Endemic Fishes of the Red Sea

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Endemic Fishes of the Red Sea

14

Sergey V. Bogorodsky and John E. Randall

Abstract

The Red Sea is characterised by a unique composition of species of fishes which, based on unpublished data of the present authors, currently consists of 1166 species from 159 families whose habitats range from shallow waters to the deep sea. There is a total of 1120 species in coastal waters of the Red Sea recorded within an overall depth range 0–200 m; among them, 165 species are exclusively endemics to the Red Sea, whilst another 51 species are restricted to the Red Sea and Gulf of Aden only, and 22 species living at depths greater than 200 m are endemic. As the westernmost peripheral area of the Indo-West Pacific region, the Red Sea is at the opposite end of the distributions of many widespread coral reef organisms that range to the easternmost regions, such as the Hawaiian Islands, Easter Island, and the Marquesas Islands. It is noted that these areas exhibit high percentages of endemism among coastal fishes. The Hawaiian archipelago has 30.7% of its fishes as endemic species; Easter Island has 21.7%, the Red Sea 14.7% (19.3% when combined with the Gulf of Aden), and the Marquesas Islands have 13.7% endemic fishes. The Red Sea is 2250 km in length and it is very deep, with an average depth of 490 m, and a maximum depth of 3040 m. As expected, the fish fauna is far from homogeneous. The most divergent sector is the Gulf of Aqaba. We have noted that its entrance to the rest of the Red Sea is shallow. It has a maximum width of only 24 km, but a maximum depth of 1850 m. The shore drops off quickly to deep water. The prevailing cross wind creates upwelling, resulting in surface sea temperature at least as low as 21 °C. Twenty-two of 46 species of Red Sea fishes living at depths greater than 200 m in the Red Sea are endemic (48% endemism). The Gulf of Aqaba has 22 endemic coastal species of fishes and eight endemic deep-dwelling species. By contrast, the neighboring Gulf of Suez, with extensive sand flats and a maximum depth of 70 m, has only seven endemic species of fishes. Of the 165 endemic Red Sea species of fishes, only two are elasmobranchs. Twenty-three families of Red Sea fishes have more than 20% of endemic species with the highest rates of endemism occurring among the Pseudochromidae, Schindleriidae (83.3% and 100% respectively) and the family Gobiidae with the greatest number of endemic species (36 of 139 recorded species). A brief summary of the history of scientific research on Red Sea fishes is provided together with complete lists of endemic species for (i) the entire Red Sea (separately for coastal and deep-dwelling fishes); (ii) the Red Sea combined with the Gulf of Aden; (iii) the Gulf of Aqaba and the Gulf of Suez; and (iv) Lessepsian migrants. Ongoing research is likely to reveal additional endemic species in the region.

Introduction

The origin and composition of the fish fauna of the Red Sea is best understood with knowledge of the geologic history of the sea, beginning with the plate tectonics of the region. During the Eocene, 40 million years ago, the Arabian Plate (including what is now the Arabian Peninsula) began to drift to the east from the plate on the African side known as Nubia at the rate of 1–2 cm per year. This separation (termed a rift) continued to the north, through what is now the Gulf of Aqaba, and created the Dead Sea. It also ranged to the south, resulting in the Great Rift Valley and the formation of the Great Lakes of East Africa. The rift of what was to become the Red Sea remained dry until 20 million years ago in the Miocene when the sea poured in from the Mediterranean part

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of the Tethys Sea. The rift expansion continues today, and given enough time, the Red Sea will become an ocean (Rasul et al. 2015).

Five million years ago during the Pliocene, the northern end of the Red Sea uplifted, and the southern subsided, resulting in the Red Sea becoming a part of the Indo-Pacific region. Corals, other invertebrates, marine plants, and fishes from the Indian Ocean then colonized the Red Sea. During the Pleistocene Ice Ages from two million years to 10,000 years ago, the sea level of the Red Sea was lowered as much as about 130 m. The maximum depth of the Red Sea is about 2900 m, and the average depth is 490 m, so a lowering of 130 m would seem insignificant. However, the Hanish Sill near the narrow southern entrance to the Red Sea called Bab-al-Mandab has a depth at present of only 137 m. Thus, Pleistocene falls in sea level created a barrier between the Red Sea and the Gulf of Aden whilst the narrow and relatively shallow Strait of Tiran restricted water exchange between the Gulf of Aqaba and the Red Sea proper. With each ice age, the cycle repeated, and with each cycle the opportunity arose for marine species in the Red Sea to evolve independently from the Indian Ocean stock from whence they came. The sea level has been stable for about the last 5000 years, but the present burning of fossil fuels and the destruction of forests have accelerated the melting of the polar ice caps, causing an alarming rise in sea level, especially to population centres barely above sea level (Lieske and Myers 2004).

Mention should be made of the impact of the Suez Canal on the ichthyofauna of both the Red Sea and the Mediterranean Sea. With the opening of the canal in 1869, the opportunity was provided for marine life to move from south to north and vice versa. The greatest movement of fishes has been the former, with 57 Red Sea species reported as established in the Mediterranean Sea (Golani et al. 2002). Currently that number has increased to 106 species, so-called Lessepsian migrants, that have thus far colonized the Mediterranean. By contrast, only 12 Mediterranean species have been discovered in the northern Red Sea (Dor 1984).

We present here a brief historical review of the systematic research on fishes of the Red Sea. The first widely accepted classification of the animal life of Planet Earth is the first volume of the tenth edition of "Systema Naturae", written by the Swedish naturalist Carl Linnaeus, and published in 1758. Linnaeus was mainly a botanist. The part on fishes was written for him by his friend Peter Artedi; they had been students together at the University of Uppsala in Sweden. We have found only one fish species from "Mari rubro" in this tome, referred to as "*Chaetodon nigricans*". The description includes a sharp spine on each side at the base of the caudal fin and nine dorsal spines. These characters readily link the fish as the oldest name for the common Red Sea surgeonfish *Acanthurus gahhm* (Forsskål 1775). *Acanthurus nigricans* is itself distributed from the Andaman Sea in the eastern Indian Ocean to Tonga in the western Pacific Ocean.

Fifty-eight species of Red Sea fishes were described in 1775 by Peter Forsskål from Finland. He led a six-man Danish scientific expedition to the Red Sea in 1762. Five of the men died during the expedition, including Forsskål who succumbed to malaria in Yemen. The survivor, Carsten Niebuhr, brought Forsskål's notes back to Denmark and edited the manuscript for publication. Ninety-nine of the skins were deposited in the Zoological Museum of Copenhagen. Klausewitz and Nielsen (1965) published photographs and x-rays of the surviving 69 skins of the Forsskål fish collection. Fricke (2008) detailed the history, authorship and taxonomic identity of species described in Forsskål's work.

In 1822, Dr. Eduard Rüppell of the Senckenberg Museum in Frankfurt collected fishes in the Red Sea. During the period 1828–1830, he published "Fishes des rothen Meeres" in his "Atlas zu der Reise im nordischen Afrika". Of 161 species accounts of fishes, 75 were new to science. After more field work in the Red Sea in 1831, his "Fische des rothen Meeres in Neue Wirbelthiere zu der Fauna van Abyssinien Gehorig" was published in four parts (1835–1838), describing 164 species, 100 of which were new.

At the same time that Rüppell was in the Red Sea, two more Germans, CG Ehrenberg and FG Hemprich, were collecting fishes. Hemprich died in Massawa, Eritrea; Ehrenberg brought back a large collection of plants and animals to Berlin. He made the fishes available to the famous Baron Georges Cuvier and Achille Valenciennes for their monumental 22-volume "Histoire naturelles des poisons" (Cuvier & Valenciennes 1828–1847); they attributed the authorship of Ehrenberg's specimens to him. They also described other species from outside the Red Sea that were later found to range into the sea.

Beginning from 1864, the German physician Carl Klunzinger commenced a five-year study of Red Sea fishes in Egypt, which culminated in 1870–1871 with his "Synopsis der Fische des Rothen Meeres"; it contained 520 species. Three more years of field work in Egypt, commencing in 1872, and subsequent research on the specimens, resulted in the publication of the first part of his "Die Fische des Rothen Meeres" (1884) that contained 261 species; the second part was not published.

Since Klunzinger, many people have collected fishes in the Red Sea, and numerous scientific papers have been published on Red Sea fishes, including four checklists (Botros 1971; Dor 1984; Goren and Dor 1994; Golani and Bogorodsky 2010). Dor (1984) listed almost 1000 species. Ten years later, Goren and Dor (1994) updated this checklist, adding another 250 species. They failed, however, to verify published records and their list contained numerous errors, improved by Golani and Bogorodsky (2010) in their revised

Table 14.1 Authors who described Red Sea fishes

Dates	Author	Number of valid species described from the Red Sea	Number of Red Sea endemic, depth 0–200 m	Number of Red Sea deep-water species, depth below 200 m
1828–1837	Rüppell	97	30	–
1775	Forsskål	93	6	–
1972–2017	Randall	52	38	1
2010–2018	Bogorodsky	32	29	–
1870–1884	Klunzinger	32	10	4
1828–1840	Cuvier and Valenciennes	24	7	–
1984–2018	Golani	20	12	5
1959–2000	Klausewitz	20	6	6
1980–2018	Fricke	15	12	3
1978–1995	Goren	13	8	2
1971–1988	Springer	6	4	–

checklist, reducing the number of species to 1078, in 154 families, 25 orders, and two classes. Since their publication many species new for science and new for the Red Sea were reported from the Red Sea, raising the number of species to 1166 (Eschmeyer et al. 2018 and unpublished authors' data).

The second author wrote a book entitled "Red Sea Reef Fishes" that was published in 1983 by Immel Publishing, based in London. The book includes 325 species, illustrated with 446 colour illustrations. The book "Fishes of the Gulf of Aqaba" by Maroof A. Khalaf and Ahmad M. Disi, also well illustrated in colour, was published in 1997 by the Marine Science Station in Jordan (Khalaf and Disi 1997). It demonstrated that the fish fauna of the Gulf of Aqaba is not the same as the rest of the Red Sea. Like the Red Sea, it is very deep, despite being very narrow by comparison. However, it is shallow at its entrance in the Strait of Tiran. As mentioned above, when the sea level was low, as during the Pleistocene, the Gulf of Aqaba was isolated from the rest of the Red Sea.

Helmut Debelius's popular book "Red Sea Reef Guide" was published in Debelius (1998) and included about 500 species of fishes and invertebrates. One of the most useful identification guides to Red Sea marine life is "Coral Reef Guide Red Sea", with a subtitle: "The definitive guide to over 1200 species of underwater life". It was written by Ewald Lieske and Robert F. Myers and published in 2004 by Harper Collins, London.

A surprising number of new species of fishes has been described from the Red Sea in recent years. Most have been small fishes, especially those of the family Gobiidae, and some are species from deep water. Table 14.1 provides a list of the ichthyologists who have described more than five valid new species of Red Sea fishes. It should also be noted that among the current authors, John E. Randall described about 800 valid species from the Indo-West Pacific, 63 of which occur in the Red Sea. Indeed, for 52 of Randall's species the holotype was designated from the Red Sea, whilst in seven cases the paratype was from the Red Sea, and the remaining four species were described outside the Red Sea.

This account would be incomplete without mentioning the significant contribution to our knowledge of Red Sea and Indo-Pacific fishes made by Dr. Pieter Bleeker, from 1847 to 1865, who described 1373 new species, of which 571 are considered as valid, 68 of them ranging to the Red Sea. Most of his new fishes were described from specimens of wide-ranging species that he collected in the East Indies.

Discussion

Based on recent unpublished data of the present authors there are 1166 fish species from 159 families recorded from shallow to deep waters in the Red Sea. In many respects, there are marked differences between species occurring in coastal waters (above 200 m depth) and those living deeper than 200 m. A total of 1120 Red Sea fish species in 143 families and 26 orders are known from depths above 200 m (Bogorodsky, Randall and Krupp unpublished). More than half of the families are represented by one to three species only. Families with the greatest number of species are: Gobiidae (139 spp.), Labridae (65 spp.), Apogonidae (60 spp.), Serranidae (41 spp.), Blenniidae (40 spp.), Carangidae (39 spp.), Muraenidae (38 spp.), Pomacentridae (34 spp.), and Syngnathidae (32 spp.). All other families have fewer than 30 species. Compared to other marine regions, the rate of endemism is extremely high (the third highest in the world, see Table 14.2); our latest revised percentage of endemic Red Sea fishes is 14.7% (i.e. 165 species listed in Table 14.3). Examples of Red Sea endemics are shown in Figs. 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7 and 14.8.

