان الموضح أدناه).

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Tribulus

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Corporate Members of the ENHG:

Production of ***Tribulus***, and many other activities of the Emirates Natural History Group, including the grant programme of the Group's Conservation Fund, would not be possible without the generous support of the Group's Corporate Members, many of whom have provided consistent assistance over many years. The Editorial Board and the Group Committee acknowledge, with thanks, the invaluable support of the following companies and bodies, currently Corporate members of the Group, and all past Corporate sponsors without whom publication would be impossible.

The ENHG acknowledges, with thanks, the support provided by the Environment Agency – Abu Dhabi, EAD, for the continued publication of this journal. The Group would also like to acknowledge the support and encouragement of its Patron, H.E. Sheikh Nahyan bin Mubarak Al Nahyan, Minister of Tolerance. ***Tribulus*** is available on subscription inside and outside the UAE. Subscription in the UAE & the Arabian Gulf states is Dh50 per year, including postage. Overseas details on request.

Cover Illustrations:

Front: An ornate reef sea snake, *Hydrophis ornatus* swimming in the Gulf of Oman off Fujairah.
Photo by Csaba Géczy

Back: A pod of Indo-Pacific common dolphins, *Delphinus delphis tropicalis* spotted from the air in the Gulf of Oman off Fujairah.
Photo by Robert Baldwin

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Editorial

As this journal enters into its second quarter-century of publication, the Editorial Board is delighted to announce that it will henceforth be published by the Environment Agency – Abu Dhabi, EAD, in association with the Emirates Natural History Group, ENHG, under whose auspices it was launched back in 1991. It is particularly appropriate that this partnership should be initiated now, since EAD, formerly known as the Environmental Research and Wildlife Development Agency, ERWDA, has recently also celebrated its 25th anniversary.

At the time that ***Tribulus*** was launched, much of the original research into the environment, flora and fauna of the Emirate of Abu Dhabi, and of the broader United Arab Emirates, was still being undertaken through voluntary non-governmental organisations like the ENHG and by a variety of independent researchers. Since the foundation of EAD, however, the Agency has taken a leading role in such studies and in the creation and implementation of a wide-ranging government programme to promote environmental conservation and to develop policies that seek to achieve sustainable development. The objectives which ***Tribulus*** was launched to advocate are now part of a central component of the long-term strategy of Abu Dhabi and of the rest of the Emirates.

Through this new association, both EAD and ENHG hope to encourage sharing of the results of research between the governmental and non-governmental sectors, in pursuit of the wider goal of publishing material related to the environment, natural history, heritage, geology, archaeology, palaeontology and history of the United Arab Emirates. We look forward to continuing to do so in the years ahead.

In this Volume, we continue to follow the well-established policy of publishing papers that examine areas of the UAE's fauna and flora that have, thus far, received little attention. We are delighted, therefore, to be able to include three major contributions on such topics. A team led by Balázs Buzás present a first detailed study of the UAE's sea snakes, surveyed off the coast of Fujairah. Robert Baldwin and colleagues, including Buzás, supplement this with the results of a survey of cetaceans, also off Fujairah, while Martin Soesbergen provides a preliminary investigation of plankton organisms of fresh and brackish waters in the northern UAE. This represents, as far as we are aware, the first detailed study of its type.

Also from Fujairah, Balázs Farkas and colleagues, again including Buzás, report on additions to the herpetofauna of the important Wadi Wurayah nature reserve. This work in Fujairah, it's appropriate to note, is all being sponsored by the Emirate's Crown Prince, Sheikh Mohammed bin Hamad Al Sharqi, who deserves thanks for his support for, and interest in, the UAE's environment and wildlife.

The UAE's birdlife again receives attention, thanks to frequent contributors Oscar Campbell and Mark Smiles, who report on a sudden, and rather remarkable, extension of the breeding range of Shikra, a raptor that is a recent colonist, and on a major influx of Pied Kingfishers into the UAE in 2015–2016. Mohammed Shahid provides the results of further studies of a coastal plant, while Jennifer Huggett, along with geologists Graham Evans and Tony Kirkham, also frequent contributors, report on the discovery of a rare mineral in the deserts of Abu Dhabi.

Finally, Peter Hellyer summarises the engagement of the UAE's founding father, Sheikh Zayed bin Sultan Al Nahyan, in the work of the Abu Dhabi Islands Archaeological Survey, ADIAS, between 1992 and 2004.

The variety of papers in this Volume, from both new and from regular contributors, will provide, we hope, a taste of the scope of material that ***Tribulus*** hopes to continue to publish in the years ahead.

Peter Hellyer

The sea snakes (Elapidae: Hydrophiinae) of Fujairah

by Balázs Buzás, Balázs Farkas, Eszter Gulyás & Csaba Géczy

Abstract

True sea snakes of the subfamily Hydrophiinae are important yet barely known elements of the reef and coastal ecosystems of the Indian and Pacific oceans. We made a total of 100 boat trips between January 2015 and July 2018 with the aim of contributing to the body of knowledge on the marine elapid fauna of the Gulf of Oman off Fujairah. Of the nine species ever recorded from the territory of the United Arab Emirates, we confirmed the presence of eight in our study area. The most frequently encountered species was *Hydrophis platurus* (n = 106), followed by *H. ornatus* (n = 97) and *H. lapemoides* (n = 43). The observation of small juveniles and gravid females suggests that these three species also breed in UAE waters. The least common were *Microcephalophis gracilis*, *Hydrophis cyanocinctus* and *H. schistosus,* represented by as few as three, four and one individual(s), respectively.

Introduction

True sea snakes of the subfamily Hydrophiinae are advanced, morphologically and ecologically diverse proteroglyphous snakes related to cobras, coral snakes, kraits, and mambas. They are highly adapted to living in marine environments. For instance, their tail is flattened and paddle-like to provide propulsion, their ventral scutes are narrow for streamlining, the valves in their nostrils can close to prevent ingress of water, their lung morphology allows them to stay underwater for prolonged periods of time and a specialised gland under their tongue eliminates excess salt (Heatwole 1999; Fig. 1). One species, the yellow-bellied sea snake, *Hydrophis platurus* is pelagic and considered one of the most widely distributed reptiles in the world. The rapid radiation of these ovoviviparous

Figure 1. Adaptations of marine elapid snakes—such as the reduced ventral scales, the laterally compressed tail (A) and the valve-like nostril flaps (B) of *Hydrophis ornatus*—serve them well in the deep but render them virtually helpless on land (C; photos by Csaba Géczy [A, B] and Balázs Buzás [C]).

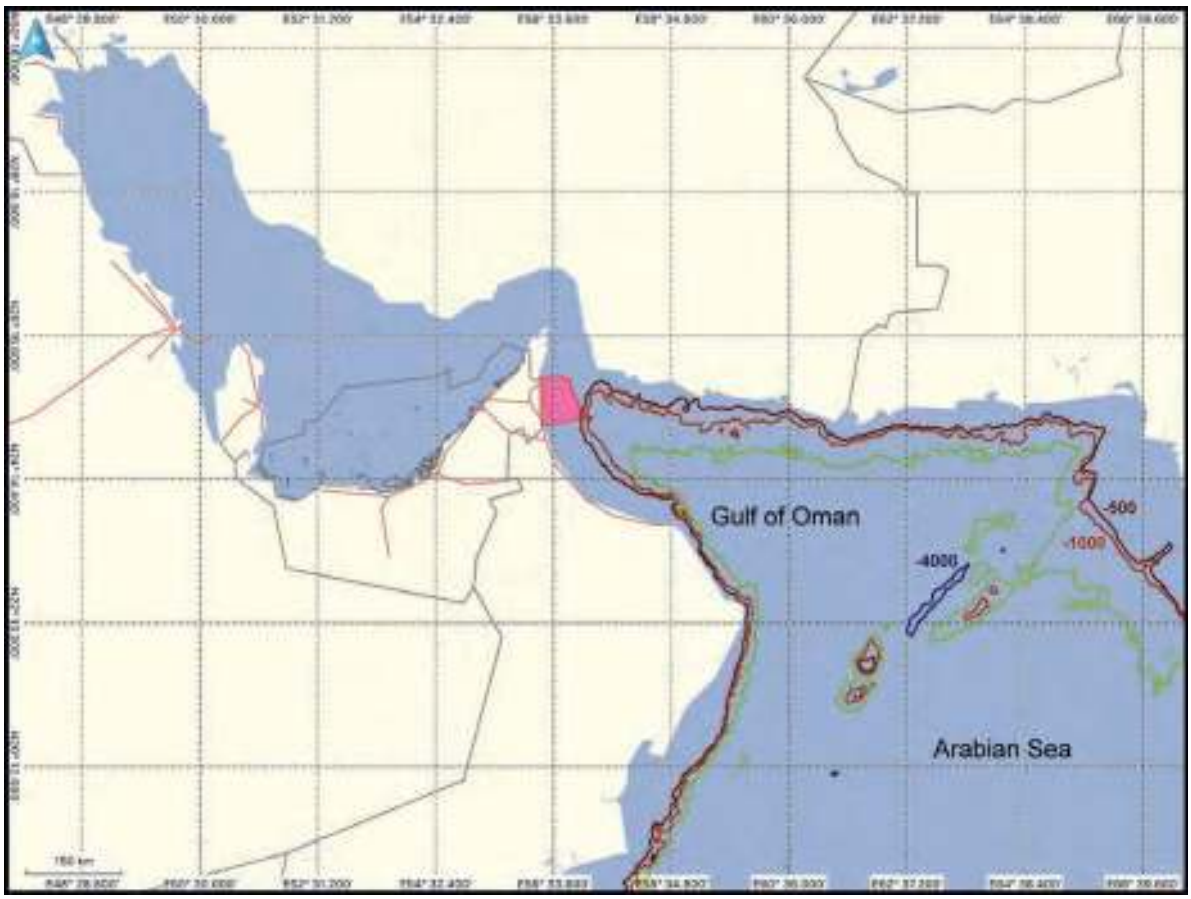

Figure 2. Bathymetry of the northwestern part of the Arabian Sea, with depth contours in metres (modified after Smith & Sandwell 1997). The Exclusive Economic Zone (EEZ) off the east coast of the UAE is highlighted with pink.

creatures is probably driven by dietary specialisation (Sherratt *et al.* 2018). While the majority of species is piscivorous, a few will also take invertebrates including gastropods, and some members of the genus *Aipysurus* eat nothing but fish eggs (Voris & Voris 1983, de Silva *et al.* 2011b). Nevertheless, they all play a crucial role in the trophic structure of reef and coastal ecosystems in tropical and subtropical waters of the Indian and Pacific oceans (Voris 1972, Rasmussen *et al.* 2011b). In general, however, the ecology of marine elapids is poorly known, mostly due to the difficulties associated with studying them, and several species—particularly those with a restricted range—appear to be in steep decline (Bonnet *et al.* 2016, Udyawer *et al.* 2018).

To this day, nine species—*Hydrophis curtus*, *H. cyanocinctus*, *H. lapemoides*, *H. ornatus*, *H. platurus*, *H. schistosus*, *H. spiralis*, *H. viperinus* and *Microcephalophis gracilis*—have been recorded from the territory of the United Arab Emirates (Gasperetti 1988, Soorae *et al.* 2006, 2010, Egan 2007, Gardner 2013). Whereas the Hydrophiinae fauna of the Arabian Gulf has received a reasonable amount of attention from herpetologists and conservationists from various countries (Volsøe 1939, Brown 1987, Gasperetti 1988, Soorae *et al.* 2006, Bishop & Alsaffar 2008, Safaei & Esmaili 2009, Rezaie-Atagholipour *et al.* 2012a, 2012b, 2013), the waters of the Gulf of Oman—and especially off the east coast of the UAE—remain largely unexplored. For the Iranian side of the Gulf, Rezaie-Atagholipour *et al.* (2016) published a major review of sea snakes recovered from the bycatch of fishing trawlers (Hormozgan, Sistan and Baluchestan provinces) or collected in mangrove swamps off Jask (Hormozgan Province) as well as proved the occasional presence of yet another species, *M. cantoris*. However, apart from two *in situ* photographs of a *H. lapemoides* and a *H. spiralis* taken by Keith Wilson and featured in Gardner (2013), we are unaware of any work even superficially dealing with the hydrophiines of Fujairah.

Recent molecular phylogenetic studies of 39 sea snake species in 15 genera revealed *Hydrophis* to be broadly paraphyletic with respect to several other genera (Lukoschek & Keogh 2006, Sanders *et al.* 2013). Instead of erecting multiple new taxa, Sanders *et al.* (2013) proposed dismantling the mostly monotypic genera *Pelamis*, *Enhydrina*, *Astrotia*, *Thalassophina*, *Acalyptophis*, *Kerilia*, *Lapemis* and *Disteira*, and recognising a single genus for the core *Hydrophis* group. This classification system better reflects the history of the very rapid radiation of marine elapids and is followed by most subsequent authors (e.g., Lillywhite 2014, Rasmussen *et al.* 2014, Ukuwela *et al.* 2014, Udyawer *et al.* 2016, 2018, D'Anastasi *et al.* 2016, Rezaie-Atagholipour et el. 2016, Mirtschin *et al.* 2017, Sherratt *et al.* 2018) as well as ourselves in this paper.

The conservation status of every sea snake species recorded from the territorial waters of the UAE was recently assessed by a team of researchers, including the authors, at the UAE National Red List Workshop, applying strict IUCN criteria (Al Hantoubi *et al.* in prep.).

Study area

Unlike the other six emirates constituting the UAE that border the Arabian Gulf, Fujairah has a coastline only to the Gulf of Oman. Situated in the northwest corner of the Arabian Sea, the Gulf of Oman is a strait rather than an actual gulf that links the Indian Ocean with the Arabian Gulf via the Strait of Hormuz. Its circulation is affected by the Northeast (March–April) and Southwest (September–October) Monsoon seasons (Jackson 2004, Pous *et al.* 2004). As confirmed recently by Seaglider surveys, the Gulf of Oman contains the largest—and continuously expanding—oxygen-depleted "dead zones" in the world, covering almost 165,000 km^2, that cannot sustain marine wildlife. The cause is a combination of climate change and environmental pollution resulting from the runoff of chemical fertilisers and wastewater (Breitburg *et al.* 2018, Queste *et al.* 2018). Average monthly sea surface water temperatures in Fujairah vary between roughly 23 °C in winter and 31 °C in summer months, i.e., the maxima reached in July and August may sometimes be just too high for sea snakes to tolerate (*seatemperature.info/fujairah-water-temperature.html*): Dunson & Ehlert (1971) report the upper lethal limit for *Hydrophis platurus* to be 33 °C. The waters off Fujairah are part of an Exclusive Economic Zone (EEZ) of 4,370 km^2 (Fig. 2). There are four Marine Protected Areas (MPAs) within the territory of Fujairah, all defined by the Emiri decree No. 1 of the year 1995: the Al Aqa MPA, the Dadna MPA, the Rul Dibba MPA, and the Al Bidiyah MPA (with the last one awaiting approval; see *www.emiratesdiving.com/marine_protected_areas*). The sole sea snake ever recorded in any of them is a stranded *H. spiralis* photographed by Csaba Varga on 19 August 2016 in the Al Aqa MPA.

Figure 3. Map showing our boat trips undertaken between January 2015 and July 2018.

Materials and methods

We undertook on-water surveys by two motor boats (35 and 48 ft long) in the EEZ between January 2015 and July 2018, both during the day as well as after sunset. Initially, we concentrated our searches to sites pinpointed to us by knowledgeable local sources—professional and recreational fishermen—for their supposed "snake-richness," including the northern part of the EEZ. However, from 2016 on we focused on areas that actually produced the most sightings of sea snakes in our first year, i.e., to a 10-km wide band off Fujairah municipality stretching from 25°9'40" to 25°5'50" N that we traversed in a large loose pattern from south to north at a speed of 5.5–8 knots (approximately 10–15 km/h). Altogether, we made exactly 100 trips, spent about 11,779 minutes (196.3 h) in the field and covered a total of 3,672.5 km during this period (Fig. 3). Snakes encountered underway were scooped up from the sea surface by using a dip net or—more rarely—collected by hand, immediately transferred to transparent plastic storage boxes containing sea water and normally brought to the laboratory for further processing. In addition to measuring their lengths and weights and determining their sex, we took blood and/or tissue samples of all individuals collected, photographed them and removed and preserved ectosymbiotic barnacles for later analysis. Cloacal—sometimes also buccal—swabs were also taken and regurgitated gut contents were preserved in order to be sent to specialists for identification (Fig. 4). For specimen and data acquisition, the protocols outlined by Bonnet *et al.* (2016) were followed. Snakes were typically released the next day, precisely at the site of collection. Individuals that could not be caught were counted only if their taxonomic identity was beyond any doubt. In addition, we visited all known diving sites off Fujairah and descended 10–50 m deep to search for sea snakes. A few specimens (about 1% of our sample) were found stranded or received from fishermen. These were preserved in alcohol and lodged at the Al Mayya Sanctuary. While lunar phases did not seem to have any effect on snake activity, wind forces above Beaufort #2 rendered detecting sea snakes on the surface considerably more difficult.

Figure 4. Acquisition of specimens and data. A: Visiting herpetologist Tamás Tóth scooping up a yellow-bellied sea snake, *Hydrophis platurus* from the sea surface by using a dip net (photo by Csaba Géczy), B: Visiting scientist Zoltan Takacs hand-collecting an ornate reef sea snake, *Hydrophis ornatus* (photo by Csaba Géczy), C: Male spine-bellied sea snake, *Hydrophis curtus* posing for a photograph (photo by Csaba Géczy), D: Two of the authors (CsG [left] and BB) tapping blood from a *Hydrophis ornatus* (photo by Eszter Gulyás), E: Sexing a female Arabian Gulf sea snake, *Hydrophis lapemoides* by cloacal probing (photo by Balázs Buzás), F: An ectosymbiotic barnacle, *Platylepas ophiophila* removed from the skin of a *H. ornatus* (photo by Andrew Hosie), G: An unidentified conger eel (Congridae) regurgitated by a yellow sea snake, *Hydrophis spiralis* (photo by Balázs Buzás), H: Returning a *H. ornatus* to the sea (photo by Csaba Géczy).

Figure 5. Colour pattern variation in spine-bellied sea snakes, *Hydrophis curtus* from the Gulf of Oman off Fujairah.
A: Female, ss_UAE363, B: Male, ss_UAE032, C: ss_UAE104 just before shedding, D: ss_UAE157 (all photos by Balázs Buzás). Not to scale.

Species accounts

***Hydrophis curtus* (Shaw, 1802)**
Spine-bellied sea snake, لافعى البحرية صغيرة الرأس

Diagnostic characters: Scales in the lowermost three or four lateral rows larger than the others. Scale rows around neck 23–38; scale rows around body 25–45. Ventrals small, 114–230, usually distinct anteriorly, very small or absent posteriorly. Maxillary teeth behind fangs 3–6 (Rasmussen *et al.* 2011a, Gardner 2013, Rezaie-Atagholipour *et al.* 2016).

Colouration: Body yellow, tan, olive, pinkish or light grey above, whitish below, with 45–55 narrow, light grey, dark greenish, brown or black—often diamond-shaped—bands, which sometimes fuse longitudinally dorsally, narrowing laterally. However, in some specimens the bands meet below and encircle the body. Juveniles typically have a yellow base colour, a blackish head adorned with a yellow curved mark above and incomplete black bands running the length of their body. Individual differences in tail pigmentation allow the field identification of *H. curtus* specimens (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013, Rezaie-Atagholipour *et al.* 2016; Fig. 5).

Size: 110 cm (Rasmussen *et al.* 2011a). According to Egan (2007), spine-bellied sea snakes may exceptionally reach 1 m but adults are typically closer to 80 cm in total length (TL). The 15 Iranian specimens measured by Rezaie-Atagholipour *et al.* (2016) had a mean TL of 716 mm, with the largest being 1015 mm (TL). The ten individuals we caught in the Gulf of Oman off Fujairah were between 65 and 94 cm long (TL). Our biggest male (94 cm TL, 344 g) surpassed our largest female (83 cm TL, 298 g) in both length and weight parameters. Nevertheless, the two sexes are capable of reaching approximately the same overall dimensions (Heatwole 1999).

Distribution: From the Arabian Gulf to Japan, the Philippines, Indonesia and the Australian region (Rasmussen *et al.* 2011a). Volsøe (1939) insisted that *H. curtus* is one of the most abundant sea snakes in the Iranian coastal waters of the eastern Arabian Gulf, and Rezaie-Atagholipour *et al.* (2016) confirmed it to be common in the western part of the Gulf (off Bushehr Province) as well. However, records from the marine territorial waters of the UAE are not very numerous. Soorae *et al.* (2006) reported this species from Abu Dhabi Island in the Arabian Gulf, while we encountered it relatively often along the southern part of the east coast, south of Fujairah city (Map 1).

Habitat: Wide range of tropical shallow-water habitats, including gulfs, bays and estuaries, over continental shelves and soft-sediments adjacent to coral reefs. *Hydrophis curtus* sometimes ascends rivers and thus also occurs in freshwater (Lukoschek *et al.* 2010, Gardner 2013). Udyawer *et al.* (2016) revealed this species to prefer slightly deeper seagrass habitats than *H. elegans* in Sri Lanka. From the Gulf of Oman, Rezaie-Atagholipour *et al.* (2016) mentioned a total of six specimens caught off Beris and Pasabandar, Iran at 20–40 m depth in

Map 1. Records of *Hydrophis curtus*.

August 2013. We encountered spine-bellied sea snakes up to 7 km off Fujairah, above depths of up to 55 m, where the bottom is sandy. However, the habitat associations of this species in the UAE are virtually unknown.

Biology: The stomachs of four specimens (out of 12) examined by Volsøe (1939) contained only fish remains, including those of a young king soldier bream (*Argyrops spinifer*, Sparidae), gobies (Gobiidae) and anchovies (*Stolephorus* sp., Engraulidae). Heatwole (1999) indicated *Hydrophis curtus* to be a generalised fish eater, whereas Lobo *et al.* (2005) found remains of fish assignable to five families in the guts of spine-bellied sea snakes, with Clupeidae and Cynoglossidae constituting the largest part of the prey along the western coast of India. Rezaie-Atagholipour (2012) stated them to consume fish referable to 33 families as well as squid and amphipods. Udyawer *et al.* (2016) confirmed the diet of these serpents to

Figure 6. Mating *Hydrophis curtus*, 27 March 2015 (photo by Abdullah Al Zaabi).

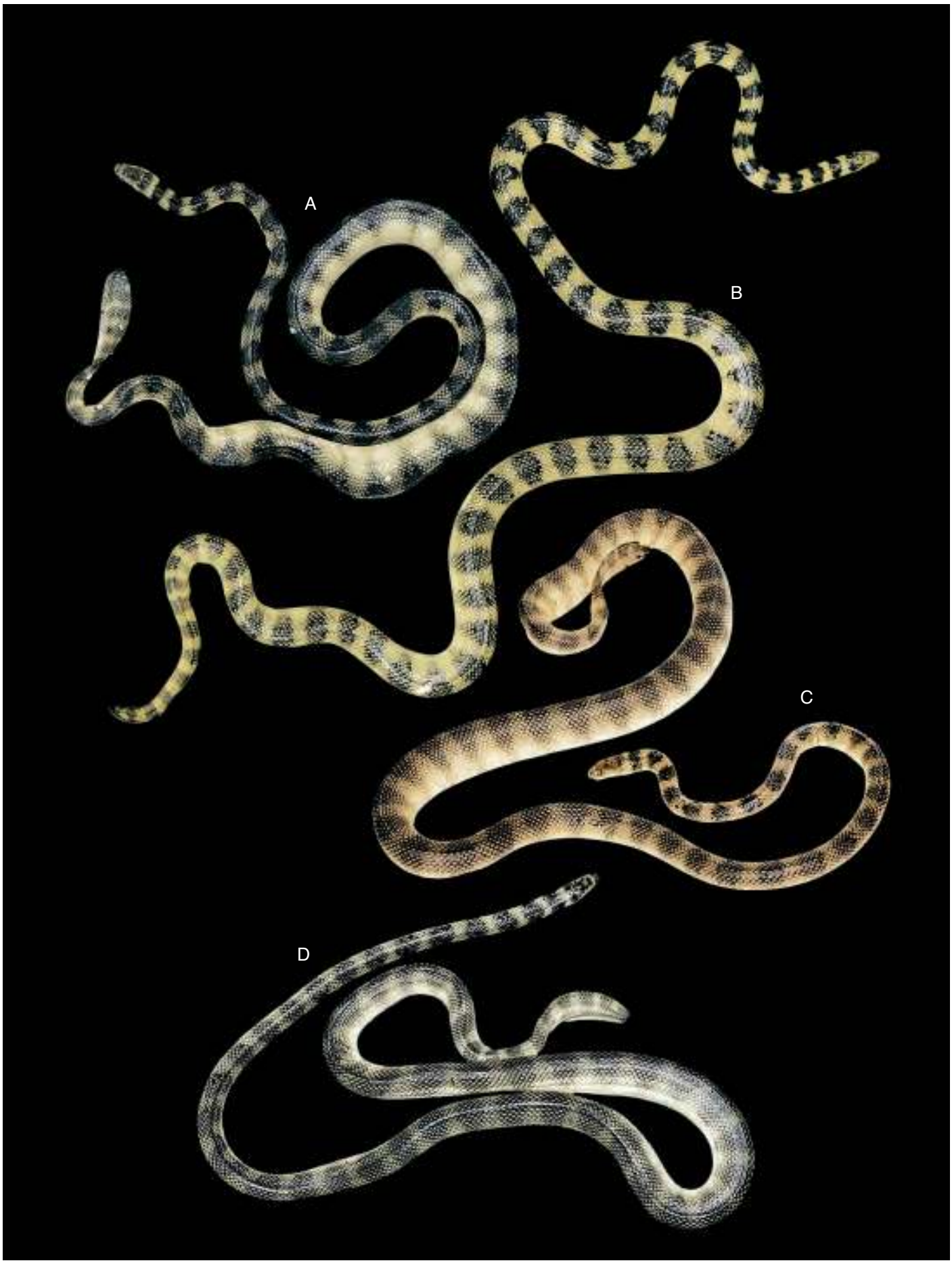

Figure 7. Colour pattern variation in blue-banded sea snakes, *Hydrophis cyanocinctus* from the Gulf of Oman off Fujairah.
A: Female, ss_UAE280 (photo by Csaba Géczy), B: Male, ss_UAE260 (photo by Balázs Buzás), C: ss_UAE384 (photo by Nathanaël Maury), D: Male, ss_UAE514 (photo by Balázs Buzás). Not to scale.

comprise at least four families of fish in Sri Lanka and even found evidence of some level of intraspecific predation. De Silva *et al.* (2011b) were the first to report a sea snail, *Babylonia spirata* in the stomach of a male *H. curtus* caught off Valvettithurai, Sri Lanka. An 80-cm (TL) specimen collected by us regurgitated upon capture a 15–17 cm long fish that was too decomposed for identification. We encountered spine-bellied sea snakes on ten occasions, in the months January, February, March, April, June, September, November and December, both during the day and after dusk. Mating was observed once, in late March (Fig. 6). Litter sizes reported for Sri Lankan *H. curtus* were 4 and 10 (de Silva *et al.* 2011a), whereas Heatwole (1999) declared an average of 3.3 young (range 1–6) to be the "norm" in this species. To our experiences, *H. curtus* are usually inoffensive when pulled out of their element but we had one that literally "jumped" out of the transport box to get hold of a glove and also Heatwole (1999) described these snakes as very aggressive if provoked or handled. In any case, their venom contains postsynaptic neurotoxins and probably also myotoxins, and this species is to be considered relatively dangerous (*www.toxinology.com*). Spine-bellied sea snakes often live in association with sessile (*Platylepas ophiophila*) and pedunculate barnacles (*Conchoderma virgatum*) adhered to the end of their tails. Wounds inflicted by sea birds or predatory fish are also relatively frequent, sometimes appearing rather serious (field Nos. ss_UAE186, 427 and 562). A single voucher specimen of undetermined sex (ss_UAE104) is deposited at the Al Mayya Sanctuary, Fujairah.

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Lukoschek *et al.* 2010), *Hydrophis curtus* was considered "widespread, common, taken as bycatch in trawl fisheries, harvested for skins, food and medicinal purposes" by Elfes *et al.* (2013). However, population size and trend within UAE waters are unknown.

Hydrophis cyanocinctus **Daudin, 1803**
Blue-banded sea snake, الافعى البحرية المحلقة

Diagnostic characters: Scale rows around neck 27–35, rarely 25; scale rows around body 33–48; ventrals 279–397. Maxillary teeth behind fangs 5–8 (Gasperetti 1988, Rasmussen *et al.* 2011a, Gardner 2013).

Colouration: Very variable. Body silvery grey or pale yellow green above, whitish below. 50–75 dark bluish or black bands, which may be either encircling the body and broadest above, or encircling the body and of rather uniform width, or broadest above and narrowing out to dissolve laterally. On the posterior part of the body the bands are always wider dorsally than the interspaces between them. The young have an olivaceous or yellowish base colour ringed with bold black and often sport a ventral stripe. Their head is black or dark olive with or without a yellowish horseshoe-shaped mark on top. As age advances, the belly pattern disappears and also the back markings lose much of their definition (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a; Fig. 7).

Size: 275 cm (Rasmussen *et al.* 2011a). Egan (2007) claimed that while *H. cyanocinctus* is capable of reaching over 2 m TL, most specimens are between 1.5 and 1.7 m long in Arabia. For Iranian waters, Rezaie-Atagholipour *et al.* (2016) reported a mean SVL of 117 cm, with their largest female measuring 155 cm SVL and weighing 1019 g. The four individuals we caught in our study area off Fujairah ranged between 105 and 137 cm TL. Our largest confirmed male was 115 cm long (TL) and weighed 251 g, whereas our largest confirmed female had a TL of 133 cm and a body mass of 390 g.

