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The Gulf Surgeon, *Acanthurus randalli*, a Junior Synonym of the Ocean Surgeon, *Acanthurus bahianus* (Teleostei: Acanthuridae)

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The Gulf Surgeon, *Acanthurus randalli*, a Junior Synonym of the Ocean Surgeon, *Acanthurus bahianus* (Teleostei: Acanthuridae)

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We compared 62 specimens, 48–126.5 mm standard length, of *Acanthurus bahianus* from the northeastern Gulf of Mexico with 95 specimens from other localities to determine if the distinguishing characters in the original description of the Gulf of Mexico endemic surgeonfish *Acanthurus randalli* were valid. No color pattern or meristic differences were found, and the only measurement that allowed distinction (91% percent concordance) was the shallower caudal concavity of northeastern Gulf of Mexico specimens. *Acanthurus chirurgus* from the northeastern Gulf of Mexico also have shallower caudal concavities (93.7% percent concordance) than do conspecifics from other areas, suggesting that this trend may be correlated with some unknown environmental influence. Considering the extended planktonic larval dispersal capabilities of Atlantic surgeonfishes, and that the single divergent morphological character state is also exhibited in a sympatric northeastern Gulf of Mexico population of *A. chirurgus*, recognition of *A. randalli* is untenable, and the name is considered a junior synonym of *A. bahianus*. An identification key to western Atlantic species of *Acanthurus* that incorporates the results of this study is given.

In a recent American Fisheries Society list of marine, estuarine, and diadromous fish stocks at risk of extinction in North America (Musick et al., 2000), the gulf surgeon, *Acanthurus randalli,* was recognized as vulnerable with "endemic, uncommon" given as primary risk factors. The categories of risk are recognized by various conservation and regulatory agencies in accordance with the Endangered Species Act of the United States. This list is an important step in assessing the conservation status of this diverse group of fishes. Inclusion of species of questionable validity weakens the credibility of such lists, and thus we decided to reevaluate the taxonomic status of the gulf surgeonfish.

Many ichthyologists have had reservations about the validity of *A. randalli,* but have continued to recognize the species as valid in the absence of any subsequent publication confirming its distinctiveness from the presumed closest relative, *Acanthurus bahianus.* Hastings (1979:73) succinctly addressed the problem when he stated: "*Acanthurus randalli* is a striking exception to the generalization that species of surgeonfishes are relatively wide-ranging (Böhlke and Chaplin, 1968), as a result of the long pelagic stage, the acronurus. There must be some limit to the transport of *A. bahianus* into the northern gulf and to the movement of *A. randalli* out of the gulf, but such a situation does not seem plausible in view of the numerous other species that are transported into the area." The Loop Current, and warm-core rings that spin off of it, largely determine the circulation patterns and ultimate survivability of larval tropical fishes transported from the southwestern Caribbean into the northeastern Gulf. The current's northward extension is highly variable, both seasonally and yearly (McEachran and Fechhelm, 1998; Wiseman and Sturges, 1999). Caldwell (1959) discussed the Loop Current system as a plausible recruitment mechanism for delivery of tropical marine fishes, including *Acanthurus,* to inshore waters in the region from Panama City to Destin, FL. As corroborating evidence for intermittent annual recruitment, he noted that the majority of the tropical fishes in the northeastern Gulf consisted of small individuals, with relatively few adults. That observation also applies to *A. bahianus;* of the 79 specimens from the Panama City to Destin, FL area examined by us or Briggs and Caldwell, only one exceeds 118 mm standard length (SL). In contrast, 41 specimens of *A. bahianus* from other areas that we measured were 119–177 mm SL, and many additional specimens in that size range or larger are available in museum collections. Reeson (1983) found that most *A. bahianus* mature at about 130 to 150 mm fork length (approximately 110–130 mm SL). Robertson (1988) estimated that surgeonfishes on patch reefs in Caribbean Panama reached sexual maturity at about 140 mm fork length within 2 yr after settlement. Although we did not attempt to determine if any of the northeastern Gulf specimens are sexually mature, their small sizes suggest that most of them are immature.