Table 14.2 Percentage of endemism in different areas of the world

Locality	Number of coastal fishes	Percentage of endemic species (%)	References
Hawaiian Islands	570	30.4	This paper
Easter Island	139	21.7	Randall and Cea (2011)
Red Sea	1120	14.6	This paper
Marquesas Islands	597	13.7	Delrieu-Trottin et al. (2017)
Galápagos Islands	550	13.6	McCosker and Rosenblatt (2010)
Ascension Island	82	11.0	Floeter et al. (2008)
East Indies[1]	2631	10.6	Allen and Erdmann (2012)
Cocos Is., Costa Rica	264	10.2	Garrison (2005)
New Caledonia	2320	4.6	Fricke et al. (2011)
Mascarene Islands	1022	3.5	Fricke (1999)
Marshall Islands	817	<1	Randall and Randall (1987)

Table 14.3 List of Red Sea endemic coastal species (165 species = 14.7%)

1. Torpedinidae- *Torpedo suessii* Steindachner 1898
2. Narkidae- *Heteronarce bentuviai* (Baranes and Randall 1989)
3. Muraenidae- *Uropterygius genie* Randall and Golani 1995
4. *Uropterygius golanii* McCosker and Smith 1997
5. *Gymnothorax baranesi* Smith, Brokovich and Einbinder 2008
6. Ophichthidae- *Mixomyrophis longidorsalis* Hibino, Kimura and Golani 2014
7. *Neenchelys microtretus* Bamber 1915
8. *Suculentophichthus nasus* Fricke, Golani and Appelbaum-Golani 2015
9. Congridae- *Ariosoma sanzoi* (D'Ancona 1928)
10. *Gorgasia sillneri* Klausewitz 1962
11. *Heteroconger balteatus* Castle and Randall 1999
12. Clupeidae- *Etrumeus golanii* DiBattista, Randall and Bowen 2012
13. Synodontidae- *Synodus randalli* Cressey 1981
14. Batrachoididae- *Barchatus cirrhosa* (Klunzinger 1871)
15. Mugilidae- *Planiliza carinata* (Valenciennes 1836)
16. Atherinidae- *Atherinomorus forskalii* (Rüppell 1838)
17. *Hypoatherina gobio* (Klunzinger 1884)
18. *Hypoatherina golanii* Sasaki and Kimura 2013
19. Cyprinodontidae- *Aphanius dispar* (Rüppell 1829)
20. Holocentridae- *Sargocentron marisrubri* Randall, Golani and Diamant 1989
21. Syngnathidae- *Hippocampus debelius* Gomon and Kuiter 2009
22. *Lissocampus bannwarthi* (Duncker 1915)
23. *Micrognathus brevirostris* (Rüppell 1838)
24. *Syngnathus macrophthalmus* Duncker 1915
25. *Syngnathus safina* Paulus 1992
26. Scorpaenidae- *Scorpaenodes steinitzi* Klausewitz and Fröiland 1970
27. Aploactinidae- *Ptarmus gallus* (Kossmann and Räuber 1877)
28. Liparidae- *Liparis fishelsoni* Smith 1968
29. Acropomatidae- *Acropoma neglectum* Okamoto and Golani 2017
30. Symphysanodontidae- *Symphysanodon disii* Khalaf and Krupp 2008
31. Serranidae- *Pseudanthias taeniatus* (Klunzinger 1884)
32. Serranidae- *Plectropomus marisrubri* Randall and Hoese 1986
33. *Pseudogramma megamyctera* Randall and Baldwin 1997

(continued)

Table 14.3 (continued)

34. Pseudochromidae- *Pseudochromis dixurus* Lubbock 1975
35. *Pseudochromis fridmani* Klausewitz 1968
36. *Pseudochromis olivaceus* Rüppell 1835
37. *Pseudochromis pesi* Lubbock 1975
38. *Pseudochromis springeri* Lubbock 1975
39. *Chlidichthys auratus* Lubbock 1975
40. *Chlidichthys rubiceps* Lubbock 1975
41. *Pectinochromis lubbocki* (Edwards and Randall 1983)
42. Plesiopidae- *Acanthoplesiops cappuccino* Gill, Bogorodsky and Mal 2013
43. Opistognathidae- *Opistognathus dipharus* Smith-Vaniz 2010
44. *Stalix davidsheni* Klausewitz 1985
45. Apogonidae- *Apogonichthyoides heptastygma* (Cuvier 1828)
46. *Cheilodipterus pygmaios* Gon 1993
47. *Ostorhinchus pselion* (Randall, Fraser and Lachner 1990)
48. *Siphamia goreni* Allen and Gon 2012
49. *Taeniamia bilineata* (Gon and Randall 1995)
50. *Taeniamia lineolata* (Cuvier 1828)
51. *Gymnapogon melanogaster* Gon and Golani 2002
52. *Pseudamiops springeri* Gon and Bogorodsky 2013
53. Sillaginidae- *Sillago suezensis* Golani, Fricke and Tikochinski 2013
54. Malacanthidae-*Hoplolatilus geo* Fricke and Kacher 1982
55. *Hoplolatilus oreni* Clark and Ben-Tuvia 1973
56. Leiognathidae- *Equulites aethopos* Suzuki and Kimura 2017
57. Emmelichthyidae- *Emmelichthys marisrubri* Fricke, Golani and Appelbaum-Golani 2014
58. Caesionidae- *Caesio suevica* Klunzinger 1884
59. Sparidae- *Argyrops megalommatus* (Klunzinger 1870)
60. *Diplodus noct* (Valenciennes 1830)
61. Nemipteridae- *Parascolopsis baranesi* Russell and Golani 1993
62. Mullidae- *Upeneus davidaromi* Golani 2001
63. *Upeneus niebuhri* Guézé 1976
64. Pempheridae-*Parapriacanthus sharm* Randall and Bogorodsky 2016
65. Pomacentridae-*Chromis dimidiata* (Klunzinger 1871)
66. *Chromis pelloura* Randall and Allen 1982
67. *Pomacentrus albicaudatus* Baschieri-Salvadori 1955
68. Labridae- *Cheilinus quinquecinctus* Rüppell 1835
69. *Cirrhilabrus blatteus* Springer and Randall 1974
70. *Coris variegata* (Rüppell 1835)
71. *Gomphosus caeruleus klunzingeri* Klausewitz 1962
72. *Hemigymnus sexfasciatus* (Rüppell 1835)
73. *Macropharyngodon marisrubri* Randall 1978
74. *Minilabrus striatus* Randall and Dor 1980
75. *Pteragogus clarkae* Randall 2013
76. *Pteragogus cryptus* Randall 1981
77. *Pteragogus trispilus* Randall 2013
78. *Thalassoma rueppellii* (Klunzinger 1871)

(continued)

Table 14.3 (continued)

79. Scaridae- *Cetoscarus bicolor* (Rüppell 1829)
80. *Chlorurus gibbus* (Rüppell 1829)
81. *Scarus collana* Rüppell 1835
82. Uranoscopidae- *Uranoscopus bauchotae* Brüss 1986
83. *Uranoscopus dahlakensis* Brüss 1987
84. *Uranoscopus marisrubri* Brüss 1987
85. *Uranoscopus rosette* Randall and Arnold 2012
86. Creediidae- *Limnichthys marisrubri* Fricke and Golani 2012
87. Tripterygiidae- *Enneapterygius altipinnis* Clark 1980
88. *Enneapterygius destai* Clark 1980
89. *Enneapterygius obscurus* Clark 1980
90. *Enneapterygius pallidus* Clark 1980
91. *Enneapterygius qirmiz* Holleman and Bogorodsky 2012
92. Blenniidae- *Adelotremus leptus* Smith-Vaniz and Rose 2012
93. *Enchelyurus petersi* (Kossmann and Räuber 1877)
94. *Omobranchus steinitzi* Springer and Gomon 1975
95. *Alloblennius jugularis* (Klunzinger 1871)
96. *Alticus magnusi* Klausewitz 1964
97. Blenniidae- *Ecsenius aroni* Springer 1971
98. *Entomacrodus solus* Williams and Bogorodsky 2010
99. *Istiblennius flaviumbrinus* (Rüppell 1830)
100. *Istiblennius rivulatus* (Rüppell 1830)
101. *Istiblennius unicolor* (Rüppell 1838)
102. *Parablennius cyclops* (Rüppell 1830)
103. Gobiesocidae- *Lepadichthys erythraeus* Briggs and Link 1963
104. Callionymidae- *Callionymus bentuviai* Fricke 1981
105. *Callionymus flavus* Fricke 1983
106. *Callionymus oxycephalus* Fricke 1980
107. *Diplogrammus gruveli* Smith 1963
108. *Diplogrammus paucispinis* Fricke and Bogorodsky 2014
109. *Diplogrammus randalli* Fricke 1983
110. Gobiidae- *Oxyurichthys petersii* (Klunzinger 1871)
111. *Amblyeleotris neglecta* Jaafar and Randall 2009
112. *Bryaninops discus* Suzuki, Bogorodsky and Randall 2012
113. *Bryaninops spongicolus* Suzuki, Bogorodsky and Randall 2012
114. *Cabillus nigrostigmus* Kovačić and Bogorodsky 2013
115. *Callogobius clarkae* (Goren 1978)
116. *Callogobius dori* Goren 1980
117. *Callogobius pilosimentum* Delventhal, Mooi, Bogorodsky and Mal 2016
118. *Coryogalops guttatus* Kovačić and Bogorodsky 2014
119. *Coryogalops nanus* Kovačić and Bogorodsky 2016
120. *Coryogalops ocheticus* (Norman 1927)
121. *Coryogalops pseudomonospilus* Kovačić and Bogorodsky 2014
122. *Cryptocentrus caeruleopunctatus* (Rüppell 1830)
123. *Ctenogobiops maculosus* (Fourmanoir 1955)

(continued)

Table 14.3 (continued)

124. *Eviota geminata* Greenfield and Bogorodsky 2014
125. *Eviota oculopiperita* Greenfield and Bogorodsky 2014
126. *Fusigobius longispinus* Goren 1978
127. *Gobiodon bilineatus* Herler, Bogorodsky and Suzuki 2013
128. *Gobiodon irregularis* Herler, Bogorodsky and Suzuki 2013
129. *Hetereleotris diademata* (Rüppell 1830)
130. *Hetereleotris dorsovittata* Kovačić and Bogorodsky 2014
131. *Hetereleotris psammophila* Kovačić and Bogorodsky 2014
132. Gobiidae- *Priolepis melanops* Bogorodsky, Suzuki and Mal 2016
133. *Psilogobius randalli* (Goren and Karplus 1983)
134. *Silhouettea aegyptia* (Chabanaud 1933)
135. *Sueviota pyrios* Greenfield and Randall 2017
136. *Tomiyamichthys dorsostigma* Bogorodsky, Kovačić and Randall 2011
137. *Trimma barralli* Winterbottom 1995
138. *Trimma filamentosus* Winterbottom 1995
139. *Trimma fishelsoni* Goren 1985
140. *Trimma quadrimaculatum* Hoese, Bogorodsky and Mal 2015
141. *Vanderhorstia opercularis* Randall 2007
142. Xenisthmidae- *Gymnoxenisthmus tigrellus* Gill, Bogorodsky and Mal 2017
143. *Xenisthmus oligoporus* Gill, Bogorodsky and Mal 2017
144. Microdesmidae- *Paragunnellichthys springeri* Dawson 1970
145. Schindleriidae- *Schindleria elongata* Fricke and Abu El-Regal 2017
146. *Schindleria nigropunctata* Fricke, Golani and Applebaum-Golani 2014
147. *Schindleria* sp.
148. Trichiuridae- *Evoxymetopon moricheni* Fricke, Golani and Appelbaum-Golani 2014
149. Bothidae- *Laeops sinusarabici* Chabanaud 1968
150. Soleidae- *Aseraggodes kruppi* Randall and Bogorodsky 2013
151. Soleidae- *Aseraggodes macronasus* Randall and Bogorodsky 2013
152. *Aseraggodes sinusarabici* Chabanaud 1931
153. *Aseraggodes steinitzi* Joglekar 1970
154. *Soleichthys dori* Randall and Munroe 2008
155. Cynoglossidae- *Cynoglossus cleopatridis* Chabanaud 1949
156. *Cynoglossus dollfusi* (Chabanaud 1931)
157. *Cynoglossus sinusarabici* (Chabanaud 1931)
158. Balistidae- *Sufflamen albicaudatum* (Rüppell 1829)
159. Monacanthidae- *Brachaluteres fahaqa* Clark and Gohar 1953
160. *Oxymonacanthus halli* Marshall 1952
161. *Paraluteres arqat* Clark and Gohar 1953
162. *Thamnaconus erythraeensis* Bauchot and Maugè 1978
163. Tetraodontidae- *Arothron diadematus* (Rüppell 1829)
164. *Canthigaster margaritata* (Rüppell 1829)
165. *Canthigaster pygmaea* Allen and Randall 1977

