Portent or accident? Two new records of thermophilic fish from the central Mediterranean

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Abstract

The blue tang Acanthus coeruleus Bloch and Schneider, 1801 and the Red Sea bannerfish Heniochus intermedius Steindachner, 1893 are reported for the first time from the Maltese Islands, which also represents the first central Mediterranean record for both species. The new records are based on an individual of A. coeruleus observed in October 2013 and a specimen of H. intermedius caught in November 2014; no individuals of either species have been found since. The occurrence of these species in Malta may be due to a westwards range expansion in the Mediterranean, given that both species were previously recorded from the Levantine Sea, but they could also have been introduced directly in Maltese waters through the aquarium trade or by shipping, particularly since evidence for established populations in the eastern Mediterranean is lacking. The relevance of these new additions of thermophilic fishes to the central Mediterranean ichthyofauna is discussed in relation to ongoing biotic changes in this sea.

Key words: Acanthuridae, Chaetodontidae, Malta, non-indigenous species, range expansion

Introduction

An ongoing warming trend is clearly evident in both the surface and deep waters of the Mediterranean Sea (Lejeusne et al. 2010; Bianchi et al. 2012), and temperatures are expected to continue rising given that climate models predict that the Mediterranean region will be one of the hotspots of global climate change (Giorgi 2006; Diffenbaugh and Giorgi 2012). The increasing seawater temperature renders this sea more receptive to invasion by thermophilic species, especially by Red Sea biota entering through the Suez Canal (Raitos et al. 2010; Galil and Goren 2014), but also by sub-tropical eastern Atlantic species extending their distribution range into the Mediterranean via the Strait of Gibraltar. Warmer temperatures also increase the survival chances for thermophilic alien species introduced intentionally or accidentally (Bianchi et al. 2013).

The appearance and spread of subtropical and tropical biota, together with seawater warming, are leading to what has been termed the ‘tropicalization’ of the Mediterranean Sea (Bianchi and Morri 2003; Bianchi 2007). Surgeonfish (Family Acanthuridae) and butterflyfish (Family Chaetodontidae) are examples of species contributing to this tropicalization. These subtropical and tropical fishes are typically found associated with coral reefs in the Atlantic, Pacific, and Indian Oceans (Froese and Pauly 2015). No acanthurid species are indigenous to the Mediterranean Sea, while one species of butterflyfish, Chaetodon hoefleri Steindachner, 1881, has on rare occasions been observed in the western basin, presumably having entered as a vagrant through the Gibraltar Strait (Psomadakis et al. 2012).

On the other hand, since the early 1980s, seven species belonging to these two families have been recorded as newcomers in the Mediterranean. Three species originate in the Atlantic Ocean: Acanthus monroviae Steindachner, 1876, first recorded in 1981 in Spain (Crespo et al. 1987); Acanthus coeruleus Bloch and Schneider, 1801,
A surgeonfish was sighted during a scuba dive in Marsamxett Harbour (Figure 1) on 11\textsuperscript{th} October 2013 (Debbie Adams and Bent Matusiak, personal communication, March 2014). The specimen was not caught but good quality photographs (Figure 2) enabled its unambiguous identification as the blue tang \textit{Acanthurus coeruleus}. This species is characterised by bright yellow juveniles, which switch to a blue to purplish-grey coloration with grey longitudinal lines on the body as adults (Randall 2002); the specimen observed in Marsamxett represents the intermediate colour form with a bluish head and body but still possessing a yellow caudal fin. The bluish coloration and absence of spots, bands or other marks on the body (as found in other acanthurids; see Randall 2001, 2002) allow positive identification of \textit{A. coeruleus} from photographs. The individual was observed over a rocky and boulder bottom in water 6–8 m deep. The divers estimated the fish to be between 100 mm and 120 mm in total length. The same individual remained in the area for at least two weeks (Bent Matusiak, personal communication, March 2014), but subsequent dives in the same place over a period of 5 months yielded no further observations of this species.