Sonnier et al. (1976) and Pattengill-Semmens and Semmens (1998) reported sight records of *A. bahianus* on reefs and banks off Louisiana and Texas, but we know of no reports of the co-occurrence of both nominal species from any locality. Robins and Ray (1986), who gave the range of *A. randalli* as Florida (Miami to Keys) and northeastern Gulf of Mexico, stated that it apparently replaces *A. bahianus* in the eastern Gulf of Mexico. No adults of *A. bahianus* or *A. randalli* have been reported from the Florida Middle Grounds (Smith et al., 1975; Smith, 1976) or from any nearshore habitats in that part of the eastern Gulf, nor do we know of any museum specimens from the region. The absence may be attributable to lack of suitable habitat (Risk, 1997) or infrequent recruitment of pelagic larvae because of the greater time required for the Loop Current to reach that part of the Gulf. In their book on Gulf of Mexico fishes, Hoese and Moore (1998) gave brief species accounts and an identification key for the three broadly distributed western Atlantic surgeonfishes, *Acanthurus chirurgus* (Bloch, 1787), *Acanthurus coeruleus* Bloch and Schneider, 1801, and *A. bahianus* Castelnau, 1855. They seemed reluctant to take a position on the validity of *A. randalli,* stating in their account of *A. bahianus* "fish resembling ocean surgeons in the northeastern Gulf but with a squarer tail and a shorter pectoral . . . have been described as the Gulf surgeon, *A. randalli* Briggs and Caldwell." The three broadly distributed species mentioned above are morphologically similar, reach about the same maximum size (Randall, 1983), and feed on a similar range of benthic algae. *A. coeruleus* has a different gut structure and ingests less sediment and detritus than the other two species (Randall, 1967; Dias et al., 2001).

The original description of the gulf surgeonfish, *A. randalli* Briggs and Caldwell (1957), was based on 21 specimens, the largest only 107 mm SL (our measurement). These specimens were collected from the northeastern Gulf of Mexico at the type locality: jetties on the west side of the inlet to St. Andrew State Park, near Panama City, FL. We found 57 additional museum specimens originally identified as *A. randalli,* all collected from the same general area as the types, including 9 that are larger (108–126.5 mm SL) than any examined by Briggs and Caldwell (1957). On the basis of these specimens and others cited in the "Material examined" section, we present data that establish *A. randalli* as a junior synonym of *A. bahianus.* We also present a revised identification key to western Atlantic *Acanthurus,* modified from the work of Randall (1956), which takes into consideration the new data presented in this paper.

Methods and Materials

Methods of taking measurements follow Randall (1956). All specimens were measured by one person (WS-V) to maximize consistency in taking measurements, all of which were taken with needlepoint dial calipers and recorded to the nearest 0.1 mm. Because caudal concavity is such an important measurement, and some readers will not have ready access to Randall's paper, we discuss the measurement here. Caudal concavity is the horizontal distance between vertical lines passing through the tips of the shortest middle ray and the longest ray of the dorsal lobe of the caudal fin. This measurement is not made from a compressed or stretched caudal fin, but one in the normal resting position. In this study, a straight line scratched on a clear plastic surface served as an accurate vertical landmark when taking caudal concavity measurements. Measurements of caudal-fin lobes are straight-line measurements from the middle of the base of the caudal fin (end of hypural plate) to the tip of the lobe. Gill-raker counts include all rudiments and were made on the first arch after it had been carefully detached with a scalpel and temporarily removed from the gill cavity. Only anterior gill rakers (those on the lateral side of the arch) were counted.

Measurements of SL, head length, pectoral length, and caudal concavity of specimens of *A. bahianus* from the northeastern Gulf of Mexico and nonnortheastern Gulf of Mexico (other) were compared. Only specimens smaller than 127 mm SL were analyzed to restrict calculations to the size range of available *A. bahianus* material from the northeastern Gulf. We used logistic regression to determine if area of collection could be distinguished based on morphological measurements. A combination of PROC CATMOD and PROC LOGISTIC programs from SAS version 8.2 (SAS Institute Inc., Cary, NC) was used to evaluate a suite of candidate logistic regression models. Model selection was based on Akaike's Information Criterion (Burnham and Anderson, 1992). Since some models adequately distinguished the two geographic areas of *A. bahianus* samples, similar measurements and analyses were applied to *A. chirurgus* from the northeastern Gulf of Mexico and nonnortheastern Gulf of Mexico (other). There were insufficient collections of

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A. coeruleus from the northeastern Gulf to permit statistical analysis.