Distribution: From the Arabian Gulf in the west to Japan in the east (Rasmussen *et al.* 2010c, 2011a). Gardner (2013) declared—probably on account of Wall's (1921) and Gasperetti's (1988) reports—this species to be abundant in the Arabian Gulf but less so in the Gulf of Oman, and also Rezaie-Atagholipour *et al.* (2012a) found *H. cyanocinctus* to be the dominant sea snake in the Hara Protected Area off the shores of Iran. However, its occurrence in the marine territorial waters of the UAE is poorly documented and presently available data indicate it to be less common than most other hydrophiines, with the only records from the Arabian Gulf originating from strandings on Dubai beaches. Besides, while such observations were more or less regular in the 1990s, their numbers declined strongly over the last decades. Evidences from along the east coast are more numerous but still relatively few (Al Hantoubi *et al.* in prep.).

Habitat: Warm, shallow waters over reefs, seagrass beds or sand; also in mangroves (Gardner 2013). We have encountered this species 4.5–7.2 km offshore in our study area.

Biology: According to Gardner (2013), *Hydrophis cyanocinctus* are often seen basking on the surface and they appear to be more active in the warm season (from April to November). We recorded blue-banded sea snakes on four occasions in our study area, in the months January, July and October, typically in the late afternoon or after dark (Map 2). Volsøe (1939) reported an Iranian

Map 2. Records of *Hydrophis cyanocinctus.*

Figure 8. Colour pattern variation in Arabian Gulf sea snakes, *Hydrophis lapemoides* from the Gulf of Oman off Fujairah.
A: ss_UAE141, B: ss_UAE537, C: Female, ss_UAE275 (photos by Balázs Buzás), D: Male, ss_UAE525 (photo by Csaba Géczy). Not to scale.

specimen to have eaten five Indian Ocean slender mudskippers (*Scartelaos tenuis*), whereas also Rezaie-Atagholipour *et al.* (2013) found almost exclusively mudskippers (*Periophthalmus waltoni*, *Boleophthalmus dussumieri*, *Scartelaos tenuis*) and tail-eyed gobies (*Parachaeturichthys polynema*) ingested head first in the stomachs of 34 *H. cyanocinctus* examined by them. Although they detected a positive correlation between predator and prey length, large snakes occasionally consumed small fish as well. In other parts of the species' distributional range, also eels may feature in the diet of *H. cyanocinctus* (Voris 1972, Voris & Voris 1982, 1983). Karthikeyan *et al.* (2008) fed their captive blue-banded sea snakes striped eel catfish (*Plotosus lineatus*). Two specimens (130 and 137 cm TL) we caught regurgitated fish (30–50 cm long), one of them actually being a *P. lineatus*, while the other was an unidentifiable pike conger (Muraenesocidae). We are unaware of any data to confirm Egan's (2007) speculation about *H. cyanocinctus* taking cephalopods (in addition to smooth-bodied fish). Volsøe (1939) recorded two gravid females to contain four eggs, the largest being 65 x 29 mm in size, while Bergman (1943) declared this species to produce about ten embryos per mother each season. According to Karthikeyan *et al.* (2008), females off the Coromandel coast, southeastern India deliver 3–5 young, depending on their size, during January–February, with female offspring being considerably larger than males at birth (469 ± 37 mm vs 382 ± 56 mm TL). A 1285-mm TL female collected early May in Sri Lanka contained five fully developed embyros with a mean SVL of 287.83 mm (De Silva *et al.* 2011a). Clutch sizes reported by Heatwole (1999) ranged between 3 and 16. To our experiences, these snakes are completely inoffensive on land and do not attempt to bite, contrary to claims made by Egan (2007) and Gardner (2013). However, also the *www.toxinology.com* web site characterises them as "easily angered if provoked" and considers their bites relatively dangerous. Barnacle (*Platylepas ophiophila*) infestation was common among the individuals we collected, and also highly virulent bacteria of the *Burkholderia cepacia* complex were isolated from faecal material (Géczy *et al.* 2017).

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010c), *Hydrophis cyanocinctus* was described as "widespread, locally common, taken as bycatch in fisheries" by Elfes *et al.* (2013). However, population size and trend within UAE waters are unknown.

Hydrophis lapemoides (Gray, 1849)
Arabian Gulf sea snake, افعى الخليج العربي البحرية

Diagnostic characters: 29–35 scale rows on the neck, 40–51 scale rows at midbody; 300–404 ventrals. Maxillary teeth behind fangs 11 (Rasmussen 1987, Gasperetti 1988, Gardner 2013).

Colouration: Base colour light grey or pale yellow. The pattern is variable but typically consists of 44–64 blackish, grey or greenish bands, which are broadest dorsally and taper to points on the flanks. These rings fade towards

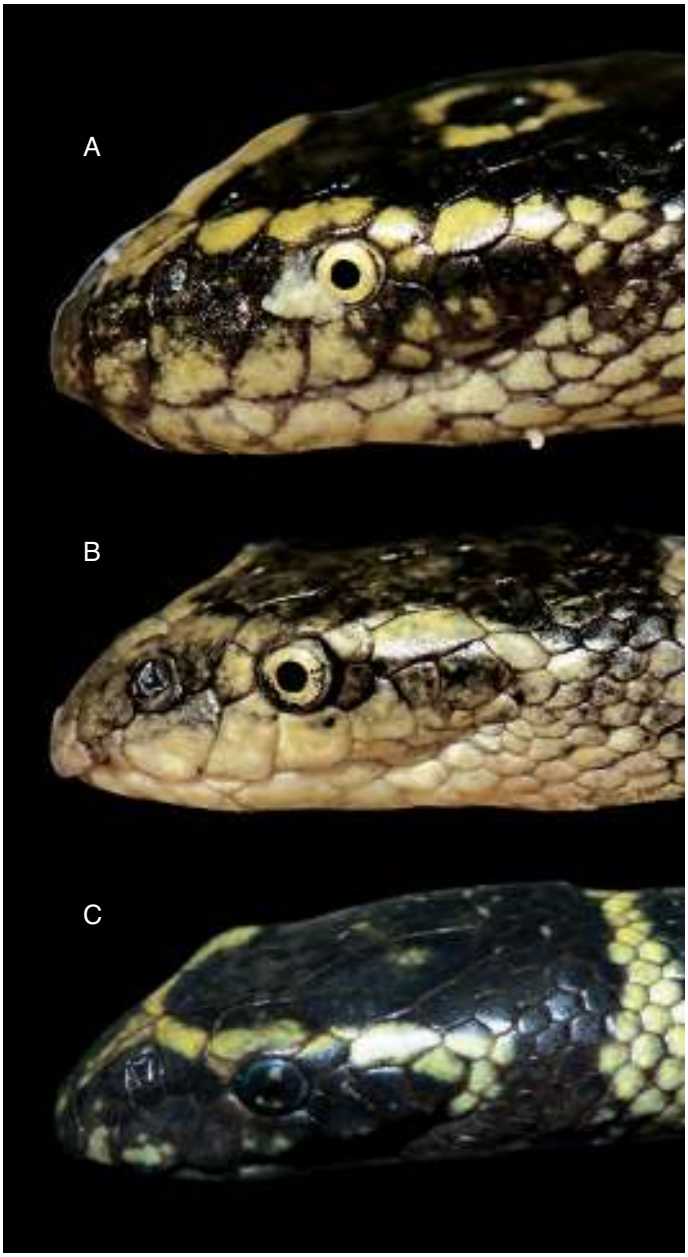

Figure 9. Variation in head pattern and scalation in *Hydrophis lapemoides*. A: ss_UAE141, B: ss_UAE139 (both photos by Balázs Buzás), C: Male, ss_UAE307 (photo by Csaba Géczy). Not to scale.

Figure 10. A *Hydrophis lapemoides* hunting for worm eels or gobies on the sea bottom in the Gulf of Oman off Fujairah (photo by Csaba Géczy).

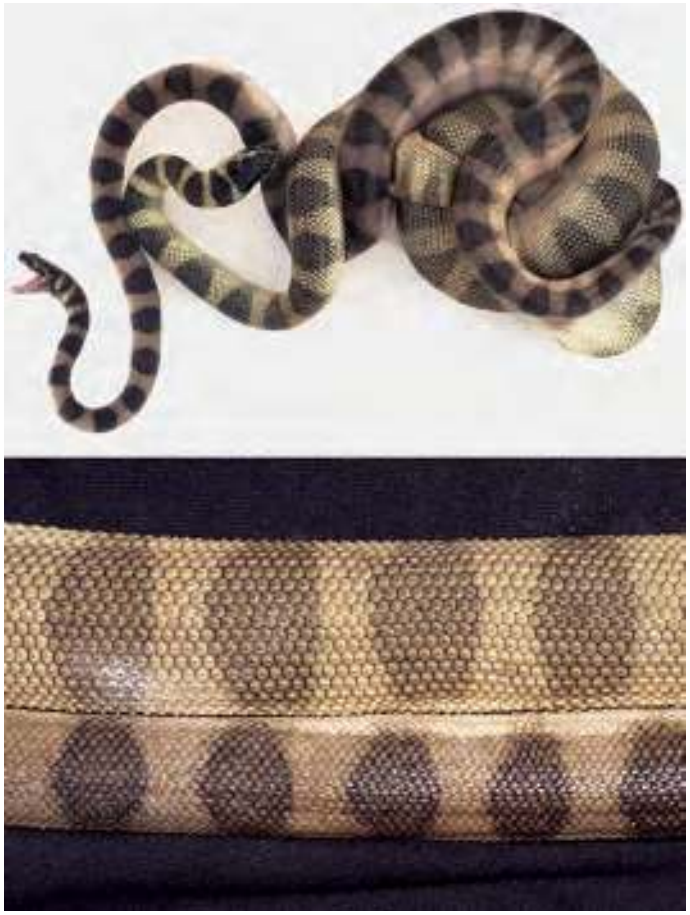

Figure 11. Mating *Hydrophis lapemoides* (male, ss_UAE219 and female, ss_UAE218) in the transport box (above, photo by Balázs Buzás) and dorsals of the same showing spine-like protuberances on the highly rugose scales of the bigger male, possibly serving as a gripping aid during copulation (below, photo by Csaba Géczy).

the ventral surface and may be completely absent in old individuals. Juveniles are white or bleached yellow with bold black bands. The head is black, usually with a yellowish or whitish horseshoe-shaped marking on top (Gasperetti 1988, Egan 2007, Gardner 2013, own data; Figs 8–9).

Map 3. Records of *Hydrophis lapemoides.*

Size: The maximum size reached by males is 960 mm (TL), with a tail 90 mm long, whereas the largest female ever reported was 925 mm long (TL) and had a tail length of 70 mm (Gasperetti 1988). Egan (2007) claimed Arabian Gulf sea snakes to be capable of surpassing 1 metre in TL but he indicated adults of 80–90 cm to be more common. The single specimen available to Rezaie-Atagholipour *et al.* (2016) from the Gulf of Oman (Jask, Hormozgan Province, Iran) measured 775 mm TL. The 34 *H. lapemoides* we caught in our study area off Fujairah were between 33 and 86 cm long (TL), and the maximum weight we recorded was 227 g. Our largest male was just 2 cm longer than our biggest female (84 cm TL).

Distribution: From the Arabian Gulf through the Gulf of Oman to the western coast of peninsular Thailand, Melanesia and Singapore (Rasmussen 1993, Rasmussen *et al.* 2010d). *Hydrophis lapemoides* was one of the four species recorded by Soorae *et al.* (2006) from the Arabian Gulf off Abu Dhabi Emirate (Jernain Island).

Habitat: Warm shallow water—sometimes less than 3 m deep—over reefs, seagrass beds or sand, often very close to shore, found also in freshwater estuaries (Egan 2007, Gardner 2013).

Biology: Gardner (2013) characterised *H. lapemoides* as a shallow water species that feeds on a great variety of fish. Five individuals caught in Iranian territorial waters of the Arabian Gulf examined by Volsøe (1939) had remnants of fish, probably Gobiidae, in their guts. Voris & Voris (1983) mentioned worm eels as typical prey of this species, while Rasmussen (1993) recovered the remains of fish belonging to four families (Gobiidae, Labridae, Mullidae, and Pseudochromidae) from the stomachs of Arabian Gulf sea snakes in Thailand. Egan (2007) believed that the preferred food of these serpents is eels, gobies and flatfish due to their easier capture. One of us (CsG) actually observed an individual in 45 m depth "lurking" at the burrow of a worm eel or goby (Fig. 10), while one of the specimens we collected regurgitated an unidentifiable cardinalfish (Apogonidae). We encountered *H. lapemoides* in each month except March and July, both during the day as well as after dusk, at 2.7–9.7 km distance from the Fujairah coastline (Map 3). With a total of 43 individuals seen, this was the third most abundant hydrophiine species in our study area. Mating individuals were recorded in May (Fig. 11) and the smallest juvenile (33 cm TL) was caught in November. Gravid females from Phuket, Thailand collected between 3rd October and 4th November (1989) and examined by Rasmussen (1993) contained 1–4 full-term embryos each, whereas Heatwole (1999) reported clutch sizes to range between 2 and 5 in this species. These snakes are typically docile when taken out of water but Brown (1986) claimed that a 42-cm long specimen "was aggressive when moved, opening its mouth and hissing loudly. It was able to move the forward part of its body from side to side a little." The venom of *H. lapemoides* contains postsynaptic neurotoxins and probably also myotoxins, and this species is considered relatively dangerous (*www.toxinology.com*). Barnacle

(*Platylepas ophiophila*) infestation was common among the individuals we collected, and several pathogenic bacteria (*Burkholderia cepacia*, *Pseudomonas aeruginosa, Pseudomonas luteola*) were isolated from faecal samples (Géczy *et al.* 2017). A single voucher specimen (male, ss_UAE064) has been deposted at the Al Mayya Sanctuary, Fujairah.

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010d), *H. lapemoides* was considered "widespread, taken as bycatch in trawl fisheries" by Elfes *et al.* (2013). This species seems to be very abundant within UAE waters.

Hydrophis ornatus (Gray, 1842)
Ornate reef sea snake, الافعى البحرية المبهرجة

Diagnostic characters: Scale rows around neck 34–41; scale rows around body 42–55; ventrals 235–312. Maxillary teeth behind fangs 9–13 (Rasmussen *et al.* 2011a, Gardner 2013).

Colouration: Body pale grey, olivaceous, brown, dark yellow or almost white above, yellowish or whitish below. About 50 broad black or dark grey bands or rhomboidal spots separated by narrow interspaces that are almost equidistant anteriorly. Head olive green or greyish dorsally, yellow ventrally (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013; Fig. 12).

Size: 115 cm (Rasmussen *et al.* 2011a). Gardner (2013) reported the maximum length to be at least 950 mm (TL) in *H. ornatus*, while Egan (2007) stated that although this species may exceptionally reach 100 cm, most individuals are between 80–90 cm long (TL). The maximum TL given by Smith (1926) was 950 mm for males and 860 mm for females. The six specimens caught by Rezaie-Atagholipour *et al.* (2016) had a mean TL of 988 mm, with the largest being 1200 mm long (TL). The 50 individuals of this species we measured in our study area ranged between 36 and 99 cm TL and the highest weight we recorded was 578 g. Our largest male (86 cm TL) was actually just 1 cm longer than our biggest female (85 cm TL) but weighed nearly 30 g more (578 vs 557 g). It is normal for males of this species to attain larger dimensions than females (Heatwole 1999).

Distribution: From the Arabian Gulf in the west to Japan, the Philippines, Indonesia, New Caledonia and the Australian region in the east (Rasmussen *et al.* 2011a).

Habitat: According to Heatwole (1999), these snakes prefer coral reefs, turbid inshore waters and estuaries. We have seen and collected them at 0.6–8 km distance from the Fujairah coast. Their depth range is unknown but potentially extends to 45 m below sea level in our study area. We have observed a single specimen underwater while diving at the Inchcape 10 ship wreck (Fig. 1A).

Biology: Even though Egan (2007) believes this species to be locally fairly rare, it is in fact reasonably abundant along the east coast of the UAE. We have observed 97 specimens off Fujairah during our study period (Map 4), in every month, both in the course of the day as well as at night. As such, *Hydrophis ornatus*

Map 4. Records of *Hydrophis ornatus.*

was the second most common species after *H. platurus*. Interestingly, also Rezaie-Atagholipour *et al.* (2016) had relatively few—just three—specimens at their disposal from the Gulf of Oman, caught off Beris and Pasabandar, Iran at 20–40 m depth in August (2013). The food of ornate sea snakes consists of a wide range of fish, including free-swimming species, which they probably attack at night, while sleeping (Gardner 2013). Although *H. ornatus* are occasionally found basking in the sun, they are more commonly seen at night, just below the surface (Egan 2007). The typical clutch size is 2–5 young and there is evidence of synchronised annual reproduction (Rasmussen 1989). The presence of small juveniles—observed by us between December and February—points to breeding off the UAE east coast. Ornate reef sea snakes are defensive and try to bite when taken out of water. However, they are not considered very dangerous, even though their venom contains postsynaptic neurotoxins and probably also myotoxins (*www.toxinology.com*). We maintained a young male (38 cm) in an aquarium for 33 days, when it was released. During this time it did not consume any of the southern platyfish (*Xiphophorus maculatus*) offered as food but shed its skin once. Fish regurgitated by freshly caught individuals were identified as eel catfish (*Plotosus lineatus*) and threadfin breams (Nemipteridae). One specimen (ss_UAE140) disgorged a small clump of gelatinous material that appeared to be a jellyfish. Sessile barnacles (*Platylepas ophiophila*) were found living in association also with these snakes, and one had several lepadids (*Conchoderma virgatum*) growing on its head, ventral scales and tail (ss_UAE552; Fig. 13). Additionally, hemiurid trematodes were recovered from the oesophagus, while faecal material of some individuals contained the bacteria *Chromobacterium violaceum* and *Photobacterium damseale* (Géczy *et al.* 2017). Two injured specimens (ss_UAE498 and ss_UAE573) were found as well. Three

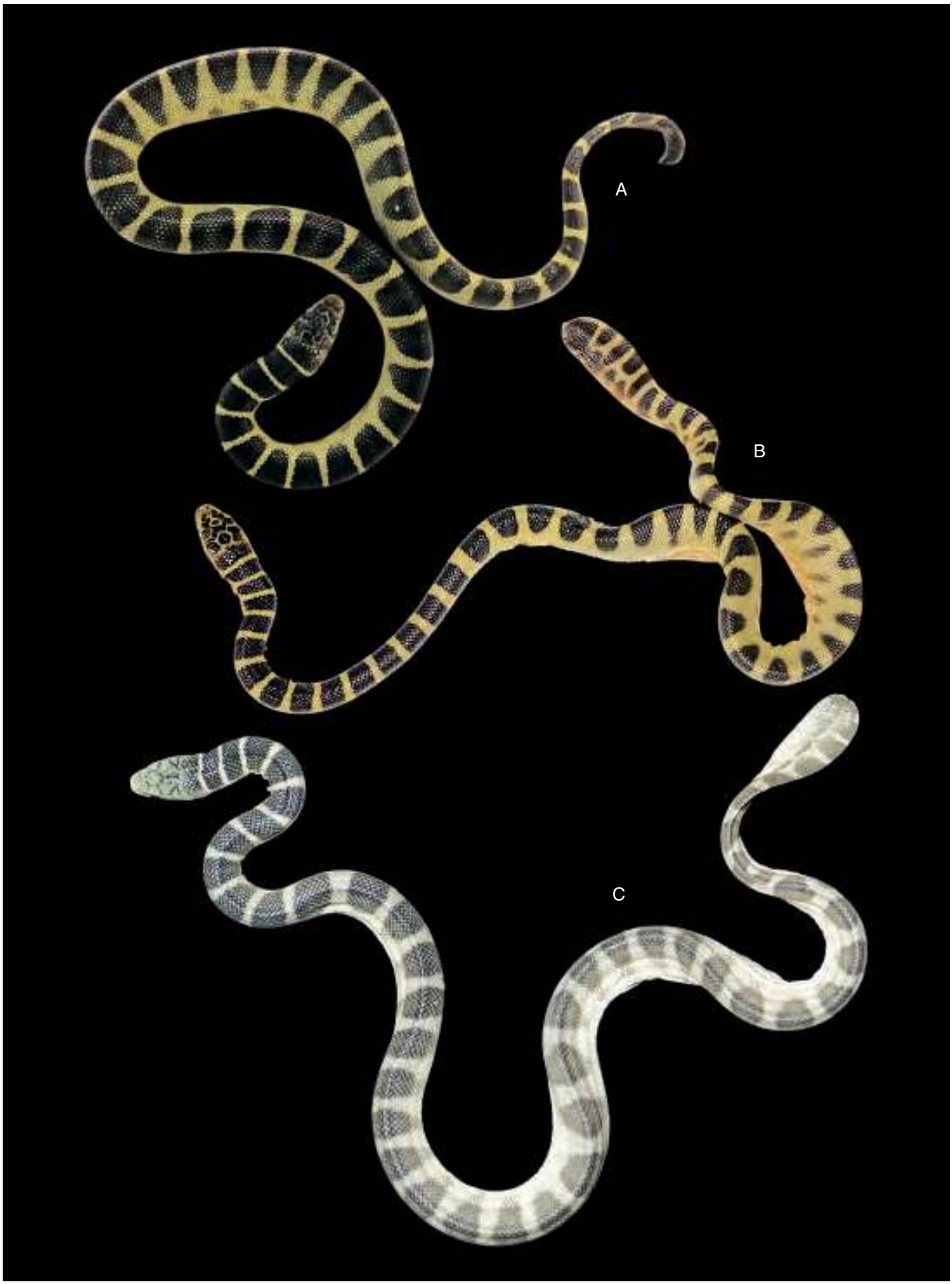

Figure 12. Colour pattern variation in ornate reef sea snakes, *Hydrophis ornatus*. A: Juvenile, ss_UAE020 (photo by Balázs Buzás), B: ss_UAE302 (photo by Nathanaël Maury), C: ss_UAE291 (photo by Csaba Géczy). Not to scale.

Figure 13. Pedunculate barnacles (*Conchoderma virgatum*) attached to various body regions of a *Hydrophis ornatus* (ss_UAE552) (photos by Balázs Buzás [A], Balázs Farkas [B, C] and Rolf Schuster [D]).

vouchers (female, ss_UAE297, male, ss_UAE528 [head only], female [?], ss_UAE571, unknown sex, ss_UAE573) have been deposited at the Al Mayya Sanctuary, Fujairah.

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010b), *H. ornatus* was considered "widespread, taken as bycatch in trawl fisheries" by Elfes *et al.* (2013). This species seems to be reasonably abundant within UAE waters.

Hydrophis platurus (Linnaeus, 1766)
Yellow-bellied sea snake, افعى المحيطات

Diagnostic characters: Scale rows around body 49–67; ventrals 264–440 or broken up and similar to adjacent scales. Maxillary teeth behind fangs 7–11 (Joger 1984, Rasmussen *et al.* 2011a).

Colouration: Extremely variable but distinct from all other sea snakes; body black, blackish green or dark brown above, yellow or light brown below. These colours meet along the sides but the exact level varies. Posteriorly (mostly on the tail) the black and yellow areas are broken up to form spots or even irregular hour-glass-shaped transverse bands (Gasperetti 1988, Rasmussen *et al.* 2011a; Figs 15–18). A nearly uniform yellow form reaching a smaller maximum size was recently described from the Golfo Dulce, Costa Rica as a separate subspecies, *H. platurus xanthos* (Besessen & Galbreath 2017).

Size: 88 cm (Rasmussen *et al.* 2011a). Gardner (2013) erroneously indicated 1000 mm as the maximum length attained by this species. The 28 individuals—some proven to be sexually mature—we measured were between 35 and 65 cm long (TL), with females just barely surpassing males in length (65 vs 61 cm TL). The maximum weight of males was 114 g, of females 154 g.

Distribution: The Indian and Pacific oceans, including the Arabian Gulf and the Gulf of Oman (Rasmussen *et al.* 2011a, Gardner 2013). *Hydrophis platurus* was one of the four species recorded by Soorae *et al.* (2006) from the Arabian Gulf off Abu Dhabi Emirate (Abu Dhabi Island).

Habitat: Yellow-bellied sea snakes are most plentiful in clear, warm, shallow water where surf and currents are weak but may also be found far out at sea, lying on the water surface and drifting with the currents (Gasperetti

Figure 14. Yellow-bellied sea snakes, *Hydrophis platurus* often venture close to shorelines. This one was encountered off Fujairah City (photo by Balázs Buzás).

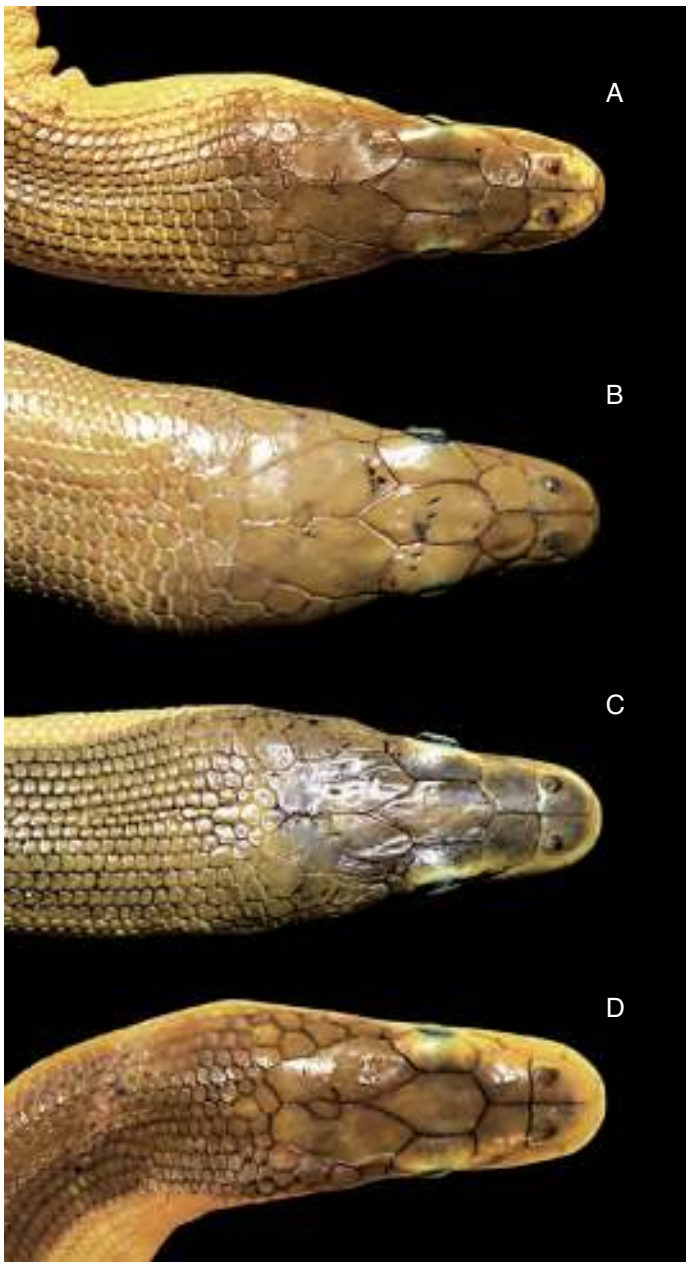

Figure 15. Variation in head scalation and pigmentation in *Hydrophis platurus* collected in the Gulf of Oman off Fujairah. A: ss_UAE143, B: ss_UAE540, C: ss_UAE542, D: ss_UAE556 (all photos by Balázs Buzás). Not to scale.

Figure 16. One of three near-term *Hydrophis platurus* embyros recovered from a female found dead (ss_UAE368; photo by Balázs Buzás).

Map 5. Records of *Hydrophis platurus.*

1988, Gardner 2013). We have met specimens in the upper 0–5 m range of the water column (Fig. 14). Out in the open ocean, *H. platurus* often occur in substantial numbers in association with flotsam or organic debris.

Biology: Although a rapid, graceful and agile swimmer, *H. platurus* is a pelagic species. We encountered it on 106 occasions (Map 5), in every month of the year, both during the day as well as after dusk. Most were seen between 1.6–8.9 km offshore, but some were observed as far as 13.8, 34.5, 44 and 78 km from the coastline. Yellow-bellied sea snakes are surface feeders that lie in ambush for small shoaling fish. If surrounded by a shoal, a repetitive random striking technique is employed. If a single fish is targeted a more precise method is used (Gardner 2013). Reproduction is not known from the marine territorial waters of the UAE but may be assumed. We caught our smallest juvenile (31 cm TL) in May, and a larger one (40 cm TL) in January. A 60-cm dead female (ss_UAE368) contained three well-developed young (22–23 cm TL) in January (Fig. 16). Heatwole (1999) indicated clutch size to range between 1 and 6 (mean 3.3) in this species. We maintained a 32-cm juvenile in an aquarium for two months. It readily accepted southern platyfish (*Xiphophorus maculatus*) as food and shed once during this period. These snakes will bite when provoked and are considered dangerous (Heatwole 1999, *www.toxinology.com*). We never found sessile barnacles (*Platylepas ophiophila*) growing on the bodies of *H. platurus* but *Conchoderma virgatum* were often attached to their tail ends. Also various bacteria (*Enterobacter* sp., *Kluyvera* sp., *Klebsiella oxytoca*, *Pseudomonas aeruginosa*, *Vibrio fluvialis*) were cultured from faecal matter (Géczy *et al.* 2017) and a single individual (ss_UAE199) bore wounds. One voucher specimen (female, ss_UAE368, head only) from our study area is available at the Al Mayya Sanctuary, Fujairah.

