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Research Article

Identification of acara (Cichlidae: *Cichlasoma*) established in Florida, USA

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Abstract

The Black Acara, *Cichlasoma bimaculatum* (Linnaeus, 1758), was first reported as introduced to Florida in 1965. Native to Venezuela, Guyana, Suriname, western French Guiana, and northern Brazil, the species is now distributed throughout Florida's southern peninsula. Examination of live and preserved acara from Central Florida, heretofore identified as Black Acara, reveal the presence of an additional acara species, the Chanchita, *Cichlasoma dimerus* (Heckel, 1840). The Chanchita is native to Bolivia, Paraguay, Uruguay, southern Brazil, and northeastern Argentina. Despite similarities, Black Acara and Chanchita can be distinguished by number of anal-fin spines, body and fin color, caudal-fin pattern, and head, nape, and upper-flank scale-rim pigment. The Chanchita is established in multiple Central Florida drainages with the earliest known record from July 27, 2000. The Chanchita has not been found to co-occur with the Black Acara. The presence of Chanchita in more than one Central Florida spring and the widespread distribution of this previously unreported introduced species may be of concern to natural resource managers.

Key words: nonindigenous species, springs, Black Acara, Chanchita

Introduction

Acara are small- to medium-sized South American cichlid fishes (Teleostei: Cichliformes: Cichlidae). Kullander (1983), henceforth Kullander, revised *Cichlasoma* Swainson, 1839, restricted *Cichlasoma* to twelve species of acara, and created groupings based upon the number of anal-fin spines. He assigned six species to a three anal-fin-spine group and six to a four anal-fin-spine group. Only rarely did specimens examined by Kullander not conform to these groupings. A thirteenth species, assignable to the four anal-fin-spine group, was described by Ottoni (2011) bringing the number of four anal-fin spine acara to seven. Acara have an asymmetric caudal-fin dot pattern or no caudal-fin pattern at all (Kullander 1983; Kullander and Nijssen 1989). Recent cichlid phylogenetic research, using combined morphological and molecular approaches, has not provided a definitive alternate hypothesis for the composition of *Cichlasoma* (e.g., Musilová et al. 2009) and thus the arrangement set forth by Kullander is followed here.

The Black Acara, *Cichlasoma bimaculatum* (Linnaeus, 1758), is an acara usually with four anal-fin spines. The Black Acara is gray to silver, beige, or yellow-gray to dark green in body color (Page and Burr 2011; Robins et al. 2018). It was introduced and established in South Florida in the early 1960s (Rivas 1965). Black Acara were of value to the aquarium trade in the 1950s but may have lost market share as jet aircraft cargo permitted the importation of a greater variety of exotic fishes, including more colorful forms (Courtenay and Stauffer 1990). Published accounts of acara in Florida to date refer to Black Acara (e.g., Shafland et al. 2007; Page and Burr 2011; Crutchfield 2016 and Robins et al. 2018) though early reports confused the species with *Cichlasoma portalegrense* (Hensel, 1870) (e.g., Rivas 1965 and Kushlan 1972, as "*Aequidens portalegrensis*").

The Chanchita, *Cichlasoma dimerus* (Heckel, 1840), is an acara usually with three anal-fin spines. The Chanchita is silver-gray in body color but frequently colorful. It may be metallic green (present study), opalescent blue, or blue-green to greenish (Kullander 1983), though the presence or absence of bright colors varies according to condition and social hierarchical status (Alonso et al. 2007). The common name "Chanchita" appears in research papers utilizing *C. dimerus* as a model laboratory organism (e.g., Pandolfi et al. 2009; Ramallo et al. 2014; Morandini et al. 2015) and though the name may be more aptly applied to a variety of small cichlids (Menni 2004) its use is adopted here. Published photos of Chanchita appear in Crutchfield (2016) and Robins et al. (2018; pg. 372, plate 198) as misattributions of Black Acara.

