Mackerel from the northern Indian Ocean and the Red Sea are *Scomber australasicus*, not *Scomber japonicus*

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Abstract The population of *Scomber* from the Red Sea and northern Indian Ocean (gulfs of Aden and Oman) is identified as *S. australasicus* rather than *S. japonicus* based on having 30–33 vs. 26–29 interneural bones under the first and second dorsal fins and the combination of interneural bone counts of 16–20 under the first dorsal fin (vs. 13–16) and first dorsal fin spine counts of 10–13 (vs. 9–10). These are the best morphological characters to distinguish these two species. This change in identification constitutes a major range extension for *S. australasicus* which was thought to be restricted to the Pacific Ocean and the southeastern Indian Ocean around Western Australia.

Key words. — *Scomber australasicus*; *Scomber japonicus*; mackerel; Indian Ocean.

Of the three known species of mackerels of the genus *Scomber*, *Scomber japonicus* has been reported from the Indian Ocean, in two isolated populations, one around South Africa and the other in the northern Indian Ocean and Red Sea (Matsui, 1967; Collette and Nauen, 1983). *Scomber japonicus* is an antitropical worldwide species that forms a number of discrete populations whose taxonomic status has been difficult to assess morphologically. The recent mtDNA study of *Scomber* by Scoles, D. R., B. B. Collette and J. E. Graves (unpubl. ms: Global phylogeography of mackerels of the genus *Scomber*.) was designed to utilize molecular characters to evaluate the genetic relationships of the different species of *Scomber* and the allopatric populations of *S. japonicus*. Because mtDNA is clonally inherited and is not recombined like nuclear DNA, there are limits to its use in taxonomy. However, Scoles et al. discovered that the Red Sea population identified as *S. japonicus* differs significantly from other populations of the species. The purpose of this study is to reappraise the systematic status of the northern Indian Ocean-Red Sea population of *Scomber* using morphological characters.

Based on the genetic divergence demonstrated between the Red Sea *Scomber* sample and populations of *S. japonicus*, three hypotheses are testable: 1) the Red Sea-northern Indian Ocean sample is morphologically similar to *S. japonicus*, despite genetic distinction; 2) this population is not *S. japonicus*, but is another nominal species of *Scomber* (presumably *S. australasicus*); or 3) this population is an undescribed species of *Scomber*, morphologically distinct within the genus.

Based on both morphological and mtDNA characters, *Scomber japonicus* and *S. australasicus* are much more closely related to each other than to the third species in the genus, *S. scombrus* (Matsui, 1967; Scoles et al.). Characters used to distinguish *S. japonicus* and *S. australasicus* include number of first dorsal fin spines, number of interneural bones (pterygiophores) under the first and second dorsal fins, ratio of the length of the first dorsal fin groove to the dorsal interspace, and degree of ventral spotting (Matsui, 1967; Collette and Nauen, 1983).

Materials and Methods

First dorsal spines were counted using a dissecting microscope and interneural bones were counted from radiographs. Interneural bone counts were of the number of bones under the first dorsal fin (up to the beginning of the second dorsal) and under the second dorsal fin (excluding the interneurals supporting the dorsal finlets). This results in counts that are similar to those given by Murakami and Hayano (1956) and Abe and Takashima (1958) but one less than the

counts given by Matsui (1967).

Specimens from the USNM collections were examined from the following regions (number examined in parentheses): southwest Pacific Ocean (n=21), northwest Pacific Ocean (n=48), northern Indian Ocean (n=30), South Africa (n=20), Gulf of Guinea (n=5), Mediterranean Sea (n=19), northwest Atlantic Ocean (n=7), and southeast Pacific Ocean (n=10).

Color patterns and the ratio of the length of the first dorsal fin groove to the dorsal interspace were examined from specimens from the following regions: northern Indian Ocean (n=23), northwest Pacific Ocean (n=15), southwest Pacific (n=4), and Mediterranean Sea (n=2).

Additional meristic characters, such as numbers of anal, dorsal and pectoral fin rays, upper and lower jaw teeth, and gill rakers of the lower, upper and entire first arch were counted for specimens from the following regions: northern Indian Ocean (n=28) and South Africa (n=20). Numbers of upper and lower jaw teeth were plotted against fork length to check for increases in number of teeth occurring with increases in fish length. Numbers of gill rakers for the upper, lower and entire arch were plotted as frequency distributions. Evaluation of possible size-related increase in number of gill rakers was made by comparing plots of lower, upper, and total first arch gill rakers vs. head length and fork length.