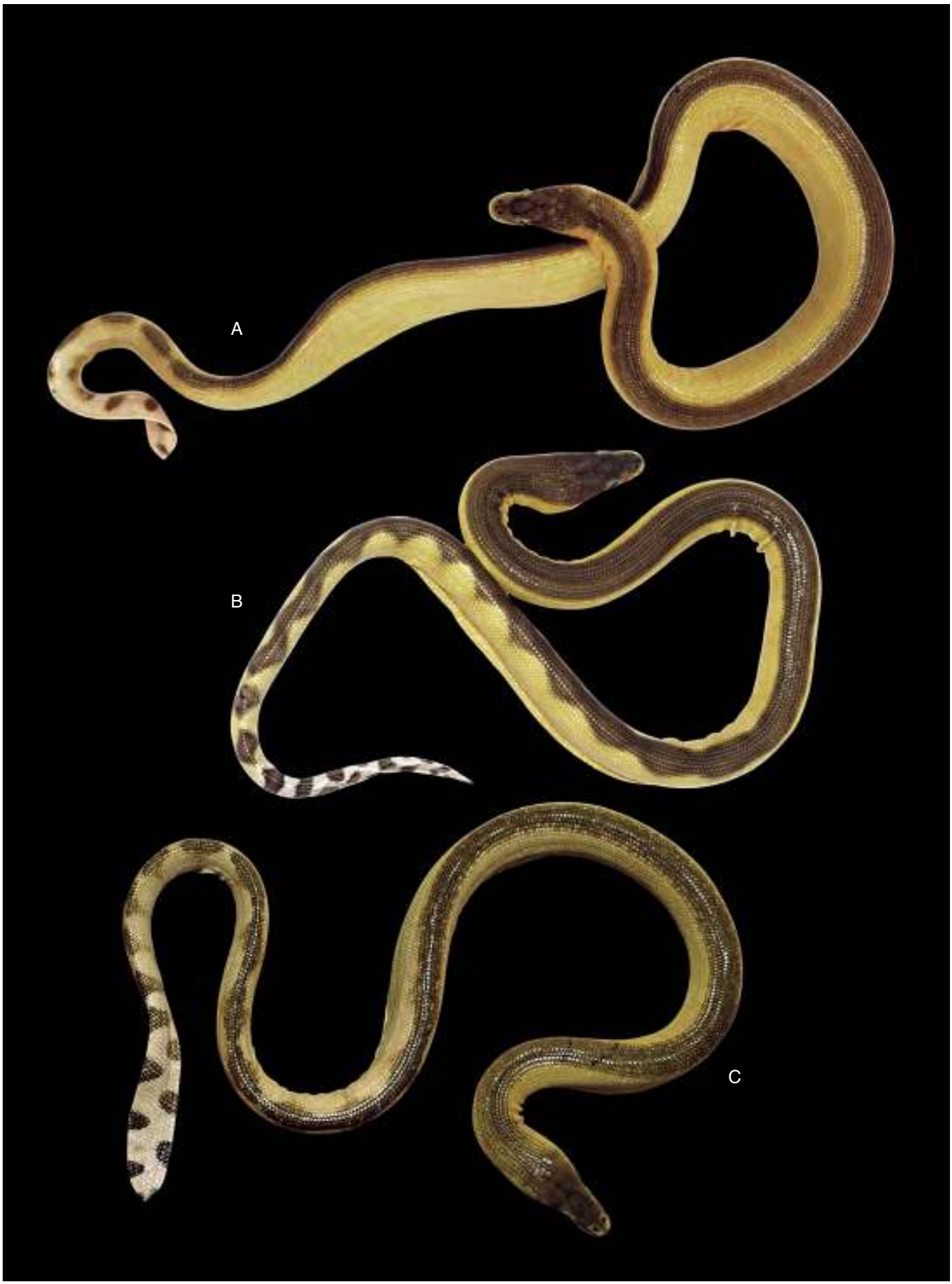

Figure 17. Colour pattern variation in yellow-bellied sea snakes, *Hydrophis platurus* from the Gulf of Oman off Fujairah.
A: ss_UAE556 (photo by Balázs Buzás), B: ss_UAE009 (photo by Csaba Géczy), C: ss_UAE143 (photo by Balázs Buzás). Not to scale.

Figure 18. Portrait of a *Hydrophis platurus* (ss_UAE143) collected in the Gulf of Oman off Fujairah (photo by Balázs Buzás).

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Guinea *et al.* 2017), *H. platurus* was characterised as the "most widely distributed sea snake [that] occurs in coastal as well as open ocean habitats, occasionally taken as bycatch in trawl" by Elfes *et al.* (2013). This species seems to be relatively abundant within UAE waters.

Hydrophis schistosus (Daudin, 1803)
Beaked sea snake, الافعى البحرية المنقارية

Diagnostic characters: Mental narrow, elongated and hidden in a groove. Scale rows around neck 40–55; scale rows around body 49–99; ventrals small but distinct, sometimes missing in the most anterior part of body, 239–354. Maxillary teeth behind fangs 3–4 (Volsøe 1939, Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013).

Colouration: Body grey, bluish grey or olive above, whitish below, with about 40 dark grey or black bands, which fade and usually disappear with age. Juveniles are whitish with vivid black or olive bands (Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013; Fig. 19).

Size: 150 cm (Gardner 2013). Gasperetti (1988) reported average TL to be in the range of 950–1150 mm. The mean TL of 14 Iranian specimens collected mostly in the Gulf of Oman was given by Rezaie-Atagholipour *et al.* (2016) as 1036 mm, and the maximum TL as 1230 mm. The only individual we had access to measured 103 cm. Females attain larger sizes than males in this species (Heatwole 1999).

Distribution: From the Arabian Gulf through India, Sri Lanka, the Indo-Malayan Archipelago, the South China Sea and Indonesia to the Australian region, where it is replaced by the recently described *H. zweifeli* (Rasmussen *et al.* 2011a, Ukuwela *et al.* 2013). Gardner (2013) stated *H. schistosus* to be relatively common in the Gulf of Oman but rare in the Arabian Gulf. However, as the two specimens collected by Rezaie-Atagholipour *et al.* (2012a) and the single individual obtained by Rezaie-Atagholipour *et al.* (2016) all originated from the Strait of Hormuz, they cannot be strictly allocated to either population. Even though Safaei & Esmaili (2009) and Rezaie-Atagholipour *et al.* (2016) claimed *H. schistosus* to be one of the most abundant species of sea snakes along the Iranian coast of the Gulf of Oman, we managed to observe and catch just a single individual off Fujairah, 6.3 km from the shore.

Habitat: Beaked sea snakes prefer near-shore shallow waters with a sandy or muddy substrate where they may be seen on the surface at night. They also enter estuarine areas, lagoons and harbours (Egan 2007, Rasmussen *et al.* 2010f, Gardner 2013). Redfield *et al.* (1978) specified the depth range of *H. schistosus* as 3.7–22.2 m.

Biology: Voris *et al.* (1978) reported the prey of *H. schistosus* to consist for about 80% of tachysurid catfish and 15% of eeltail catfish (Plotosidae) and puffers (Tetraodontidae) at the mouth of the Muar River in Malaysia. However, Egan (2007) argued that beaked sea snakes would take almost any small fish but preferred gobies (particularly shrimp gobies) and eels—apparently due to their easy capture. Mating beaked sea snakes were seen floating on the surface by Rezaie-Atagholipour

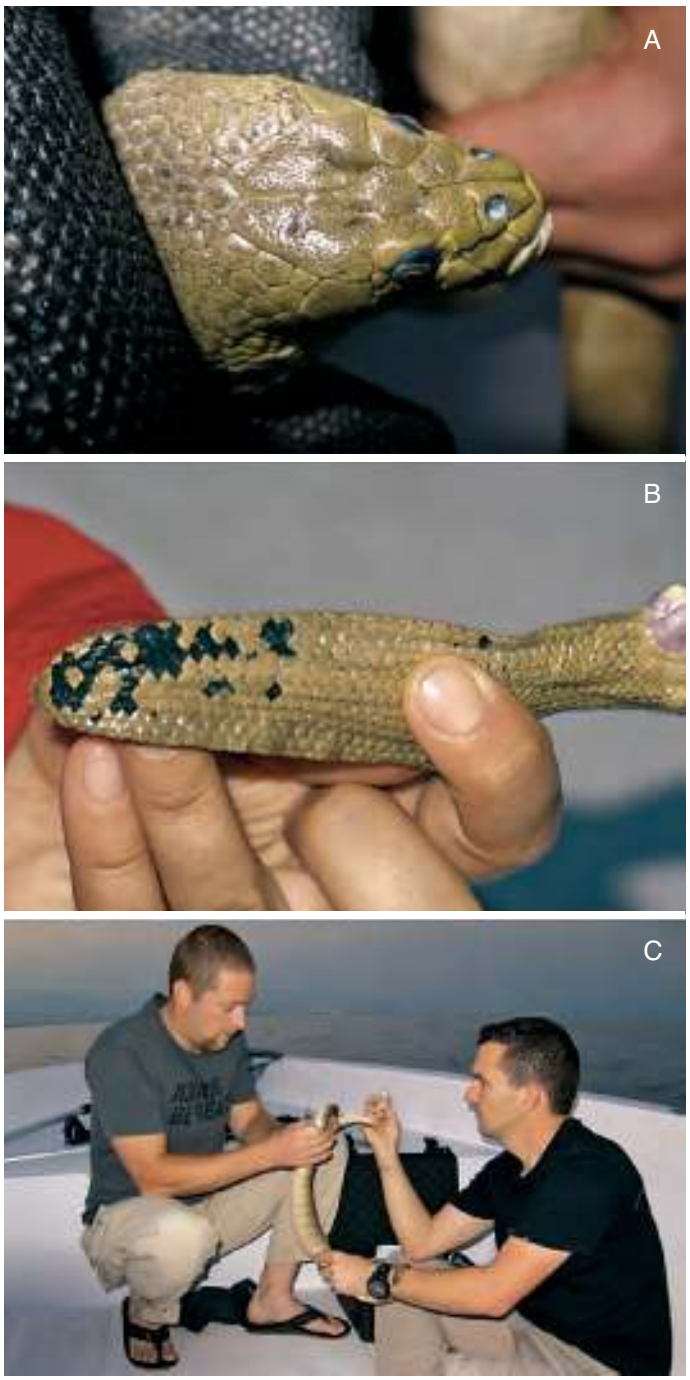

Figure 19. A beaked sea snake, *Hydrophis schistosus* caught in the Gulf of Oman off Fujairah. A, B: Details of specimen ss_UAE010 (both photos by Balázs Buzás), C: Two of the authors (CsG [left] and BB) taking a blood sample for molecular studies (photo by Eszter Gulyás).

et al. (2016) in December (2013) off the Iranian coast in the Gulf of Oman. Of three specimens taken at the end of March and examined by Volsøe (1939), two were gravid females containing four or five eggs 45 mm in length, near ovulation. Also Bergman (1943) attested this species to produce five embryos per mother each season, while Razzaque Sarker *et al.* (2017) found ten eggs measuring 9–16 x 18–25 mm in a gravid female obtained as fisheries bycatch in Cox's Bazar District, Bangladesh in September–October (2013). The egg numbers of females collected in June 2010 from two different locations in the Puttlam Lagoon, Sri Lanka ranged between 7 and 16 (de Silva *et al.* 2011a). On the other hand, Heatwole (1999) reported

Map 6. Record of *Hydrophis schistosus.*

—based on various sources—a mean clutch size of 18.3 and a range of 4–11 in this species. Our single specimen was caught late in the afternoon (Map 6). On account of this individual we can confirm previous claims that beaked sea snakes are easily angered and aggressively defend themselves on land (Heatwole 1999, Gardner 2013, Kularatne *et al.* 2014, Rezaie-Atagholipour *et al.* 2016). With its venom containing postsynaptic neurotoxins and systemic myotoxins, *H. schistosus* is to be regarded as the most dangerous marine elapid in the region (*www.toxinology.com*).

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010f), *H. schistosus* was considered "widespread and common, taken as bycatch in trawl fisheries" by Elfes *et al.* (2013). However, this species appears to be a rare vagrant within UAE waters.

***Hydrophis spiralis* (Shaw, 1802)**
Yellow sea snake, الافعى البحرية الصفراء

Diagnostic characters: Scale rows around neck 25–32; scale rows around body 29–39; ventrals 295–373. Maxillary teeth behind fangs 6–7 (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013).

Colouration: Body yellow, mustard or brown above, pale yellow or white below, with 30–60 narrow black bands. Interspaces broader than bands, at least posteriorly. Sometimes there is a black ventral line. Head of adults usually yellow above, paler below; that of young with a yellow horseshoe-shaped mark on dark ground (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a; Figs 20–22).

Size: 275 cm, but most specimens are below 2 m TL (Rasmussen *et al.* 2010g, 2011a). Yellow sea snakes reported from Arabian waters were less than 2,200 mm long (Gardner 2013) or much smaller (1.6–1.9 m; Egan 2007). The longest of the six individuals we caught in our

study area, a gravid female, measured 186 cm TL. The largest male weighed 422 g, the biggest female 576 g. Females attain larger dimensions than males in *H. spiralis* (Heatwole 1999).

Distribution: From the Arabian Gulf eastwards to Vietnam, Indonesia and New Caledonia (Rasmussen *et al.* 2011a). There are very few confirmed records of this species from UAE waters.

Habitat: Generally found in shallow waters over coral reefs or sandy substrates, down to 50 m depth (Rasmussen *et al.* 2010g, Gardner 2013). In the Gulf of Oman, we have observed yellow sea snakes at 3.2–6.5 km distance from the Fujairah coast (Map 7).

Biology: Very little is known about the natural history of these serpents. They are occasionally seen close to shore, basking at the surface on calm days (Egan 2007). We encountered *H. spiralis* on nine occasions, in the months January, April, July, September and December, both during the day as well as after dark. The food of yellow sea snakes is claimed to consists of eels and other slender hole-dwelling fish (Gardner 2013). Volsøe (1939) reported a male with a total length 1100 mm, tail 85 mm having swallowed an approximately 300-mm long snake eel, *Pisoodonophis hoevenii*, whereas a 140-cm individual we collected regurgitated an undeterminable, 25-cm long conger eel (Congridae; Fig. 4G). Heatwole (1999) reported clutch sizes ranging between 5 and 14 in this species. A 186-cm long gravid female received by us for autopsy from Ra's al-Khaimah (Arabian Gulf) contained 15 eggs in January. Yellow sea snakes are, as also we can confirm, easily irritated and have a rather aggressive disposition, therefore to be regarded as dangerous (Heatwole 1999, *www.toxinology.com*). A single voucher specimen (male, ss_UAE330, Figs 20C and 21D) is deposited at the Al Mayya Sanctuary, Fujairah.

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010g), *H. spiralis* was considered "widespread, taken as bycatch in trawl fisheries" by Elfes *et al.* (2013). However, population size and trend within UAE waters are completely unknown.

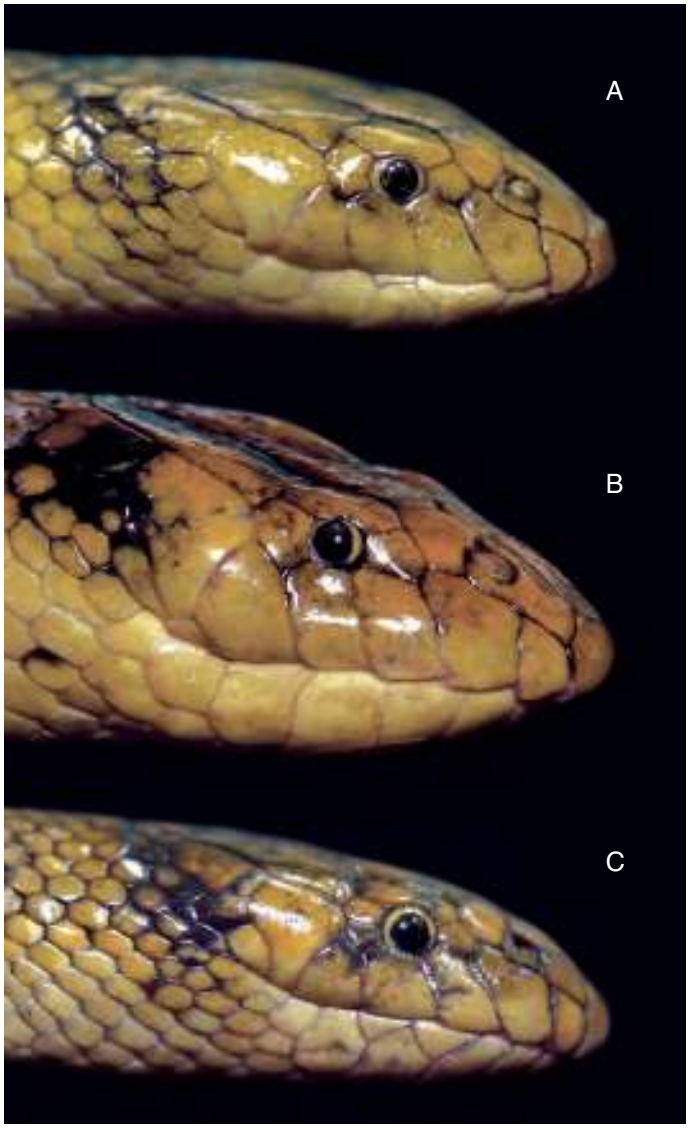

Figure 20. Variation in head and neck scalation of *Hydrophis spiralis*. A: Male, ss_UAE313, B: Female, ss_UAE320, C: ss_UAE330 (all photos by Balázs Buzás). Not to scale.

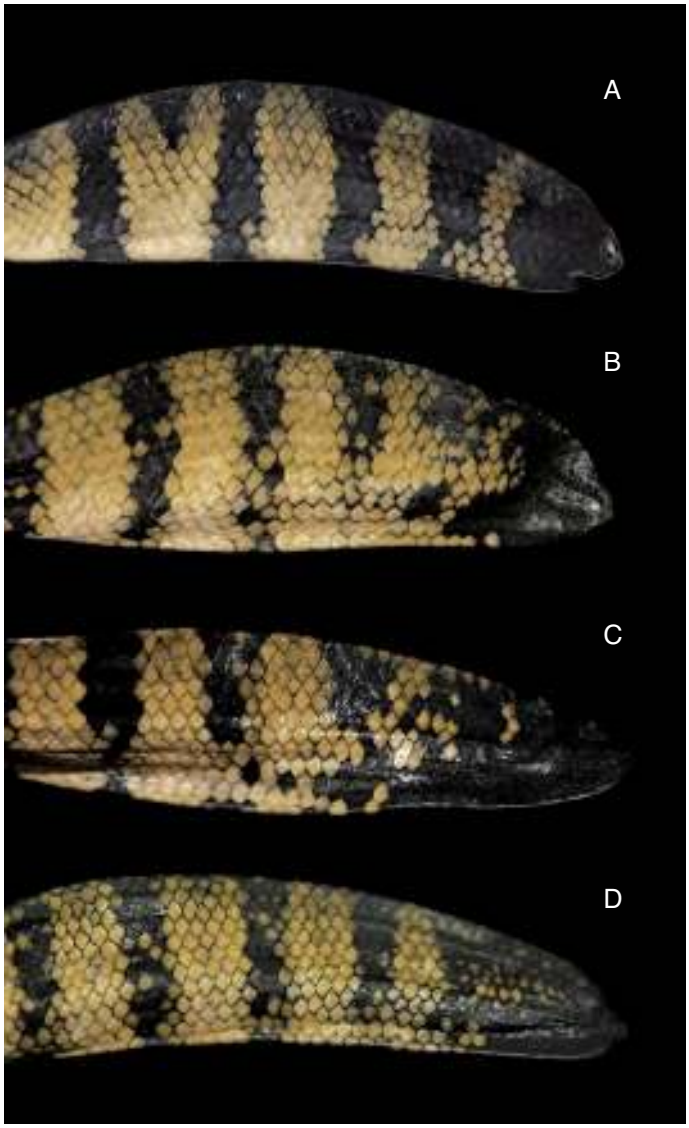

Figure 21. Tail pattern differences and wounds allow the field recognition of *Hydrophis spiralis* individuals. A: ss_UAE166, B: Male, ss_UAE313, C: Female, ss_UAE320, D: ss_UAE330 (photos by Balázs Buzás). Not to scale.

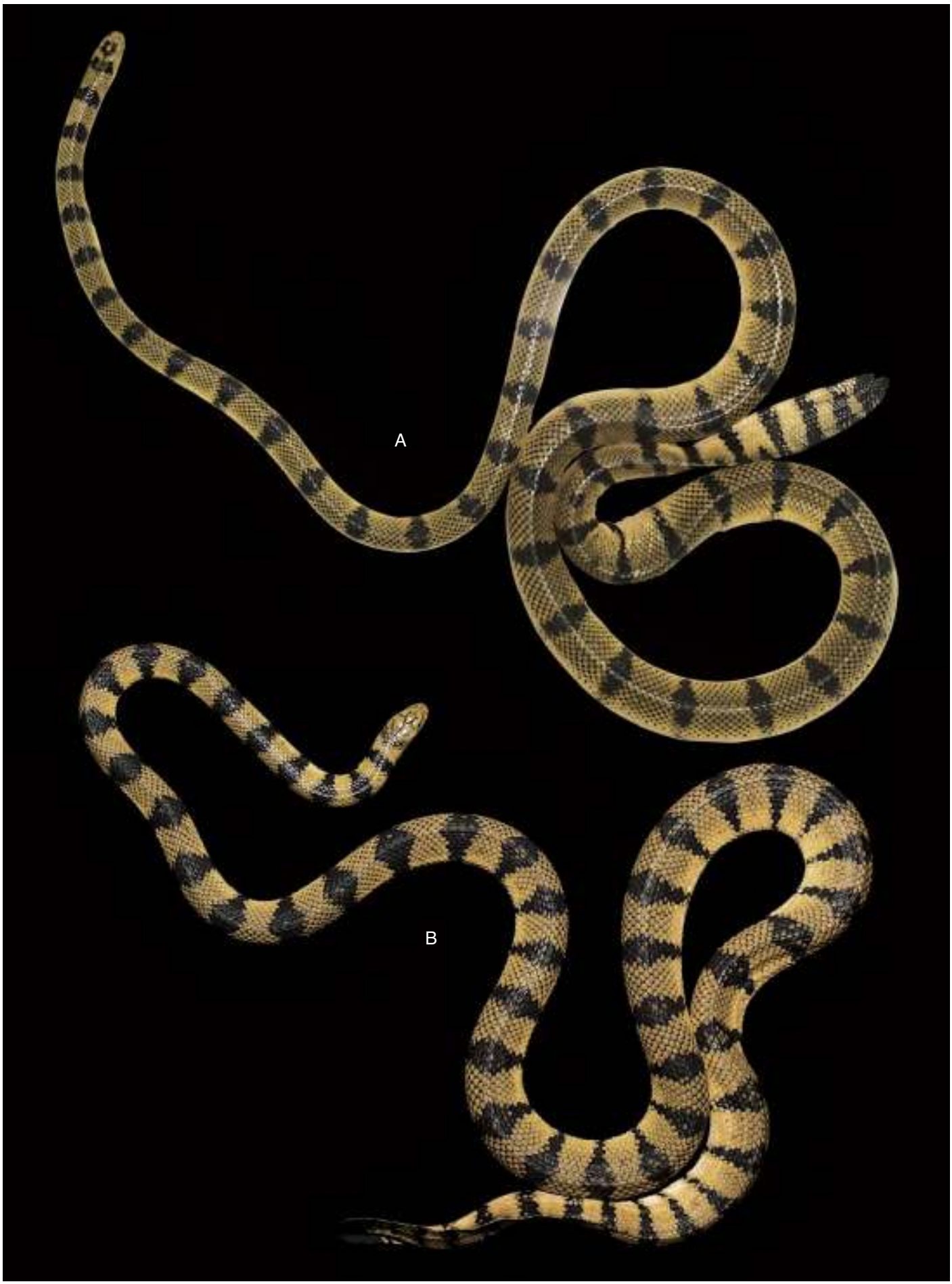

Figure 22. Colour pattern variation in yellow sea-snakes, *Hydrophis spiralis* from the Gulf of Oman off Fujairah.
A: ss_UAE166, B: Male, ss_UAE313 (both photos by Balázs Buzás). Not to scale.

Map 7. Records of *Hydrophis spiralis.*

Map 8. Records of *Microcephalophis gracilis.*

***Microcephalophis gracilis* (Shaw, 1802)**
Graceful small-headed sea snake, الافعى البحرية صغيرة الرأس

Diagnostic characters: Ventrals entire anteriorly, more or less completely divided by a longitudinal furrow posteriorly. Head small. Body slender anteriorly. Scale rows around neck 17–23; scale rows around body 29–43; ventrals 215–350. Maxillary teeth behind fangs 5–6 (Gasperetti 1988, Rasmussen *et al.* 2011a, Gardner 2013).

Colouration: Anterior part of body black, dark olive or dark grey, with whitish lateral patches or complete pale transverse bands. Posterior part of the body with more unbroken alternating black and whitish bands. The young are black with a series of whitish dorsal bands or oval spots on the slender part of the body and more or less complete bands posteriorly, 40–60 spots or bands in total. With age the dorsal colour fades to grey or bluish grey and the markings become indistinct (Gasperetti 1988, Egan 2007, Rasmussen *et al.* 2011a, Gardner 2013; Figs 23–24).

Size: 122 cm (Rasmussen *et al.* 2011a). Egan (2007) claims that whereas this species may exceptionally reach 110 cm TL, adults of around 85 cm are more common. The longest female from Arabia reported by Gasperetti (1988) was 1025 mm long (TL). The three individuals we caught in our study area off Fujairah had total lengths of 85–94 cm, with the largest weighing 166 g at capture. Females attain larger sizes than males in this species (Heatwole 1999).

Distribution: From the Arabian Gulf through the South China Sea, Indonesia, the Arafura Sea to the Gulf of Papua (New Guinea; Rasmussen *et al.* 2011a). The presence of this rarely seen species in the Arabian Gulf is proven only by a small number of strandings, while it is known from as few as four records on the east coast of the UAE, probably due to its bottom-dwelling habits and/or low population densities. The depth range is not certain but graceful small-headed sea snakes are likely to be found to approximately 55 m below sea level off Fujairah (Al Hantoubi *et al.* in prep.).

Figure 23. Two views of the head of a female *Microcephalophis gracilis* (ss_UAE374) from the Gulf of Oman off Fujairah (both photos by Nathanaël Maury).

Figure 24. Graceful small-headed sea snakes, *Microcephalophis gracilis* from the Gulf of Oman off Fujairah.
A, B: Female, ss_UAE374 (both photos by Nathanaël Maury), C: ss_UAE548 (photo by Balázs Buzás). Not to scale.

Habitat: *Microcephalophis gracilis* inhabits clear coastal waters with a sandy or coral substrate down to 30 (Volsøe 1939) or 50 m depth (Gardner 2013) but is typically observed further offshore than any other sea snake. We recorded specimens at 5.9–6.2 km distance from the Fujairah coast (Map 8).

Biology: As a specialist feeder on slender bottom-dwelling fish such as snake eels and gobies, *M. gracilis* presumably dives deeper than almost all other species of Hydrophiinae. Its tiny head allows it to investigate little holes and narrow crevices in search of prey (Egan 2007, Gardner 2013). The stomachs of three individuals (out of nine) examined by Wall (1921) contained maimed worm eel (*Muraenichthys schultzei*) remains. We encountered this species on as few as three occasions during our study period, in the months January, February and November, exclusively after dark, at a distance of 5.9–6.2 km from the shoreline. Females produce 1–16 eggs per season (Heatwole 1999). Reported to be inoffensive by Egan (2007), *M. gracilis* often wriggle wildly and attempt to flee when taken out of water. Although graceful small-headed sea snakes have a potent venom containing postsynaptic neurotoxins (*www.toxinology.com*), they are not considered particularly dangerous due to their small gapes.

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Guinea *et al.* 2010), *Microcephalophis gracilis* was typified as "widespread, locally common, taken as bycatch in trawl fisheries" by Elfes *et al.* (2013). However, population size and trend within UAE waters are unknown.

Figure 25. Viperine sea snake, *Hydrophis viperinus* caught in Iranian coastal waters of the western Gulf of Oman (photo by Mohsen Rezaie-Atagholipour).

The following two species are included here for completeness. Although both are known from the Gulf of Oman, there are no confirmed records of either of them from the territorial waters of the UAE.

Hydrophis viperinus (Schmidt, 1852)
Viperine sea snake, الافعى البحرية الثعبانية

Diagnostic characters: Easy to identify by its ventrals, which are broad anteriorly and narrow posteriorly. Scale rows around neck 27–38; scale rows around body 37–50; ventrals 226–291. Maxillary teeth behind fangs 5 (Gasperetti 1988, Rasmussen *et al.* 2011a, Gardner 2013, Rezaie-Atagholipour *et al.* 2016).

Colouration: Body dark grey dorsally, dirty white ventrally, with or without pale bands (Fig. 25).

Size: Approximately 97 cm (Rasmussen *et al.* 2010e). Males reach larger sizes than females in this species (Heatwole 1999).