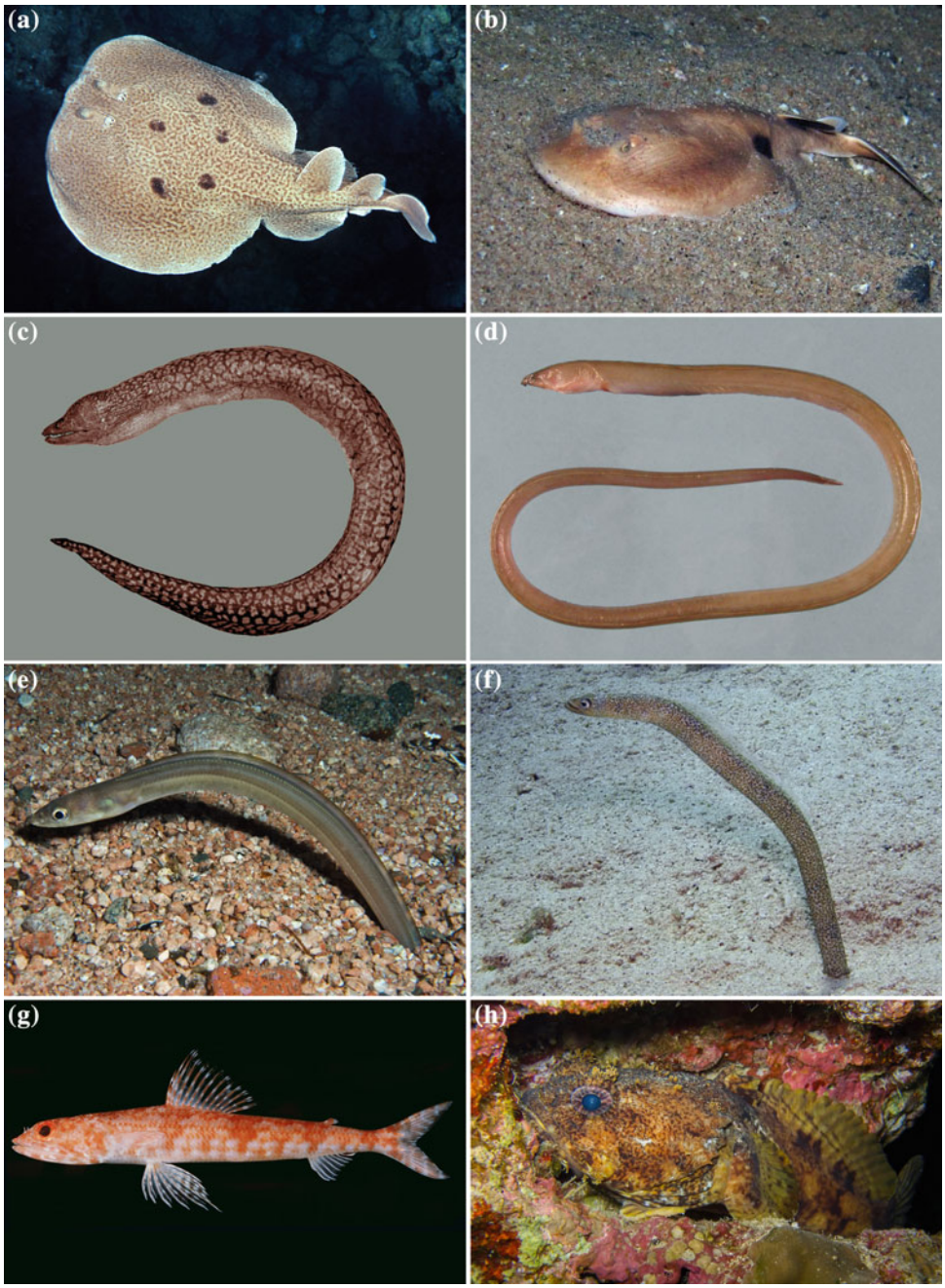

Fig. 14.1 Examples of Red Sea endemics. **a** *Torpedo suessii*, Sudan (J.E. Randall); **b** *Heteronarce bentuviai*, Dahab, Egypt (T. Malkerova); **c** *Gymnothorax baranesi*, 76.2 cm TL, Eilat, Israel (E. Brokovich); **d** *Suculentophichthus nasus*, 37.5 cm TL, Eilat, Israel (D. Golani); **e** *Ariosoma sanzoi*, Dahab, Egypt (S.V. Bogorodsky); **f** *Gorgasia sillneri*, El Quseir, Egypt (S.V. Bogorodsky); **g** *Synodus randalli*, 11.3 cm SL, Sudan (J.E. Randall); **h** *Barchatus cirrhosa*, Dahab, Egypt (P. Vorotnikov)

The number of endemic Red Sea species may need further revision, however, with more research in the Gulf of Aden in recent years, especially through utilisation of underwater photography (e.g., Lips et al. 2017), revealing an increasing number of species, thus far considered Red Sea endemics, further to the south. With inclusion of 51 species restricted to the Red Sea and Gulf of Aden (Table 14.4) the percentage of endemism in the region is calculated as 19.3% (examples of such endemics are shown in Figs. 14.9, 14.10 and 14.11). The shallow strait of Bab-al-Mandab possibly permitted some Red Sea endemic species to extend their distribution to the inner region of the Gulf of Aden. For this reason we provide separate lists of endemic fishes of the Red Sea alone and also for the Red Sea combined with the Gulf of Aden. More detailed information on each endemic species will be included in the authors' monograph on coastal fishes of the Red Sea (presently under preparation for publication). In addition, new records of Indian Ocean fishes that have been discovered in the Red Sea have lowered the percentage of endemics. Despite this, in total about 25% of the Red Sea fishes (i.e. 275 species) are confined to the Middle East including the Red Sea, the southern coast of the Arabian

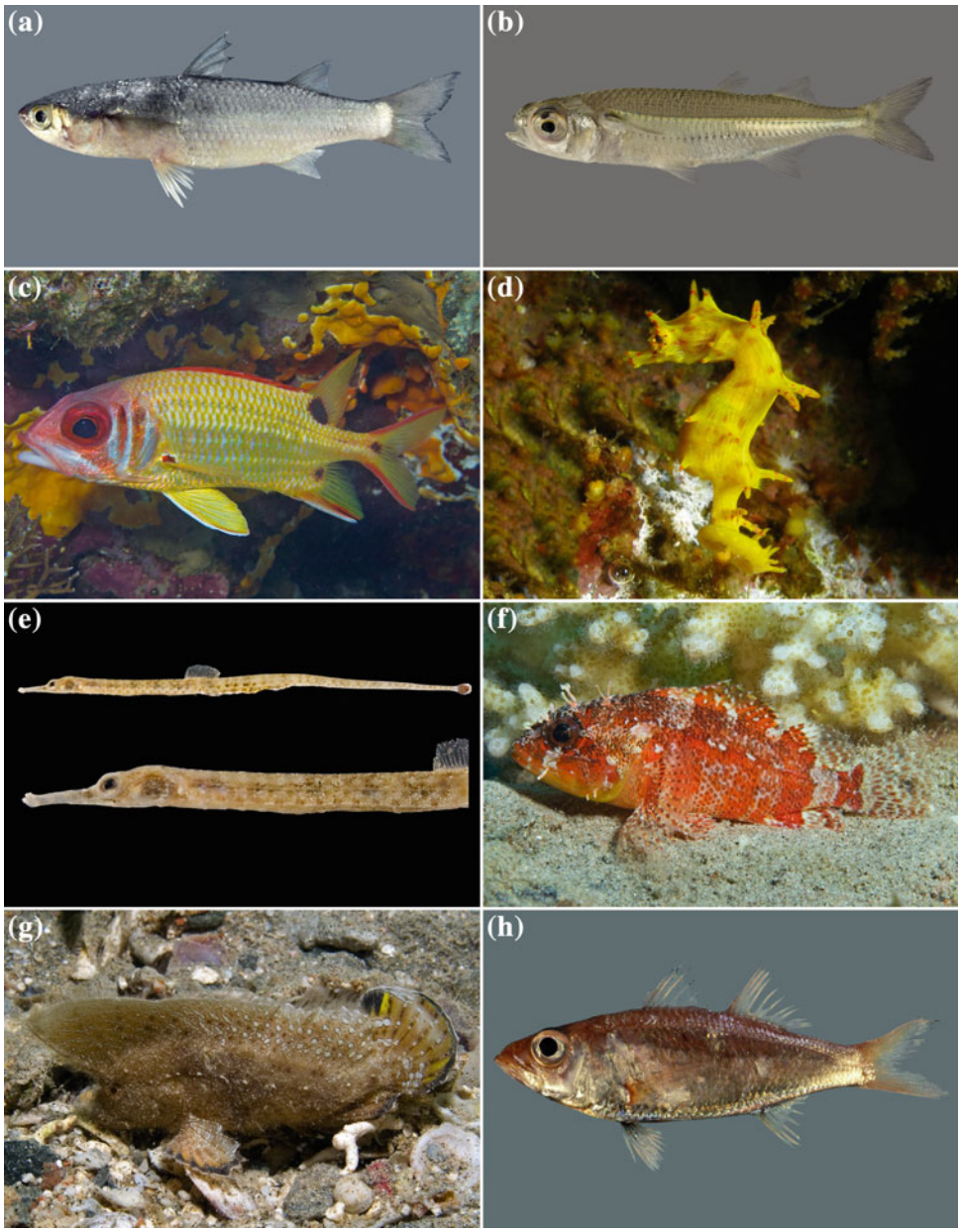

Fig. 14.2 Examples of Red Sea endemics. **a** *Planiliza carinata*, 14.6 cm SL, Haifa, Israel (D. Darom); **b** *Atherinomorus forsskali*, 5.9 cm SL, Al Lith, Saudi Arabia (S.V. Bogorodsky); **c** *Sargocentron marisrubri*, Naama Bay, Egypt (S.V. Bogorodsky); **d** *Hippocampus debelius*, Hurghada, Egypt (S. Kahlbrock); **e** *Syngnathus macrophthalmus*, 9 cm SL, Gulf of Suez (S.V. Bogorodsky); **f** *Scorpaenodes steinitzi*, Dahab, Egypt (S.V. Bogorodsky); **g** *Ptarmus gallus*, Marsa Alam, Egypt (S.V. Bogorodsky); **h** *Acropoma neglectum*, 13.6 cm SL, Eilat, Israel (D. Darom)

Peninsula, and the Arabian Gulf. While there are no endemics among highly migratory pelagic species, endemism is particularly high in demersal fishes without pelagic eggs or larvae.

As mentioned above, the number of species that have migrated from the Red Sea to the Mediterranean Sea via the Suez Canal now contains 106 species (Table 14.5), and only 12 Mediterranean species have been discovered in the northern Red Sea (Table 14.6). According to Doiuchi and Nakabo (2005), *Sphyraena chrysotaenia* Klunzinger 1884 is a junior synonym of *S. pinguis* Günther 1874, however, unpublished genetic analysis has indicated that it is a valid species and confirms the synonymy of *Sphyraena flavicauda* Rüppell 1838 with *Sphyraena obtusata* Cuvier 1829. Both species are Lessepsian migrants, *S. chrysotaenia* was collected as far away as the northern Black Sea, whilst *S. obtusata* was recorded from Malta. All eight Red Sea recorded species of *Sphyraena* are non-endemic species, but unpublished phylogenetic analysis showed that the Red Sea population of *S. iburiensis* Doiuchi and Nakabo 2005, known from two disjunct localities, Japan (type locality) and the Red Sea (see Doiuchi et al. 2011), forms a separate lineage. The following 16 Red Sea endemic species (including species reported from the Gulf of Aden) are Lessepsian migrants: *Etrumeus golanii* DiBattista et al. 2012, *Herklotsichthys punctatus* (Rüppell 1837), *Planiliza carinata* (Valenciennes in 1836), *Atherinomorus forskalii* (Rüppell 1838), *Epinephelus geoffroyi* (Klunzinger 1870),

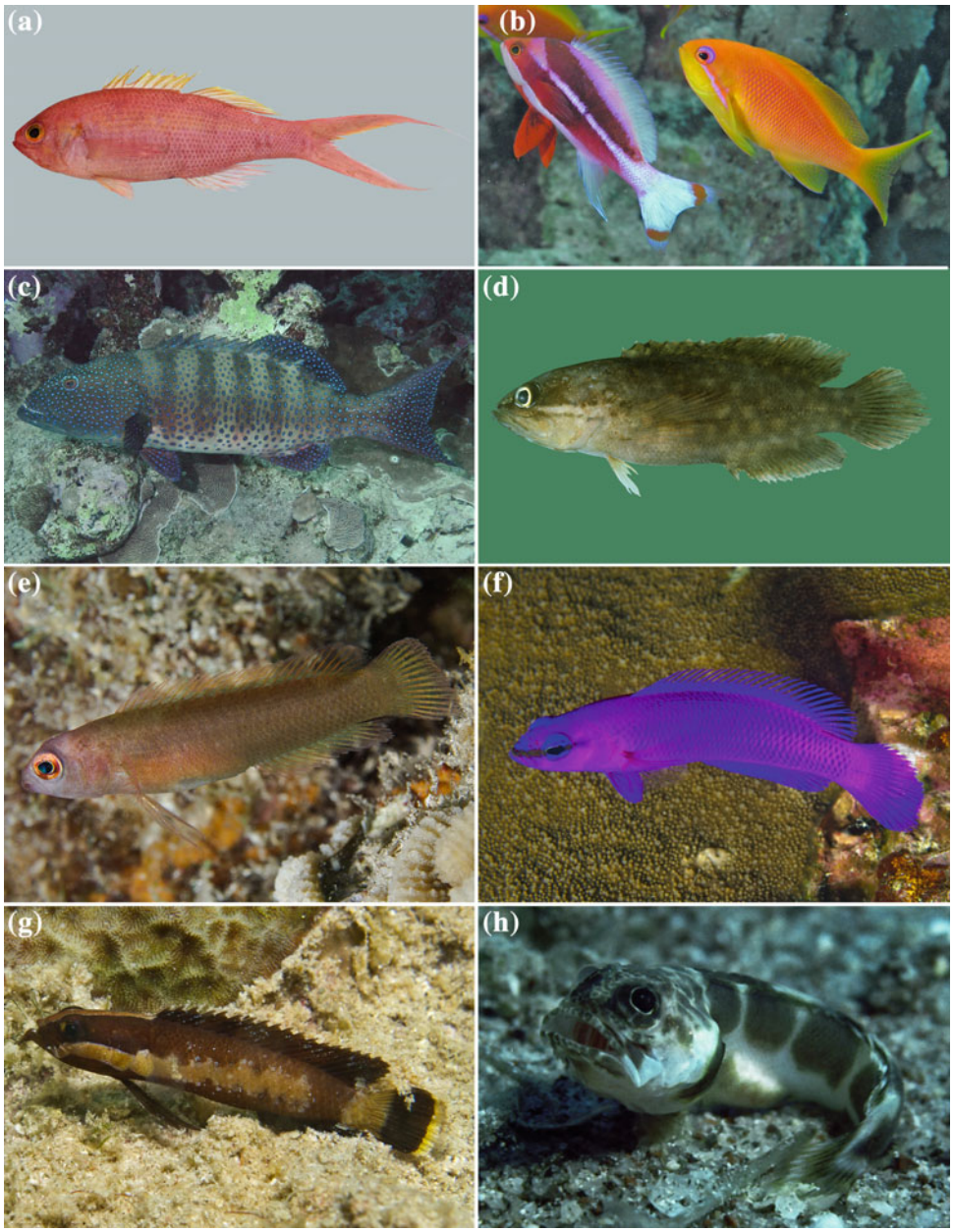

Fig. 14.3 Examples of Red Sea endemics. **a** *Symphysanodon disii*, 16.5 cm SL, Jordan (M.A. Khalaf); **b** *Pseudanthias taeniatus*, male & female, Sharm el Sheikh, Egypt (S.V. Bogorodsky); **c** *Plectropomus marisrubri*, Sharm el Sheikh, Egypt (S.V. Bogorodsky); **d** *Pseudogramma megamyctera*, 5.8 cm SL, Eilat, Egypt (J.E. Randall); **e** *Chlidichthys rubiceps*, Al Wajh, Saudi Arabia (S.V. Bogorodsky); **f** *Pseudochromis fridmani*, Sharm el Moya, Egypt (S.V. Bogorodsky); **g** *Acanthoplesiops cappuccino*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **h** *Stalix davidsheni*, Gulf of Aqaba (D. Shen)