Collection data for material examined are abbreviated. The number of specimens, followed by size in mm SL (rounded to nearest 0.5 mm), is given in parentheses. Institutional or collection abbreviations are as follows: Academy of Natural Sciences of Philadelphia (ANSP); Texas Cooperative Wildlife Collection, College Station, TX (TCWC); Florida Museum of Natural History, Gainesville (UF); and National Museum of Natural History, Washington, DC (USNM).

Material examined. Acanthurus bahianus (159 specimens, 40–177 mm SL from 59 lots):—**Northeastern Gulf of Mexico**: UF 5394 (1, 107), holotype of *A. randalli,* jetties at St. Andrew State Park, Panama City, 8 Oct. 1955; ANSP 75167 (1, 79), UF 5400 (2, 84–89), UF 5416 (1, 86), and USNM 174925 (1, 88), all paratypes of *A. randalli;* UF 5693 (3, 82–111), Panama City jetties, Oct. 1956; UF 67429 (2, 64.5–67), St. Andrew Bay jetties, 22 Jul. 1959; UF 67552 (28, 64.5–118), St. Andrew Bay jetties, 22 Aug. 1959; UF 67595 (1, 97.5), Destin jetties, 2 Sep. 1959; UF 68704 (1, 86), St. Andrew Bay jetties, 13 Oct. 1970; UF 69574 (1, 88.5), Destin jetties, 10 Jul. 1959; UF 69619 (18, 48–109), Destin jetties, 11 Sep . 1969; UF 69670 (1, 126.5), Destin jetties, 3 Nov. 1969; UF 68221 (2, 73–88), St. Andrew Bay jetties, 23 Oct. 1969. **Cuba**: USNM 6139 (1, 170) and USNM 12541 (1, 165), "F. Poey," no specific locality; USNM 364252 (1, 129), 22°58′N 78°37′W, R/V Oregon II, cruise 13, sta. 10856. **Bermuda**: ANSP 32681 (3, 82.5–123), ANSP 126288 (3, 63.5–81.5), ANSP 133874 (1, 177), ANSP 133853 (2, 134–141.5). **Florida Keys**: ANSP 90311 (3, 65–66), Pelican Shoals; UF 10838 (2, 68.5–104) and UF 16144 (4, 59–132), Looe Key; UF 218041 (1, 136.5), UF 219523 (1, 107), UF 220108 (1, 161.5) and UF 204980 (8, 69–158), Alligator Light vicinity; UF 115552 (2, 135–157), southwest of Key Vaca; USNM 117278 (2, 123–138), Dry Tortugas, W. H. Longley; TCWC 7343.05 (1, 147), Dry Tortugas vicinity, 24°36′N 82°42′W. **Bahamas**: ANSP 74630 (3, 40–105), ANSP 74631 (1, 92.5), ANSP 74637 (2, 124.5–130), ANSP 74638 (1, 104), ANSP 74639 (2, 95–162), ANSP 74998 (2, 137.5–141.5), ANSP 74999 (1, 136.5), ANSP 82674 (1, 120), ANSP 82687 (1, 102), ANSP 94823 (1, 167.5), ANSP 94824 (1, 139), ANSP 94825 (1, 122), ANSP 94826 (12, 64.5–112.5), ANSP 126801 (1, 129), ANSP 137947 (2, 77–92.5), ANSP 147304 (5, 41.5–100). **Puerto Rico**: ANSP 115583 (4, 45–72.5), ANSP 115661 (3, 72–89), ANSP 116682 (1, 120), ANSP 132004 (5, 117–157), USNM 50141 (1, 105). **Virgin Islands**: USNM 183481 (1, 108.5). **Mexico**: UF 209215 (1, 119) and USNM 37120 (1, 109), Cozumel. **Belize**: USNM 337447 (1, 130.5). **Tobago**: USNM 319193 (1, 112), USNM 319194 (1, 136.5), USNM 319196 (2, 119–136.5).