Distribution: From the Arabian Gulf to the South China Sea, Borneo and Java (David & Ineich 1999, Rasmussen *et al.* 2011a). Even though Smith (1926) and Wall (1921) claimed the Arabian Gulf to be the westernmost distribution limit of this species, Volsøe (1939) and Rezaie-Atagholipour *et al.* (2016) expressed their doubts about its occurrence there. Reports of its presence in UAE marine territorial waters have been repeatedly questioned but Gasperetti (1988) mentioned a museum specimen allegedly collected off Sir Abu Nu'ayr (Emirate of Abu Dhabi) by the crew of the HMS Dalrymple (British Royal Navy) around 1963. We have not encountered a single individual in the Gulf of Oman off Fujairah, but *H. viperinus* is known from adjacent waters near Muscat in Oman (Volsøe 1939; the holotype of *Hydrophis jayakari* Boulenger, 1887, a junior synonym of *H. viperinus*, originated from there) and from off Beris and Pasabandar in Iran (Rezaie-Atagholipour *et al.* 2016; Fig. 25).

Habitat: According to Rasmussen *et al.* (2010e), *H. viperinus* frequents 15–30 m deep waters. Gardner (2013), on the other hand, reported warm, shallow waters over reefs, seagrass or sand as typical habitat for the species and noted viperine sea snakes to enter estuaries, lagoons and creeks. From the Gulf of Oman, Rezaie-Atagholipour *et al.* (2016) mentioned two specimens collected between 20–40 m depth off Beris and Pasabandar, Iran in August 2013.

Biology: *Hydrophis viperinus* is a poorly known species. Due to its rectangular-shaped and enlarged ventrals it is reportedly more mobile on land than most other sea snakes. The prey consists of dragonets (*Callionymus* sp.), spiny flatheads (*Kumococius rodericensis*), gobies and eels (Volsøe 1939, Voris & Voris 1983, Rasmussen *et al.* 2010e). Females typically give birth to three large young (Lemen & Voris 1981, Heatwole 1999). A female collected at the end of March in Iranian waters carried three eggs, about 23 mm long and nearly ripe for ovulation (Volsøe

1939). Females caught in the northern coastal regions of Sri Lanka in late April and early May (2010) contained between two and six embryos measuring on average 227.56 mm SVL (de Silva *et al.* 2011a). The venom of *H. viperinus* has powerful myotoxic components, and even though viperine sea snakes are not considered particularly aggressive, they are capable of delivering a lethal bite (*www.toxinology.com*).

Conservation status: Listed as "Least Concern (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010e), *H. viperinus* was considered "widespread, rare [and] occasionally taken as bycatch in trawl fisheries" by Elfes *et al.* (2013).

Microcephalophis cantoris Günther, 1864
Gunther's sea snake, الافعى البحرية جنثر

Diagnostic characters: Ventral scales divided by a longitudinal fissure. The third supralabial usually contacts the prefrontal. Head small. Body slender anteriorly. Scale rows around neck 21–25; scale rows around body 41; ventrals 404–468. Maxillary teeth behind fangs 5–6 (Leviton *et al.* 2003).

Colouration: Head and neck dark greenish olive or yellow dorsally and yellowish ventrally; anterior part of body with 20–28 blackish bands—paler above and darker below—that merge on the back and the belly, posterior part unpatterned (Günther 1864, Rezaie-Atagholipour *et al.* 2016; Fig. 26).

Figure 26. Gunther's sea snake, *Microcephalophis cantoris* caught in Iranian coastal waters of the western Gulf of Oman (photo by Mohsen Rezaie-Atagholipour).

Size: 1450 mm in males and 1880 mm (TL) in females (Leviton *et al.* 2003). The single voucher specimen taken in Iranian territorial waters of the Gulf of Oman measured 1124 mm in length (TL; Rezaie-Atagholipour *et al.* 2016). Females reach larger sizes than males in this species (Heatwole 1999).

Distribution: The Indian Ocean from the Gulf of Oman to the Malay Archipelago (Heatwole 1999).

Habitat: Shallow coastal waters over soft bottom substrates down to 20 m depth (Leviton *et al.* 2003, Rasmussen *et al.* 2010a).

Biology: Inadequately known but probably similar to that of *M. gracilis*. The mean clutch size of females is 6 (Heatwole 1999).

Conservation status: Listed as "Data Deficient (LC)" globally by the IUCN Red List of Threatened Species (Rasmussen *et al.* 2010a), *M. cantoris* was considered "poorly known, considered rare, probably restricted to Andaman Sea" by Elfes *et al.* (2013).

Remarks: Safaei & Esmaili (2009) were the first to record this species from the Gulf of Oman on account of four individuals collected off Jask (Hormozgan Province, Iran) but they were not taken seriously until Rezaie-Atagholipour *et al.* (2016) found another specimen among the bycatch of a fishing trawler working in the same area in October–November 2013 (Fig. 23). *Microcephalophis cantoris* is morphologically very similar to and can thus potentially be mistaken for *M. gracilis*, another small-headed sea snake species known from but infrequently encountered in Fujairah waters.

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Growing knowledge of cetacean fauna in the Emirate of Fujairah, UAE

by Robert Baldwin, Andrew Willson, Elayne Looker & Balázs Buzás

Abstract

Most records of cetaceans in the United Arab Emirates come from relatively few studies undertaken in Arabian Gulf waters. However, recent study off the coast of Fujairah, in the Gulf of Oman, has revealed a rich diversity of cetaceans with 11 or more species now known to occur in the emirate. Among them are three new records for the UAE, spotted, striped and rough-toothed dolphins, as well as infrequently recorded large whales such as sperm, Bryde's and blue whales. Most species are primarily distributed in offshore waters over 500 m deep, though some species, such as the Indo-Pacific common dolphin, also regularly occur closer to shore, including within the Port of Fujairah anchorage area. Continuing research aims to investigate the population size, status and structure of cetaceans present in waters off Fujairah using a variety of line transect, photographic, genetic and acoustic research techniques.

Introduction

There has been relatively little scientific study of cetaceans in the UAE. Many of the recorded species are known only from a few sightings at sea or from dead individuals washed ashore. Reviews of cetacean occurrence and distribution in the Arabian region as late as the 1980s (e.g., Leatherwood 1986, De Silva 1987) omit reference to the UAE entirely. Later reviews and accounts (Baldwin *et al.* 1999, Preen 2004) reveal that limited historical information is, however, available (Morzer-Bruyns 1971, Slijper *et al.* 1964) albeit largely unsubstantiated. Nineteenth century whalers and observers on 20th century merchant vessels were the first to document large whales in the Arabian Sea region (e.g., Brown 1957, Wray & Martin 1980, Reeves *et al.* 1991). Some species, such as humpback whales, were documented in UAE waters, including in the Arabian Gulf (Slijper *et al.* 1964) where they continue to occur today (Dakhteh *et al.* 2017). A record of a dead humpback whale was also documented off Khor Fakkan in 1973 (Baldwin *et al.* 1999).

Recent whaling also occurred in the Arabian region in three successive seasons during the period 1963 to 1966 (Mikhalev 1997, Mikhalev 2000), when illegal Soviet fleets swept northwards from the Gulf of Aden, along the eastern shoreline of the Arabian peninsula and eastwards across the Oman Sea as far as the Pakistan–India border. The final Soviet tally from this Arabian region campaign was 3,339 whales, including 1,294 blue whales, 954 sperm whales, 849 Bryde's whales and 242 humpback whales (Mikhalev 2000). Almost nothing is known of the population status of these species in the wider region today, with the exception of the humpback whale, for which a population estimate off Oman of 82 (95% CI = 60–111) individuals was estimated in 2008 (Minton et al. 2008), and appears little changed since then, suggesting no population growth since the whaling era.

Gallagher (1991) was among the first researchers to document occurrence of small odontocete cetaceans in the UAE based on data from six skulls collected between 1972 and 1973, representing three different species. Ad hoc surveys for small cetaceans in the mid-1980s, focusing on the Indo-Pacific humpback dolphin, *Sousa chinensis* (now known as *S. plumbea*), resulted in reports of several unidentified cetaceans, including large whales, but records are often vague, lacking supporting data.

More substantive information was collected later that decade (Preen 1989) during aerial surveys for dugongs, although only three species of dolphins were recorded. A dedicated study of the UAE's cetacean fauna in 1995 (Baldwin 1995, Baldwin 2003) increased the number of species recorded in the country to 13, including three species of baleen whale and ten odontocetes. The former Environmental Research and Wildlife Development Agency of Abu Dhabi (ERWDA) (now the Environment Agency Abu Dhabi–EAD) conducted summer and winter aerial surveys of western UAE waters in the Arabian Gulf in summer 2000 and winter 2001 (Al-Ghais & Das 2001). This focused on estimating the population size and distribution of dugongs, but also recorded incidental dolphin sightings. More recent surveys between 2014 and 2015 by the EAD Dolphin Conservation Programme revealed that the waters off Abu Dhabi hold the largest reported population of *Sousa plumbea* in the world comprising 701 (95% CI = 473–845) individuals (Diaz López *et al.* 2017). Other recent information has been collected during the course of the UAE Dolphin Project, with most records coming from Arabian Gulf waters.

Of all of these previous studies and surveys, only one (Baldwin 1995) refers to dedicated survey work conducted off the UAE East Coast of Fujairah.

Figure 1. Fujairah Whale Research Project survey area showing transect stations (circles).
Transects are typically surveyed along E–W orientation, but may also be surveyed along N–S orientation.

Establishing an updated baseline

The Fujairah Whale Research Project began in February 2017 and has included eight dedicated vessel surveys and one aerial survey for cetaceans to date, undertaken approximately every 3–4 months. Surveys were typically between 3 and 5 days in length and followed pre-designed survey transects. A minimum of three observers and consistent replication of survey methods allows for comparison between data sets. The survey area includes deep, offshore waters and is depicted in Figure 1.

Distribution of cetaceans off Fujairah

Cetaceans are distributed throughout the survey area, based on both sightings and acoustic detections made during vessel transect surveys. The majority of sightings were in relatively deep water (500 m+). The data reveal a concentration of sightings towards the southwest corner of the survey area, which is considered a 'hotspot' for several dolphin species. Figure 2 depicts a sub-set of sightings recorded during vessel-based surveys, as well as acoustic detections made during routine acoustic surveys using a drop-down hydrophone at transect stations.

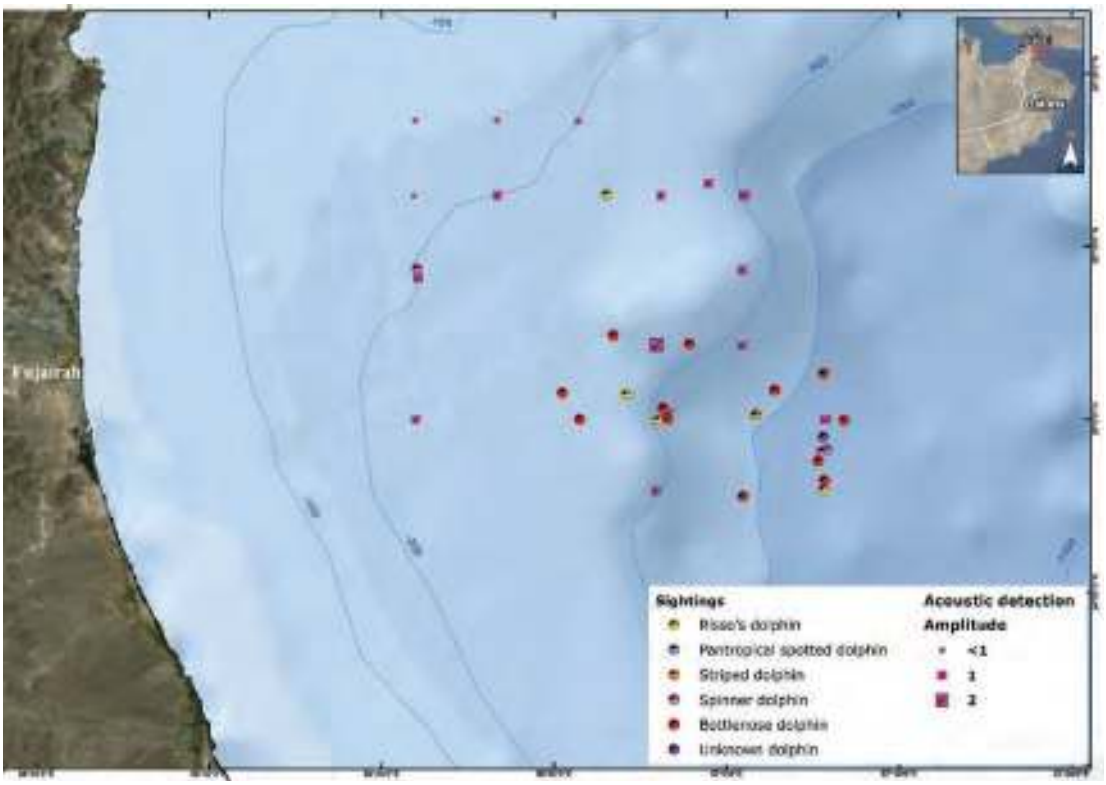

Figure 2. Summary of vessel-based observations and acoustic detections of cetaceans recorded during offshore transect surveys.

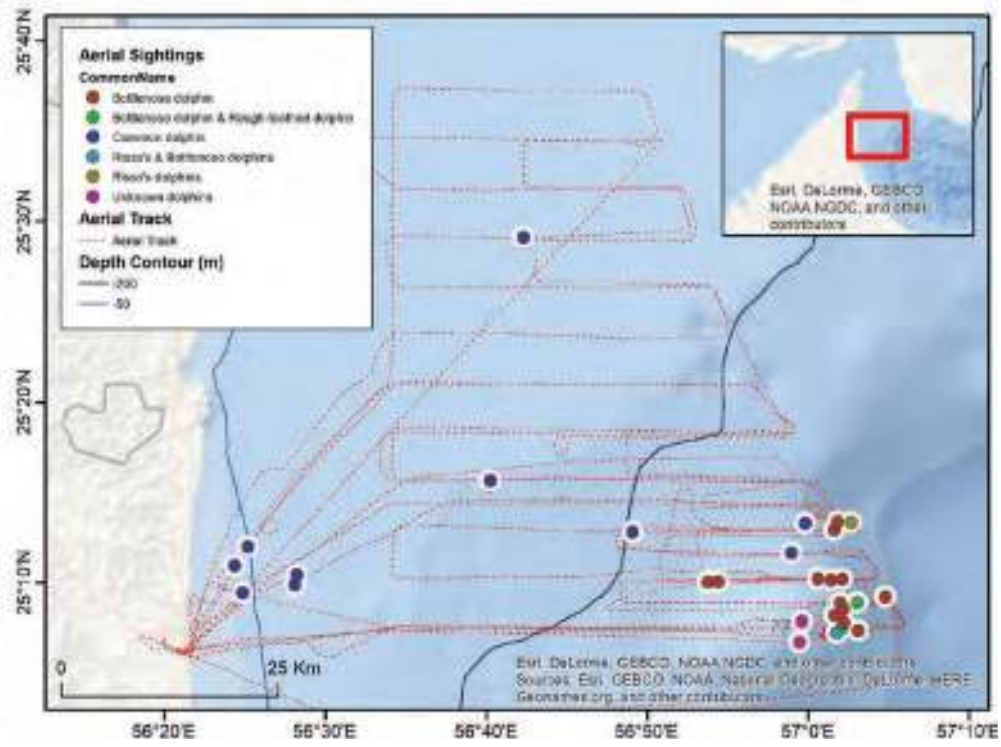

Figure 3. Summary of observations recorded during an aerial survey of waters off Fujairah in March 2018.

A dedicated aerial survey was conducted between 20–22 March 2018 inclusive. Flights were conducted both during the morning and the afternoon, with flights generally lasting 2–2.5 hours. A total of 2,414 kms were searched along predetermined transects. In terms of distribution, aerial survey results were similar to those of the vessel surveys in that the majority of sightings were recorded in the southwest corner of the survey area (Figure 3). The aerial survey additionally revealed common dolphins between the survey area and shore, including in the Port of Fujairah anchorage. Observations (supported by photographs) recorded by Port of Fujairah personnel from work vessels have since revealed the repeated presence of common dolphins in this area.

Figure 4. Common bottlenose dolphins, *Tursiops truncatus* (photo by Jacky Judas).

Figure 5. A small group of rough-toothed dolphins, *Steno bredanensis* revealed by our aerial survey, representing a first record of the species for the UAE (photo by Andy Willson).

Cetacean species recorded off Fujairah, including new records for the UA

Figures 2 and 3 show the distribution of a range of species recorded during vessel and aerial surveys. Of the species recorded, three represent new records for the UAE, including pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*S. coeruleoalba*) and rough-toothed dolphin (*Steno bredanensis*; Figs 5–7).

Other records from the recent vessel and aerial surveys included common bottlenose dolphin (*Tursiops truncatus*), Indo-Pacific common dolphin (*Delphinus delphis tropicalis*), Risso's dolphin (*Grampus griseus*) and spinner dolphin (*Stenella longirostris*; Figs 4, 8–10, 12–13).

Additional third party observations (with photographic evidence) were reported, including sperm whale (*Physeter macrocephalus*) and Bryde's whale (*Balaenoptera edeni*). A reported sighting of orca (*Orcinus orca*) was also received and, although it was not supported by photographic evidence, is thought to be an accurate identification.

Species that have been additionally recorded in the literature in the past (Baldwin 1995, 2003), but for which no recent evidence is available, include false killer whale (*Pseudorca crassidens*). The blue whale (*Balaenoptera musculus*) is considered highly likely to occur in Fujairah waters from time to time, based on a stranding of a dead blue whale at Khor Fakkan, Sharjah reported in November 2017 (with photographic evidence).

Figure 6. Pantropical spotted dolphin, *Stenella attenuata*, previously unrecorded from the UAE (photo by Robert Baldwin).

Figure 7. Striped dolphins, *Stenella coeruleoalba*, previously unrecorded from UAE waters (photo by Robert Baldwin).

Figure 8. Indo-Pacific common dolphins, *Delphinus delphis tropicalis* (photo by Balázs Buzás).

Figure 9. A large group of Indo-Pacific common dolphins, *Delphinus delphis tropicalis* seen from the air (photo by Robert Baldwin).

Figure 10. Indo-Pacific common dolphins, *Delphinus delphis tropicalis* (photo by Balázs Buzás).

Strandings reveal conservation concerns

Two dead sperm whales have been recorded at Fujairah in recent years; one washed ashore on a beach next to Fujairah Port in 2012 and more recently one was found by Fujairah Port authorities on 15th June 2017, floating at sea approximately 1 nautical mile from the port breakwater.

In both cases, determination of the cause of death was not possible. Broken bones noted during the recovery of the skeletons could have been caused by a ship strike, and/or by bulldozers and cranes when moving the carcasses on the beach. The proximity of both animals to the port, and the condition of the carcass in the recent case, suggests that death occurred close by and that ship strike may have been the most likely cause.

The dead male blue whale found near the port in Khor Fakkan (on 27th November 2017), also had suspected ship strike injury. The evidence of potential ship strike on this whale highlights the need for more comprehensive management of shipping activities to avoid unnecessary whale mortality. Work has already begun at the Port of Fujairah to help address this issue.

Both sperm whale carcasses were recovered. The more recent skeleton remains buried to allow for decomposition, whilst the skeleton from the 2012 stranding was recovered, treated and cleaned (Fig. 11) in preparation for a proposed public display.

Figure 11. Sperm whale, *Physeter macrocephalus* bones recovered from a stranding at Fujairah in 2012 (photo by Robert Baldwin).

Recommendations for further study

The Fujairah Whale Research Project has begun collection of behavioural and acoustic data, as well as samples for future genetic analysis. Analysis of photographs as part of a photo-identification study has also begun on specific species (e.g., bottlenose and Risso's dolphins). It is recommended that these studies are continued and expanded where possible, and that dedicated transect surveys, both vessel-based and aerial, are repeated in the future. This combination of work will enable detailed investigation of populations status, size and structure of cetaceans off Fujairah and will provide information of value to conservation planning as well as planning for a 'blue economy', such as that related to marine tourism and other maritime industries. It is additionally recommended that a specific study of Indo-Pacific common dolphins in the Port of Fujairah anchorage is initiated due to the potentially interesting interaction between this species and the on-going shipping and industrial activities at the port.

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Figure 12. Risso's dolphins, *Grampus griseus* (photo by Balázs Buzás).

Figure 13. A Risso's dolphin, *Grampus griseus* detected by aerial survey (photo by Robert Baldwin).

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Additions to the herpetofauna of the Wadi Wurayah National Park, Fujairah

by Balázs Farkas, Balázs Buzás & Valér Farkas

Situated in the Emirate of Fujairah, Wadi Wurayah lies within a priority WWF Global 200 Ecoregion (Ecoregion 127, Arabian Highlands and Shrublands). On account of its rich diversity of rare and endangered mountainous and freshwater habitats and species it was granted protection on March 15th, 2009, following the issuance of Law No. 2 of 2009 by His Highness Hamad bin Mohammad Al Sharqi, the Ruler of Fujairah. The safeguarded area covers a total of 219 km^2, comprising a core zone of 118 km^2, a buffer zone of 92 km^2, and an ecotourism zone of 9 km^2 and reaches an elevation of 1080 m a.s.l. In January 2013, Fujairah Municipality and Emirates Wildlife Society–World Wide Fund for Nature signed a three-year agreement to transform the newly created preserve into a national park of outstanding importance, the Wadi Wurayah National Park (WWNP; Tourenq *et al.* 2009, Judas 2016). Due to these developments the WWNP received considerable attention from conservationists. Tourenq *et al.* (2009) recorded nine reptile species—*Pseudotrapelus sinaitus* (all UAE populations are now allocated to *P. jensvindumi*, see Tamar *et al.* 2016), *Pristurus celerrimus*, *Pristurus rupestris*, *Ptyodactylus hasselquistii*, *Bunopus spatalurus* (ssp. *hajarensis*), *Omanosaura cyanura*, *Omanosaura jayakari*, *Platyceps rhodorachis*, and *Echis omanensis*—from the WWNP but failed to confirm the occurrences of three species—*Hemidactylus* sp. (later identified as *H. flaviventris*), *Psammophis schokari*, and *Echis carinatus* (ssp. *sochureki*)—previously documented from the area (WWF United Arab Emirates Project Office 2006). Since then, following the discoveries of *Asaccus gallagheri* (Pierson 2014), *Mesalina adramitana*, *Chalcides ocellatus* (ssp. *ocellatus*), and *Trachylepis tessellata* (Judas 2016), the total number of reptile species raised to 15, with nine being endemic to the Hajar Mountains. We here wish to report the presence of yet another lizard and a snake species as well as to correct the taxonomic assignment of fan-footed geckos inhabiting the WWNP.

Figure 1. Photographic voucher specimen of *Asaccus caudivolvulus* from the Wadi Wurayah National Park (photo by Valér Farkas).

Asaccus caudivolvulus Arnold & Gardner, 1984
Musandam leaf-toed gecko, وزغة ورقية الأصابع من الامارات

One specimen photographed on November 6th, 2017 at 19:16 hrs, 25°23.845' N, 56°16.184' E, at ± 195 m altitude (Figure 1) and another on December 12th, 2017 at 18:46 hrs on boulders in the vicinity of the celebrated freshwater pools, 25°23.847' N, 56°16.186' E, at ± 190 m a.s.l. Unfortunately, our permit did not allow the actual capture of individuals and we were thus not able to take measurements and count scales of either lizard. However, *A. caudivolvulus* is easily distinguished from *A. gallagheri*

Figure 2. An *Asaccus gallagheri* encountered close to the entrance gate of the WWNP in 2016 (photo by Balázs Buzás).

(Figure 2) by having enlarged tubercles on the back extending to the upper arms, clearly visible in our photo as small white dots (Gardner 2013). In comparison, both microendemic species—*A. gardneri* and *A. margaritae*—recently split off from *A. caudivolvulus* chiefly on the basis of molecular data have smooth brachia (Carranza *et al.* 2016). Even though it may be locally abundant within its restricted coastal range, urban development seriously threatens the continued existence of *A. caudivolvulus* (Carranza *et al.* 2016). Gardner (2013) recorded it from "the rocky wadis draining west into the Gulf, around Khasab; Harf, Khawr Niad, Jiddat Sahasa, Rawdah, Wadi Bih, Wadi Khabb Shamsi, Tayyibah, Wadi Uyaynah, Khabb, Wadi al Qulaydi, and in the isolated rocky headland of Jebel Ras south of Khawr Fakkan." Meanwhile, the Wadi al Helo (Sharjah) population has been shown to represent a distinct species, *A. margaritae*, whereas the Musandam Peninsula as a whole is believed to be occupied by *A. gardneri* (Carranza *et al.* 2016). *Asaccus caudivolvulus* occurs in sympatry with a fan-footed gecko of dubious identity within the limits of the WWNP (see below).

Ptyodactylus orlovi
Nazarov, Melnikov & Melnikova, 2013
Orlov's fan-footed gecko, وزغة اورلف مروحية الاقدام

One specimen photographed on November 6th, 2017 at 19:45 hrs and a second one on December 12th, 2017 at 18:07 hrs on rock slabs, 25°24' N, 56°16' E, at ± 180 m a.s.l., at a few metres' distance from the spots where our *Asaccus caudivolvulus* were located. Whilst we were regrettably not permitted to manipulate and thoroughly examine them, our images reveal these lizards to have had non-contrasting head patterns, which challenges their identification as *P. hasselquistii* (Figures 3–4). Alas, the low resolution of our digital pictures makes a detailed comparison with the two species consistent with this feature—*P. orlovi* and *P. ruusaljibalicus*—impossible. However, while *P. ruusaljibalicus* seems to be resticted to the Dibba region of Fujairah (Simó-Riudalbas *et al.* 2017), *P. orlovi* is known from numerous locations in the Hajar Mountains between the Masafi/Dibba Depression (UAE) and Al Ashkarah (Oman) so we tentatively reassign the WWNP fan-footed geckos to the latter taxon.

***Telescopus dhara dhara* (Forsskål, 1775)**
Arabian cat snake, حية القطط العربية

One specimen photographed in rocky terrain close to the entrance gate of the WWNP on December 12th, 2017 at 19:42 hrs, 25°23.335' N, 56°18.659' E, at ± 80 m a.s.l. (Figure 5). According to Gardner (2013), this unmistakable opisthoglyphous colubrid snake has a large distribution range stretching along "the peripheral mountains of Arabia, from the Gulf of Aqaba, southwards through the Hijaz to the Yemen mountains [and] the mountainous and rocky areas of Oman," with scattered records from "northern central Arabia including the Riyadh area." Within UAE

Figure 3. *Ptyodactylus orlovi* photographed on a rock in the WWNP, within a few metres from the spot where the *A. caudivolvulus* were observed. Note the loss of a fingertip and the tail in response to attempted predation (photo by Valér Farkas).

territory, the species has been found at Ain al Ghamour and Al Aqah (both in Fujairah), as well as in Wadi al Helo and Kalba (both in Sharjah; Gardner *et al.* 2009, Gardner 2013). Unfortunately, we were not allowed to handle and examine this individual in greater detail either but its general appearance matched that of a Jiddat as Sahasa (Musandam Governorate, Oman) conspecific figured by Gardner *et al.* (2009).

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Figure 4. The second individual of *Ptyodactylus orlovi* clinging to an overhanging rock surface (photo by Balázs Buzás).

Figure 5. Photographic voucher specimen of *Telescopus d. dhara* from the WWNP (photo by Balázs Buzás).

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A preliminary investigation of plankton organisms of fresh and brackish inland waters in the northern United Arab Emirates

by Martin Soesbergen

Key words: Cladocera, cyanobacteria, desmids, phytoplankton, Rhizopoda, zooplankton

Introduction

Freshwater habitats in the United Arab Emirates are scarce and the knowledge of their ecology is even less. Some research has been done on indigenous (wadi) fish (Feulner 1998, 2000, 2006) and aquatic invertebrates (Burt 2003). Some large branchiopods have been found in the UAE (Hornby 1999, Al-Khalili & Thompson 2003, Al Dhaheri & Saji 2013, Saji *et al.* 2016). Even from the best studied freshwater site, Wadi Wurrayah, however, the plankton is unknown. From the fresh to hypersaline Al Wathba Wetland, the macro zooplanktonic brine shrimp is known (Al Dhaheri & Saji 2013, Saji *et al.* 2016).

The status of the freshwater biodiversity in the Arabian Peninsula was compiled recently for five priority taxa: fishes, crabs, molluscs, dragonflies and aquatic plants by García *et al.* (2015). Not surprisingly, no plankton organisms were included although plankton is the basis of the food chain in freshwaters and thus an important part of the biodiversity. These organisms compose the majority of the biodiversity in fresh- and brackish waters. They are also useful as indicators for water quality (desmids and diatoms), control of algal blooms (cladocerans) or can produce harmful toxins (cyanobacteria), these factors being sufficient to warrant some attention. As far as is known, no studies exist on plankton of freshwater or other inland aquatic habitats in the UAE. Published plankton studies in the UAE are restricted to the marine environment, which is relatively well studied (Sharif & Al-Ghais 1997, Rao & Al-Yamani 1998, El-Sherehy 1999a, 1999b, Esharbagy 2005, Al Qubaisi 2006, Rajan & Abdessalaam, 2008, Bauman *et al.* 2010, Al-Shehhi *et al.* 2012). Relative to this, the inland waters are poorly understood.

Figure 1. Wasit Wetland (photo by Martin Soesbergen).

This article gives a description of the plankton organisms found in some inland waters in the northern UAE. Plankton are free-living micro-organisms in the water column and consist of phyto- and zooplankton. Important groups in the phytoplankton are cyanobacteria, green-algae and diatoms. Zooplankton in freshwaters consists of three main groups: water-fleas, copepods and rotifers.

Material and Methods

Samples were taken at three different locations in 2014 and 2016. A short description of the locations is given.