Degree of tooth crenulation was rated on a scale of one to five, with five being the most crenulated, for samples from the northern Indian Ocean (n=28) and South Africa (n=20). Analyses were done on upper and lower jaw teeth separately. t-tests were conducted to examine for statistically significant differences between the two species.

Following Collette et al. (1978), 28 measurements were made using dial calipers to the nearest tenth of a millimeter (maximum depth, bony snout length, postorbital distance, and second dorsal to caudal distance were not measured) for the following specimens: South Africa (n=20), northern Indian Ocean (n=28), northwest Pacific Ocean (n=23), and southwest Pacific Ocean (n=15). Morphometric data were screened using scatter plots. Scatter plots of 27 morphometric characters vs. fork length, and four morphometric characters vs. head length were examined.

Collection data is given only for the northern Indian Ocean specimens of *Scomber australasicus* and the southern Indian Ocean specimens of *S. japonicus* that were examined. Most specimens are in the collections of the National Museum of Natural History (USNM) except for one lot from the Bernice P. Bishop Museum (BPBM) in Hawaii. Comparative material of both species from other areas is from the USNM collections.

Scomber australasicus: BPBM 21337 (2 specimens, 265–270 mm FL), Gulf of Oman, Oman, Muttrah fish market, J. E. Randall, 4 Mar. 1977; USNM 292688 (2, 145–155), Gulf of Aden, Somalia, 11°59'24"N, 50°44'18"E, 14 Oct. 1986; M/V *Beinta* cr. 15, sta. 2, G. J. Small; USNM 321050 (6, 219–255), Gulf of Aden, Somalia, 08°12'36"N, 50°22'18"E, 10 Feb. 1986, M/V *Beinta* cr. 8, G. J. Small; USNM 321051 (6, 210–233), Gulf of Aden, Somalia, 11°05'30"N, 51°26'48"E, 6 Feb. 1987, M/V *Beinta* cr. 19, sta. 9, G. J. Small; USNM 321052 (2, 178–233), Gulf of Aden, Somalia, 12°00'06"N, 50°51'00"E, 12 Jan. 1987, M/V *Beinta* cr. 18, sta. 9, G. J. Small; USNM 321053 (1, 179), Gulf of Aden, Somalia, 11°29'12"N, 51°15'00"E, 25 Nov. 1985, M/V *Beinta* cr. 5, sta. 2, G. J. Small; USNM 321054 (1, 180), Gulf of Aden, Somalia, 11°42'36"N, 50°21'24"E, 16 Jan. 1987, M/V *Beinta* cr. 18, sta. 23, G. J. Small; USNM 321055 (1, 157), Gulf of Aden, Somalia, 11°16'18"N, 51°15'36"E, 5 Feb. 1987, M/V *Beinta* cr. 19, sta. 6, G. J. Small; USNM 321056 (4, 158–173), Gulf of Aden, Somalia, 11°58'28"N, 50°45'06"E, 10 Jan. 1986, M/V *Beinta* cr. 7, G. J. Small. *S. japonicus*: USNM 307269 (17, 162–287), off S coast of Madagascar, 25°41'48"S, 44°37'06"E, 5 Dec. 1988, R/V *Vityaz* cr. 17, sta. 2663, B. B. Collette no. 1891; USNM 325795 (3, 247–287), South Africa, 34°25'S, 23°46'E, 15 Sept. 1992, R/V *Africana* cr. 106, sta. A13947, L. W. Knapp no. 92-13.

Results

Scomber australasicus can be completely separated from *S. japonicus* by the greater number of interneural bones under the first and second dorsal fins (30–33 vs. 26–29, Table 1). Using Matsui's (1967) diagnostic character of number of interneural bones under the first dorsal fin on 144 *Scomber* (Table 2), 57 specimens had 13 or 14, 17 had 15, 3 had 16 and 67 had 17 to 22 interneural bones. Adding one count to the ranges given by Matsui (1967) for number of interneural bones for *S. japonicus* (13–16) and *S. australasicus* (16–22), 74 specimens were identified as *S. japonicus* and 67 specimens were identified as *S. australasicus*. Overall, 98% of 144 specimens could be identified based on number of interneural bones under the first dorsal fin alone. The three specimens with 16 interneural bones, the count where *S. japonicus* and *S. australasicus* overlap, could not be identified using this character. These three specimens all had unambiguous dorsal spine counts that allowed them to be clearly identified as either *S. japonicus* or *S. australasicus*. The use of the two meristic characters allowed successful identification of all 144 specimens. Used independently, dorsal spine counts were able to distinguish only 66% (105/160) of specimens examined (Table 3).

Degree of ventral spotting was variable within each