Acanthurus chirurgus (89 specimens, 51–200 mm SL from 43 lots):—**Northeastern Gulf of Mexico**: UF 5415 (3, 58–86), Panama City jetties, FL; UF 66998 (2, 72–73), UF 67542 (8, 81.5–125.5), UF 67591 (1, 96), UF 69253 (1, 92), UF 69399 (1, 70), UF 69415 (1, 98), UF 69603 (1, 94), UF 69618 (6, 51–109), UF 70244 (1, 126), UF 70631 (3, 97–109), and St. Andrew Bay jetties, FL. **North Carolina**: UF 77413 (1, 68), Cape Lookout. **Florida East Coast**: UF 62021 (1, 114), UF 212148 (1, 79). **Florida Keys**: UF 5136 (1, 112), UF 7034 (5, 66–92), UF 11001 (10, 85–132), UF 54535 (2, 70–89), UF 115974 (1, 191), UF 207511 (1, 84), UF 218098 (3, 53–68), UF 218163 (1, 117), UF 220014 (2, 93–111), USNM 88096 (1, 91), Dry Tortugas. **Bahamas**: UF 14101 (1, 95), UF 18735 (2, 68–95), UF 205776 (3, 44–94), UF 207858 (3, 86–131), UF 208905 (1, 121). **Haiti**: USNM 133723 (1, 151). **Puerto Rico**: USNM 162785 (1, 123). **Virgin Islands**: UF 56846 (1, 76), UF 204956 (1, 117), UF 214993 (1, 105), **Tobago**: USNM 319201 (1, 82). **Brazil**: UF 115872 (4, 98–130), Atol dos Rocas. **Mexico**: USNM 79250 (1, 95), Yucatan. **Belize**: USNM 327618 (1, 147), Carrie Bow Cay. **Serrana Bank**: UF 115969 (1, 200). **Panama**: ANSP 49070 (1, 100), Canal Zone; UF 222499 (5, 66–81.5), Limon Bay. **Colombia**: UF 25789 (1, 79), Providencia; UF 230295 (1, 72), Santa Marta.

Results

Briggs and Caldwell (1957) compared 154 specimens of *A. bahianus* with 21 specimens of *A. randalli,* but no localities or size data were given for *A. bahianus.* Only 10 specimens of *A. bahianus* were used in their scatter plots. They stated that *A. randalli* was closest to *A. bahianus,* but there were ". . . clear-cut differences in the shape of the caudal concavity, the length of the pectoral fin, and, to some extent, the diameter of the eye." They further noted that *A. bahianus* tended to have a smaller eye although ". . . considerable overlap in variation is present in the ratio between the species." For convenience of comparison of our much larger data set with the original scatter plots of Briggs and Caldwell (1957), we used their same mea-

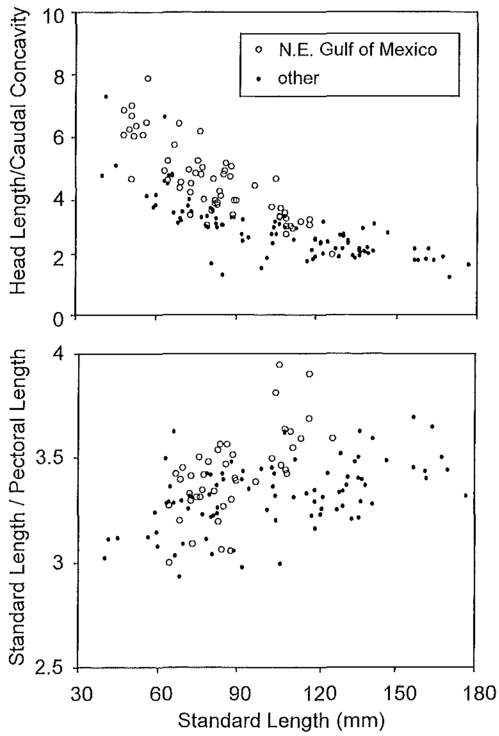

Fig. 1. Selected measurements for *Acanthurus bahianus* from the northeastern Gulf of Mexico and other localities: head length in caudal concavity versus SL (top) and SL in pectoral fin length versus SL (bottom). Ratio data are used in these graphs for ease of comparison with those given in the original description (Briggs and Caldwell, 1957; Figs. 4, 5).