On 9\textsuperscript{th} November 2014 a single specimen of \textit{Heniochus intermedius} (Figure 3) was caught during recreational fishing by one of us (RT) in the Grand Harbour (Figure 1). The fish was kept...
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| Table 1. Morphometric measurements, meristic counts and body mass of the specimen of Heniochus intermedius caught from the Grand Harbour, Malta, in November 2014. |
|----------------------------------|---------------------|---------------------|
| Morphometric measurements       | Absolute value (mm) | % of Standard Length |
| Total Length                    | 115.0               | 116.8               |
| Standard Length                 | 98.5                | 100.0               |
| Body depth                      | 79.0                | 80.2                |
| Body width                      | 15.0                | 15.2                |
| Head length                     | 33.0                | 33.5                |
| Snout length                    | 12.0                | 12.2                |
| Jaw length                      | 6.5                 | 6.6                 |
| Eye diameter                    | 9.5                 | 9.6                 |
| Dorsal fin base length          | 74.0                | 75.1                |
| Dorsal fin length (4th spine)   | 117.0               | 118.8               |
| Anal fin base length            | 36.5                | 37.1                |
| Anal fin length                 | 30.0                | 30.5                |
| Pectoral fin base length        | 9.0                 | 9.1                 |
| Pectoral fin length             | 26.0                | 26.4                |
| Pelvic fin base length          | 8.5                 | 8.6                 |
| Pelvic fin length               | 27.0                | 27.4                |
| Caudal fin length               | 16.5                | 16.8                |
| Caudal peduncle height          | 10.5                | 10.7                |
| Meristic counts                 |                     |                     |
| Dorsal fin rays                 | XI + 25             |                     |
| Anal fin rays                   | III + 18            |                     |
| Pectoral fin rays               | 16                  |                     |
| Pelvic fin rays                 | 1 + 5               |                     |
| Caudal fin rays                 | 23                  |                     |
| Total mass (g)                  | 47.6                |                     |

The initial record of *H. intermedius*, based on a pair of individuals sighted in the Gulf of Antalya in Turkey in 2002, was originally attributed to shipping or aquarium release (Gökoglu et al. 2003), but individuals of this species were subsequently observed in Lebanon in 2005 and again in 2011. This suggests that immigration of this Red Sea species through the Suez Canal, aided by warming of eastern Mediterranean waters, is a more likely mode of introduction (Bariche 2012). It is not known whether the separate sightings are due to unrelated multiple introductions or to the presence of an established population in the Levantine area, but it is unlikely that this species could be overlooked given that it is very conspicuous and easily recognizable.

In the case of *A. coeruleus*, a climate-induced range expansion is less likely since it is primarily found in the western Atlantic Ocean; its occurrence in Cyprus was more likely due to direct human-mediated introduction, either through shipping or aquarium release (Langeneck et al. 2012). Between 2011 and 2014, juveniles of *A. coeruleus* were sighted in different locations along the southern coast of Cyprus, suggesting that this species may have become established in the region, even though there are no records of adult individuals (Langeneck et al. 2015).

The duration of the pelagic larval phase of *A. coeruleus* ranges from around 46 to 57 days (Rocha et al. 2002). While no information on that of *H. intermedius* is available, the mean pelagic larval duration of three congeneric species ranges between 32 and 41 days (Luiz et al. 2013). This provides ample time for these species to disperse to the central Mediterranean from elsewhere in the sea, so the new records of *A. coeruleus* and *H. intermedius* from the Maltese Islands may represent a westwards expansion from any populations already established in the eastern Mediterranean. On the other hand, the limited evidence for such established populations in the Levantine region, particularly in the case of *H. intermedius*, suggests that the two Maltese records could be due to separate direct introductions in the central Mediterranean.

Direct introductions may have occurred via aquarium release or shipping: both pathways have been suggested as likely modes of introduction of other exotic fishes in Maltese waters, e.g., *Scatophagus argus* (Linnaeus, 1766) (Zammit and Schembri 2011) and *Oplegnathus fasciatus* (Temminck and Schlegel, 1844) (Schembri et al. 2010). The intentional or accidental release of specimens imported via the aquarium trade was considered to be the most likely introduction pathway.
Figure 4. Newcomer fishes in the central Mediterranean region grouped according to their biogeographic affinity; A: number of new records per decade; B: establishment success (% number of species) of subtropical and tropical species.

for *A. coeruleus* in Cyprus (Langeneck et al. 2012), as well as for other recently introduced acanthurids: *A. chirurgus* (Langeneck et al. 2015) and *Z. flavescens* (Weitzmann et al. 2015). Aquarium release was also suggested as the initial mode of introduction for *H. intermedius* in Turkey (Gökoglu et al. 2003). However, shipping-related modes cannot be excluded given that the two new records were both made in harbours. The relatively long pelagic life of the larval stage of these species allows the larvae to be taken up together with ballast water in one place and subsequently discharged in another location. This would require a period of post-larval development in the destination port, so such a scenario would be more plausible if the new records were based on juvenile specimens. On the other hand, transport of sub-adult or adult fish can also occur in seawater-containing compartments, such as sea chests, enabling the long-distance translocations of large fish (see discussion in Schembri et al. 2010).