Sillago suezensis Golani et al. 2013, *Argyrops megalommatus* (Klunzinger 1870), *Parupeneus forsskali* (Fourmanoir and Guèzè 1976), *Heniochus intermedius* Steindachner 1893, *Pteragogus trispilus* Randall 2013, *Diplogrammus randalli* Fricke 1983, *Oxyurichthys petersii* (Klunzinger 1871), *Coryogalops ocheticus* (Norman 1927), *Silhouettea aegyptia* (Chabanaud 1933), *Siganus rivulatus* Forsskål 1775, *Cynoglossus sinusarabici* (Chabanaud 1931).

Eschmeyer et al. (2010) provided comprehensive data on history and discovery of marine fishes worldwide. These authors gave the number of endemic species as 159 (endemism rate 13.6%) but they combined coastal and deep-water species. DiBattista et al. (2015) summarised both published and unpublished data on Red Sea endemic species of fishes and invertebrates with an explanation of the phenomena of high endemism in the region. They also demonstrated that, among 33 selected endemic fishes, there were no major differences in species richness or abundance across 1100 km of the Saudi Arabian coastline. They reported a lower percentage of Red Sea endemic fishes than our present data: 12.9% for the entire Red Sea and 14.1% for the Red Sea combined with the Gulf of Aden. Their analysis, however, was based on shorefishes occurring in less than 200 m depth. Such a small inconsistency suggests that continuing research in the Red Sea is likely to reveal higher levels of endemism than previously thought. Ongoing

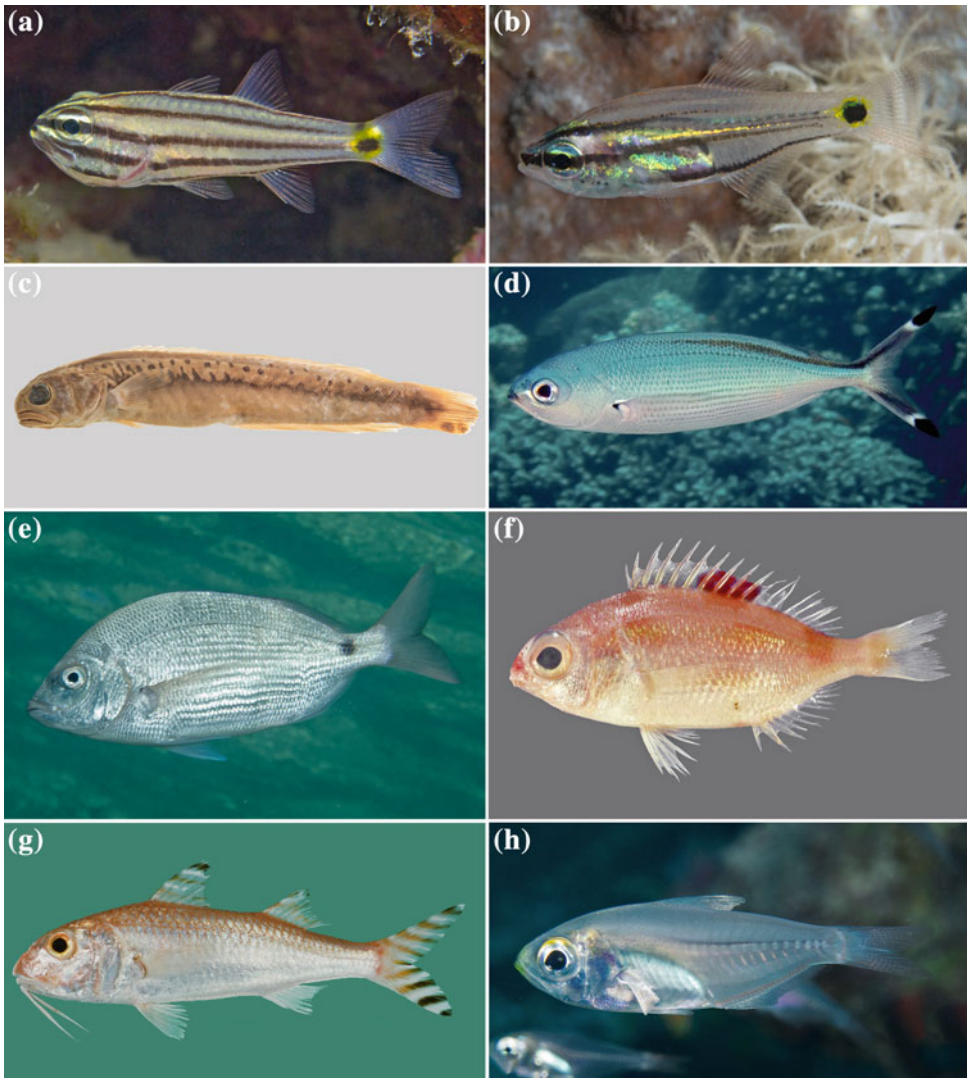

Fig. 14.4 Examples of Red Sea endemics. **a** *Cheilodipterus pygmaios*, Ras Mohammed, Egypt (S.V. Bogorodsky); **b** *Taeniamia bilineata*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **c** *Hoplolatilus oreni*, preserved holotype, 14 cm SL, Dahlak Archipelago (S. Raredon); **d** *Caesio suevica*, Elphistone Reef, Egypt (S.V. Bogorodsky); **e** *Diplodus noct*, Dahab, Egypt (S. V. Bogorodsky); **f** *Parascolopsis baranesi*, 10.5 cm SL, Eilat, Israel (D. Darom); **g** *Upeneus davidaromi*, 16.5 cm SL, Egypt, Gulf Aqaba (J.E. Randall); **h** *Paraprіacanthus sharm*, Ras Abu Galum, Egypt (S.V. Bogorodsky)

studies show about two percent more endemic species in the region than presently recorded (Bogorodsky, unpublished). Much of this is driven by modern molecular methods that reveal previously undetected or underappreciated differences in populations between regions.

Recent studies (Zajonz, unpublished) recorded about 160 species in 118 genera from depths ranging between 100 m and more than 1000 m; among them 46 species are typical deep-dwelling species never reported above 200 m. The number of endemic species in waters deeper than 200 m is extremely high in the Red Sea; among 46 species of deep-dwelling species belonging to 34 families, half are endemics—an endemism rate of 50%. The highest levels are found among the order Anguilliformes where there are eight Red Sea species of eels from four families; seven of these species are endemics to the Red Sea (Table 14.7). Two more potentially endemic species of Nettastomidae, described from the leptocephalus stage, *Nettenchelys bellottii* (D'Ancona 1928) and *Saurenchelys lateromaculata* (D'Ancona 1928) are not included in the Table 14.7 since adult specimens are needed for redescription. Eight deep-dwelling species are exclusively known from the Gulf of Aqaba. Hydrographic conditions in the deep zone of the Red Sea are exceptional with high temperatures for such depths of about 21.5 °C continuing down to its greatest depths. Meanwhile, the shallow sill at Bab-al-Mandab, its southern entrance, prevents primary deep-sea organisms from colonizing the Red Sea basin. This is the main reason for the higher level of endemism in deep waters compared to shallow-water fish assemblages.

Fish assemblages in the Gulf of Suez and Gulf of Aqaba differ from those of the main basin of the Red Sea, but they also differ significantly from each other. Species richness in the Gulf of Suez with its shallow and relatively turbid waters is lower than in the much deeper Gulf of Aqaba, where coral reefs prevail. At present seven species are known to be

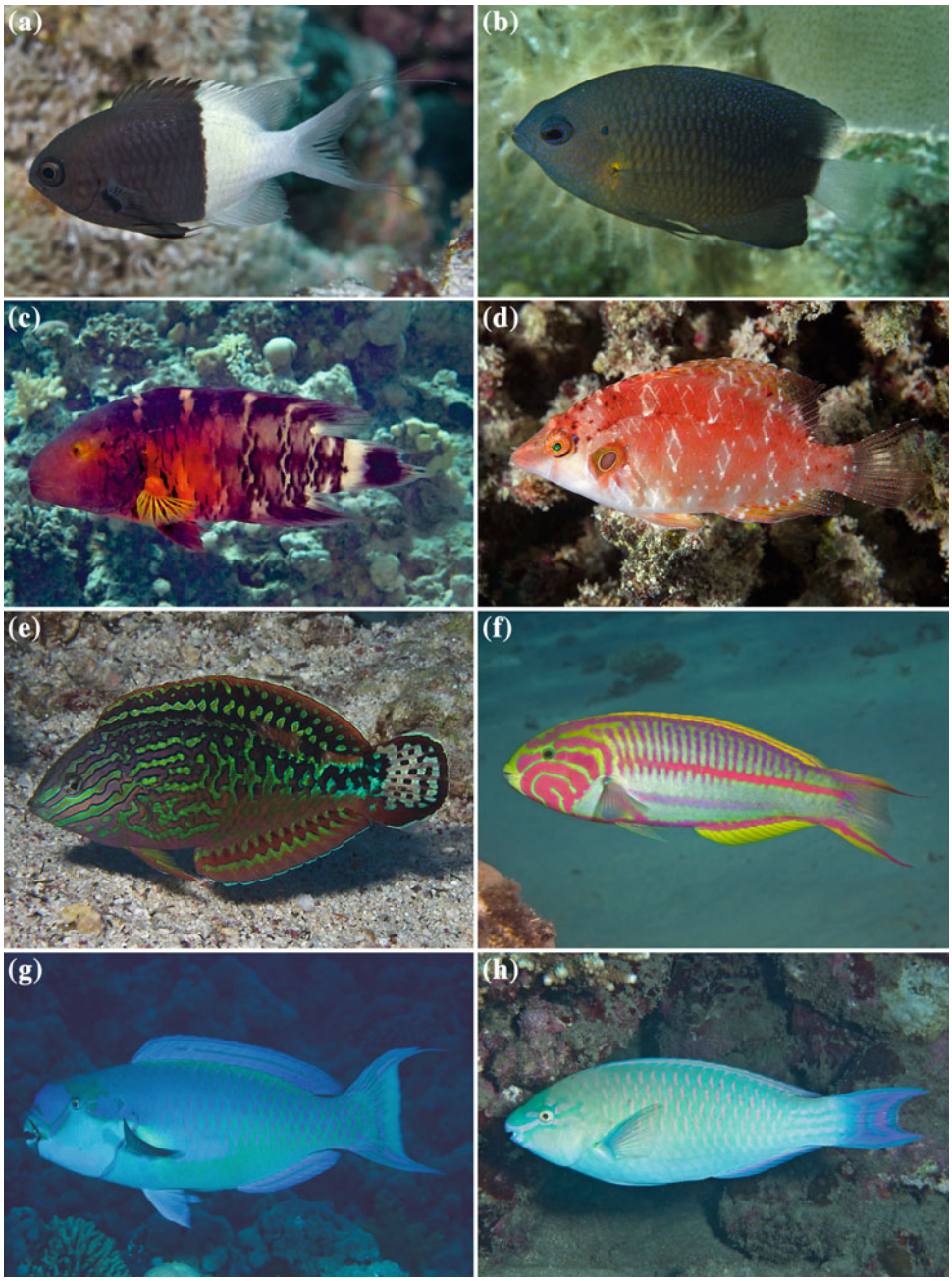

Fig. 14.5 Examples of Red Sea endemics. **a** *Chromis dimidiata*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **b** *Pomacentrus albicaudatus*, Towartit Reef, Sudan (J.E. Randall); **c** *Cheilinus quinquecinctus*, male, Sharm el Sheikh, Egypt (S.V. Bogorodsky); **d** *Pteragogus cryptus*, Jeddah, Saudi Arabia (H. Sjoeholm); **e** *Macropharyngodon marisrubri*, male, Dahab, Egypt (S.V. Bogorodsky); **f** *Thalassoma rueppellii*, male, Dahab, Egypt (S. V. Bogorodsky); **g** *Chlorurus gibbus*, male, Gulf of Aqaba (J.E. Randall); **h** *Scarus collana*, male, Lahami Bay, Egypt (S.V. Bogorodsky)