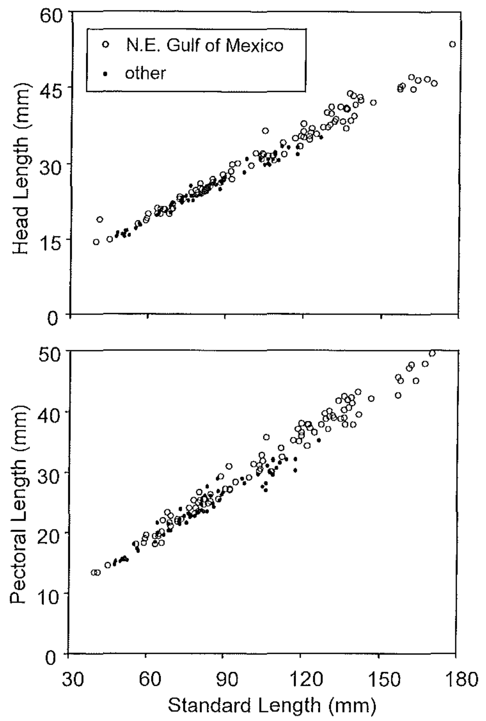

Fig. 2. Selected measurements for *Acanthurus bahianus* from the northeastern Gulf of Mexico and other localities: head length versus SL (top) and pectoral length versus SL (bottom).

surement ratio combinations (Fig. 1). Our data revealed that northeastern Gulf of Mexico specimens exhibit a considerable amount of overlap with specimens from other localities. Head and pectoral-fin length in particular showed no apparent differences (Fig. 2). The upper lobe of the caudal fin, the longer of the caudal-fin lobes, exhibited the same relative growth pattern at all localities (Fig. 3). As shown by their original caudal-fin outline drawings and our data, the caudal concavity is usually shallower in northeastern Gulf of Mexico specimens (Figs. 3, 4), although caudal concavity measurements cannot be reliably used to distinguish all specimens. Of particular relevance is the caudal concavity of the largest specimen (126.5 mm SL) from the area (UF 69670), which is well within the range of similar sized non–Gulf of Mexico specimens.

As each of the length measurements (standard, head, and pectoral) was highly correlated (i.e., r > 0.97), we used SL to reduce parameter redundancy. We substituted head length and pectoral length for SL to ensure that SL was the most suitable in the models. For *A. bahianus,* area of collection was most parsimoniously estimated by SL, caudal concavity, and interaction of these two variables (Table 1). With this model, 91% of the specimens could be correctly assigned to area. Models that included head length and pectoral length were much less appropriate (Table 1). Model evaluation was repeated for *A. chirurgus* with the identical model being the most parsimonious at 93.7% concordance (Table 1). Specimens of *A. bahianus* and *A. chirurgus* from the northeastern Gulf of Mexico have a shallower caudal concavity relative to SL than those from other areas (Fig. 4). Slopes of regressions are not significantly different within species and are significantly different between species ($P < 0.01$).

No color pattern differences were mentioned in the original description and our comparisons of preserved specimens from the northeastern Gulf of Mexico with those of *A. bahianus* from other localities revealed none (Fig. 5). The absence of any differences in color pattern would be exceptional if two species were actually represented. Excluding *A. ran-*