Wasit Wetland

Wasit Wetland (Figure 1) is a formerly tidal lagoon, with some freshwater input at its inner end, once connected to the Arabian Gulf. It is situated in the emirate of Sharjah, adjacent to the border between the city of Sharjah and the city of Ajman. Prior to its designation as the Al Wasit Nature Reserve, it was severely affected by a variety of anthropogenic impacts, including the construction of a highway that separated inner areas of the former lagoon from access to the sea.

Construction activities, in particular since the mid-1990s, have taken place on part of the site, with the clearance of some areas. Berms across the lower end divided existing water bodies, with the result that some small pools and reedbeds disappeared. Between the late 1980s and the mid-1990s, the site was used by Sharjah Municipality for the disposal of sewage and wastewater, while surrounding vegetation was affected by grazing by domestic livestock. A baseline report prior to remedial work related to its designation as a nature reserve (Hellyer & Aspinall 2005) summarises the status at that time.

In 2005, the area was designated as the Wasit Nature Reserve. In 2007, it was declared a protected area by an Emiri Decree No. 7 issued by His Highness Dr. Sheikh Sultan bin Mohammed Al Qasimi, Supreme Council Member and Ruler of Sharjah.

From 2006 until 2015, a programme of habitat restoration was implemented. Rubbish was removed and the area was fenced, with trees being planted around the reserve to provide screening, these being irrigated. Islands were constructed and cable and storm-water berms were removed to form a continuous water body, whose level could be controlled. In 2015 the Wasit Wetland Centre opened.

The nature reserve includes salt and brackish lagoons as well as freshwater pools. Some subterranean groundwater from inland areas enters at the inner end of the lake. This may represent the terminus of a palaeo-channel (aquifer) from the Hajar Mountains to the east. In recent years, the water has become more saline (Cornelie van der Feen de Lille, pers. comm.). The salinity fluctuates in relation to the amount of rainfall and there is a gradient present. Blooms of cyanobacteria occur (pers. obs. 2014). The samples from Wasit in both years were

Figure 2. A temporary water body along the Sharjah–Kalba road (photo by Martin Soesbergen).

taken from the same locations, but in 2014 the locations contained freshwater (by the taste of it) and in 2016 they contained brackish water (by the taste of it). In Wasit very young fish (0+) were observed in 2016.

Wadi Halah

Adjacent to and north-east of the Sharjah–Kalba road, between Munay and Shawka, and 3.4 km from Shawka, a tributary of Wadi Halah was sampled. After heavy rains, a temporary lake forms (Figure 2). This water body had been formed by rainfall several weeks before sampling and was relatively deep, with high turbidity. Since water-borne silt had already settled, the water was clear.

Sharjah Desert Park

The Sharjah Desert Park consists of a zoo, the Breeding Centre for Endangered Arabian Wildlife (BCEAW), two botanical gardens and a children's zoo. In the park, several ponds are present. Four of these were sampled. All ponds are man-made and are fed with desalinated water. Two of them are very small concrete-lined water bodies (Figure 3); they are almost identical and treated as one location in Table 1 (last column). The other two are real ponds.

In 2014, water plants (Rice field waternymph) collected in the Hajar Mountains were temporarily stored in the Desert Park. From the concrete containers in which the water plants were kept, two samples were taken.

Figure 3. Concrete ponds in Sharjah Desert Park (photo by Martin Soesbergen).

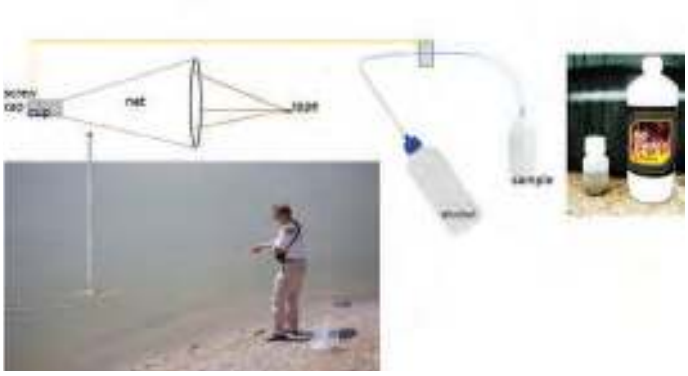

Figure 4.Taking a sample at Wasit Wetland (photo by Joris de Raedt).

In December 2014 and March 2016, samples were taken with a zooplankton net (HydroBios resp. EFE & GBNETS) with a 30 cm opening and 250 µm mesh size. In total, 12 samples were taken at three locations. Samples were taken by pulling the net through the water (Figure 1) and through the vegetation, if present, and scraped over hard substrate like logs or stones. Following the hauling in of the net, the residual material and animals were rinsed out of the cup and collected in a bottle (Figure 4). These samples were used for further analysis.

Some properties of the waters are given in Table 1. The flow in the ponds in the Desert Park is artificial and in ponds 1 and 2 the water is pumped around. Velocity is rather high. In both concrete ponds, the flow was caused by continuous filling with a garden hose, as seen in Figure 4. In both concrete ponds, numerous specimens of several species of domesticated fish were present.

The zooplankton samples were preserved in 95% ethanol (denaturated bio-ethanol GN 2207.20). Lugol was used for phytoplankton. Analysis took place under an Olympus IM70 or Carl Zeiss 4676635 microscope with magnifications 40x–1000x. From each sample, 100 organisms were counted and identified to the lowest possible taxonomic level. In addition, the samples were checked for other taxa. If possible, the identification was done to species level. Photographs were taken with Olympus CellSense (IM70) or Canon EOS 1200 with AmScope camera adaptor (Zeiss).

Identification

Since there are no published works identifying most tropical plankton species by name, it is usual to use guides written for European or American organisms. As a result, force fitting will occur, whereby because an organism looks very similar to one known to be present in a different region, it is assumed to be the same organism. This obviously has several disadvantages and is probably one of the reasons for the concept of cosmopolitan micro-organisms. Only for rotifers does a list of Arabian species exist (Segers & Dumont 1993). To check names and distribution, Algae Base (*http://www.algaebase.org*) is a useful site. For rhizopods, good photographs can be found on *https://www.arcella.nl/*.

Not only does the lack of guides make identification difficult, but, at the present time, genetic research is leading to rapid changes in taxonomy. Frequently, a recognised

Table 1. Some properties of the sampled waters

Description	Wasit W	Wasit E	Wadi	Desert Park	Desert Park	Desert Park	Water plants
Abbreviation (table 2)	WW	WE	WA	DP1	DP2	DP3	HM
Coordinates	25°22'14" N	25°22'02" N	25°03'42" N	25°17'13" N	25°16'50" N	25°16'51" N	unknown
	55°27'22" E	55°27'52" E	56°03'10" E	55°41'54" E	55°41'38" E	55°41'26" E	unknown
2014	28-XII	28-XII	–	31-XII	–	–	31-XII
2016	1-III	1-III	2-III	4-III	2-III	3-III	–
Type	altered	altered	natural	artificial	artificial	artificial	unknown
Salinity	fresh-brackish water	brackish water	freshwater	freshwater	freshwater	freshwater	freshwater
Vegetation	none	none	none	reeds	reeds	reeds/lily	*Najas*
Depth (cm)	10–15	10–15	250	30–70	30–70	30–70	unknown
Flow	none	none	none	yes	little	little	unknown
Fish	yes (0+)	none	none	yes	yes	yes	unknown

genetic species lacks a good morphological description, making it more difficult to assign a valid name to a (plankton) organism. Genetics have a valuable role to play in the classification of organisms, but, for example in the Euglenophyceae, strains of tropical taxa are not available (Bicudo & Menezes 2016).

For most cladoceran groups, there exist worldwide guides. Cladocera is a group with many species formerly considered to be cosmopolitan. Most are now recognised as species complexes as a result of genetic studies and have different species in the Tropics, Neotropics, the Nearctic and the Eastern and Western Palearctic. The same can be expected for other micro-organisms. For some groups, the concept of cosmopolitanism still survives and is probably accurate.

Literature concerning tropical taxa is scarce and scattered in specialist journals that are difficult to access. Identifying plankton from tropical regions should be done with considerable care. Species described as being newly-discovered for a particular country should at least cite not just the name but also the literature used for identification, including author and year of publication, and, if possible, should be documented with photographs or drawings.

Results

The organisms found are classified for the higher taxa according to Ruggiero *et al.* (2015). In terms of common names, these are blue green algae (Class Cyanophyceae), euglenids (Order Euglenida), rhizopods (Order Arcellinida), diatoms (Class Bacillariophyceae), green algae (Class Chlorophyceae), desmids (Order Desmidiales), water fleas (Suborder Cladocera of the Order Diplostraca), copepods (Orders Cyclopoida and Harpactacoida), ostracods (Class Ostracoda) and rotifers (Order Ploima). Some groups were impossible to identify to species level at all. No female copepods with egg sacks were encountered, so further identification was impossible. Most diatoms can only be identified with certainty when preparations are made. This has not yet been done. For ostracods and most rotifers, knowledge to permit identification is lacking. A short summary of the species composition of the locations is given below.

Samples from the Wasit Wetland were dominated by cyanobacteria in 2014, most being filiform threads belonging to the Order Oscillatoriales, accompanied by small and coccoid forms belonging to the Orders Synechococcales and Chroococcales. Only a few were identified with any certainty to the species level. In 2016, one sample only contained copepods and in the other sample no plankton was found.

The sample of the temporary water body in Wadi Halah was dominated by nauplius larvae of copepods. A few rhizopods and desmids were present.

The samples from Sharjah Desert Park are very different from those from the Wasit Wetland and Wadi Halah. Two samples were dominated by ostracods. One sample was dominated by green algae, one by diatoms and another one by euglenids. Desmids, cladocerans and rhizopods were present in low quantities.

Of the samples taken from water plants collected in the Hajar mountains, one was dominated by a desmid and the other by euglenids.

All species identified and some of the samples identified only to the level of genera are given in Table 2, arranged by the common names of the groups, with the higher taxonomic classification identified being given. Copepods were present, all from the two major groups: Cyclopoida and Harpacticoida. Some of the more interesting species are discussed below.

Table 2. List of groups, genera and species present (X). WW – Wasit Wetland, WH – Wadi Halah, DP – Sharjah Desert Park and HM – Hajar Mountains, for abbreviations see table 1.

	WW	WE	WA	DP1	DP2	DP3	HM
CYANOBACTERIA (BLUE GREEN ALGAE)							
Class Cyanophyceae, Order Synechococcales							
Woronichinia naegeliana (Unger) Elenkin, 1933		X					
Synechococcus sp.	X						
Class Cyanophyceae, Order Oscillatoriales							
Geitlerinema splendidens (Greville ex Gomont) Anagnostidis, 1989	X	X					
Oscillatoria nigro-viridis Thwaites ex Gomont, 1892		X					
Planktolyngbia limnetica (Lemmermann) Komárková-Legnerová et Cronberg, 1992	X	X					
Planktothrix compressa (Utermöhl) Anagnostides & Komárek, 1988	X	X					
Pseudanabaena limnetica (Lemmermann) Komárek, 1974	X	X					
Spirulina major Kützing ex Gomont, 1892	X						
Kamptonema sp.	X	X					
Class Cyanophyceae, Order Chroococales							
Aphanocapsa sp.	X	X					
Aphanothece sp.		X					X
Gloeocapsa sp.		X					
Microcystis sp.		X					
EUGLENIDS							
Class Euglenophyceae, Order Euglenida							
Cryptoglena pigra Ehrenberg, 1832				X			
Euglena proxima P. A. Dangeard, 1901							X
Phacus acuminatus Stokes, 1885 (ssp. *triquetra* has 1 paramylon)				X			
Phacus curvicauda Svirenko, 1915							X
Phacus minutus (Playfair) Pochman, 1942							X
Phacus onyx Pochman, 1942							X
Phacus pleuronectus (O. F. Müller) Nitzsch ex Dujardin, 1841				X			
Lepocinclis sp.							X
RHIZOPODS							
Class Lobosea, Order Arcellinida							
Arcella crenulata Deflandre, 1928			X				
Centropyxis aculeata Stein, 1859			X	X		X	
Cyphoderia ampulla Leydig, 1878							X
DIATOMS							
Class Bacillariophyceae, Order Thalassiosirales							
Cymbella meneghiniana Kützing, 1844				X			
Class Bacillariophyceae, Order Tabellariales							
Diatoma tenuis C. Aghard, 1912			X				
Tabularia fasciculata (C. Aghardh) D. M. Williams & Round, 1986				X			
GREEN ALGAE							
Class Chlorophyceae, Order Sphaeropleales							
Desmodesmus grahneisii (Heynig) Fott, 1973						X	
Desmodesmus communis E. Hegewald, 2000						X	X
Desmodesmus dispar (Brébsson) E. Hegewald, 2000						X	
Tetradesmus ginzbergeri (Kammerer) M. J. Wynne, 2016						X	
Tetradesmus obliquus (Turpin) M. J. Wynne, 2016						X	
Tetradesmus dimorphus (Turpin) M. J. Wynne, 2016						X	
Tetrastrum staurogeniiforme (Schröder) Lemmerman, 1900				X			

Table 2 (continued).

	WW	WE	WA	DP1	DP2	DP3	HM
DESMIDS Class Conjugatophyceae, Order Desmidiales							
Closterium acerosum Ehrenberg ex Ralfs, 1848							X
Closterium lunula Ehrenberg & Hemprich ex Ralfs, 1848						X	
Closterium pseudolunula O. Borge, 1909							
Cosmarium pseudoformulosum Van Westen, 2015				X	X		
WATERFLEAS Class Branchiopoda, Order Diplostraca, Suborder Cladocera							
Coronatella anemae Van Damme & Dumont, 2008				X		X	
Macrothrix spinosa King, 1953						X	
COPEPODS Class Maxillopoda, Subclass Copepoda							
Order Cyclopoida	X	X	X			X	X
Order Harpacticoida	X	X	X				
OSTRACODS Class Ostracoda				X	X	X	X
ROTIFERS Class Eurotatoria, Order Ploima							
Lecane spec.				X			

Cyanobacteria

Between 10–20 species were present in the samples taken in 2014 in the Wasit Wetland, most not being identified with enough certainty to mention here. The coccoid forms belong to *Aphanothece*, *Synechococcus*, *Microcystis* and *Woronichinia*. The filiform species belong to *Geitlerinema*, *Kamptonema*, *Planktolyngbia*, *Planktothrix* and *Spirulina*. Tropical species of *Planktothrix* are reviewed and partially re-described by Komárek & Komárková (2004) who also give a key to the species. In Wasit Wetland, *Planktothrix compressa* (Utermöhl) Anagnostides & Komárek is found. The genus *Planktothrix* Anagnostides & Komárek 1988 is an important, potentially toxic, cyanobacterial genus, forming water blooms. The other species is *Woronichinia naegeliana* (Unger) Elenkin (Figure 5) a species with a very characteristic colony. The identification is confirmed by Ton Joosten. *Woronichinia naegeliana* is a potentially toxic species (Pearl & Otten 2013). Blooms of *W. naegeliana* show toxic activity towards invertebrate zooplankton (Bober & Bialczyk 2017).

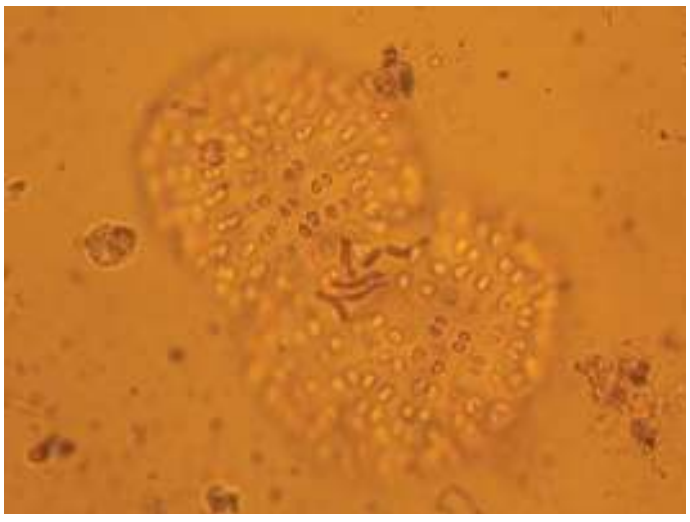

Figure 5. *Woronichiana naegeliana* (photo by Martin Soesbergen).

A third species, *Geitlerinema splendidens* (Greville ex Gomont) Anagnostidis 1989, is characterised by the end of the trichomes which are attenuated, ending in a knob. It is the only species left in the revised genus *Geitlerinema* (Strunecký *et al.* 2017). It is a widespread cosmopolitan species that can produce toxins.

Euglenids

From the genus *Phacus*, several species and/or varieties were present. They were identified with Huber-Pestalozzi & Hustedt (1955) as *P. acuminatus* Stokes, 1885, *P. curvicauda* Svirenko, 1915, *P. pleuronectus* (O. F. Müller) Nitzsch ex Dujardin, 1841 and *P. megaparamylica* Roll, 1925. *Phacus megaparamylica* is probably only a variety of the first species (Huber-Pestalozzi & Hustedt 1955).

In many cases, previously described species and subspecies that have been 'lumped' together prove to be valid species when using genetic methods. Any separation now needs particular caution, since, if again lumped back into one species, they cannot be separated again.

It has become clear that *P. megaparamylica* is an older (in age) form of *P. pleuronectus* with large paramylon grains (Kosmala *et al.* 2007). Identification is done with a European key (Huber-Pestalozzi & Hustedt 1955). *Euglena proxima* is a characteristic spindle-shaped truncate species with a blunt hyaline tail end (John 2005). Klaveness & Løvhøiden (2007) say it is a species complex in need of

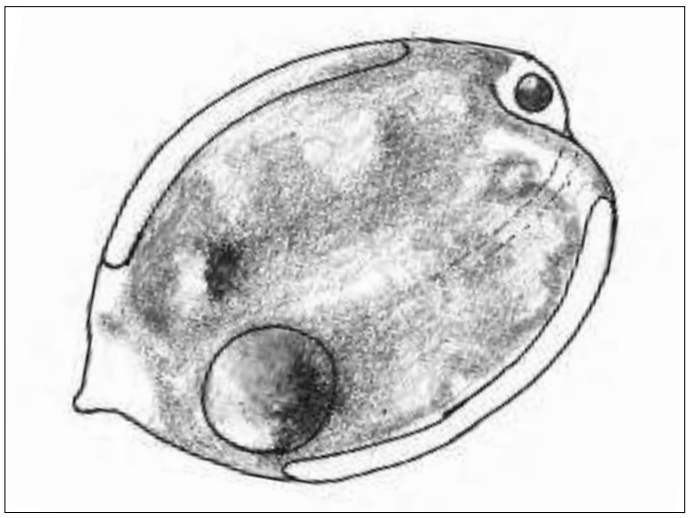

Figure 6. *Cryptoglena pigra* (drawing by Martin Soesbergen).

revision by modern methods. These are believed to be cosmopolitan species. Within these species, however, many varieties have been described and these taxa may encompass several, including tropical, species. *Phacus onyx* and *P. minutus* are more or less tropical species (Algae Base).

A species of the genus *Cryptoglena* was found (Figure 6). This is a genus with rigid cells, two paramylon plates instead of the normal euglenoid paramylon discs, one or two chloroplasts and one median furrow which makes it look like a coffee bean. According to Marin *et al.* (2003), who examined both known species side by side, it looks like *C. pigra*. Kim *et al.* (2013) recognised cryptic species in *Cryptoglena*, the two previously known species (*C. skujai* and *C. pigra*) and three new species without known distinctive morphological differences.

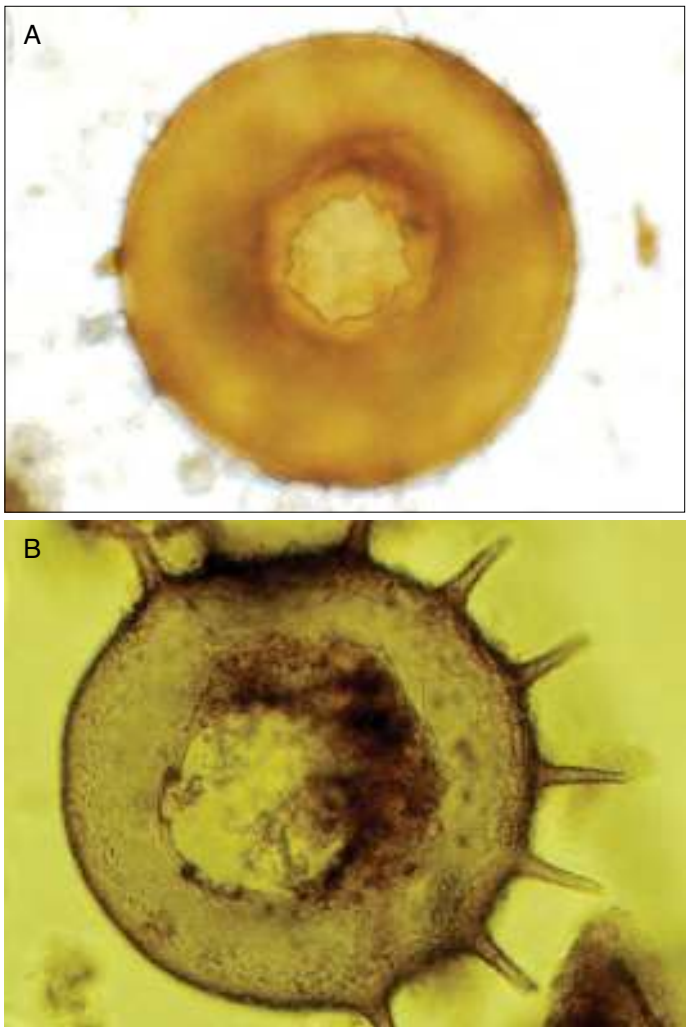

Figure 7. A: *Arcella crenulata*, B: *Centropyxis aculeata* (both photos by Martin Soesbergen).

Rhizopods

Three species were found and identified: *Arcella crenulata* Deflandre, 1928 (Figure 7A), *Centropyxis aculeata* Stein, 1859 (Figure 7B) and *Cyphoderia ampulla* Leydig, 1878. Identification was carried out with Hoogenraad & De Groot (1940) and checked with photographs on microworld amoboid organisms. Most rhizopods are cosmopolitan (Hoogenraad & De Groot 1979, Bobrov *et al.* 2010) and a geographical division between a northern and a southern fauna is recognised. There seems to be no typical tropical fauna (Hoogenraad & De Groot 1979). *Cyphoderia ampulla* is supposed to be cosmopolitan, but Todorov *et al.* (2009) found significant differences in this species that might indicate a complex of cryptic species.

Diatoms

Only some species can be recognised under a light microscope. Empty frustules of *Cyclotella meneghiniana* and *Tabularia fasciculata* were present in the ponds of Sharjah Desert Park. Both are very common and widespread species belonging to a species complex (Beszteri *et al.* 2007, Snoeijs 1992) *Diatoma tenuis* was recognised in the sample from Wadi Halah.

Green algae

Several species of the genus '*Scenedesmus*' (Komárek & Fott 1983) are present. *Scenedesmus*, always a common and well-known part of the phytoplankton, is no longer simply *Scenedesmus*. Hegewald *et al.* (2013) describe the history of the revision of this genus. Komárek & Fott (1983) had already recognised six different groups. The prototype (4-spined) *Scenedesmus* is now called *Desmodesmus* and *Scenedesmus* is now a group of unarmed blunt-celled algae (An *et al.* 1999). The third important group is the acute-celled colonies (*Acutodesmus*). The name *Acutodesmus* has been recently replaced by *Tetradesmus* (Wynne & Hallan 2015).

The species of the Scenedesmaceae that are most abundant are smooth-walled acute-celled colonies. Ribbed obtuse-celled colonies and short-spined colonies are also present. The acute cells with obtuse top of the cell are characteristic of *Tetradesmus ginzbergeri* (Figure 8). It is a little-known and probably rare species (Hindák & Hindáková 2008). According to Komárek & Fott (1983), it is a tropical species. It is also found in India (Nandi *et al.* 2017). The two other species are common and widespread: *T. obliquus* (Hegewald 1997) and *T. dimorpus*. The colonies with ribs and warts belong to *Desmodesmus grahneisii*

(Hindák 1990, Hegewald 2000). Four- to eight-celled colonies with spines shorter than cells and additional spines are assigned to *Desmodesmus dispar* (Komárek & Fott 1983, Hindák 1990, Hegewald 2000). In one of the ponds in Sharjah Desert Park, *Tetrastrum staurogeniiforme* (Schröder) Lemmerman, 1900 was found. The small colonies are four-celled and have 3–7 setae on each cell.

Desmids

Most interesting is a recently-described species of *Cosmarium*, *C. pseudoformulosum* Van Westen, 2015 (Figure 9), found 5,000 kilometres from the original location from which it is described. Originally described from *Elodea* vegetation in fens in the Netherlands (Van Westen 2015), it is now recorded on Ricefield Waternymph plants originating from the Hajar Mountains. The identification was made by M. van Westen, the describer of the species. This species measures 33.0–41.0 µm (length) by 29.5–35.5 µm (width) in the Netherlands (Van Westen 2015). The population in Sharjah is slightly bigger and measures 38.9–45.6 µm (length) by 33.3–37.0 µm (width). The cells are slightly longer than broad with length : breadth ratio between 0.75–0.91. This small desmid seems to challenge the concept of non-cosmopolitan distribution of plankton organisms.

Other species of the genus *Closterium* found in the Desert Park include *C. lunula* and *C. pseudolunula* and, in Wadi Halah, *C. acerosum*. *Closterium lunula* is believed to be cosmopolitan (John *et al.* 2002) and the other two taxa are widely distributed (Algae Base). However, within these species a lot of varieties are described and the taxa may include several, including tropical, species not yet described.

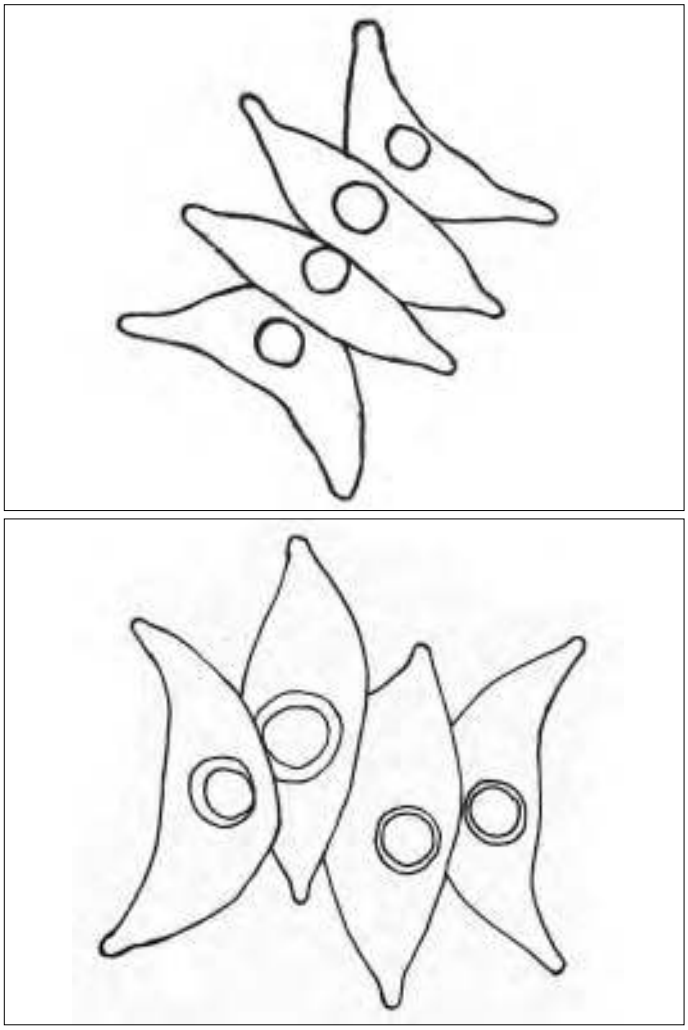

Figure 8. *Tetradesmus ginzbergeri* with obtuse cell tops (both drawings by Martin Soesbergen).

Water fleas

Both artificial concrete ponds at the Sharjah Desert Park (Figure 3) are the only locations where Cladocera were found. A species of the genus *Macrothrix* was found together with *Coronatella anemae*, a species already known from Sharjah Desert Park (Van Damme & Dumont 2008). Identification was done with Smirnov (1992). The antennule is distally dilatated (Figure 10B). The animals are featured by the dorsal outline without tooth but with a fine serrulated outline along the dorsal margin of the valves and head (Figure 10A) which is characteristic for *Macrothrix spinosa* and *M. pseudospinosa*. No other species can be confused with these two species. *Macrothrix laticornis* has such serrulations but they are coarser and situated only along the dorsal margin of the valves. The difference between the very similar species *M. spinosa* and *M. pseudospinosa* is the length of the distal part of the setae natatoriae (Smirnov 1992, Błędzki & Rybak 2016). Because of the short distal part of the setae natatoriae, the animals were determined as being *M. spinosa*. In the pond with a luxurious growth of waterlily, *M. spinosa* was more abundant.