Herein we report widespread populations in Florida of Chanchita, *Cichlasoma dimerus*, dating to July 27, 2000, describe their distribution based on museum specimens, provide key characters for identification, and discuss potential concerns for natural resource managers.

Materials and methods

Field collections were made by the authors on five separate occasions between August 31, 2018 and June 6, 2019. Specimens were collected using dip nets and hook-and-line fishing and were deposited in the Florida Museum (University of Florida). Online specimen records were accessed in FishNet2 (FishNet2 2019) including records from the California Academy of Sciences (CAS) and Royal Ontario Museum (ROM). Institutional acronyms for museum collections follow Sabaj (2016). Counts and measurements were made of newly collected and legacy specimens. All counts were made on the left side, unless damage was present (count or measure then made on right side), using a Leica MZ75 dissecting microscope. All measurements were made with Helios dial calipers and rounded to the nearest tenth millimeter. Specimens less than 32 mm standard length (SL) and heavily damaged specimens were excluded. To

Table 1. Frequency distribution of anal-fin spines in *Cichlasoma* introduced to Florida. Number of anal-fin spines.

	3	4	5	N	X	SD
C. bimaculatum	1	49	1	51	4	0.2
C. dimerus	52	3	0	55	3.05	0.23

document color in life, photographs were taken immediately after capture in the field and of fishes held in aquaria. To examine the lower-jaw teeth and micro-gill rakers of the fourth branchial arch of two specimens, which could not be seen with a microscope, computed tomography (CT) scans were generated using a GE Phoenix v|tome|x m CT scanner. X-ray data were processed using datos|x software v. 2.3 and segmented and visualized using Volume Graphics StudioMax v. 3. Manual dissection and visual examination of the fourth branchial arch of these and one additional specimen were performed for comparative purposes.

Results

All acara from Central Florida examined by this study were identified as Chanchita, *Cichlasoma dimerus*. Ninety-five percent (N = 52/55) had three anal-fin spines; three specimens had four spines (UF 241328 (n = 2 of 5) and UF 242256 (n = 1 of 6)). Chanchita were from the Alafia (HUC-0310024), Kissimmee (HUC-03090101), Pithlachascotee (HUC-03100207), Tampa Bay (HUC-03100206), and Upper St. Johns (HUC-03080101) river drainages (USGS watershed hydrologic unit codes in parentheses). All acara from South Florida examined by this study were identified as Black Acara, *Cichlasoma bimaculatum*. Ninety-six percent (N = 49/51) had four anal-fin spines; one specimen each had three (UF 239097 (n = 1 of 9)) or five spines (UF 238812 (n = 1 of 3)). Black Acara were from the Caloosahatchee (HUC-03090205) and Everglades (HUC-03090202) drainages. Anal-fin spine counts are presented in Table 1. The distribution of Chanchita and Black Acara in Florida, based on museum records, is presented in Figure 1 (Supplementary material Table S1).

Counts of other fin elements did not show substantial differences between Chanchita and Black Acara useful for discriminating species (Table S2).

Body and fin color was examined for 30 live Chanchita (UF 241006 n = 2; UF 241009 n = 3; UF 241107 n = 6; UF 241150 n = 3; UF 241318 n = 2; UF 241328 n = 5; UF 242525 n = 6; UF 242732 n = 1; UF 242528 n = 1; UF 242740 n = 1). While live, fish larger than approximately 45 mm SL (n = 24) exhibited a brilliant metallic green to light blue on the body and occasionally the pelvic fins (Figure 2). A Black Acara maintained in captivity was consistently beige in body color with clear to light gray fins (Figure 2).