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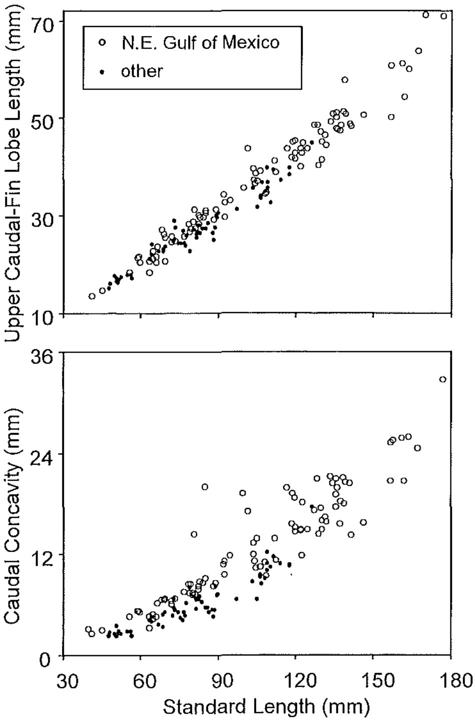

Fig. 3. Selected measurements for *Acanthurus bahianus* from the northeastern Gulf of Mexico and other localities: upper caudal-fin lobe length versus standard length (top) and caudal concavity versus standard length (bottom).

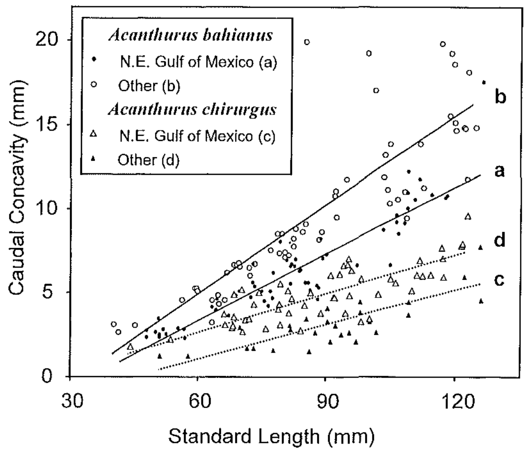

Fig. 4. Relationship between caudal concavity versus standard length in *Acanthurus bahianus* and *Acanthurus chirurgus* from the northeastern Gulf of Mexico and other localities.

dalli from consideration, 37 species of *Acanthurus* are currently recognized (Randall, 2001), all differing from each other in at least some aspect of their respective color patterns. Recently, Rocha et al. (2002) reported a strong genetic separation and different coloration (yellow versus bluish white) of the pale distal margins of the dorsal and caudal fins between Brazilian and Caribbean populations of *A. bahianus,* which they attributed to the isolating effect of the large freshwater discharge from the Amazon River, suggesting the possibility that this wide-ranging species may actually comprise a pair of sibling species.

Discussion

Caldwell (1959) noted that "if the differences between *A. randalli* and *A. bahianus* are the result of ecological influence, it is surprising that other Western Atlantic species of the genus, *A. chirurgus* (Bloch) and *A. coeruleus* Bloch and Schneider, are not also influenced." Our larger data set supports the observation of Briggs and Caldwell (1957) that caudal-concavity development is different (delayed or reduced) in *A. bahianus* from the northeastern Gulf compared to that observed in specimens from other geographic areas. This relative growth pattern, however, is also mirrored in populations of *A. chirurgus* from the same locales. Specimens from the northeastern Gulf are too uncommon in collections to determine if a similar pattern of caudal-concavity development occurs in *A. coeruleus.* We know of no

Table 1. Logistic regression model selection based on Akaike's Information Criterion (AIC) for two species of *Acanthurus.* Models are listed in descending order of AIC with percent concordance, number of model parameters, and the difference between each model and the preferred model (ΔAIC)[a].

Model	% Concordance	Number of parameters	AIC	ΔAIC
Acanthurus bahianus				
A = PL CC PL*CC	83.6	4	134.9	35.1
A = PL CC	83.4	3	133.3	33.5
A = HL CC	87.0	3	125.9	26.1
A = HL CC HL*CC	87.6	4	125.0	25.2
A = SL CC	91.0	3	103.4	3.6
A = SL CC SL*CC	91.0	4	99.8	0.0
Acanthurus chirurgus				
A = HL CC	91.0	3	63.8	7.6
A = HL CC HL*CC	91.5	4	63.2	7.0
A = SL CC	92.4	3	60.4	4.2
A = SL CC SL*CC	93.9	4	56.2	0.0