Most records of *Macrothrix* Baird, 1843 on the Arabian Peninsula are reported as *Macrothrix* sp. These records are from three sites in the Tabuk region (Aloufi and Obuid-

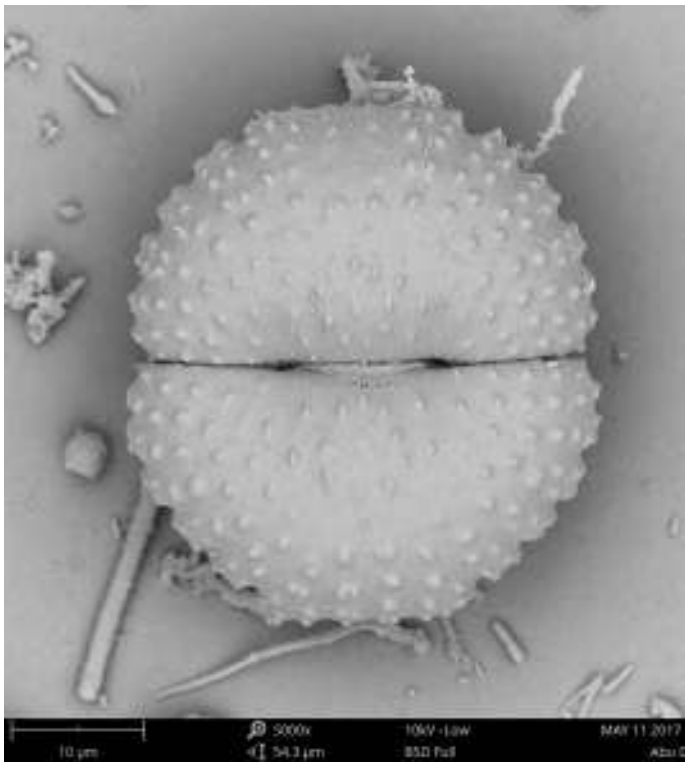

Figure 9. SEM image of *Cosmarium pseudoformulosum* (photo by Frans Kouwets).

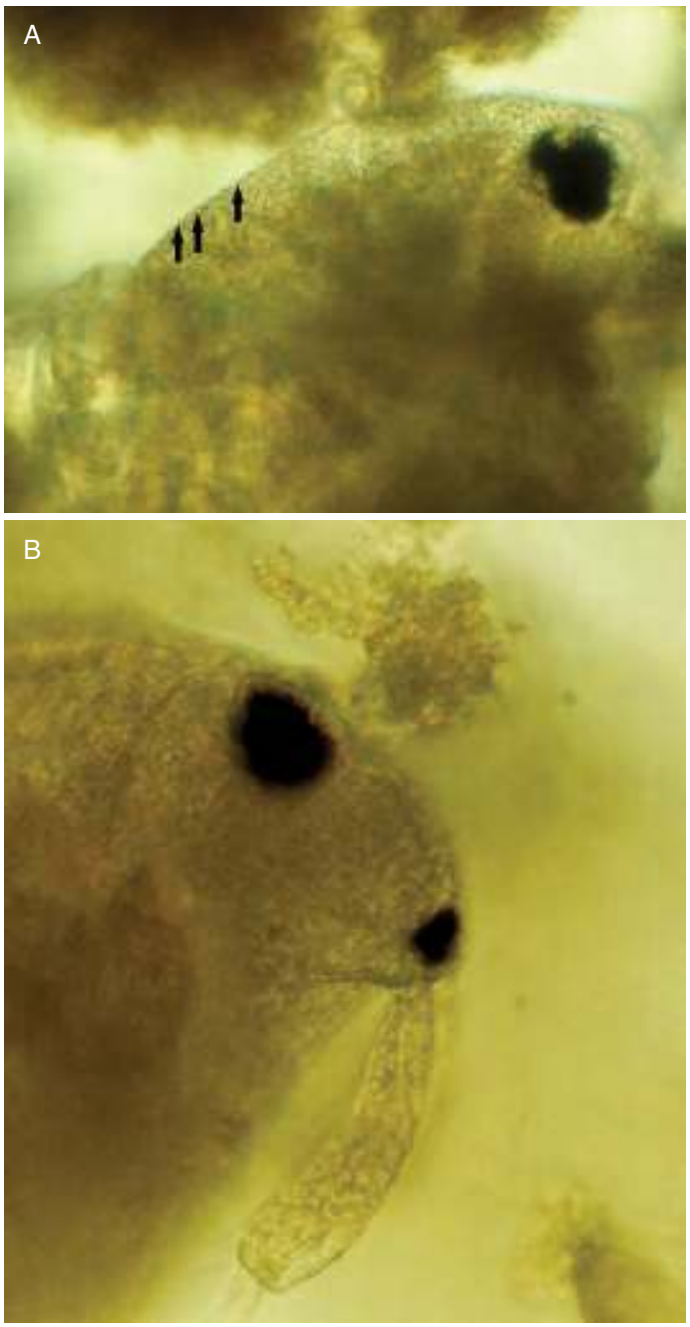

Figure 10. *Macrothrix spinosa*. A: spines at the head (arrows), B: dilated antennule (both photos by Martin Soesbergen).

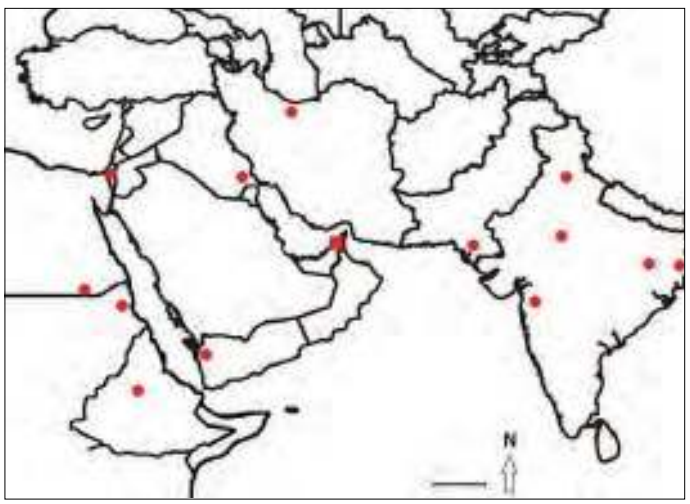

Figure 11. Records of *Macrothrix spinosa* in the area.

Allah 2014a) and five sites in the Al-Madinah Almonawwarah region (Aloufi & Obuid-Allah 2014b) in Saudi Arabia. This is believed be a circumtropical species (Smirnov 1992) with a very wide distribution but it is probably a complex of species (Elmoor-Loureiro 2007, Kotov *et al.* 2013). The nearest records are from Hadah in Yemen (Smirnov 1992), Bashrah in Iraq (Ajeel & Abbas 2013, Abbas *et al.* 2015) and Jamshoro in Pakistan (Baloch *et al.* 2015). In the region (Figure 11) it is also found in Iran (Jafari *et al.* 2011), Israel (Bromley 1993), Egypt (Khalifa *et al.* 2015), Sudan (Dumont *et al.* 1984) and Ethiopia (Akoma *et al.* 2014). It seems to be common in India (Biswas 1971, Venkatraman 1999, Lekhida & Shika 2014, Kulkarni *et al.* 2015). Since *M. spinosa* is probably a species complex, the Sharjah Desert Park record is of particular interest as it may be a species from Asia or Africa, an introduced species from Europe or even a species restricted to the Saharo-Arabian subregion.

Discussion

Knowledge of the composition of the plankton community can have several useful benefits. First, it provides an insight into the food chain and thus the potential of a lake, pool or any other water body for the presence of fish, aquatic insects, tadpoles and birds. The plankton and algae community can support local populations of the fish Muscat cyprinion (*Cyprinion microphthalmum muscatensis*). *Cyprinion* species feed on algae, zooplankton and small crustaceans (Güçlü 2012). The endemic *C. mhalensis* in Saudi Arabia prefers phytoplankton for diet (Ahmad *et al.* 2013) and *C. macrostomum* prefers plankton (Faghani-Langroudi & Moustavi-Sabet 2018). Muscat cyprinion is known to feed mainly on filamentous (aufwuchs) algae but also on unicellular algae and aquatic insects (Krupp 1988). Dragonflies, such as the endemic *Arabineura khalida*, which is strongly tied to the waters in which it lives and nearby areas, (Giles 1998), are predators, indirectly dependent on the plankton organisms eaten by their prey.

Secondly, studies of the plankton community give insights into potential toxic algal blooms and the possible negative effects on other biota. This includes possible effects on the tadpoles of the Dhofar toad and the regionally endemic Arabian toad. Toxins can negatively affect tadpoles (Daniels *et al.* 2014).

Last but not least, such studies locally provide more knowledge of biodiversity in the UAE. Understanding the functioning of aquatic ecosystems is important for good management of those ecosystems. One possible benefit could be the encouragement of further plankton and hydro-biological research in fresh and brackish waters in the UAE.

Identifying plankton organisms provides a contribution to the building up of a species list for the UAE with notes on their identification and distribution. Many organisms are, thus far, only identified to genus or a higher level. Further work and time is required to identify them further.

The identifications are, where possible, done with guides, including those for tropical species. For desmids, euglenids and rhizopods this was not possible. For green

algae and cyanobacteria, the Tropics are only partly covered. This can lead to inaccuracies or misidentifications. The development of a local plankton guide is recommended to improve the accuracy of biological assessments and to enhance the knowledge of the biodiversity of the unique and important wetland ecosystems in the UAE.

The groups for which enough knowledge is present are cladocerans and most groups of phytoplankton and, to a lesser extent, rotifers, rhizopods and copepods. Small species are lacking. The samples were collected with a zooplankton net, which selects for larger organisms, missing many small organisms.

Two samples contained more small organisms. One of the artificial waters contained a lot of detritus and the net collected a lot of silt. From the water plants, a squeeze sample was taken and filtered over the net. To obtain a good record of all plankton organisms present, more and different methods should be used for sampling. Moreover, it is clear that the species present in each location reflect some properties of the water body.

Wasit Wetland was dominated by cyanobacteria in December 2014. In March 2016 only copepods could be found. Salinity differed between the two periods. This suggests that the water body may be changing from fresh-brackish, with cyanobacteria, to a more saline one, with no, or far fewer, cyanobacteria. A better understanding of the system could be obtained through a survey combining plankton data with physico-chemical and other parameters.

The temporary water at Wadi Halah was dominated by copepods. Colonisation of temporary waters generally begins with copepods (Frisch & Green 2007) or cladocerans (Louette *et al.* 2008) but is dependent on several factors, for instance the resting stadia in the bottom and transport from other sources. The dominance of copepod nauplius larvae reflects the relatively short existence and high turbidity of this water. At the start of colonisation, only a few species dominate. To understand better the build-up of communities in such temporary (wadi) systems, systematic survey during the lifetime of such water bodies would be of value.

The artificial ponds in the Sharjah Desert Park reflect another system. Dominance of euglenids and ostracods indicate a higher organic load. The shallow systems have a good deal of organic matter and extensive algal vegetation on the bottom. Such artificial water bodies are introduced systems, whose ecological role deserves study.

The bodies of fresh water in the UAE can be classified into three types: natural, altered and artificial. Natural waters are those wholly or largely without alterations by humans. Altered waters are waters with significant anthropogenic alteration, such as dams, wastewater disposal and agriculture. Artificial waters are man-made waters such as ponds fed with desalinated water. Human activity is commonly accepted as a threat to biodiversity.

The threat posed to wadi fish species by the introduction of exotic fish is well-known (Harnan 2008). Are artificial freshwater pools a thread to plankton biodiversity in an area that is as arid as the United Arab Emirates? Theoretically, they could have three major influences on biodiversity: (1) they can be a habitat or refuge for native species and/or (2) they can be a source of (undesirable) exotic species or (3) they have no significant influence on the biodiversity.

To decide either way, we have to know and compare the composition of the plankton present in aquatic habitats, both natural and artificial. Artificial waters will increase in number with the continuing development of the urban environment in the UAE. Agricultural areas continue to expand and irrigation channels and pools for farms are also new habitats. Also areas of treated liquid waste discharge (El Serehy *et al.* 2013) near inland sewage facilities contribute to the establishment of more wetland areas. Understanding the ecological communities associated with these habitats will allow for improved management.

Indices and species composition can be used to assess trophic and saprobic status, diversity, disturbance or influences of salt or toxic substances. Indicator values are present for all organisms to calculate the saprobic index (Sládeček 1973). Diversity indices (Abulwahab & Rabee 2015) and species composition (Ferdous & Muktadir 2009, Ismail & Adnan 2016) give more information on the functioning of aquatic ecosystems. For diatoms (Van Dam *et al.* 1994) and desmids (Coesel 2001, 2003) indicator values are present.

First, however, the basic data related to the species that are present is required. There is a need for an annotated checklist of species in the UAE and an overview of suitable literature for identification. Secondly, there is a need for researchers who are interested in this field of study and its use for the management of wetlands.

Conclusion and recommendations

Records of plankton organisms from inland fresh- and brackish waters in the UAE were not identified during a literature survey on the Internet. Such records may, indeed, not exist. The samples taken and discussed above indicate the presence of a wide variety of planktonic and semi-planktonic species. To create an overview of these organisms, it will be necessary to collect more samples, either through random and voluntary collection or through the establishment of a formal programme and monitoring scheme.

Recent hydrobiological research in the United Arab Emirates has been focused on fish (Feulner 1998, 2000), insects (Burt 2003), molluscs (Feulner & Green 1999) and crustaceans (Hornby 1999, Al-Khalili & Thompson 2003). For the understanding of the functioning of wetlands, pools, wadis and lakes, knowledge of the species composition of the plankton collected through hydrobiological research will be a valuable addition to the research already done in the UAE.

It is, therefore, recommended that a preliminary annotated checklist should be developed to provide an overview of the biodiversity of this group of organisms in the UAE, such a list being public and freely accessible. The development of a local plankton guide is also recommended to improve the accuracy of biological assessments and to enhance the knowledge of the biodiversity of the unique and important ecosystems.

The author would welcome additional information on the presence of species and additional samples, accompanied by appropriate site information.

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Range expansion of the Indian Crested Porcupine (*Hystrix indica*) with the first confirmed record in Abu Dhabi Emirate, United Arab Emirates

by Shaikha Al Dhaheri, Robert E. Gubiani, Rashed Al Zaabi, Eissa Al Hammadi, Shakeel Ahmed & Pritpal Soorae

Abstract

We provide evidence for range expansion of the Indian Crested Porcupine (*Hystrix indica*) in the UAE and the first record for this species in Abu Dhabi Emirate. The footprints and quills of the Indian Crested Porcupines recorded at one of the coastal sites in Mirfa led to the deployment of trail camera traps into an area suspected of harbouring individuals. Camera traps results revealed the presence of at least one individual with images captured on several occasions. This evidence confirms the range expansion of this species in addition to the recent discovery of *H. indica* in Fujairah Emirate.

Introduction

While there is an abundance of rodent studies globally, there is a paucity of information on mammal communities in the Arabian Peninsula (Melville & Chaber 2016). Although the greater part of the habitat within the Arabian Peninsula is desert or semi-arid, diversity of small mammal and rodent species is relatively high with 46 known species present within the region (Harrison & Bates 1991, Strauss *et al.* 2008). Of these, only a single large rodent species has been recorded in the region, that being the Indian Crested Porcupine (*Hystrix indica*) (Harrison & Bates 1991).

Distribution of this species globally is broad, ranging from central Asia to southwestern Asia and regionally in the Middle East (Harrison & Bates 1991, Amori *et al.* 2016, Chreiki *et al.* 2018). In parts of its natural range, high population densities of this species have led it to be deemed as a pest (Qumsiyeh 1996, Hafeez *et al.* 2011) and therefore subsequently persecuted. Within the Middle East, records currently exist from Iran, Iraq, Jordan, Yemen and Saudi Arabia (Harrison & Bates 1991, Amori *et al.* 2016). However, absolute population numbers are currently unknown. Within the Arabian Peninsula, regional population numbers are believed to be in decline due to conversion of land for agricultural practices (Khadim 1997, Amori *et al.* 2016) and from local hunting due to the species being seen as a delicacy (Khadim 1997, Amori *et al.* 2016, Yürümez 2016, Chreiki *et al.* 2018). Although globally it is considered to be Least Concern by the IUCN (see Amori *et al.* (2016), it is considered to be threatened in some countries due to these threats (Chreiki *et al.* 2018).

A recent discovery of Indian Crested Porcupine in Wadi Wurayah National Park in Fujairah, on the UAE East Coast, has confirmed the species' presence in the United Arab Emirates, with it being believed possible that it might occur in other mountainous areas of the region (Chreiki *et al.* 2018). This discovery significantly increased the species' known range by approximately 600 km from the nearest known previous record in the central desert of Oman (Harrison & Bates 1991, Chreiki *et al.* 2018). It further confirmed that the necessary environmental requirements for this species are available in the UAE and are sufficient to sustain a population, albeit likely to be limited in nature.

This paper provides additional records of the presence of *H. indica* in the UAE and confirms further expansion of the geographic range of this species with a new record occurring within Abu Dhabi Emirate.

Study area

Anecdotal evidence of this species occurring within the Emirate of Abu Dhabi had been recorded in the past (Gasperetti 1967) but there was no reliable confirmed evidence of their occurrence within the UAE (Cunningham 2004) even though suitable habitat was likely available. A review of mammal species believed extinct or whose presence was not proven in the UAE in 2004 made no mention of the species (Aspinall *et al.* 2005).

The confirmation of the presence of *H. indica* in the Al Dhafra region of Abu Dhabi Emirate occurred through the identification of footprints suspected to be those of Indian Crested Porcupine by a staff member of the Environment Agency – Abu Dhabi, who was conducting surveys for threatened species in the Al Mirfa area, part of the Al Dhafra region, west of Abu Dhabi. Discarded quills of the species were also collected. The preliminary identification of the footprints by experts as being those of *Hystrix* sp., coupled with credible anecdotal information provided by residents, suggested there was sufficient evidence to warrant further investigation. At the time, the discovery of the presence of *H. indica* in Wadi Wurayah (Chreiki *et al.* 2018) was unpublished and consequently was not known by the authors of this paper.

Al Mirfa is situated approximately 90 kilometres WSW of Abu Dhabi Island along the southern coastline of the Arabian Gulf. Although no formal terrestrial protected areas exist within the core region of Al Mirfa, three protected areas exist within close proximity, with the Marawah Marine Biosphere Reserve incorporating part of the Al

Figure 1. Indian Crested Porcupine (*Hystrix indica*) recorded in Abu Dhabi's Al Dhafra Region.

Mirfa coastline directly north. The other two protected areas are terrestrial, the Marzoum Protected Area, located 37 kilometres to the SE (1,141 km^2 in size), and the Al Houbara Protected Area located 8 kilometres SW (770 km^2 in size). Recent surveys have recorded the presence of rare mammal species, namely Arabian Sand Cat (*Felis margarita*), in Marzoum Protected Area (R. Gubiani pers. comm.) and Al Houbara Protected Area (Ahmed *et al.* 2016).

The survey area is traditionally known as Umm A Laqah (henceforth referred to as Mirfa) and is mixed use in nature, with forestry dominating the periphery and the southern portion of the site and limited farming occurring within a small area (0.55 ha). Habitat within Mirfa comprises eight types, namely: (1) Coastal Cliffs, Headlands, Rocky Slopes and Wadis In Coastal Situations; (2) Coastal Plains on Well-Drained Rocky or Gravelly Terrain; (3) Jebels (Including Mesas and Barqats); (4) Moist Ground with *Phragmites*, *Tamarix* and Grass Mats; (5) Coastal Plains on Well-Drained Sandy Ground; (6) Coastal Sabkha, including Sabkha Matti; with (7) Coastal Sand Sheets and Low Dunes with Coastal Plains on Well-Drained Rocky or Gravelly Terrain and (8) Forestry Plantations, the latter comprising the majority of the site. The survey area is fenced and covers approximately 4.21 km^2. However, it is likely that access into and out of the site is possible through holes in the boundary fence. The northwest boundary adjoins multiple small-scale farming areas that are easily accessible, whereas the remaining boundary areas are surrounded by coastal plains and sabkha habitat that is devoid of vegetation.

Material and methods

Difficulty in obtaining regular access to the site made long-term survey methods, primarily camera trap deployment, to be the most appropriate means of investigation. The camera traps deployed comprised two models; Reconyx PC800 Hyperfire Professional IR (3 units), and Bushnell Trophycam HD (1 unit). All camera traps deployed operated by PIR sensors triggered through a combination of temperature and motion. Deployed cameras were mounted on either camera tripods or metal stakes in a north or south orientation to eliminate misfires. Placement of camera traps occurred in areas deemed to provide the greatest evidence of species movement such as funnel points or areas with high resource density. In areas devoid of obvious funnel points, cameras were placed in patches of vegetation or on elevated locations. Placement of camera traps on elevated locations has, in the past, shown to be more likely to carry scent from baiting products further as well as being often used as scent marking locations for several species.

In order to increase the likelihood of species capture, bait was placed approximately one metre directly in front of deployed camera traps. Although many types of artificial lures are available internationally, very few dedicated lure products are available domestically. Therefore, locally available fresh vegetables were utilised as bait. Additionally, placement of bait occurred in areas that were quite exposed to increase the visual appeal as well as enhancing scent movement into lower-lying areas within the survey area.

Upon the second deployment period, a single spotlight survey was conducted to identify porcupine individuals and determine information related to the overall site ecology. The site was surveyed from two vehicles using high-powered torches along pre-determined pathways.

Results

Two camera trap deployment periods occurred during 2017/2018 with the initial and subsequent survey deployment periods constituting 185 trapping nights.

The first deployment period occurred in December 2017 through to January 2018 covering a total of 43 trapping nights. Of the four camera traps deployed, three occurred within habitat types classified as Coastal Sand Sheets and Low Dunes with Coastal Plains On Well-Drained Rocky Or Gravelly Terrain. These three cameras were all located in close proximity (within less than 1 km^2) as evidence of footprints and quills were identified in this area. Given the amount of evidence present at this location, it was deemed to be the most likely location to obtain positive records and therefore camera trap density was increased. The final camera trap was deployed within forestry habitat at what was considered to be a possible den site. The furthest distance between the four camera traps was 200 metres.

On the second deployment, Camera traps 1, 2 and 3 were deployed within the habitat type classified as Coastal Sand Sheets and Low Dunes with Coastal Plains On Well-Drained Rocky Or Gravelly Terrain. Camera trap locations 1 and 3 were also close to prominent jebels, with both of these locations having a greater concentration of native vegetation patches. Camera trap location 2 had lower levels of vegetation present. Camera trap location 4 was located within two well-established plantation sites deemed to show high evidence of wildlife traffic. The distance between waypoints 1–4 was 1.5 km, 0.5 km and 1.9 km respectively. The distance between camera locations during the second deployment period was increased to survey a larger portion of the protected area.

The first record for the species occurred on November 21st, 2017 and subsequently on three more occasions on 24/11/17, 28/11/17 and 1/1/2018 during the first deployment survey (Figures 1–2). During the second deployment, additional records occurred at a single location on 13/07/2018 and 25/07/2018.

Camera traps deployed at the site as well as a subsequent spotlight survey highlighted the presence of a number of other species including: eight mammal species; Mountain Gazelle (*Gazella gazella cora*), Cape Hare (*Lepus capensis*), Red Fox (*Vulpes vulpes arabica*), Ethiopian Hedgehog (*Paraechinus aethiopicus*), Feral Cat (*Felis catus*), Feral Dog (*Canis familiaris*), bat sp., and Cheeseman's Gerbil (*Gerbillus cheesmanii*); three reptile species, namely Arabian Horned Viper (*Cerastes gasperettii*), Slevin's Sand Gecko (*Stenodactylus slevini*) and Arabian Sand Gecko (*Stenodactylus arabicus*) and 14 avian species, namely Chestnut-bellied Sandgrouse (*Pterocles exustus*), Red-wattled Lapwing (*Vanellus*

Figure 2. Arabian Red Fox (*Vulpes v. arabica*) also recorded at the survey site.

indicus), Little Owl (*Athene noctua*), Green Bee-eater (*Merops orientalis*), Common Myna (*Acridotheres tristis*), Eurasian Collared Dove (*Streptopelia decaocto*), Laughing Dove (*Spilopelia senegalensis*), Purple Sunbird (*Cinnyris asiaticus*), Graceful Prinia (*Prinia gracilis*), Crested Lark (*Galerida cristata*), Indian Silverbill (*Lonchura malabarica*), White-eared Bulbul (*Pycnonotus leucotis*), Feral Pigeon (*Columba livia*) and House Sparrow (*Passer domesticus*).

Discussion

The presence of Indian Crested Porcupine in Mirfa is the first confirmed record in Abu Dhabi Emirate for this species. Although historical anecdotal accounts indicated this species was present in the past in low numbers, no confirmed evidence had been established in the emirate prior to the survey. It was widely believed by researchers that this species had never been present in the Emirate (Aspinall *et al.* 2005, Cunningham 2008).

Initial thoughts that the individuals identified might have been the result of release or escape from a private collection were dispelled upon investigation into importation records, with no official record occurring for the species in Abu Dhabi. Further investigations continue although it is considered highly unlikely that the presence of the species is the result of a private collection escape.

The recent discovery of Indian Crested Porcupine in Wadi Wurayah in Fujairah was a first record of the presence of this species within the UAE. This discovery, reported in 2018, provided clear evidence of range extension from the last known record in Oman (Chreiki *et al.* 2018). The confirmation of *H. indica* in Mirfa demonstrates a further range expansion of approximately 310 kilometres from the recent discovery reported by Chreiki *et al.* (2018). Range expansion for *H. indica* is not unique in that there was recorded range expansion occurring in Europe (Pigozzi & Patterson 1990, Alkon & Saltz 1998), the Middle East (Chreiki *et al.* 2018) and into urban areas (Lavori *et al.* 2017, Więckowski *et al.* 2013).

However, the likelihood of range expansion from Oman is considered to be less probable. It is more plausible that the species has always occurred in the area and that it was merely discovered, as opposed to it extending its range significantly from Oman. The rediscovery of elusive species has occurred in the Abu Dhabi Emirate with records of Sand Cat (*Felis margarita*) and Ruppell's Fox (*Vulpes rueppellii*) reported recently (Ahmed *et al.* 2016, Todorova 2018). Although the discovery of *H. indica* does represent a range expansion in terms of known species distribution globally, it probably does not represent a physical location expansion of individuals recorded from Oman.

Both recent sightings within the UAE occurred within areas that are afforded significant levels of protection or are difficult to access. The difficulty in accessing protected areas and the lack of confirmed records makes identifying further potential areas harbouring this species difficult. Additionally, the lack of extensive written documentation of their occurrence across the UAE and the Middle East provides an additional barrier to discovery of not only *H. indica* but also other elusive species, such as Honey Badger (Ratel), *Mellivora capensis*, for which the only UAE record is of three animals, two live, one dead, recorded near Ruwais in 2005 (Aspinall *et al.* 2005).

Local knowledge and consultation with traditional land users was crucial to the discovery in Abu Dhabi. The use of local knowledge also allowed the discovery of *H. indica* in the UAE (Chreiki *et al.* 2018), Iraq (Khadim 1997), Italy (Mori *et al.* 2017) and Yemen (Al-Safadi & Nader 1991). Recommendations by Chreiki *et al.* (2018) of the inclusion of social studies into species detection programmes are further supported by the use of this knowledge for the discovery at the Mirfa site. In areas where documentation is poor, utilisation of local knowledge is invaluable and should be incorporated into field studies prior to site visit to increase the likelihood of rare species discovery.

The habitat types of traditional locations of *H. indica* occur in close proximity to farmland (Saltz & Alkon 1989, Mushtaq *et al.* 2010, Hafeez *et al.* 2015, Kahn *et al.* 2016) and this is the case for the Mirfa site although movement of porcupines between the site and surrounding farmland has yet to be confirmed. This species has a broad habitat tolerance, occupying rocky hillsides, tropical and temperate shrubland, grasslands, forests, arable land, plantations, and gardens (Pigozzi & Patterson 1990, Amori *et al.* 2016, Lavori *et al.* 2017), which aligns with the habitat types where the Mirfa individuals occurred. The type of substrate within the protected areas consists of mesas/jebels, which are also locations of frequent activity by individuals recorded in Saudi Arabia (Seddon *et al.* 1997). Although there are similarities in habitat type with records in Saudi Arabia and Abu Dhabi, the habitat type in Wadi Wurayah is significantly different, being mountainous in nature with several deep wadis (Chreiki *et al.* 2018).

Studies have shown that *H. indica* has a broad diet (Pigozzi & Patterson 1990, Hafeez *et al.* 2011, 2015, Sarwar 2018) which indicates a generalist behaviour in response to food availability that serves the porcupine well during peak summer periods in the emirate. Food sources can easily be found in the surrounding environment and likely supplemented from farmed produce located in close proximity to the site. Travelling considerable distances for additional food sources is not uncommon, with radio-tracked individuals travelling up to 4 km from their den site and even swimming across 8-metre canals to feed in neighbouring farmland (Pigozzi & Patterson 1990).

Definitive identification of the number of individuals recorded is very difficult to achieve using camera trap photos as no obvious scars, marks or deformities were identified. Local agricultural workers indicated that they had observed up to three individuals within the previous three months, which may represent a small isolated population. Currently, there has been no confirmation of breeding and camera trap photos show specimens of the same size. Individuals are considered to be solitary in nature except during the breeding season (Guring & Singh 1996, Yürümez & Ulutürk 2016) but are known to wander occasionally as couples (Sarwar 2018). Sexual dimorphism is not obvious and therefore records of two or more individuals together or the presence of porcupettes would be considered the best indicator of breeding occurring in

Mirfa. Further surveys of the area are needed to confirm definitive numbers or whether breeding is occurring within the protected area.