restricted to the Gulf of Suez: *Neenchelys microtretus* Bamber 1915, *Upeneus niebuhri* Guézé 1976, *Uranoscopus bauchotae* Brüss 1986, *Callionymus oxycephalus* Fricke 1980, *Diplogrammus gruveli* Smith 1963, *Cynoglossus cleopatridis* Chabanaud 1949, and *Cynoglossus dollfusi* (Chabanaud 1931). It is also noted that three other species were reported as endemics to the Gulf of Suez, however, the recently described species *Sillago suezensis* Golani et al. 2013 was collected by the first author from southern Saudi Arabia; *Ariomma dollfusi* (Chabanaud 1930) is a synonym of *A. indica* (Day 1871) according Parin and Piotrovsky (2004); and the status of *Cynoglossus pottii* Steindachner 1902 is uncertain because the description is brief and syntypes were not found by the first author in the NMW collection. The Gulf of Aqaba has fewer fish species recorded from 0 to 200 m than the main basin of the northern Red Sea with 22 endemic species thus far noted as restricted to its waters including neighboring areas Sharm el Moya and Ras Mohammed (Table 14.8). However, several fish species in the Gulf of Aqaba inhabit shallower waters than their counterparts in the main branch of the Red Sea. This may have resulted in a bias in distribution records (e.g., *Pseudanthias taeniatus* (Klunzinger 1884), *Apolemichthys xanthotis* (Fraser-Brunner 1950).

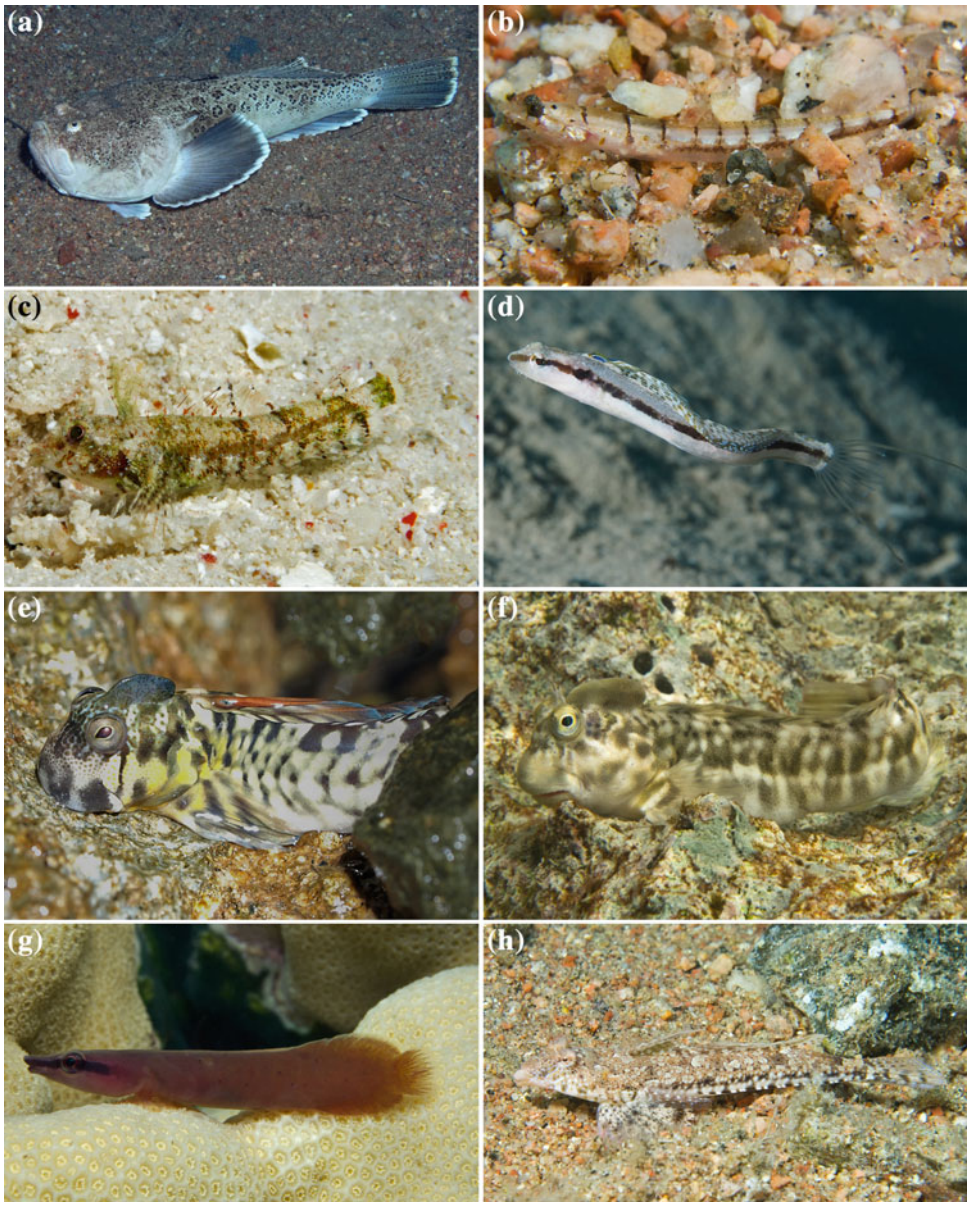

Fig. 14.6 Examples of Red Sea endemics. **a** *Uranoscopus rosette*, Dahab, Egypt (S.V. Bogorodsky); **b** *Limnichthys marisrubri*, Dahab, Egypt (S.V. Bogorodsky); **c** *Enneapterygius altipinnis*, Farasan Archipelago, Saudi Arabia (S.V. Bogorodsky); **d** *Adelotremus leptus*, male, Abu Dabab, Marsa Alam, Egypt (B. Hazes); **e** *Alticus magnusi*, male, Jeddah, Saudi Arabia (S.V. Bogorodsky); **f** *Istiblennius flaviumbrinus*, male, Farasan Island, Saudi Arabia (S.V. Bogorodsky); **g** *Lepadichthys erythraeus*, Sharm el Moya, Egypt (S.V. Bogorodsky); **h** *Diplogrammus paucispinis*, male, Dahab, Egypt (S.V. Bogorodsky)

Compared with other parts of the tropical Indo-Pacific bony fishes of the Red Sea are comparatively well documented but research on elasmobranch diversity within the Red Sea remains sparse despite recent work by several researchers (e.g., Baranes 2013; Spaet and Berumen 2015). Only 58 elasmobranchs (28 sharks and 30 rays) have thus far been recorded in the Red Sea and almost nothing is known about their population ecology, reproductive biology or resource partitioning. With only one shark species in the Red Sea studied extensively (*Iago omanensis* (Norman 1939)), information critical for elasmobranch management is almost totally lacking. Only two species of elasmobranch, Ben-Tuvia's Sleeper Ray *Heteronarce bentuviai* (Baranes and Randall 1989) and Suess' Torpedo Ray *Torpedo suessii* Steindachner 1898, are known as endemic species to the Red Sea. However, this, or a similar species of sleeper ray, was recently collected from the Gulf of Aden (Jabado et al. 2017). In contrast, 94 elasmobranchs (49 sharks and 45 rays) are reported when the Red Sea is combined with the Gulf of Aden (Bonfil and Abdallah 2004) and many of these species are confined to deep waters.

The distribution of most fish species within the Red Sea is still not well documented. Relevant information is largely restricted to selected taxa of coral-reef associated species (e.g., Pseudochromidae, Chaetodontidae). Coral reefs support the most diverse and complex fish assemblages of the Red Sea and most endemic species live in close association with coral reef habitats. The Red Sea may be hypothetically divided into a northern and central region, north of latitude 20°N, and a southern region south of this latitude. The

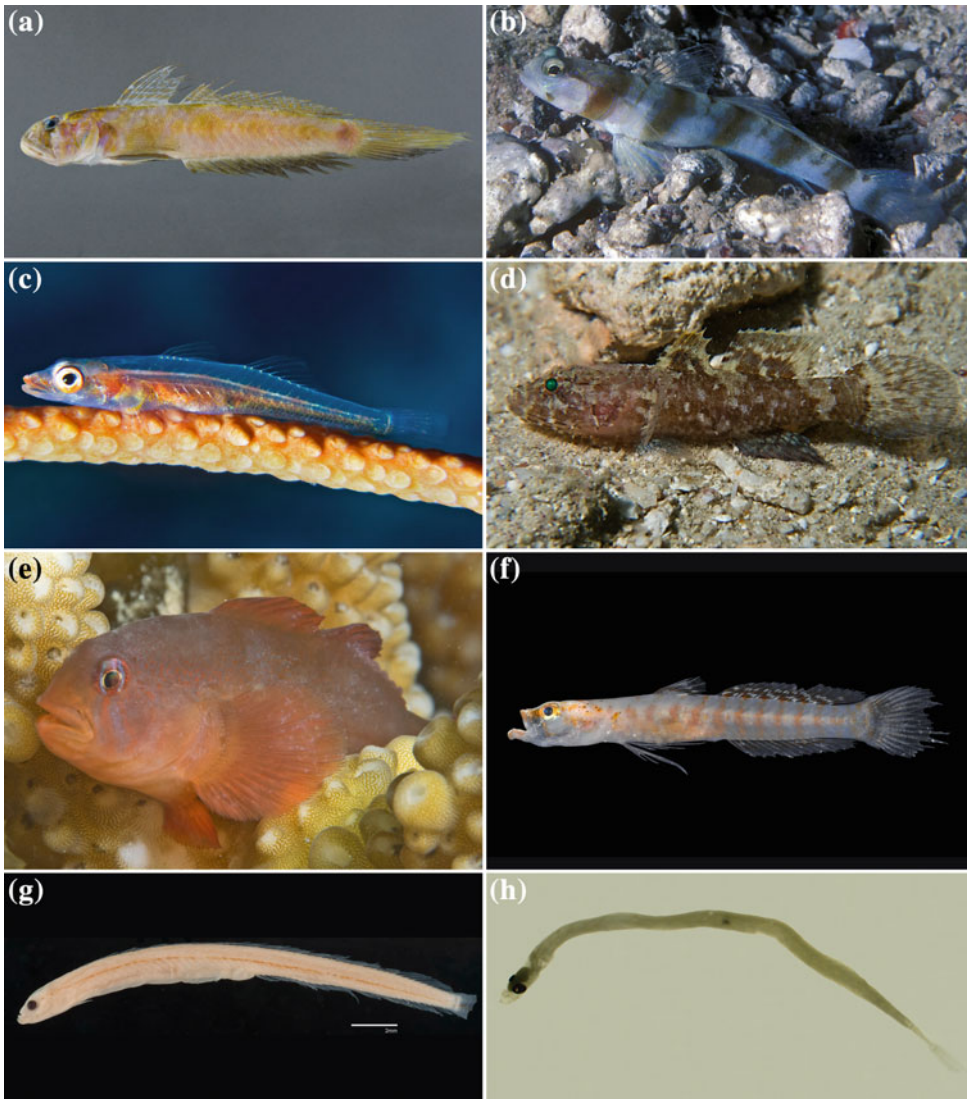

Fig. 14.7 Examples of Red Sea endemics. **a** *Oxyurichthys petersii*, male, 12.7 cm SL, Jizan, Saudi Arabia (S.V. Bogorodsky); **b** *Amblyeleotris neglecta*, Eilat, Isreal (J.E. Randall); **c** *Bryaninops discus*, Dahab, Egypt (S.V. Bogorodsky); **d** *Callogobius pilosimentum*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **e** *Gobiodon irregularis*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **f** *Gymnoxenisthmus tigrellus*, 1.5 cm SL, Farasan Archipelago, Saudi Arabia (S. Traenkner); **g** *Paragunnellichthys springeri*, preserved holotype, 2.2 cm SL, Sharm el Moya, Egypt (S. Raredon); **h** *Schindleria elongata*, holotype, 1.14 cm SL, Magawish I, Egypt (M. Abu Al-Regal)

species composition and abundance can be loosely correlated to this subdivision, with some species far more common in the northern and central Red Sea (e.g., *Pseudanthias squamipinnis* (Peters 1855)), whilst others are more abundant in the southern part (e.g., *Neopomacentrus cyanomos* (Bleeker 1856)), and some are entirely absent from one or the other region. This may partly be attributed to differences in reef development and distribution of coral species, or due to ecological conditions with the southern region being far more turbid than most areas to the north which tend to drop off quickly into very deep water. However, the distribution of endemic Red Sea species, even within the same genus cannot be simply explained. A typical example is provided by the distribution of dottybacks *Pseudochromis*, with some species (e.g., *Pseudochromis pesi* Lubbock 1975) restricted to the northern Red Sea whereas other species (e.g., *Pseudochromis sankeyi* Lubbock 1975) are restricted to the southern part. For some of these restricted range endemics gaps in available preferred microhabitat may account for this.