The caudal fins of Chanchita and Black Acara differed. Greater asymmetry was found between the upper and lower lobes in Chanchita than

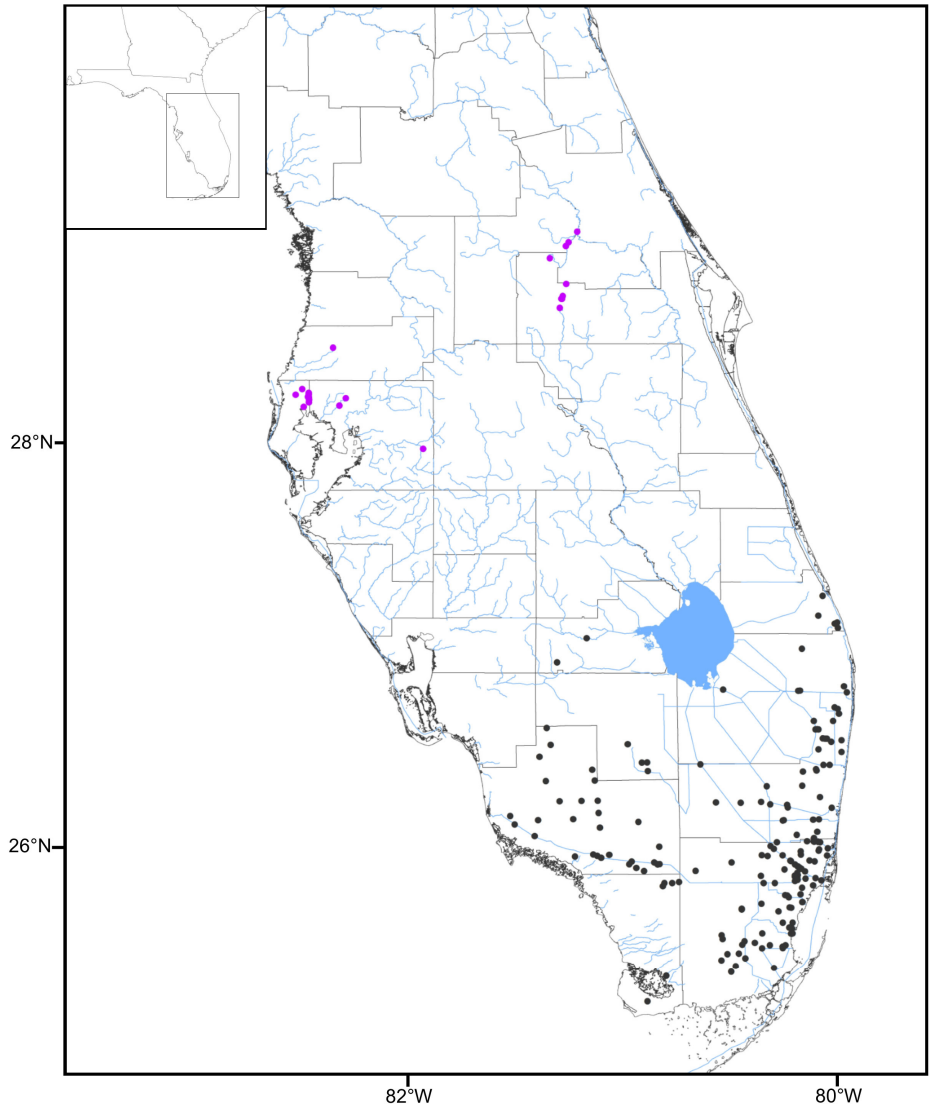

Figure 1. Distribution of acara in Florida based on museum records. Black dots = Black Acara, *Cichlasoma bimaculatum*, purple dots = Chanchita, *Cichlasoma dimerus*.

Figure 2. Body and fin color in two species of acara. Left: Black Acara, *Cichlasoma bimaculatum*, ditch, Broward County, FL, Everglades drainage; beige with clear to light gray fins. Photographed in aquarium. Right: Chanchita, *Cichlasoma dimerus*, Lake All Bright, Hillsborough County, FL, (UF 241107), Tampa Bay drainage; metallic green to light blue. Photos by Robert Robins.