[a] A, area of collection (northeastern Gulf of Mexico and other); SL, standard length; HL, head length; PL, pectoral length; CC, caudal concavity; *, interaction. PL was not measured for *A. chirurgus.*

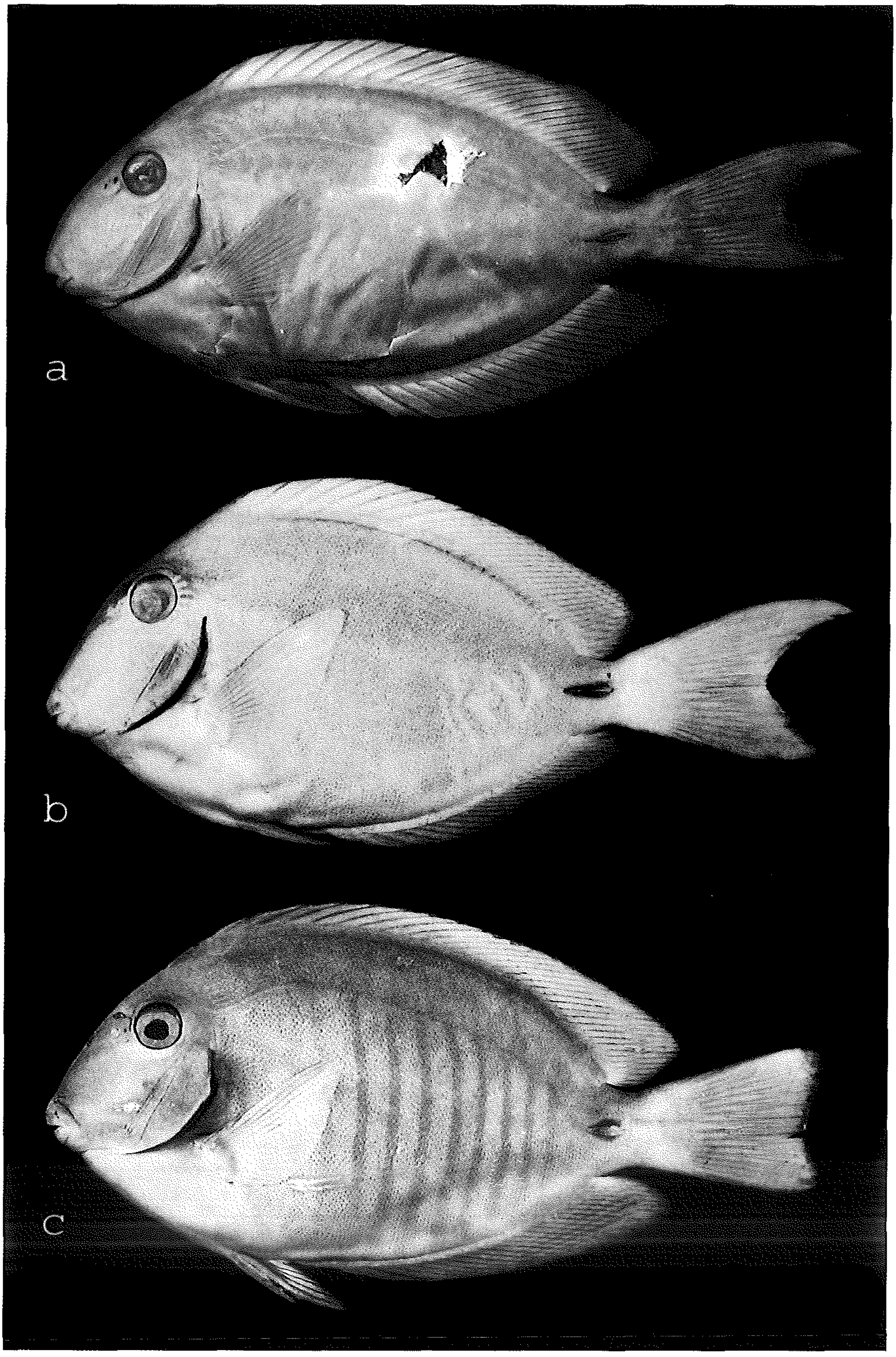

Fig. 5. Comparison of *Acanthurus* specimens from selected localities: (a) *Acanthurus bahianus,* UF 69670, 126.5 mm SL, Gulf of Mexico, Florida, Destin jetties (reversed right side view); (b) *Acanthurus bahianus,* UF 207258, 126 mm SL, Straits of Florida, Ajax Reef; (c) *Acanthurus chirurgus,* UF 69618, 109 mm SL, Gulf of Mexico, Florida, Destin jetties.

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other northeastern Gulf of Mexico fishes that have a geographic distribution restricted to inshore waters from Panama City to Destin, FL. It is possible that cold temperatures affect caudal fin development, and also might occasionally result in the extirpation of adult *Acanthurus* from the area.

The following observations have particular bearing on whether *A. randalli* should be recognized as a valid biological species: 1) a similar pattern of relative caudal concavity growth trajectory occurs in sympatric northeastern Gulf of Mexico populations of two species of *Acanthurus* (*A. bahianus* and *A. chirurgus*) that is not duplicated in other populations of either species; 2) a shallow caudal concavity is a juvenile character state in surgeonfishes, and only a slight change in developmental rate could alter the growth trajectory of the caudal fin resulting in a shallower caudal concavity in juveniles and subadults; 3) although caudal concavity measurements are significantly different in northeastern Gulf of Mexico populations of *A. bahianus* versus those from other localities, the distinction does not hold for all specimens, and no other morphological differences were detected; and 4) northeastern Gulf of Mexico populations of *A. bahianus* and *A. chirurgus* exhibit no unique color pattern differences (live coloration not observed), in contrast to all other currently recognized species of *Acanthurus*.