Red Sea endemic fishes can be divided formally into two groups: free-swimming fishes usually living in areas close to coral reefs and a group of benthic fishes usually living in crevices within coral reefs. Most species of the latter group are known from relatively few specimens due to their cryptic habitat and are usually collected with use of an ichthyocide.

The proportion of endemism among Red Sea fishes per family varies from 0 to 100%. High levels of endemism, exceeding 20% (when the Red Sea and Gulf of Aqaba are combined) are found among 23 families of coastal fishes: Congridae (42.8%), Atherinidae (75%), Aploactinidae (50%), Serranidae (20%), Pseudochromidae (83.3%), Opistognathidae (66.7%), Apogonidae (21.7%), Sillaginidae (50%), Chaetodontidae (23.5%), Pomacentridae (23.5%), Labridae (23%), Uranoscopidae (66.7%), Tripterygiidae (41.7%), Blenniidae (37.5%), Gobiesocidae (50%),

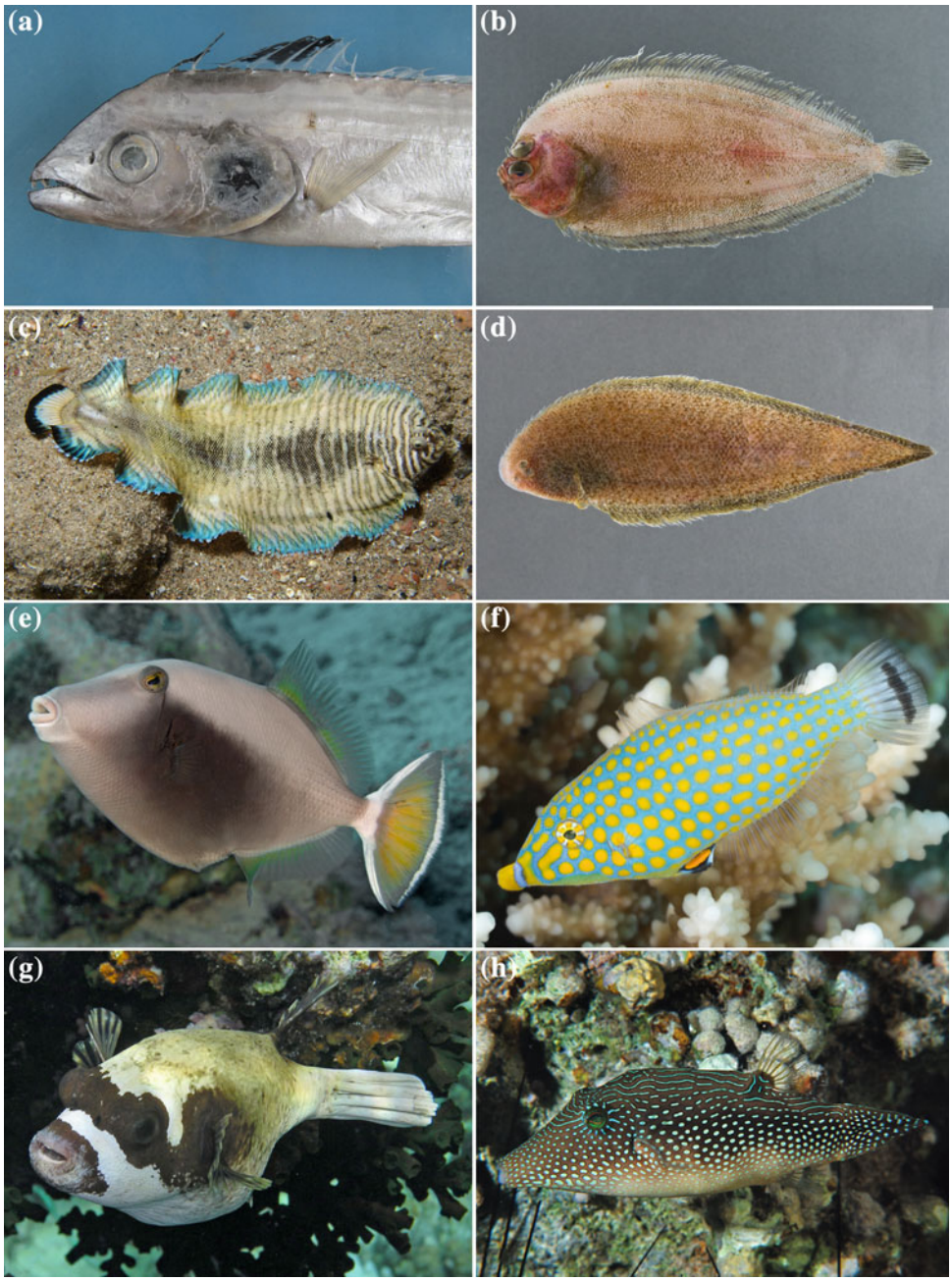

Fig. 14.8 Examples of Red Sea endemics. **a** *Evoxymetopon moricheni*, head close-up, 83 cm SL, Eilat, Israel (D. Golani); **b** *Laeops sinusarabici*, 10.2 cm SL, Jizan, Saudi Arabia (S.V. Bogorodsky); **c** *Soleichthys dori*, Dahab, Egypt (S.V. Bogorodsky); **d** *Cynoglossus sinusarabici*, 10.7 cm SL, Jizan, Saudi Arabia (S.V. Bogorodsky); **e** *Sufflamen albicaudatum*, female, Dahab, Egypt (S.V. Bogorodsky); **f** *Oxymonacanthus halli*, Marsa Alam, Egypt (A. Golubev); **g** *Arothron diadematus*, Sharm el Sheikh, Egypt (S.V. Bogorodsky); **h** *Canthigaster margaritata*, Gulf of Aqaba (J.E. Randall)

Callionymidae (46.1%), Gobiidae (25.2%), Xenisthmidae (50%), Schindleriidae (100%), Soleidae (71.4%), Cynoglossidae (50%), Monacanthidae (41.7%), and Tetraodontidae (23.1%). Furthermore, only a few Red Sea endemics are commercially important species. Examples include *Etrumeus golanii* DiBattista et al. 2012 (Clupeidae), *Planiliza carinata* (Valenciennes 1836) (Mugilidae) and *Argyrops megalommatus* (Klunzinger 1870) (Sparidae) from the northern Red Sea, the parrotfish *Scarus collana* Rüppell 1835 (Scaridae), and the grouper *Plectropomus marisrubri* Randall and Hoese 1986 (Serranidae) which is the most valuable species occurring there.

Several species continue to be considered as endemic species to the Red Sea despite being reported outside of the Red Sea: *Synodus randalli* Cressey 1981 was listed by Fricke et al. (2018) from Madagascar without a description of the specimen: the authors omitted another species from Madagascar *S. vityazi* Ho et al. 2010; Allen and Erdmann (2012) reported *Pseudogramma megamyctera* Randall and Baldwin 1997 from the West Papua, Indonesia, but the record is probably represented by an undescribed species; records of *Pteragogus cryptus* Randall 1981 from the Indo-West Pacific belong to an undescribed species (Randall 2013); a record of *Enneapterygius obscurus* Clark 1980

Table 14.4 List of endemic species of the Red Sea combined with the Gulf of Aden, including Socotra (51 species = 4.6%)

Clupeidae- *Herklotsichthys punctatus* (Rüppell 1837)
Hemiramphidae- *Hyporhamphus gamberur* (Rüppell 1837)
Holocentridae- *Myripristis xanthacra* Randall and Guèzè 1981
Syngnathidae- *Siokunichthys bentuviai* Clark 1966
Platycephalidae- *Thysanophrys springeri* Knapp 2013
Serranidae- *Cephalopholis oligosticta* Randall and Ben-Tuvia 1983
Serranidae- *Pseudanthias heemstrai* Schuhmacher, Krupp and Randall 1989
Serranidae- *Epinephelus geoffroyi* (Klunzinger 1870)
Serranidae- *Epinephelus summana* (Forsskål 1775)
Serranidae- *Diploprion drachi* Roux-Estève 1955
Pseudochromidae- *Pseudochromis flavivertex* Rüppell 1835
Pseudochromidae- *Pseudochromis sankeyi* Lubbock 1975
Apogonidae- *Lepidamia multitaeniata* (Cuvier 1828)
Apogonidae- *Nectamia annularis* (Rüppell 1829)
Apogonidae- *Nectamia zebrinus* (Fraser, Randall and Lachner 1999)
Apogonidae- *Rhabdamia nigrimentum* (Smith 1961)
Apogonidae- *Zapogon isus* (Randall and Böhlke 1981)
Epigonidae- *Epigonus marisrubri* Krupp, Zajonz and Khalaf 2009+Somalia
Caesionidae- *Caesio striata* Rüppell 1830
Haemulidae- *Diagramma punctata* Cuvier 1830 (see Zajonz et al. unpubl)
Mullidae- *Parupeneus forsskali* (Fourmanoir and Guèzè 1976)
Pempheridae- *Pempheris flavicycla marisrubri* Randall, Bogorodsky and Alpermann 2013
Chaetodontidae- *Chaetodon fasciatus* Forsskål 1775
Chaetodontidae- *Chaetodon mesoleucos* Forsskål 1775
Chaetodontidae- *Chaetodon paucifasciatus* Ahl 1923
Chaetodontidae- *Heniochus intermedius* Steindachner 1893
Pomacentridae- *Amphiprion bicinctus* Rüppell 1830
Pomacentridae-*Amblyglyphidodon flavilatus* Allen and Randall 1980
Pomacentridae- *Chromis trialpha* Allen and Randall 1980
Pomacentridae-*Neopomacentrus xanthurus* Allen and Randall 1980
Pomacentridae- *Pristotis cyanostigma* Rüppell 1838
Labridae- *Cheilinus abudjubbe* Rüppell 1835
Labridae- *Larabicus quadrilineatus* (Rüppell 1835)
Labridae- *Oxycheilinus mentalis* (Rüppell 1828)
Labridae- *Paracheilinus octotaenia* Fourmanoir 1955 (see Zajonz et al. unpubl)
Scaridae- *Chlorurus genazonatus* (Randall and Bruce 1983)
Trichonotidae- *Trichonotus nikii* Clark and von Schmidt 1966
Pinguipedidae- *Parapercis simulata* Schultz 1968
Blenniidae- *Meiacanthus nigrolineatus* Smith-Vaniz 1969
Blenniidae- *Alloblennius pictus* (Lotan 1969)
Blenniidae- *Ecsenius dentex* Springer 1988
Blenniidae- *Ecsenius frontalis* (Valenciennes 1836)
Blenniidae- *Ecsenius gravieri* (Pellegrin 1906)
Gobiidae- *Koumansetta hoesei* Kovačić et al. 2018
Gobiidae- *Trimma avidori* (Goren 1978)
Gobiidae- *Trimma flavicaudatum* (Goren 1982)

(continued)

Table 14.4 (continued)

Gobiidae-*Trimma mendelssohni* (Goren 1978)
Siganidae- *Siganus rivulatus* Forsskål 1775
Siganidae- *Siganus stellatus* Forsskål 1775
Acanthuridae- *Acanthurus gahhm* Forsskål 1775
Monacanthidae- *Pervagor randalli* Hutchins 1986

from the Maldives by Fricke and Randall (1992) should be confirmed; *Bryaninops discus* Suzuki et al. 2012 was originally described from the Red Sea and Gulf of Aden but the record from the latter locality is based on misidentification of *Bryaninops yongei* (Davis and Cohen 1969) (Suzuki and Bogorodsky, in prep.); *Callogobius dori* Goren 1980 was reported by Delventhal et al. (2016) from the Seychelles, however, more material is needed for confirmation; *Canthigaster margaritata* (Rüppell 1829) is reported by some authors from the Indian Ocean (e.g., Fricke et al. 2018) but