Moon phase and lunar-phobic activity, primarily amongst herbivores, is a well-studied and documented phenomenon (Cresswell & Harris 1988, Gilbert & Boutin 1991, Kotler *et al.* 1993, Michalski & Norris 2011, Prugh & Golden 2014). Previous research highlights that *Hystrix indica* also demonstrates moonlight avoidance, with foraging activity being noticeably longer on darker nights (Alkon & Saltz 1998, Alkon & Mitrani 1998) and individuals also foraging less distance from their dens during moonlit nights (Saltz & Alkon 1989). Of all sighting records, the majority of activity was seen during the first moon phase (<25% illumination), although records were obtained in all moon phases. The number of captured images during the 1st moon phase were significantly higher during than the rest with 56 photos obtained compared to 9, 4 and 4 for the 4th, 3rd and 2nd phase respectively. Although this does not definitively prove increased foraging activities, it provides some insight into preferred activity period based on moon phase. Furthermore, only a single record occurred before midnight with all other activities occurring between 12:30 am and 04:30 am. It is not known why this occurred but it may be associated with the nocturnal period with the lowest level of noise and human disturbance, which is considered a deterrent to activity in previous studies (Pigozzi & Patterson 1990, Yürümez & Ulutürk 2016, Lovari *et al.* 2017).

The positive identification of *H. indica* in Abu Dhabi Emirate is important in terms of increased home range for this species as well as the increased possibility of further elusive or rare species occurring in protected areas within the Emirate. The presence of this species close to urban areas and its recent discovery also indicates that small pockets of remnant habitat in development areas should also be considered ecological hotspots, especially if protected for alternative reasons other than that of conservation.

The recent discovery of *H. indica* in both Wadi Wurayah and at Mirfa may provide evidence that this species may be more widely present in the country than previously thought, albeit in very low populations. If this is the case, then the Mirfa area that supports *H. indica* should be afforded full protection as it also provides important habitat for other ecologically important species. Continued studies into the behaviour and population dynamics of the Mirfa porcupines is of paramount importance and, given the rapid development in the area, should be a major focal point of research in the immediate future.

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Recent sudden expansion in the breeding range of Shikra *Accipter badius* in the UAE

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The Shikra *Accipiter badius* is a small, woodland-dwelling hawk, widespread across sub-Saharan Africa and from the southern Caspian region across the Indian subcontinent to south-east China. It is predominantly resident and sedentary across most of its range, although birds from Kazakhstan and adjoining areas vacate breeding areas in winter, reaching the Indian subcontinent, southern Iran, Kuwait and even, rarely, Turkey and southern Israel (Smith 2012, Kemp & Kirwan 2018). Within Arabia, Shikra is a scarce resident in the south west, occurring in the western foothills and highlands of Yemen and south-west Saudi Arabia. It was recorded from less than 12 census squares as part of the Arabian Breeding Birds Atlas project, although its generally very reclusive nature and a paucity of observers mean that it is likely under-recorded; a population of 600 breeding pairs has been suggested (Jennings 2010). As expected from biogeographical affinities, these birds represent the African subspecies, *A. b. sphenurus*. The Shikra is also an established breeder in the United Arab Emirates, having been first recorded there in April 1996 in Dubai (Djerf & Djerf 2003), with breeding suspected that year and confirmed in 1997 (Aspinall 1997, 2010). This was regarded as a most unexpected development at the time as the species was not known to breed within 1000 km of Dubai, although it is uncertain how well known the status of Shikra in Iran was known at that stage (see below)

The origin of Shikra in the UAE is also uncertain and subject to speculation. Discovery of the birds and subsequent breeding were first described by Aspinall (1997), with subspecies *A. b. cenchroides* tentatively suggested as the most likely candidate. This subspecies breeds in south-central Asia and in Iran within (at least) 1000 km of Dubai. An unnatural origin was not explicitly mooted by Aspinall (1997) but Richardson (2003) placed the species in Category B of the UAE list (defined as species considered to have probably occurred in a wild state, but for which the possibility of escape or introduction cannot be satisfactorily excluded). This decision was presumably largely informed by the site of the species discovery in suburban Dubai, the Zabeel palace area being well known for its number of captive species, some of which are free-flying (Richardson, 2003). Diskin (2004) provided an update on status in the UAE and added that the lack of confirmed records away from the Dubai area also implied an origin from released or escaped birds, rather than natural migrants. Aspinall (2010) and Jennings (2010) note this assertion, without taking a stand on the issue. Evidence that Shikra may have reached the UAE as a natural migrant was for a long time merely circumstantial; a record of an unidentified displaying *Accipter* in Ra's al-Khaimah in March 1992 was retrospectively suggested to be Shikra (Aspinall 1997) whilst an adult observed at Qeshm, Iran in April 2001 was 130 km from Dubai (Richardson 2003). However, it is now considered certain that wild Shikra have reached the UAE, following records from the Western (Al Dhafra) Region from winter 2008 onwards (see below). Moreover, a specimen record from Riyadh, Saudi Arabia in October 1938 (Jennings 2010) is unlikely to be anything other than natural. The species is now a scarce but regular migrant and winter visitor to Kuwait (Jennings 2010, M. Pope *in litt.*) and has, at least recently, been quite widely reported from southern and eastern Iran (N.P. Williams *in litt.*). Shikra breeds as far west as Azerbaijan (where recently discovered to be more widespread than realised; Gauger & Heiss 2011) and Armenia (Ananian *et al.* 2010). Direction of migration from the western parts of its breeding range is south-east towards Pakistan (Cramp & Simmons 1980) and it is not at all inconceivable that such migrants could reach the UAE. There is no evidence that Shikra is, or ever was, frequent in captivity in the UAE. It has, for example, never been observed by Margit Muller of the Abu Dhabi Falcon Hospital among birds brought in for treatment (M. Muller *pers. comm.*).

However, it seems peculiar that, away from the UAE, the species remains extremely rare in eastern Arabia; of 34 Omani records to 2018, only five are from northern Oman/Musandam areas and it was first recorded from the Eastern Region of Saudi Arabia as recently as 2014, despite observers being aware of the possibility of occurrence for years previously (Babbington 2018, J. Babbington *in litt.*). Even given the species' extremely reclusive nature (at least when not breeding; the far-carrying and distinctive call renders the species quite obvious if vocalising) and the chronically under-watched nature of much of the region, if migrant Shikras are occurring, they must be very rare. Setting aside a genetic analysis, perhaps the one issue that may move this discussion on from speculation is an accurate determination of the subspecific identity of birds occurring in the UAE. Aspinall (1994) tentatively suggested *A. b. cenchroides* but Forsman (2016) recently proposed that UAE birds bear some resemblance to *A. b. dussumieri*. The latter is resident from Pakistan across the Indian subcontinent and is rather less likely to be a natural migrant to the UAE. However, definitive subspecific identification is likely to require trapping birds, and there is some indication of clinal differences between *A. b. cenchroides* and *A. b. dussumieri* (Rasmussen & Anderton 2012).

Table 1. Summary of UAE records of Shikra *Accipter badius* outside the greater Dubai area from 2013 onwards. Sources: UAE Bird Database, *www.ebird.org*, N.P. Williams and S.L. James *in litt.*

Location	Details
Abu Dhabi island and adjacent mainland, Abu Dhabi emirate	*First record June 2013, although rather infrequently reported 2013–2014. First reported nesting 2014. More widely reported from 2015 with a juvenile seen in October 2015, the first indication of successful breeding. Recorded fairly frequently thereafter, with breeding confirmed at Mushrif Palace Gardens (nest found 2017) and suspected at Emirates Palace (2017 and 2018). Two, possibly three, additional pairs are known from another site since 2014. Large areas of private gardens in Abu Dhabi offer much suitable habitat and the species may be breeding much more widely than these limited records suggest. Also reported from Abu Dhabi airport (September 2013, February 2014; see text) and from nearby Masdar City (August 2017).*
Al Ain, Abu Dhabi emirate	*First record October 2014 followed by several records, including a male and an immature at a separate site March–May 2015 (potentially implying local breeding in 2014). Further records throughout 2016 and 2017, including a juvenile in August 2016. Up to five seen at one site, 2016–17, and up to three at two other sites February–August 2018 with display-flight reported. Records have been from a number of sites in the city area of Al Ain, but mainly from five sites in the south-eastern part of the city. A minimum of five pairs in recent years.*
Al Wathba area, Abu Dhabi emirate	*Two pairs at one site, 2015 onwards. One, March 2016 (with a probable seen briefly, August 2016) at a second site.*
Rahba Farms	*One, March 2018.*
Sila'a, Abu Dhabi emirate	*One, March 2018. This individual was seen one date only and is likely to represent a migrant.*
Ghantoot & Saih al-Salam areas, Abu Dhabi & Dubai emirates	*One, on two dates, November 2016.*
Ajman emirate	*One juvenile, August 2018.*
Umm al-Qaiwain emirate	*One, April 2017.*
Wamm Farms, Fujairah emirate	*One juvenile, September 2017 (first record of the species from the UAE East Coast).*

Status in the UAE prior to 2013

Since the first records in 1996, Shikra quickly became established in the greater Dubai area, but was virtually unknown outside this area prior to 2013. It has been widely reported at various suburban sites from Mamzar Park in the north, south to Jebel Ali and east to Mushrif National Park, an area of approximately 800 km^2. It is likely only limited by habitat requirements and can clearly disperse across high density urban areas from one patch of suitable habitat to another. In the Dubai area, virtually all such habitats are parks and gardens with tall, secluded and shady trees for nesting and cover, although the species has also been recorded over the mangroves of Ra's al-Khor and at the former Dubai Pivots Fields, locations where it is less likely to breed. Most confirmed breeding records have been from urban parks accessible to observers, such as Safa, Dubai Creekside and Mamzar Parks, although doubtless the species is frequenting, and nesting in, other private gardens with suitable tall trees to which there is no public access. Jennings (2010) estimated the breeding population to be 12 pairs and this has certainly increased since then.

Outside the immediate Dubai area, Shikra remained unaccountably rare, although small numbers of observers and difficulties in distinguishing it from the very similar Eurasian Sparrowhawk *Accipiter nisus* (widespread at low densities in autumn and winter), especially on a typical brief view, doubtlessly partly account for this. Shikra was not recorded outside the greater Dubai area until December 2008, when one was found at Sila'a, Al Dhafra (Western) Region, Abu Dhabi (380 km south-west of Dubai). This bird overwintered, remaining to April 2009 and a second individual, a juvenile, was there September–December 2012. Timing and geographical location of these birds strongly suggest natural vagrancy from southern Asia, and both records were accepted as wild by the Emirates Bird Records Committee. A further record of a juvenile, at Kharran, Ra's al-Khaimah (100 km north-east of Dubai) in November 2012 could also conceivably have concerned an Asian bird, although (hitherto unrecorded) dispersal from the greater Dubai area could also account for this sighting. The only other records of the species outside Dubai came from the Abu Dhabi airport area, where singles (and, once, a pair) were seen on a number of dates from March 2011 to February 2014 (S. James *in litt.*). The area utilised has been off-limits since then and there has been no opportunity for further observation.

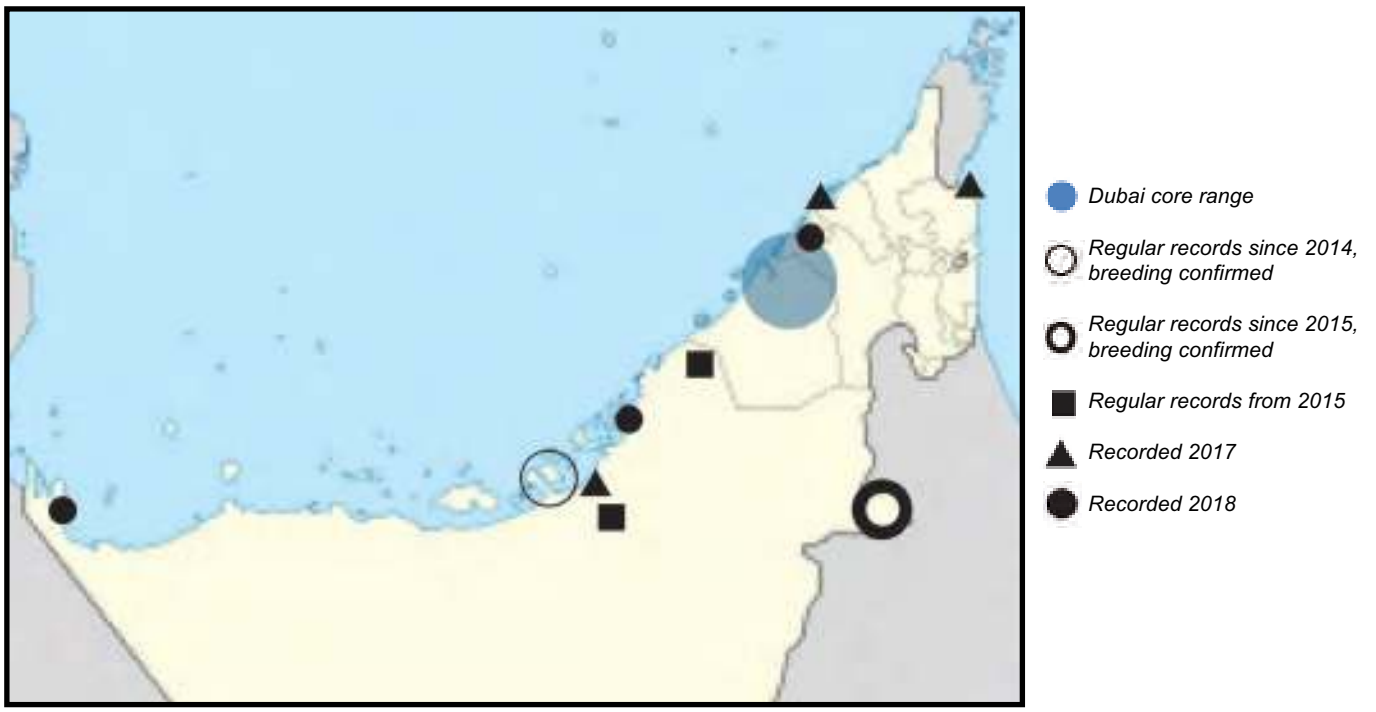

Figure 1. Map of UAE records of Shikra *Accipter badius*, 2014 to present. Sources: as Table 1.

Status in the UAE since 2013

Since 2013, there has been a marked change in the status of Shikra in the UAE, with a significant expansion of its range beyond the greater Dubai area. The species was first recorded on Abu Dhabi Island in June 2013, and in the Al Ain area in October 2014, and records taken as a whole (summarised in Table 1 and Figure 1) indicate that the species has simultaneously become established in both cities and is starting to occur more widely in other areas, perhaps due to further dispersal of young birds. Data presented in Table 1 and Figure 1 should be regarded as an underestimation (possibly major) of the true situation, given the species' retiring nature and the existence of much suitable habitat in locations that are inaccessible to (or simply unattractive to) observers.

Observations of a breeding pair and young at a nest, Abu Dhabi, April–May 2018

The breeding biology of Shikra on the Arabian Peninsula is rather poorly described, with information presented in Jennings (2010) being based mainly on observations in Somalia. There have been isolated observations from nests in Dubai (for example Diskin 2004). Therefore, observations from a nest discovered in Abu Dhabi in May 2018 and monitored on a near-daily basis for a subsequent month are described below.

Mushrif Palace Gardens (24.45 N, 54.37 E) is a regularly watched urban parkland site in the middle of Abu Dhabi island. Shikra have been observed frequently there, including juveniles, since 2013. In April 2018, a large, rather loose and untidy nest of large twigs was noticed in a tall *Eucalyptus* sp. tree. No birds were evident, but, in early May, an adult was noted in attendance (P. Jaquith *in litt.*). The nest was approximately 25 m up in the fairly open canopy of one of the tallest trees in the general area and several metres from the main trunk (Figure 2). The rather open aspect of the nest is dissimilar to the very secluded nature of a nest described from Yerevan, Armenia (Ananian *et al.* 2010). The actual tree was within the walled grounds of the palace itself, and the birds presumably benefited from very little disturbance

Figure 2. Nest in tall *Eucalyptus* tree, Mushif Palace Gardens, Abu Dhabi, May 2018 (photo by Oscar Campbell).

Figure 3. Adult female perching openly near nest with young, Mushrif Palace Gardens, Abu Dhabi, May 2018 (photo by Oscar Campbell).

Figure 4. Three young visible at nest, still with extensive down on head and underparts. The birds had fledged within approximately one week of this picture being taken. Mushrif Palace Gardens, Abu Dhabi, May 2018 (photo by Oscar Campbell).

therein. The nest was, however, easily visible at fairly close range from outside the palace wall although, due to its height, seeing into the nest was impossible. On 5th and 6th May, an adult was perched on the nest, with wings partially open as if shading small chicks; however, chicks were not observed until 11th May. On 12th May up to three young were visible, with the largest estimated to be approximately 50% of adult size with plumage still extensively downy white. On 20th May, it was clear that four young were present with the first making short flights on 22nd May. Two juveniles, almost free-flying, were evident on 23rd May. By 27th May, two juveniles were still at the nest, but clearly free-flying with an adult present nearby. On 28th May, all four juveniles were back at the nest, being fed by the adult female, although all departed within 10 minutes. From that date onwards, juveniles and adults were only occasionally seen in the vicinity of the nest, with none apparent on most dates. Prey brought in by adults (observed on two occasions) comprised small birds, most likely recent fledglings of White-eared Bulbuls *Pycnonotus leucotis* or House Sparrow *Passer domesticus*. On one occasion, after feeding young, the female flew directly at the observer before veering upwards at a range of circa 10 m. Otherwise, both adults (Figure 3) and young (Figure 4) in the nest or perched nearby were surprisingly tolerant of an observer in the immediate vicinity, showing little interest and certainly no alarm. This general tolerance of observers and propensity to call was similar to the behaviour of birds attending two nests in Armenia (Ananian *et al.* 2010). On another date, an adult was heard calling and then aggressively mobbing a Crested Honey-Buzzard *Pernis ptilorhynchus*. Otherwise, no interaction with other species was recorded, although birds were quite frequently heard giving their distinctive, sharp calls. These calls were given by adults and fledged juveniles.

The timing of breeding at this nest closely matches that noted for Dubai (Jennings 2010). Fledging period is at least 30 days (Kemp & Kirwan 2018). If fledging is assumed to have occurred by 25th May, this would imply hatching on approximately 25th April and, with an incubation period of 33–35 days (Cramp & Simmons 1980), egg-laying on approximately 20th March. As is common for many raptors, hatching is asynchronous, as observed in Abu Dhabi. A clutch size of four (at least) for the Mushrif Palace Gardens nest is greater than clutch sizes noted in Jennings (2010) but is in close accordance with those reported in Cramp & Simmons (1980) and Kemp & Kirwan (2018) (clutch size 2–7; mainly 3–4 in Azerbaijan and India). Near-daily visits to the nest ceased in early June, but birds were still present in the vicinity later in the month, including two juveniles soaring together on 29th June. When regular visits resumed in September 2018, birds were generally absent or, at least, extremely inconspicuous although occasional sightings of up to two individuals and, from October, bouts of calling suggested that the territory is still occupied.

Conclusions

Based on the analysis presented here, it seems very likely that Shikra will consolidate its range in suitable parts of the UAE, the population will continue to increase and, ultimately, it will become a familiar bird to urban residents in the country and, in the longer term, in adjoining countries. Increased numbers and densities of birds may also lead to greater persecution, with individuals reported killed at one site in 2018 (N. P. Williams *in litt.*). Across the UAE as a whole, the species will always be limited by availability of suitable habitat, although, as noted by Aspinall (1997), large areas of plantations established in recent decades, including along highways, will certainly aid dispersal, although many may not have the requisite large and shady trees necessary for nesting. As well as private gardens in urban areas, suitable areas for breeding include along the E11 highway immediately north of Abu Dhabi Island and public parks in areas such as Yas Island, Mafraq and Baniyas. Such sites are within easy reach of confirmed breeding areas but are not generally frequented by observers. Hence, the species is already likely to be significantly more widespread than the records presented herein suggest.

Acknowledgements

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An exceptional influx of Pied Kingfishers into the United Arab Emirates in winter 2015–16

by Oscar Campbell & Mark Smiles

Pied Kingfisher *Ceryle rudis* is a common and conspicuous species along waterbodies in sub-Saharan African and across southern Asia, from Pakistan to China. It also occurs in south-west Asia, from southern Turkey to Iraq and western Iran, and south through the Levant area to Egypt (Woodall 2018). Despite the relative proximity of its breeding range to the United Arab Emirates, it is a rare and erratic visitor here, predominantly from October to March, with 34 records (totalling 37 individuals) recorded up to September 2018 (UAE Bird Database). The species' rarity in the UAE is no doubt due to its mainly sedentary nature, indicated by the fact that the species is very scarce in Kuwait (Pope & Zogaris 2010) despite being very common in suitable habitat in nearby Iraq (Cramp & Simmons 1985). However, local movements (up to several hundred kilometres) and variations in abundance outside the breeding season are known; for example, a bird ringed in Ethiopia was recorded 760 km away in Uganda (Woodall 2018). Vagrants have been recorded as far west as Italy and north to Poland (Woodall 2018), albeit very rarely. This paper documents a significant arrival of the species to the UAE in the winter of 2015–16 and compares this with records from neighbouring countries over the same period.

Status, distribution and phenology of Pied Kingfisher in the UAE

First recorded in February 1980, there has been a total of 37 individual birds recorded to date, of which a significant proportion (59%) were first recorded in October–November. Some individuals have remained for prolonged periods, sometimes an entire winter (Pedersen *et al.* 2018). Records of a bird overwintering at the same site on Abu Dhabi Island in both 1996–97 and 1997–98 suggest that some individuals may return for successive winters. There is also circumstantial evidence that a bird may have over-summered, being recorded in Abu Dhabi November 1986–March 1987, and again August–September 1987.

The number of individuals recorded in any one winter is invariably very small (two or less) except for three (1999–2000) and five (2008–09), the latter representing a notable influx at the time (see Figure 1). There were no records at all in 20 winters between 1980 and 2015–16.

The vast majority of UAE records are from the Arabian Gulf littoral or at wetland sites not far inland from there. Records have ranged from Ra's al-Khaimah emirate to Abu Dhabi emirate, with noticeable concentrations in the Dubai area and, to a lesser extent, at Eastern Lagoon, Abu Dhabi Island. Of course, this may reflect the distribution of observers rather than site preferences of the actual birds. There are also records from the Al Dhafra (Western) Region of Abu Dhabi, with singles at Ruwais (March 2010) and on Sir Bani Yas Island (January–March 2011, October 2015). There are only two records from the East Coast of the UAE, both from Khor Kalba (October 1987, December 1999). This distribution doubtless reflects availability of suitable habitat (of which there is very little on the East Coast) but also provides a clear indication that the likely origin of Pied Kingfishers reaching the UAE is to the north west, presumably Iraq and environs. This supposition was suggested by Cramp & Simmons (1985) and further support comes from an analysis of Omani records, where the species is much rarer than in the UAE. To September 2013, there have been just seven records in Oman, and, of these, four were in Dhofar, a location otherwise very strongly associated with the annual arrival of many waterbirds from the Indian sub-continent (Eriksen & Victor 2013). Timing of records in Oman broadly correlates with that from the UAE, although none have been recorded in October.

The 2015–2016 influx to the UAE

This influx was remarkable in terms of scale and, to a lesser extent, in terms of timing. In all, ten individuals were recorded, comprising 27% of all records 1980–2017 (see Figure 1). This is more than double the number recorded in the next best winter (2008–09) and compares to a mean of 0.7 individuals per year 1980–2015. For the

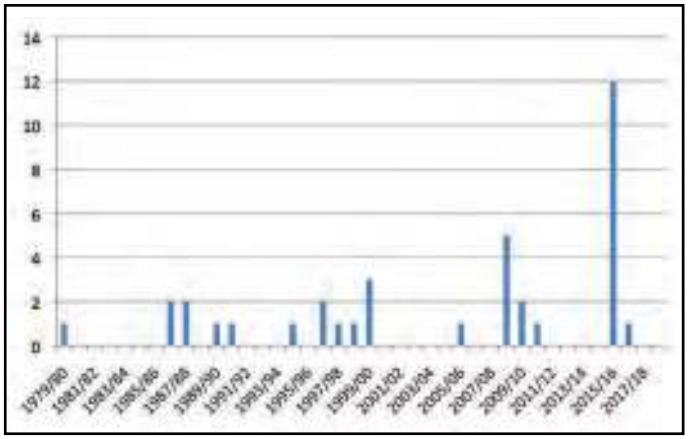

Figure 1. Number of individuals of Pied Kingfisher *Ceryle rudis* in the UAE each winter, 1979–80 to 2017–18. Source: UAE Bird Database. The total number of individuals recorded was 37.

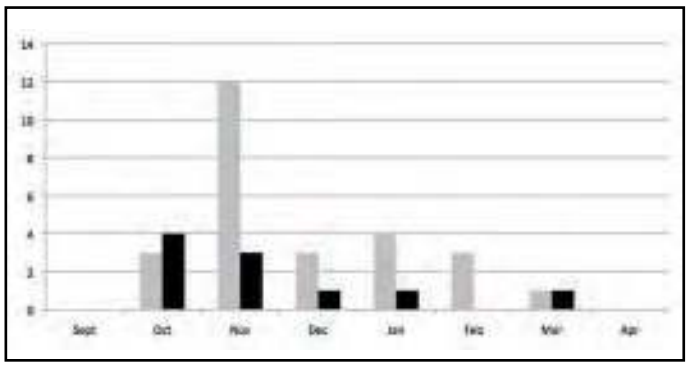

Figure 2. Month of arrival of 36 Pied Kingfishers *Ceryle rudis* in the UAE comparing winter 2015–16 (black bars) to all other winters 1979–80 to 2017–18 (grey bars). One individual, recorded in August–September and counted in Figure 1, has been excluded from Figure 2.

first time, the species was recorded as multiples, with two individuals seen at Al Wathba Camel Racetrack (October) and Ajban Farms (December). There was also a single unconfirmed report of three at Khor al-Beida (November), where one bird was certainly present. All records prior to 2015–16 involved single birds. Most remained for relatively short periods (one week or less) but individuals at Ajban and Dubai Creek over-wintered, remaining until February and March respectively. Comparable to the distribution pattern from previous years, all records were from, or not far inland from, the Gulf littoral and mainly between Khor al-Beida in the north and Abu Dhabi Island in the south-west, with two outliers in the Al Dhafra Region (see Figure 3). Significantly, these latter records dated from 21 October (Sir Bani Yas Island) and 6 March (Dalma Island) and were likely to involve birds arriving and departing respectively. However, observer coverage in the Al Dhafra Region is extremely low and it is possible that these birds may have over-wintered locally. The date and location of these records does not contradict the contention that the origin of Pied Kingfishers reaching the UAE is to the north-west of the Arabian Gulf.

The timing of the influx of 2016 was broadly comparable with records from previous years in that seven of the ten birds were found from mid-October to late November (see Figure 2). However, of the four that arrived in October, all were first recorded from 15–21 October. It is quite possible that other individuals arrived in this short timespan but, moving on quickly or frequenting sites which are rarely visited by observers, were not detected. These arrival dates average five days earlier than the three other October records in the UAE from earlier years (which arrived on 16, 26 and 27 October). Given the scale of the influx in October–November, it is rather surprising that only two further birds were found later in winter and early spring. It is likely that these represented individuals that arrived during the autumn and were only detected at a later date, although it is possible that they represented wandering individuals, already recorded elsewhere earlier in the season. In contrast, just one Pied Kingfisher was recorded the following winter, in November 2016; interestingly, however, this record came from Khor al-Beida, a site that held one (possibly three) the previous winter. None were recorded anywhere in the UAE in winter 2017–2018 (Pedersen *et al.* 2018).

Records from elsewhere in the region, winter 2015–16

Records from elsewhere in the region are summarised in Table 1. For all countries listed therein, Pied Kingfisher is a vagrant or rare winter visitor with no breeding populations. Based on this data, it is clear that both Qatar

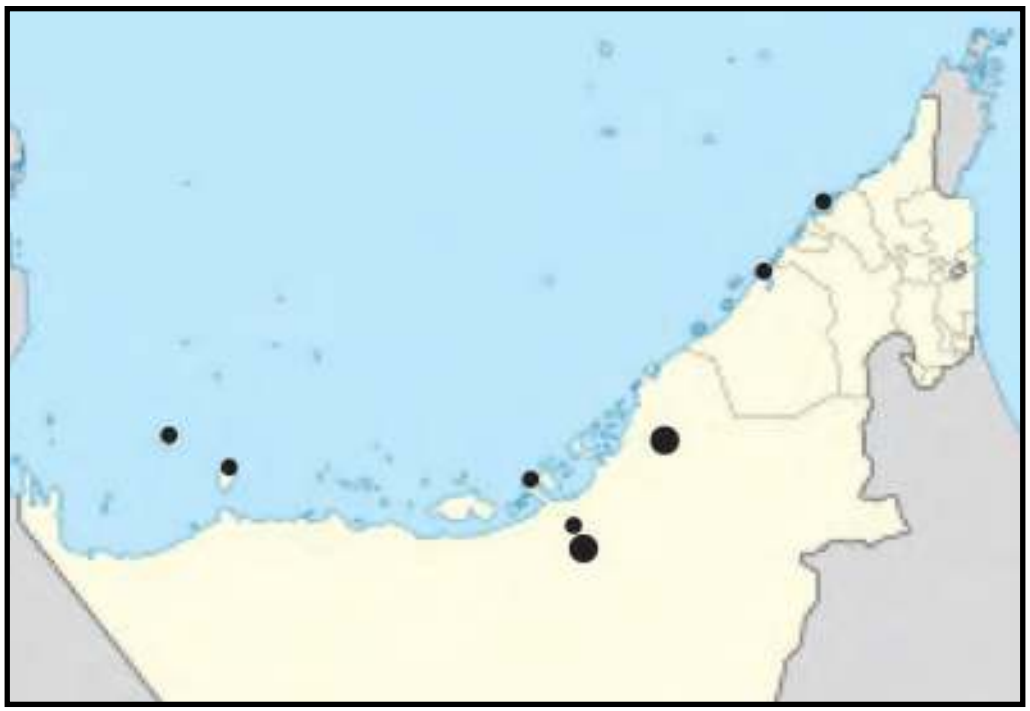

Figure 3. Location of records of Pied Kingfisher Ceryle rudis from the UAE, October 2015–March 2016. Source: UAE Bird Database. Relative size of dots represents the number of birds (1 or 2) at any one site.