Irrespective of the exact mode of introduction, the occurrence of *A. coeruleus* and *H. intermedius* in the central (and eastern) Mediterranean can still be linked to the current climatic changes since warming sea temperature increases the likelihood that incoming warm-water species can survive in their new environment (at least long enough to be detected). Indeed, these two records add on to an increasing list of subtropical and tropical fishes that have been found in the Maltese Islands, including: *Abudelfadl saxatilis* (Linnaeus, 1758); *Alepis djedaba* (Forsskål, 1775); *Cephalopholis taeniops* (Valenciennes, 1828); *Epinephelus malabaricus* (Bloch and Schneider, 1801); *Fistularia commersonii* Rüppell, 1838; *Ophiodon elongatus* atlanticus (Valenciennes, 1836); *Oplegnathus fasciatus*; *Parablennius pilicornis* (Cuvier, 1829); *Scatophagus argus*; *Selene dorsalis* (Gill, 1863); *Seriola fasciata* (Bloch, 1793); *Siganus luridus* (Rüppell, 1829); and *Sphyraena chrysotaenia* Klunzinger, 1884 (Evans et al. 2015). Langeneck et al. (2015) also mention the sighting of another acanthurid (*Acanthurus monroviae*) in Malta, but this is based on a personal communication and is not substantiated by a photograph or specimen.

The central Mediterranean appears to be becoming more amenable to the occurrence of thermophilic species. To assess whether this is the case, a database (supplementary material Table S1) of non-indigenous species and other newcomers occurring in this region to date was compiled. For the purpose of this exercise, the “central Mediterranean” was considered to include south Sicily, Malta, Tunisia, Libya and the Ionian coasts of Greece, Albania and Italy. For each species, the climatic conditions in its native range (temperate/deep-water/subtropical/tropical), the country and date of first occurrence in the central Mediterranean (taken as “prior to” the date of publication when the actual date of the record was not indicated) and establishment success (casual/established/invasive) were recorded; questionable records were not included.

A total of 60 fish species were included in the list of newcomers in the central Mediterranean, with an increasing trend in the number of new records over the last two decades (Figure 4). Most of these species (90%) are of subtropical or tropical affinity, and the proportion of tropical newcomers appears to have increased (30% of newcomers in the 1960s vs 45% of newcomers in the 2000s). Overall, there has been a clear augmentation in the number of thermophilic fish species in the central Mediterranean, and the present records of *A. coeruleus* and *H. intermedius* are the latest in this ongoing trend.

Since only a single specimen each of *A. coeruleus* and *H. intermedius* was recorded from Malta, their presence in the central Mediterranean may be considered fortuitous, and it is unlikely that these species have established breeding populations at present. Nevertheless, when *A. coeruleus* was
first sighted in Cyprus, Langeneck et al. (2012) commented that it was “probably an accident: the establishment of this western Atlantic species in the Mediterranean seems unlikely”, yet this species may have become established in Cyprus (Langeneck et al. 2015). Moreover, more than half of the subtropical/tropical species recently introduced into the central Mediterranean have established populations in the area, while nearly 20% are classified as invasive (Figure 4), clearly showing that some thermophilic newcomers do have the ability to become established. Furthermore, the possibility of multiple separate introductions, as may have occurred for *A. coeruleus* and *H. intermedius* in the Mediterranean, increases the chances that some of these species will eventually become established. Thus, while the present records of *A. coeruleus* and *H. intermedius* from Malta may be deemed an accident, they also portend further tropicalization of central Mediterranean waters. Given their location within the Sicilian Channel, the Maltese Islands are well sited to act as an observatory for these ongoing biogeographic changes.

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Supplementary material

The following supplementary material is available for this article:

Table S1. List of recent new records of ichthyofauna from the central Mediterranean region, including non-indigenous species and Atlantic species that have recently extended their range to reach the central Mediterranean.

This material is available as part of online article from:
http://www.reabic.net/journals/btr/2015/Supplements/BTR_2015_Evans_etal_Supplement.xls