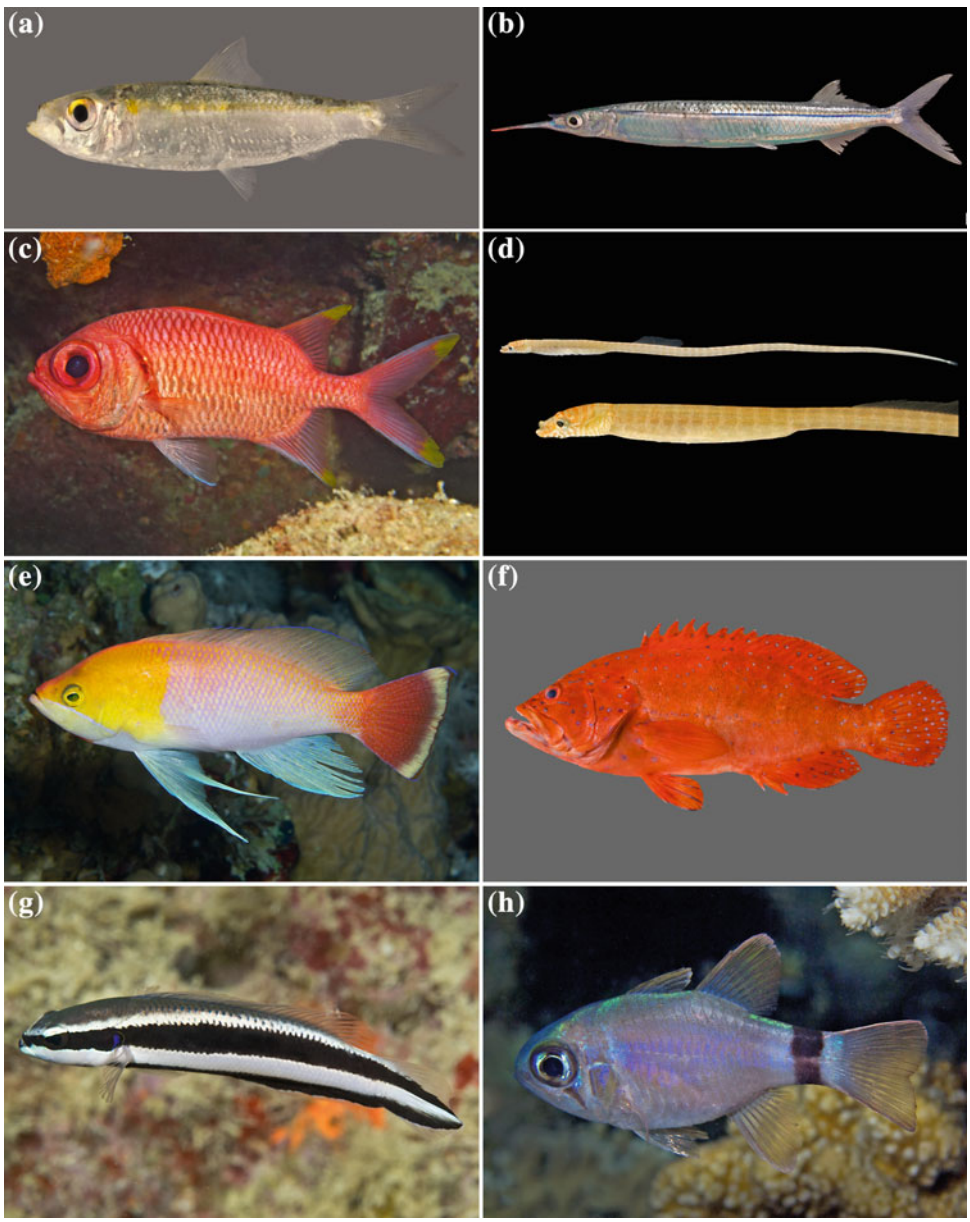

Fig. 14.9 Examples of species restricted to the Red Sea and Gulf of Aden **a** *Herklotsichthys punctatus*, 7.8 cm SL, Farasan Island, Saudi Arabia (S.V. Bogorodsky); **b** *Hyporhamphus gamberur,* 22.1 cm SL, Hurghada, Egypt (S.V. Bogorodsky); **c** *Myripristis xanthacra*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **d** *Siokunichthys bentuviai*, 5.5 cm SL, Al Lith, Saudi Arabia (S.V. Bogorodsky); **e** *Pseudanthias heemstrai*, male, Dahab, Egypt (S.V. Bogorodsky); **f** *Cephalopholis oligosticta*, 23 cm SL, Al Lith, Saudi Arabia (S.V. Bogorodsky); **g** *Pseudochromis sankeyi*, Farasan Archipelago, Saudi Arabia (S.V. Bogorodsky); **h** *Nectamia annularis*, Sharm el Moya, Egypt (S.V. Bogorodsky)

Fig. 14.10 Examples of species restricted to the Red Sea and Gulf of Aden **a** *Diagramma picta punctata*, Lahami Bay, Egypt (S. V. Bogorodsky); **b** *Caesio striata*, Gulf of Aqaba (J.E. Randall); **c** *Parupeneus forsskali*, Shams Alam, Egypt (S.V. Bogorodsky); **d** *Pempheris flavicycla marisrubri*, Foary Shoals, Egypt (S.V. Bogorodsky); **e** *Chaetodon fasciatus*, Mangrove Bay, El Quseir, Egypt (S.V. Bogorodsky); **f** *Heniochus intermedius*, Lahami Bay, Egypt (S.V. Bogorodsky); **g** *Amphiprion bicinctus*, Lahami Bay, Egypt (S.V. Bogorodsky); **h** *Neopomacentrus xanthurus*, Port Sudan, Sudan (J.E. Randall)

records are based on misidentification of *C. petersii* (Bianconi 1854) (see Allen and Erdmann 2012), specimens from the Gulf of Aden are needed for positive identification.

Five Red Sea families of eels belong to the group of benthic fishes and comprise 64 species; only three species of morays (Muraenidae) and three snake eels (Ophichthidae) are endemics whereas three of seven species (42.8%) of the family Congridae are endemics. For other families of benthic fishes attention is drawn to stargazers (Uranoscopidae), triplefins (Tripterygiidae), blennies (Blenniidae), dragonets (Callionymidae), gobies (Gobiidae), collared wrigglers (Xenisthmidae), soles (Soleidae), and tonguefishes (Cynoglossidae). In each of these families there are genera that exhibit high levels of endemism; in the Uranoscopidae for example, of six Red Sea species of *Uranoscopus* four are endemics; in the Tripterygiidae of the nine Red Sea species of *Enneapterygius* five are endemics; in the Blenniidae both species of *Alloblennius*, four of five Red Sea *Ecsenius*, and three of five Red Sea *Istiblennius* are endemics; in the Callionymidae of four species of *Diplogrammus* three are endemics; in the Gobiidae four of five Red Sea *Coryogalops*, three of five Red Sea *Hetereleotris*, and seven of nine Red

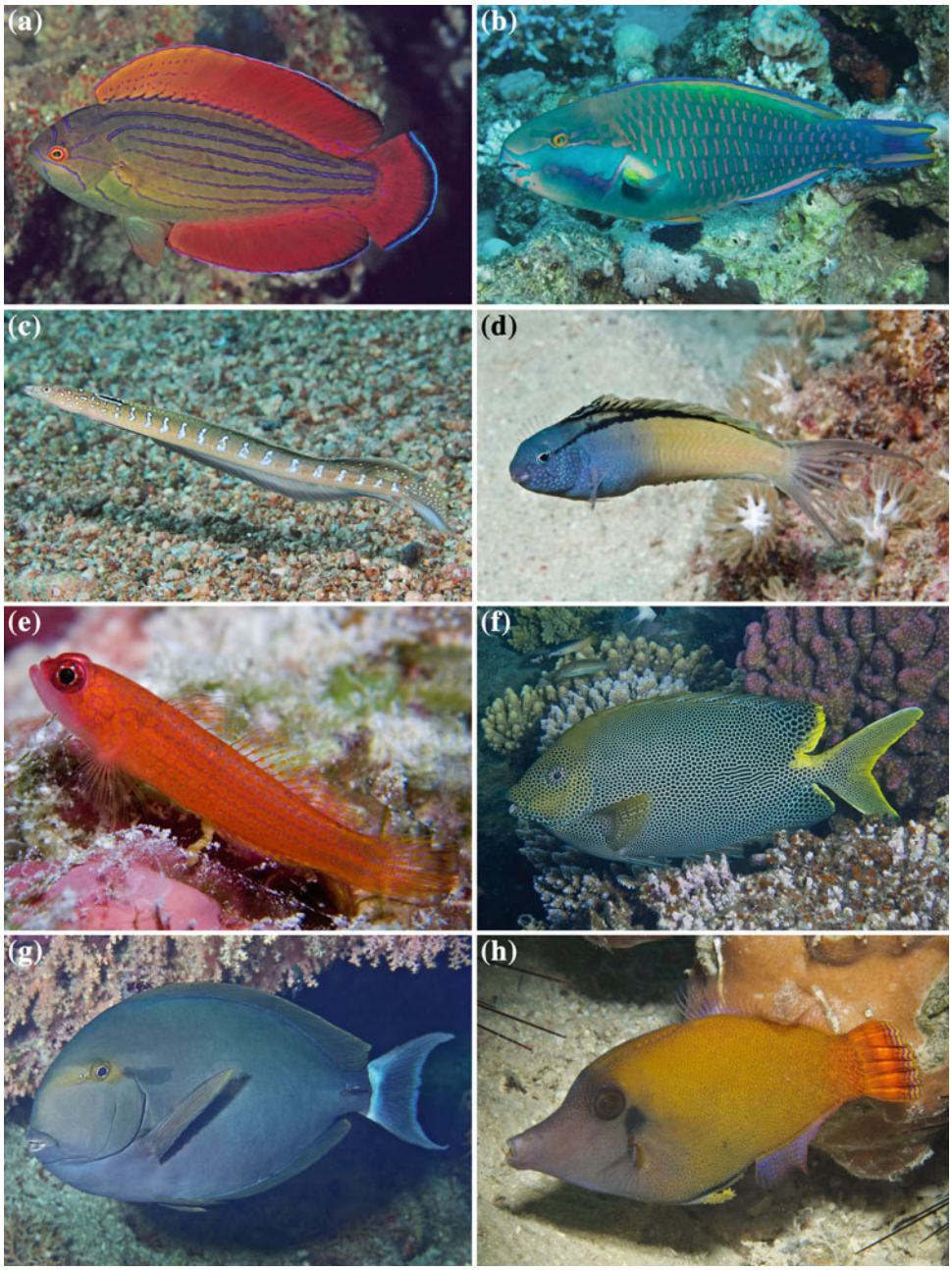

Fig. 14.11 Examples of species restricted to the Red Sea and Gulf of Aden **a** *Paracheilinus octotaenia*, male, Gulf of Aqaba (J.E. Randall); **b** *Chlorurus genazonatus*, male, Dahab, Egypt (S.V. Bogorodsky); **c** *Trichonotus nikii*, male, Dahab, Egypt (S.V. Bogorodsky); **d** *Meiacanthus nigrolineatus*, Jeddah, Saudi Arabia (S.V. Bogorodsky); **e** *Trimma avidori*, Shaab Suedi, Sudan (S.V. Bogorodsky); **f** *Siganus stellatus*, Shams Alam, Egypt (S.V. Bogorodsky); **g** *Acanthurus gahhm*, Foary Shoals, Egypt (S. V. Bogorodsky); **h** *Pervagor randalli*, Farasan Archipelago, Saudi Arabia (S.V. Bogorodsky)

Sea *Trimma* are endemics; in the Xenisthmidae one or two of three species of *Xenisthmus* are endemics (based on unpublished data it is likely that the widespread *Xenisthmus polyzonatus* (Klunzinger 1871) is the Red Sea endemic); in the Soleidae all four species of *Aseraggodes* are Red Sea endemics; and in the Cynoglossidae three of five Red Sea *Cynoglossus* are endemics.

Among free-swimming fishes the family Pseudochromidae is particularly interesting with the genus *Pseudochromis* demonstrating an example of high endemism; seven of eight species of the genus are endemics. The largest families of this group are Apogonidae with 13 endemic among its 60 Red Sea species; Pomacentridae with eight of 34 Red Sea species, and Labridae with 15 of 65 Red Sea species. A few genera have two (*Taeniamia* in Apogonidae, *Cheilinus* in Labridae) or three (*Chromis* in Pomacentridae, *Pteragogus* in Labridae) species whereas other genera contain a single endemic species.

Small schooling silversides (Atherinidae) are also interesting. It was formerly considered that all Red Sea species of silversides are widespread until Japanese researchers (Kimura et al. 2007; Sasaki and Kimura 2014) confirmed the presence of four species from the Red Sea (one of them an endemic species of *Atherinomorus* and two endemic species of *Hypoatherina*).

Of the 17 butterflyfish (Chaetodontidae) species present in the Red Sea none is truly endemic. It is only when the Red

Table 14.5 List of species that have migrated from the Red Sea to the Mediterranean Sea via the Suez Canal (106 species =9.2%)

Glaucostegus halavi (Forsskål 1775)
Himantura uarnak (Forsskål 1775)
Gymnothorax reticularis Bloch 1795
Rhynchoconger trewavasae Ben-Tuvia 1993
Muraenesox cinereus (Forsskål 1775)
Dussumieria elopsoides Bleeker 1849
Etrumeus golanii DiBattista, Randall and Bowen 2012[a]
Herklotsichthys punctatus (Rüppell 1837)[a]
Sardinella gibbosa Bleeker 1849
Spratelloides delicatulus (Bennett 1832)
Encrasicholina gloria Hata and Motomura 2016
Stolephorus indicus (van Hasselt 1823)
Stolephorus insularis Hardenberg 1933 (unknown from Red Sea)
Chanos chanos (Forsskål 1775)
Plotosus lineatus (Thunberg 1787)
Saurida lessepsianus Russell, Golani and Tikochinski 2015
Planiliza carinata (Valenciennes 1836)[a]
Atherinomorus forskalii (Rüppell 1838)[a]
Tylosurus choram (Rüppell 1837)
Hemiramphus far (Forsskål 1775)
Hyporhamphus affinis (Günther 1866)
Parexocoetus mento (Valenciennes 1847)
Sargocentron rubrum (Forsskål 1775)
Fistularia commersonii Rüppell 1838
Fistularia petimba Lacepède 1803
Hippocampus fuscus Rüppell 1838
Pterois miles (Bennett 1828)
Synanceia verrucosa Bloch and Schneider 1801
Papilloculiceps longiceps (Cuvier 1829)
Platycephalus indicus (Linnaeus 1758)
Sorsogona prionota (Sauvage 1873)
Epinephelus areolatus (Forsskål 1775)
Epinephelus coioides (Hamilton 1822)
Epinephelus fasciatus (Forsskål 1775)
Epinephelus geoffroyi (Klunzinger 1870)[a]
Epinephelus malabaricus (Bloch and Schneider 1801)
Pelates quadrilineatus (Bloch 1790)
Terapon jarbua (Forsskål 1775)
Terapon puta Cuvier 1829
Terapon theraps Cuvier 1829
Priacanthus sagittarius Starnes 1988
Apogonichthyoides pharaonis (Bellotti 1874)
Cheilodipterus novemstriatus (Rüppell 1838)
Jaydia queketti (Gilchrist 1903)
Jaydia smithi Kotthaus 1970
Ostorhinchus quadrifaciatus Cuvier 1828