In the absence of any consistent distinguishing characteristics, and strong circumstantial evidence that the restricted geographic distribution of the northeastern Gulf of Mexico population may depend on periodic recruitment of planktonic juveniles from the southwestern Caribbean, we conclude that *A. randalli* is a junior synonym of the broadly distributed western Atlantic species *A. bahianus*. Continued recognition of *A. randalli* as a valid species is also biologically inconsistent unless the sympatric population of *A. chirurgus* is also described as a new species.

Key to Western Atlantic Species of Surgeonfishes

1a. Anal fin segmented rays 24–26; dorsal fin segmented rays 26–28 (usually 27); no dark area around caudal spine and sheath of spine pale; no short lines radiating posteriorly from orbit; in life, adults bluish gray to dark blue, with narrow gray longitudinal stripes on body, and without a distinct pale area on caudal peduncle (juveniles mostly yellow); anterior gill rakers 13 or 14 . . . . Blue tang, *A. coeruleus*

1b. Anal fin segmented rays 21–24 (rarely 24); dorsal fin segmented rays 23–26 (rarely 26); dark area around caudal spine and sheath of spine dusky; short lines often radiating posteriorly from orbit; in life, adults gray to dark brown, with or without narrow gray longitudinal stripes on body, and often with a pale area on caudal peduncle; anterior gill rakers 16–24 2

2a. Caudal fin with a distinct pale posterior margin, broadest centrally (about one-fourth to one-third width of pupil in adults, wider in young); no dark vertical bars on sides; caudal fin of adults moderately to strongly forked, with lobes bluntly acute to pointed and upper lobe longer than lower lobe; caudal concavity 4.5–15.5 times in SL, in specimens > 10 cm SL, Figure 4; anterior gill rakers 18–24 .Ocean surgeon, *A. bahianus*

2b. Caudal fin without a distinct pale posterior margin, either absent or pale margin about the width of a pencil line; 8–12 well-spaced, dusky, vertical bars on sides (may not be evident in preserved specimens); caudal fin of adults shallowly forked with upper and lower fin lobes usually symmetrical and bluntly rounded; caudal concavity 17–38.5 times in SL, in specimens > 10 cm SL, Figure 4; anterior gill rakers 16–19 . . . . Doctorfish, *A. chirurgus*

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