Table 1. Records of Pied Kingfisher *Ceryle rudis* from selected countries on the southern edge of the Arabian Gulf, and from Cyprus each winter 2014–15 to 2016–17. Source: Harrison & Lamsdell (2015a, 2015b, 2016), Harrison (2016, 2017a, 2017b).

	2014–15	2015–16	2016–17
Cyprus	1 (Mar)	2 or 3, first record 15 Oct (to Feb)	3 (Nov to Apr)
Saudi Arabia	2 (Nov, Feb)	1, 23 Oct, with 12 at a site (in Eastern Region) by early Dec. At least 5 others elsewhere (to Apr)	5, including 4 at same site that hosted 12 previous winter (Oct to Dec)
Qatar	Data for 2014 not available but no records 2015	1, 24 Oct; 4 present at one site 26 Nov	No records
Oman	No records	No records	No records

and Saudi Arabia witnessed a significant influx of Pied Kingfishers during winter 2015–16 compared to the winters immediately before and after and that the initial timing of this influx closely matched the first arrivals in the UAE. As might be expected given geographical distance, records from Cyprus show a much less marked similarity to the pattern of records from Arabian Gulf countries, although the first record in 2015–16, arriving almost simultaneously with the start of the influx to the UAE, is interesting. Pied Kingfisher is regular in Kuwait in small numbers in winter, with one to four birds typical at a wetland site near Kuwait City and hence data from that country is not included in Table 1. However, December 2015 saw exceptional numbers recorded, with peak count reaching 17, a national record (N. Tovey *in litt.* June 2018).

The reason for this influx of Pied Kingfishers to the UAE and neighbouring countries along the southern Arabian Gulf remains unknown. Birds are known to undergo post-breeding dispersal from breeding areas in Turkey, Iraq and south-western Iran (Cramp & Simmons 1985), partly in response to fluctuations in river height. Other potential contributory factors may include a particularly successful breeding season prior to any influx and weather conditions prevailing over the Arabian Gulf and environs when the birds start to disperse. It is conceivable that a combination of all such factors is required to cause an influx of the scale witnessed in 2015–16. However, it is notable that summer 2015 witnessed further deterioration in the scale and water quality of the recently reflooded Iraq Marshes (Schwartzstein 2015). During the course of summer 2015, these shrank to 10–20% of their former extent, with profound consequences for both local people and organisms dependent on the marshes. This led to the departure of Pied Kingfishers and other wetland-dependent species, in search of more suitable habitats (L. A. Al-Obeidi *in litt.* July 2018).

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"*Tell them thank-you and carry on!*"—Sheikh Zayed and the Abu Dhabi Islands Archaeological Survey, ADIAS

by Peter Hellyer

Abstract

The establishment of the Abu Dhabi Islands Archaeological Survey, ADIAS, in 1992 led to a programme of survey and excavation over the next 14 years that identified some of the most important archaeological sites in the Emirate of Abu Dhabi. These included the internationally-significant 7th-8th Century AD Christian monastic site on the island of Sir Bani Yas and the Neolithic villages on the islands of Dalma and Marawah, as well as many other sites of different periods on the islands of the Emirate, along its coastline and in the deserts of the Al Dhafra (Western) Region.

This paper describes the way in which ADIAS was created on Sheikh Zayed's instructions, as an independent structure under the patronage of His Highness Sheikh Mohamed bin Zayed Al Nahyan, now Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces, and the continued interest displayed by Sheikh Zayed in its work and discoveries until his death in 2004, in particular in the discovery of the Sir Bani Yas monastic site.

The year 2018 marks the sixtieth anniversary of the formal commencement of archaeological studies in the United Arab Emirates, six decades on from the invitation extended in 1958 to Professor P.V. Glob and Geoffrey Bibby, of the Danish Archaeological Mission in Bahrain, to investigate the stone structures reported to be present on the island of Umm an-Nar, adjacent to Abu Dhabi.

The work they began at Umm an-Nar the next year attracted the attention of Sheikh Zayed bin Sultan Al Nahyan, the brother of the Abu Dhabi Ruler of the day, Sheikh Shakhbut. Sheikh Zayed was then his brother's Representative in the inland oasis-town of Al Ain. In his book '*Looking for Dilmun*', Bibby, and subsequently his Danish colleagues reported on the way in which Sheikh Zayed invited them to visit Al Ain, to look at the tombs on Jebel Hafit (Bibby 1969: 293–294) and, later, arranged for them to be taken to the site of the 3rd Millennium BC Hili Great Tomb (Bibby 1969: 299, 302). Sheikh Zayed continued to take an interest in the work at Hili and other nearby sites and later ordered the construction of the UAE's first museum, in Al Ain, where some of the finds from Jebel Hafit and Hili were displayed.

In subsequent years, following the formation of the United Arab Emirates in 1971, Sheikh Zayed, not surprisingly, devoted a substantial part of his attention to the building of the new state. His interest in archaeology took a back seat, though his support for the study of the country's heritage continued. That was evident in his support for what became the Abu Dhabi Islands Archaeological Survey, ADIAS, which was formally established in 1992, over a quarter of a century ago.

In archaeology as in so much else, serendipity played a major part.

In early 1990, the Emirates Natural History Group, co-publishers of *Tribulus*, selected Abu Dhabi's western island of Sir Bani Yas as a destination for one of its regular weekend outings. Many of those who took part spent their time looking at animals like Arabian Oryx or Sand Gazelles that had been introduced to the island by Sheikh Zayed or recording migratory birds, including a number of rarities.

One participant, however, the late Carolyn Lehmann, a member of the Dubai Natural History Group, spent her weekend looking for archaeological sites. In a fenced enclosure for llamas on the east of the island, she noted a scatter of potsherds and collected a few, one of which was a rather battered green-glazed sherd.

A little while later, I had the opportunity of showing that sherd to Dr. Geoffrey King, then of the School of Oriental and African Studies at London University, who was excavating at Julfar, in Ra's al-Khaimah. He immediately recognised it as being of late pre-Islamic/early Islamic date, the first indication that sites of that period might be present on Sir Bani Yas.

At the time, Sheikh Nahyan bin Mubarak Al Nahyan, now the UAE's Minister of Tolerance, was the ENHG Patron, a position he continues to hold today. The Group had developed the practice of inviting archaeologists working elsewhere in the country to come to Abu Dhabi to give a talk on their work to the Group's fortnightly meetings. It had become customary on such occasions for the archaeologists to be taken to Sheikh Nahyan so that they could brief him on their work. Thus it was, on a Ramadan evening in 1991, that Geoffrey King and I were sitting in Sheikh Nahyan's majlis, chatting away while waiting for a meeting.

In those years, archaeology in the Emirate of Abu Dhabi was mainly confined to work in the Al Ain area, it having been several years since any work had been done on the coast and islands. Our conversation turned to wondering what might be found on the largely-unexplored islands. We concluded that Sir Bani Yas and Dalma might well be good places to start. When Sheikh Nahyan asked Dr. King where he might like to excavate in Abu Dhabi, we put this idea to him.

Later that night, Sheikh Nahyan mentioned this to Sheikh Zayed, who promptly instructed that a survey should get under way as soon as possible. Besides Sir

Bani Yas, dear to his heart as his private nature reserve, and Dalma, Sheikh Zayed also instructed that work should be undertaken on another island, Marawah.

It was not possible to get work under way immediately, since the winter archaeological season was coming to an end and summer was approaching. We asked Sheikh Nahyan to inform Sheikh Zayed that a team would be put together for the next year, while Dr. King consulted with colleagues like Dr. Joseph Elders, then working with him at Julfar, to draw up a plan of campaign.

In March and April 1992, that first survey of Sir Bani Yas, Dalma and Marawah took place, with Sheikh Nahyan arranging for airline tickets, accommodation and transport to be supplied, including the use of a plane from the UAE Air Force, thanks to help from the then Chief of Staff, His Highness Sheikh Mohamed bin Zayed.

Sheikh Zayed himself was present on Sir Bani Yas at the time of the survey and invited the team, led by Dr. King, to dinner. On being shown some of the potsherds that had been found, he recalled that one type of local Late Islamic manufacture—conventionally known as 'chocolate-chip ware' because of its dark, gritty inclusions—was one that he remembered using as a young man. It was promptly renamed 'Sheikh Zayed ware'. Sheikh Zayed also asked for a full report to be submitted to him at the end of the season.

The results of that first season were beyond expectations. Over 100 previously unrecorded sites were identified, among them those later identified as the important Neolithic villages on Dalma and Marawah and the early Christian monastic site on Sir Bani Yas.

At the end of the season, Sheikh Nahyan reported the results to Sheikh Zayed. He promptly ordered the formal establishment of the Abu Dhabi Islands Archaeological Survey, ADIAS, allocating regular funding from his own Private Department, and assigning Sheikh Mohamed bin Zayed to be the ADIAS Patron.

Between 1992 and 2004, the year in which he died, Sheikh Zayed retained his interest in the work of ADIAS, being regularly briefed on its activities, and, on occasion, asking to see some of the artefacts found during survey and excavation work. He continued, in particular, to show interest in the work on Sir Bani Yas, which, we were informed, he discussed with a number of visitors, including Britain's Prince Charles, who visited the site in 1994.

During the first couple of seasons of work at the site in the vicinity of the llama pens, directed by Dr. Joseph Elders, first a single small, four-roomed building was excavated, and then a range of buildings. Associated with these were fragments of decorated plaster, indicative of sophisticated building techniques but not, in themselves, sufficient to confirm the purpose of the settlement.

Figure 1. A plaster cross from a frieze at the Sir Bani Yas Christian monastery. Picture courtesy of Department of Culture & Tourism – Abu Dhabi.

Then, one evening in early 1995, Dr. Elders turned over a piece of plaster that had been excavated close to one of the walls of the largest building that had been identified to find on its face a very finely-delineated cross (Figure 1). It was evident that the building and the associated settlement was part of a Christian community.

The presence of Christian communities in eastern Arabia around the time of the coming of Islam in the early 7th Century AD was known from textual evidence. There had, however, previously been no archaeological evidence that the faith might have extended into the Emirates, even though textual references to the presence of a bishopric in Sohar, Oman, suggested that this was possible.

On the basis of the pottery at the site, it was already clear that it dated to somewhere between the late sixth or early seventh centuries and the early eighth century. The discovery of the plaster cross now proved that a Christian community had been living on Sir Bani Yas during the early decades of the Islamic period, after the people of the Emirates had accepted Islam. It was—and remains—the first physical evidence of the presence of early Christianity in the Lower Arabian Gulf.

A few days later, the cross, carefully nestled in a small jewellery box, made its way to Abu Dhabi. Despite some slight concern about how Sheikh Zayed would respond to news of the discovery of a Christian settlement on his private island, I was reassured by Sheikh Nahyan, the first official to see the plaster cross, that Sheikh Zayed would be delighted—and that proved to be the case. A message came back to the ADIAS team: "*Tell them thank-you—and carry on*." The funds for further excavations and surveys were guaranteed for the years ahead.

At the time, I was editor of the UAE's official English language paper, '*Emirates News*', and promptly ran a story about the discovery on the front page. My colleagues in the official Arabic daily, '*Al Ittihad*', were

Figure 2. The Marawah Vase, now on display at the Louvre - Abu Dhabi. Picture courtesy of Department of Culture & Tourism – Abu Dhabi.

worried that this might be deemed unwelcome news, but, reassured by the feedback from Sheikh Zayed, I had no worries. Indeed, as news of the discovery spread, another UAE Ruler asked if ADIAS could find a church in his Emirate while another senior Abu Dhabi Sheikh asked if ADIAS could find a church on his private island just north of the city of Abu Dhabi. Subsequent surveys and excavations there did not find a church, although sites that provided evidence of occupation as far back as the middle Bronze Age, around 4,000 years ago, were identified, and much else besides.

In subsequent years, as further discoveries at the Sir Bani Yas site were made by Dr. Elders and his team, we continued to ensure that Sheikh Zayed was briefed of the work of ADIAS, by officials such as Sheikh Abdullah bin Zayed Al Nahyan, at the time Under Secretary and then Minister of Information and Culture. We were told that Sheikh Zayed viewed the discovery as being important evidence not only of the past history and heritage of the UAE, but also as evidence of the philosophy of religious tolerance that he himself continually emphasised as being one of the fundamental elements of the make-up of the UAE today.

"*This is part of our heritage*," he was quoted to ADIAS as saying. "*We are proud of it.*"

ADIAS investigated the archaeology of the coast and islands of Abu Dhabi, as well as parts of the deep deserts of the Al Dhafra (Western) Region, for over a decade, between 1992 and 2006, at which time the responsibility for its work was transferred to the Abu Dhabi Authority for Culture and Heritage, ADACH, now the Department of Culture and Tourism–Abu Dhabi, DCT. During those years, ADIAS made numerous discoveries that helped to shed light on areas that were described, at the time it began its work, as being effectively 'a blank on the face of Arabia' in terms of its archaeology and history. ADIAS can claim that it played its part in '*Filling in the Blanks*' (Hellyer 1998).

Today, the DCT is continuing to make major new discoveries on sites that were originally identified by ADIAS. These include the internationally-important Neolithic village on Marawah, where the continuing excavations are being directed by former ADIAS team member Dr. Mark Beech, now the Head of Archaeology, Al Dhafra and Abu Dhabi, in the Historic Environment Department of Abu Dhabi's Department of Culture and Tourism.

Other sites of international significance first identified by ADIAS include the Late Miocene fossil elephant trackway at Mleisa, in the Al Dhafra region of Abu Dhabi, fossil elephant remains at Ruwais and Bida al-Mutawa, the Neolithic village on Dalma, the Neolithic desert sites of Khor al-Manahil and Kharimat Khor Al-Manahil, the Bronze Age settlement on the island of Balghelam, the mid-Islamic desert fortress of Husn al-Sirra and the UAE's only sulphur mines, at Jebel Dhanna.

Over the course of its life, members of the ADIAS team of archaeologists included not only Dr. Geoffrey King, Dr. Joseph Elders and Dr. Mark Beech, all mentioned above, and the doyenne of UAE archaeology, Beatrice de Cardi, who died at the age of 102 in 2016, but a number of others who became and, in some cases, continue to be familiar names in the UAE's archaeological community. Amongst them are Dr. Richard Cuttler, now working with the DCT, Dr. Robert Carter, author of a major study on the Gulf's pearling industry, and Dr. Heiko Kallweit, while others, like Dr. Salvatore Garfi and Dr. Elizabeth Shepherd-Popescu have gone on to work in the former Spanish Sahara, the United Kingdom and elsewhere. Dr. Emma Loosley, an early contributor to studies of the Sir Bani Yas monastery, is now Professor of Theology and Religion at Britain's Exeter University and a leading expert on early Eastern Christianity, while Dr. Elders is now Major Projects Officer, Cathedrals and Church buildings, for the Church of England, in charge of the archaeology of much of England's ecclesiastical heritage. Dr. Soren Blau is now Senior Forensic Anthropologist at the Victoria Institute of Forensic Medicine in Australia.

Besides its direct contribution to knowledge of the ancient history of Abu Dhabi, ADIAS also served as a training ground for many who have continued to contribute to knowledge of the UAE's past today.

The work of ADIAS could not have been undertaken without the direct personal interest of Sheikh Zayed who, in the midst of his other tasks, never lost sight of his belief that "*A people that knows not its past has neither present nor future… For it is from the past that we learn*."

With 2018 celebrated as the Year of Zayed, the 100th anniversary of his birth, it is right and proper that his consistent and substantial support for studies of the heritage and history of the UAE and its people should be recognised.

(**Note:** The author was first Co-ordinator and then Executive Director of the Abu Dhabi Islands Archaeological Survey from 1992–2006.
An earlier version of this paper was presented at the International Conference on Archaeology of the UAE, '*Archaeology '18'*, organised by the Department of Culture and Tourism–Abu Dhabi, in Al Ain, 27–29 March 2018.)

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An occurrence of palygorskite in the UAE

by Jennifer Huggett, Graham Evans & Anthony Kirkham

During a localised geological reconnaissance of Abu Dhabi in the 1990s, an excavation for a pipeline across a continental, interdune sabkha immediately southeast of the National Auto Museum (Figs. 1–2) revealed a sharply defined, white, putty-like seam 1–3 cm thick approximately 30–40 cm below the salt encrusted surface of a Quaternary (Pleistocene or Holocene) brown aeolian sand. It was above the water table, which was approximately 1 m below the surface at the time of observation.

The seam superficially looked like the layers of anhydrite found so widespread in the coastal sabkhas of the area but X-ray diffraction analysis (XRD) of this material showed it comprised mainly palygorskite, sepiolite and smectite, with very small amounts of quartz (Fig. 3, Table 1). Scanning electron microscopy (SEM) strongly supported the dominance of the fibrous clays, palygorskite and sepiolite (Fig. 4).

The monoclinic palygorskite (2MgO.3SiO2.4H2O) and sepiolite (2MgO.3SiO2.nH2O) are relatively uncommon clay minerals, but they have been described previously from the UAE either singly or together (Peebles *et al.* 1997, Evans & Kirkham 2005, Farrant *et al.* 2012, Lacinska *et al.* 2014). However, none of the previous recordings have discovered these clays in the form of such a well-defined seam.

These two Mg-rich clay minerals form in soils and evaporitic lakes under arid climates (e.g., Jones & Galán 1988, Galán & Pozo 2011, Kadir *et al.* 2016, 2017). Palygorskite and sepiolite may form *in situ* by interaction between relatively Mg-rich, high pH, saline ground water and pre-existing more common clay minerals; or precipitate directly from highly saline water under evaporative conditions (Jones & Galán 1988, Galán & Pozo 2011). Sepiolite is thought to indicate more brackish conditions than palygorskite (Warren 2016).

Although there are no analyses of the groundwater at the site where the clay-rich sediment was found, there is data on the composition of the groundwaters in the nearby inner sabkha which have shown that the waters are highly saline (e.g., Wood *et al.* 2002). Solutes in the highly saline continental groundwaters are thought to be derived from Tertiary rocks, as are those of the site. The sediment is possibly pedogenic or has been deposited in an interdune saline pond. The SEM results show a sediment without obvious framework grains and the delicate, elongated fibrous clay crystallite morphologies are consistent with an authigenic occurrence. The source of the silica is likely to have been detrital feldspar or quartz grains that were dissolved by the alkaline pore waters.

For XRD the samples were scanned on a Siemens PSD X-ray diffractometer using Ni-filtered CuKa radiation.

Figure 1. General location map (from Google Earth) of central Abu Dhabi. Rectangle shows the general location of the sampled trench.

Figure 2. Approximate clay sample location area (from GoogleEarth) shown as an ellipse to the southeast of the Automobile Museum.

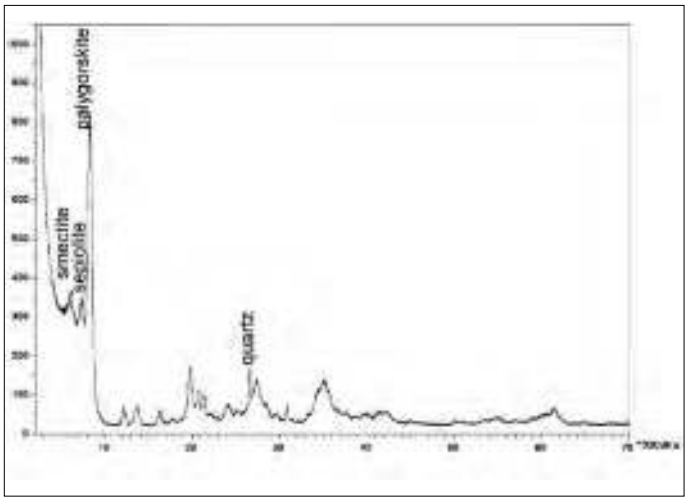

Figure 3. Whole rock X-ray powder diffractogram for a sample from the white clay seam.

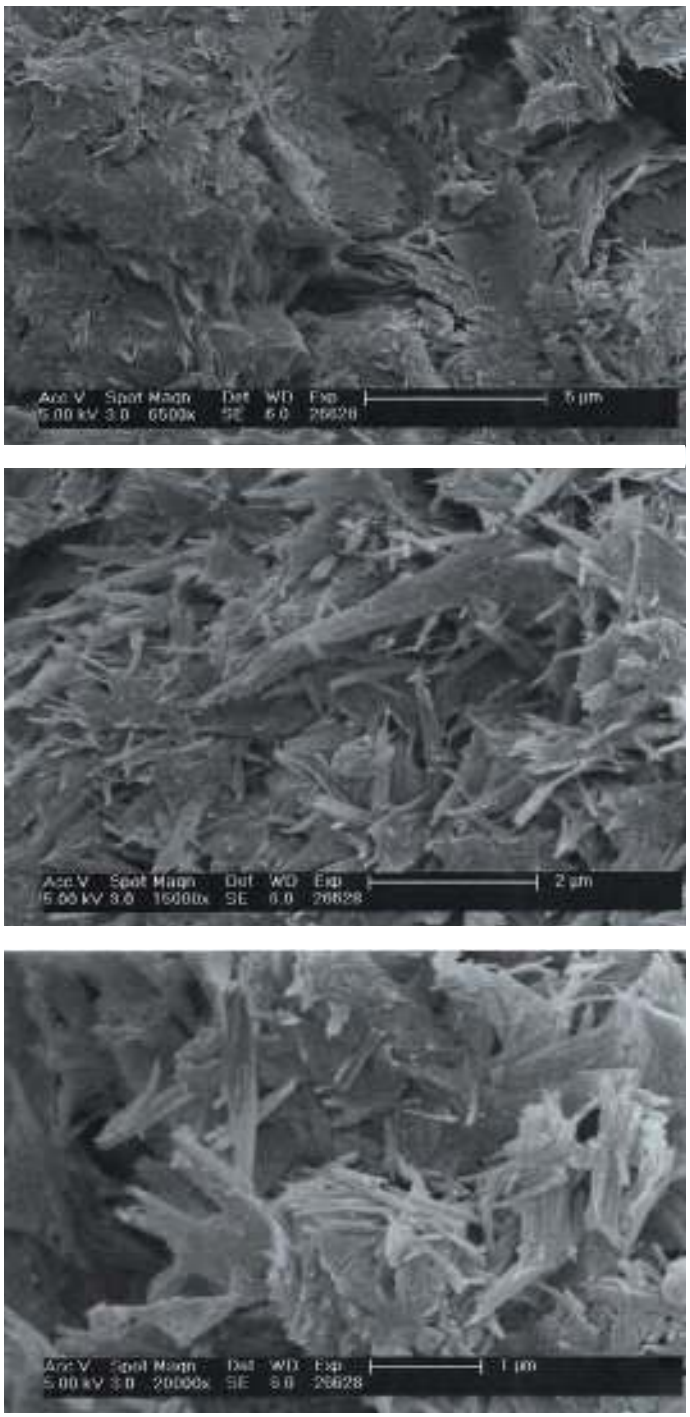

Figure 4. Scanning electron photomicrographs showing dominance of palygorskite clay fibres.

The clay tiles were scanned using a 0.02° step width, with 0.2 mm slits from 2 to 40° 2Ø. The tiles were scanned again after treating with glycol, after heating at 400 °C for 4 hours, and after heating at 550 °C, also for 4 hours. The SEM used was a Zeiss Ultra in the Imaging and Analysis Centre in the Natural History Museum, London.

Table 1. Semi-quantitative X-ray diffraction analysis of the palygorskite-rich seam.

Minerals	%
Smectite	18
Palygorskite	51
Sepiolite	29
Chlorite	0
Quartz	2
K-feldpar	0
Plagioclase	0
Calcite	0
Dolomite	0
Gypsum	0
Halite	0
Anhydrite	0
Haematite	0

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A newly-reported *Salicornia europaea* population under threat

by Mohammad Shahid

Abstract

A previously unreported population of *Salicornia europaea* has been found on the edges of a small tidal inlet in the emirate of Umm al-Qaiwain. It appears to be different from two ecotypes of the species found in other parts of the United Arab Emirates (UAE). The location has large numbers of an introduced halophytic plant species, *Sesuvium portulacastrum*, which serve to inhibit the growing of local species. The number of plants of the local *S. europaea* ecotype is low and the species may disappear. The eradication of the alien species of *S. portulacastrum* from the area is necessary to protect the *S. europaea* ecotype and other local flora in the area.

Introduction

Salicornia europaea L., a member of the Amaranthaceae family, is an annual halophytic herbaceous plant with multi-branched, fleshy stems, growing up to 45 cm in height. Flowers are tiny, off-white to yellow, hermaphrodite. Flowering occurs in November, while seeds mature in December. The species is found in coastal areas of North America, Europe, Africa and Asia. In the Arabian Peninsula, it is native to Kuwait (Omar 2001), Qatar (Norton *et al.* 2009), Saudi Arabia (Chaudhary 1999) and the UAE (Brown & Sakkir 2004). The plant, popularly known as sapphire or glasswort, is edible and can be eaten either raw or cooked. It can also be used as a fodder while its seed is rich in high quality oil, making it suitable for cultivation as an oilseed crop.

Sesuvium portulacastrum L. (L.), a member of the Aizoaceae family, is a facultative halophyte plant species. Commonly called sea purslane, it is found in tropical and subtropical regions around the world. It is perennial, prostrate or semi-erect, succulent, growing up to 1 m in length and 30 cm in height. It flowers and produces seed all year round. It is considered to be an aggressive and spreading plant having no serious pest problem. These traits make it a successful invasive species in different areas of the world. In the UAE, it was introduced as an ornamental and ground cover plant in different parts of the country and, due to its tenacity, has become established. In some farms, it has become a weed and competes with the cultivated crops. The species has been identified in several areas, especially close to saline water bodies, where it competes with local flora, including *S. europaea* (Shahid 2018). It has been recorded as an invasive species in the UAE (Soorae *et al.* 2015) and five other countries

Figure 1. Red arrow indicates location of the *Salicornia europaea* population.

Figure 2. A few indigenous *Salicornia europaea* plants (upper right) growing among invasive *Sesuvium portulacastrum* at Khor al-Madfaq.

Figure 3. The dominant species at the study area in Khor al-Madfaq is *Sesuvium portulacastrum*.

Figure 4. *Salicornia europaea* plants surrounded by *Sesuvium portulacastrum* at Khor al Madfaq.

Figure 5. A thickly-growing population of *Salicornia europaea* at Rams, Ra's al-Khaimah.

Figure 6. *Avicennia marina* seedlings growing among *Sesuvium portulacastrum* plants at Khor al Madfaq.

Figure 7. Flowering *Salicornia europaea* at Khor al-Madfaq (all photos by Mohammad Shahid).

(GBIF Secretariat 2017). In Saudi Arabia, it has been found on the eastern coast as an invasive plant that affects the growth of other floral species (Thomas *et al.* 2014) including *Ipomoea pes-caprae* (L.) R. Br. (Convolvulaceae) and *Malephora crocea* (Jacq.) Schwant. (Aizoaceae).

Materials and Methods

In 2018, during a botanical expedition to the coastal areas of the emirate of Umm al-Qaiwain, a population of *Salicornia europaea* was found on the edge of the tidal inlet of Khor al-Madfaq (N 25°38.393, E 55°44.035, (Figure 1), where it was present in a very small area (Figure 2). The place is about 25 km from a previously reported *S. europaea* population in Khor al-Beida, Umm al-Qaiwain (given the name UAQ in Shahid, 2017) and around 40 km from the second ecotype found at Rams (given the name RAK in Shahid [2017]), in a location between these two ecotypes. Apart from *S. europaea*, another local plant species, the mangrove, *Avicennia marina*, was also present, with a population of differing ages, but primarily at seedling stage. The most visible plant species in the area was *Sesuvium portulacastrum* (Figure 3), which covered a larger area than the other species.

Results

In contrast to the two other previously reported *Salicornia europaea* populations in the UAE (Shahid 2018), the number of plants of the species at Khor al-Madfaq in the area is very small, with only a few dozen plants of what appears to be a unique ecotype present, all being surrounded by the aggressive *Sesuvium portulacastrum* plants (Figure 4). In other areas, plant density of *S. europaea* is very high. At Rams, (RAK), where *S. portulacastrum* is also present, it is growing on a patch of land that extends over 1 km along the coast (Figure 5). At Khor al-Madfaq, it is sparsely found among thickly growing *S. portulacastrum*. It is suggested that this alien species may be responsible for the poor growth of *S. europaea* in the area.

At Rams (RAK) and the other Umm al-Qaiwain site in Khor al-Beida (UAQ), the number of *S. europaea* plants ecotypes is very high and spread over larger areas, suggesting that the two populations are relatively safe. In case of Khor al-Madfaq, the very small population of *S. europaea* is highly vulnerable due to the lower number of plants and presence of invasive alien plants.

Many of the mangrove (*Avicennia marina*) seedlings at Khor al-Madfaq were also surrounded by *S. portulacastrum* (Figure 6), which may also affect their growth.

Observation indicates that the *S. europaea* ecotype at Khor al-Madfaq starts flowering in the 2nd week of November (Figure 7), the same period as the Rams (RAK) population. The other population in Umm al-Qaiwain, (UAQ), begins flowering in the 1st week of November.

Conclusion

To save the *Salicornia europaea* population at Khor al-Madfaq, consideration should be given to the eradication of *Sesuvium portulacastrum*, collection and preservation of the seed of the unique population of *S. europaea* and subsequent reintroduction of the *S. europaea* ecotype in the area through sowing of seed and transplanting of seedlings.

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