(continued)

Table 14.5 (continued)

Sillago suezensis Golani, Fricke and Tikochinski 2013[a]
Alepes djedaba (Forsskål 1775)
Decapterus russelli (Rüppell 1830)
Trachurus indicus Nekrasov 1966
Equulites klunzingeri (Steindachner 1898)
Equulites popei (Whitley 1932)
Lutjanus argentimaculatus (Forsskål 1775)
Lutjanus fulviflamma (Forsskål 1775)
Dipterygonotus balteatus (Valenciennes 1830)
Pomadasys stridens (Forsskål 1775)
Acanthopagrus bifasciatus (Forsskål 1775)
Argyrops megalommatus (Klunzinger 1870)[a]
Crenidens crenidens (Forsskål 1775)
Rhabdosargus haffara (Forsskål 1775)
Monotaxis grandoculis (Forsskål 1775)
Nemipterus randalli Russell 1986
Parupeneus forsskali (Fourmanoir and Guèzè 1976)[a]
Upeneus moluccensis (Bleeker 1855)
Upeneus pori Ben-Tuvia and Golani 1989
Pempheris rhomboidea Kossmann and Räuber 1877
Chaetodon austriacus Rüppell 1836
Chaetodon larvatus Cuvier 1831
Heniochus intermedius Steindachner 1893[a]
Pomacanthus imperator (Bloch 1787)
Pomacanthus maculosus (Forsskål 1775)
Abudefduf vaigiensis (Quoy and Gaimard 1825)
Iniistius pavo (Valenciennes 1840)
Pteragogus trispilus Randall 2013[a]
Scarus ghobban Forsskål 1775
Champsodon nudivittis (Ogilby 1895)
Champsodon vorax Günther 1867 (unknown from Red Sea)
Omobranchus punctatus (Valenciennes 1836) (unknown from Red Sea)
Petroscirtes ancylodon Rüppell 1835
Callionymus filamentosus Valenciennes 1837 (but see *C. haifae* Fowler and Steinitz 1956)
Diplogrammus randalli Fricke 1983[a]
Synchiropus sechellensis Regan 1908
Trypauchen vagina (Bloch and Schneider 1801) (unknown from Red Sea)
Oxyurichthys petersii (Klunzinger 1871)[a]
Coryogalops ocheticus (Norman 1927)[a]
Cryptocentrus caeruleopunctatus (Rüppell 1830)
Hetereleotris vulgaris (Klunzinger 1871)
Papillogobius melanobranchus (Fowler 1934)
Silhouettea aegyptia (Chabanaud 1933)[a]
Vanderhorstia mertensi Klausewitz 1974
Platax teira (Forsskål 1775)

(continued)

Table 14.5 (continued)

Siganus luridus (Rüppell 1829)
Siganus rivulatus Forsskål 1775[a]
Sphyraena chrysotaenia Klunzinger 1884
Sphyraena obtusata Cuvier 1829
Scomberomorus commerson (Lacepède 1800)
Cynoglossus sinusarabici (Chabanaud 1931)[a]
Stephanolepis diaspros Fraser-Brunner 1940
Ostracion cubicus Linnaeus 1758
Tetrosomus gibbosus (Linnaeus 1758)
Lagocephalus guentheri Miranda-Ribeiro 1915
Lagocephalus sceleratus (Gmelin 1789)
Lagocephalus suezensis Clark and Gohar 1953
Torquigener flavimaculosus Hardy and Randall 1983
Tylerius spinosissimus (Regan 1908)
Cyclichthys spilostylus (Leis and Randall 1982)

[a]Endemic species

Sea is combined with the Gulf of Aden that four species are considered endemics. Another six species have a Middle East distribution, also occurring in Oman and the Arabian Gulf, whilst the seven remaining species have a widespread Indo-West Pacific range.

Another group with interesting endemic species is the family of filefishes (Monacanthidae) in which each of five Red Sea endemic species is replaced by a closely related species in the Indo-West Pacific.

There are no endemic families in the Red Sea but five genera are endemics: *Suculentophichthus* from the family Ophichthidae, *Pectinochromis* from Pseudochromidae, *Larabicus* and *Minilabrus* from Labridae, and *Gymnoxenisthmus* from Xenisthmidae.

Several families contain 100% endemics but these families are generally represented by a single species reported from the Red Sea: for example, *Heteronarce bentuviai* (Narkidae) known from the Gulf of Aqaba only; *Barchatus cirrhosa* (Klunzinger 1871) (Batrachoididae) confined to the northern Red Sea; *Aphanius dispar* (Rüppell 1829) (Cyprinodontidae) broadly distributed in shallow large lagoons or brackish waters (but Freyhof et al. (2017) showed that probably three Red Sea endemic species apply to the name *A. dispar*); *Liparis fishelsoni* Smith 1968 (Liparidae) known from a single specimen from the Dahlak Archipelago; *Symphysanodon disii* Khalaf and Krupp 2008 (Symphysanodontidae) endemic to the Gulf of Aqaba; *Emmelichthys marisrubri* Fricke et al. 2014 (Emmelichthyidae) known

Table 14.6 List of species that have migrated from the Mediterranean Sea to the Red Sea via the Suez Canal (12 species = 1.0%)

Muraena helena Linnaeus 1758
Engraulis encrasicolus (Linnaeus 1758)
Planiliza aurata (Risso 1810)
Dicentrarchus labrax (Linnaeus 1758)
Dicentrarchus punctatus (Bloch 1792)
Serranus cabrilla (Linnaeus 1758)
Sparus aurata Linnaeus 1758
Argyrosomus regius (Asso y del Rio 1801)
Uranoscopus scaber Linnaeus 1758
Gobius cobitis Pallas 1811
Gobius paganellus Linnaeus 1758
Solea aegyptiaca Chabanaud 1927

Table 14.7 List of endemic species living deeper than 200 m (22 species = 50%)

Synaphobranchidae- *Dysomma alticorpus* Fricke, Golani, Appelbaum-Golani and Zajonz 2018 (Gulf of Aqaba)
Synaphobranchidae- *Dysomma fuscoventralis* Karrer and Klausewitz 1982
Congridae- *Rhynchoconger trewavasae* Ben-Tuvia 1993
Congridae- *Uroconger erythraeus* Castle 1982
Nettastomatidae- *Facciolella karrerae* Klausewitz 1995
Nettastomatidae- *Saurenchelys meteori* Klausewitz and Zajonz 2000
Sternoptychidae- *Maurolicus mucronatus* Klunzinger 1871
Phosichthyidae- *Vinciguerria mabahiss* Johnson and Feltes 1984 (Gulf of Aqaba)
Synodontidae- *Harpadon erythraeus* Klausewitz 1983
Synodontidae- *Saurida golanii* Russell 2011 (Gulf of Aqaba)
Moridae- *Physiculus marisrubri* Brüss 1986
Trachichthyidae- *Hoplostethus marisrubri* Kotlyar 1986
Holocentridae- *Ostichthys sufensis* Golani 1984 (Gulf of Aqaba)
Tetrarogidae- *Neocentropogon mesedai* Klausewitz 1985
Triglidae- *Pterygotrigla spirai* Golani and Baranes 1997 (Gulf of Aqaba)
Serranidae- *Plectranthias klausewitzi* Zajonz 2006
Sciaenidae- *Atrobucca geniae* Ben-Tuvia and Trewavas 1987 (Gulf of Aqaba)
Callionymidae- *Callionymus profundus* Fricke and Golani 2013 (Gulf of Aqaba)
Gobiidae- *Obliquogobius turkayi* Goren 1992
Gobiidae- *Priolepis goldshmidtae* Goren and Baranes 1995 (Gulf of Aqaba)
Bothidae- *Arnoglossus marisrubri* Klausewitz and Schneider 1986
Cynoglossidae- *Cynoglossus crepida* Fricke, Golani and Appelbaum-Golani 2017 (Gulf of Aqaba)

Table 14.8 List of species endemic to the Gulf of Aqaba (22 species species = 10.2% of endemic species when Gulf of Aden is combined)

Heteronarce bentuviai (Baranes and Randall 1989)
Uropterygius genie Randall and Golani 1995[a]
Uropterygius golanii McCosker and Smith 1997[a]
Gymnothorax baranesi Smith, Brokovich and Einbinder 2008
Mixomyrophis longidorsalis Hibino, Kimura and Golani 2014
Suculentophichthus nasus Fricke, Golani and Appelbaum-Golani 2015
Syngnathus safina Paulus 1992
Symphysanodon disii Khalaf and Krupp 2008
Pseudogramma megamyctera Randall and Baldwin 1997
Stalix davidsheni Klausewitz 1985
Gymnapogon melanogaster Gon and Golani 2002
Parascolopsis baranesi Russell and Golani 1993
Upeneus davidaromi Golani 2001
Chromis pelloura Randall and Allen 1982
Limnichthys marisrubri Fricke and Golani 2012
Amblyeleotris neglecta Jaafar and Randall 2009
Cabillus nigrostigmus Kovačić and Bogorodsky 2013
Tomiyamichthys dorsostigma Bogorodsky, Kovačić and Randall 2011
Vanderhorstia opercularis Randall 2007
Paragunnellichthys springeri Dawson 1970[a]
Evoxymetopon moricheni Fricke, Golani and Applebaum-Golani 2014
Thamnaconus erythraeensis Bauchot and Maugè 1978

[a]Formally considered endemic to the Gulf of Aqaba but also known from Sharm el Moya and Ras Mohammed, close to entrance of the Gulf of Aqaba

from a few specimens collected in Eritrea; and *Limnichthys marisrubri* Fricke and Golani 2012 (Creediidae) endemic to the Gulf of Aqaba.

An exception to the single species rule mentioned above is the wide-ranging pelagic neotenic gobioid family Schindleriidae where all three known Red Sea species of *Schindleria* are endemics restricted to the northern sector of the Red Sea, including an undescribed species which we believe to be endemic. It should be noted, however that these minute fishes are severely under sampled as well as under studied. Prior to the development of modern genetic techniques, only two widespread species were recognized; since then as many as 21 cryptic undescribed species from a single location have been distinguished genetically (Kon et al. 2011).

In families where more than ten Red Sea species are represented by endemics, the highest rate of endemism has been recorded in Pseudochromidae, where ten of 12 species are endemic (i.e. 83.3%). Four other large families with more than ten endemics are present in the Red Sea but their rate of endemism is less than 50% because the families also contain species with a broad distribution: Apogonidae with 13 species, Labridae with 15 species, Blenniidae with 15 species, Gobiidae with 36 species.

Interestingly, among the Ophidiiformes, with nine Red Sea species, and the Lophiiformes, also with nine species, there are no endemics. In addition, it should be noted that genetic analysis is playing an increasingly important role in fish taxonomy. For example, when two species from the family Pempheridae, *Parapriacanthus guentheri* (Klunzinger 1871) and *Pempheris rhomboidea* Kossmann and Räuber 1877 (both of which were originally described from the Red Sea) appeared to be endemics, genetic analysis revealed a broader distribution of these species in the western Indian Ocean (Bogorodsky, unpublished). Seven species of *Pempheris* (*P. orbis*, *P. sergey*, *P. shirleen*, *P. tau*, *P. tilman*, *P. tiran*, and *P. viridis*) were described from the Red Sea by Randall and Victor (2015) but their validity awaits further confirmation following preliminary genetic analysis of available specimens that did not demonstrate divergence. Some species described from the Red Sea as endemics (e.g., *Saurida lessepsianus* Russell et al. 2015, *Hippocampus fuscus* Rüppell 1838, *Cheilodipterus lachneri* Klausewitz 1959, *Calotomus viridescens* (Rüppell 1835), and *Lagocephalus suezensis* Clark and Gohar 1953 were reported from the Arabian Sea or Arabian Gulf (Randall 1995; first author in prep.). A species of flatfish listed by Goren and Dor (1994) as a valid endemic species *Parabothus budkeri* (Chabanaud 1943) is in fact a junior synonym of *Bothus pantherinus* (Rüppell 1830) (K. Amaoka, pers. comm.).

It is clear that, despite a lengthy history of scientific research on Red Sea fishes, information on the distribution and potential endemism remains fluid with numbers of new endemic species either decreasing due to new records outside the Red Sea, or increasingly as a result of more detailed taxonomic research resulting in re-descriptions and recognition of new species (see for example, Bogorodsky et al. 2016; Gill et al. 2017). There are also still some relatively unexplored areas where endemic species are confined to small areas (e.g., *Acanthoplesiops cappuccino* Gill et al. 2013 from Obhur at Jeddah, Saudi Arabia). Integrated research on morphology and phylogenetic analysis has also led to recognition of new species (see Kovačić et al. submitted) and will continue to do so in the foreseeable future, requiring adjustments to the levels of endemism recognized for Red Sea fishes.

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