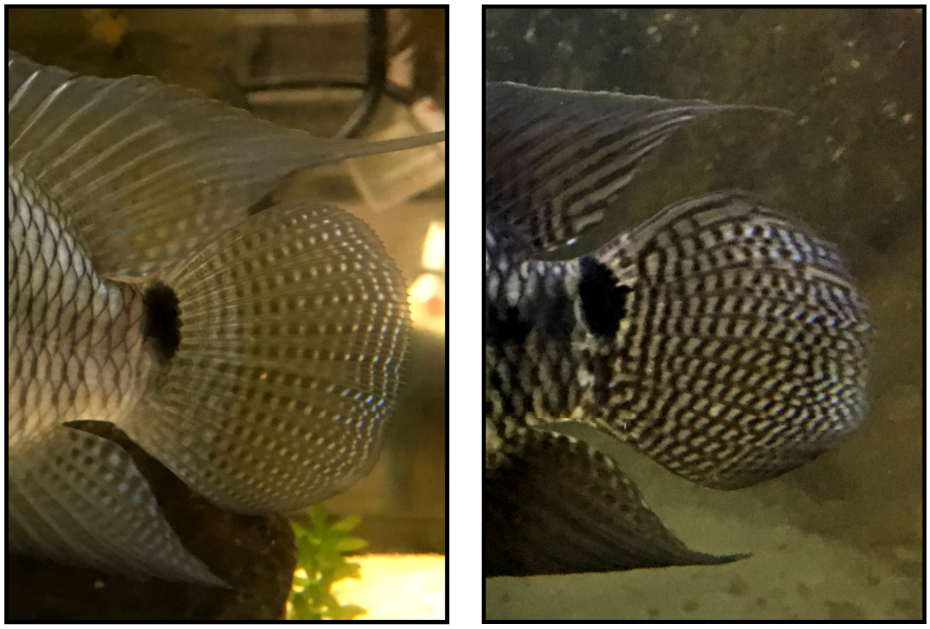

Figure 3. Caudal-fin pattern in two species of acara. Left: Black Acara, *Cichlasoma bimaculatum*, ditch, Broward County, FL, Everglades drainage; caudal-fin pattern of upper and lower lobes nearly symmetric, spotted. Right: Chanchita, *Cichlasoma dimerus*, retention pond, Pinellas County, FL, Tampa Bay drainage; caudal-fin pattern of upper and lower lobes asymmetric, web-like. Photographed in aquaria. Photos by Robert Robins.

in Black Acara (Figure 3). In Chanchita, the caudal rays were nearly as dark as the vertical, excurved bands that crossed the caudal rays and caudal-fin membrane, resulting in a web-like pattern. The dark bands and nearly as dark caudal rays formed the "web" and the clear caudal membrane formed the spaces in between. These clear spaces in the caudal membrane were largest in the upper-posterior caudal fin. These spaces were far larger than the pigmented bands that separate them and contributed to the asymmetry between the upper and lower halves of the caudal fin. In extreme cases the clear spaces between the uppermost one to four caudal rays were as long or nearly as long as the caudal rays (i.e., they were not crossed by vertical banding). That vertical bands were more excurved in the lower half of the caudal fin than the upper also contributed to asymmetry; the lower lobe of the caudal fin appeared obliquely banded and the upper lobe more clear. In Black Acara, the caudal rays were not as dark as the vertical bands crossing the caudal rays and caudal membrane and these bands were less excurved. The resulting pattern was one of nearly even rows of spots (the "dotted" pattern of Kullander) rather than web-like. The clear spaces in the caudal-fin membrane were largest in the center of the fin but nowhere proportionally as large as the clear spaces found in Chanchita. The overall pattern was nearly symmetric from upper to lower lobe.

Scale rimming, or the presence of a gray to black margin on the posterior edge of the scales of the head, nape, and anterior-upper flanks, though most prominent in large fish, was present in all Chanchita. Unlike color that fades or is lost in alcohol, this feature remained observable in preserved specimens. All Chanchita had scale rimming that was dark, thick,

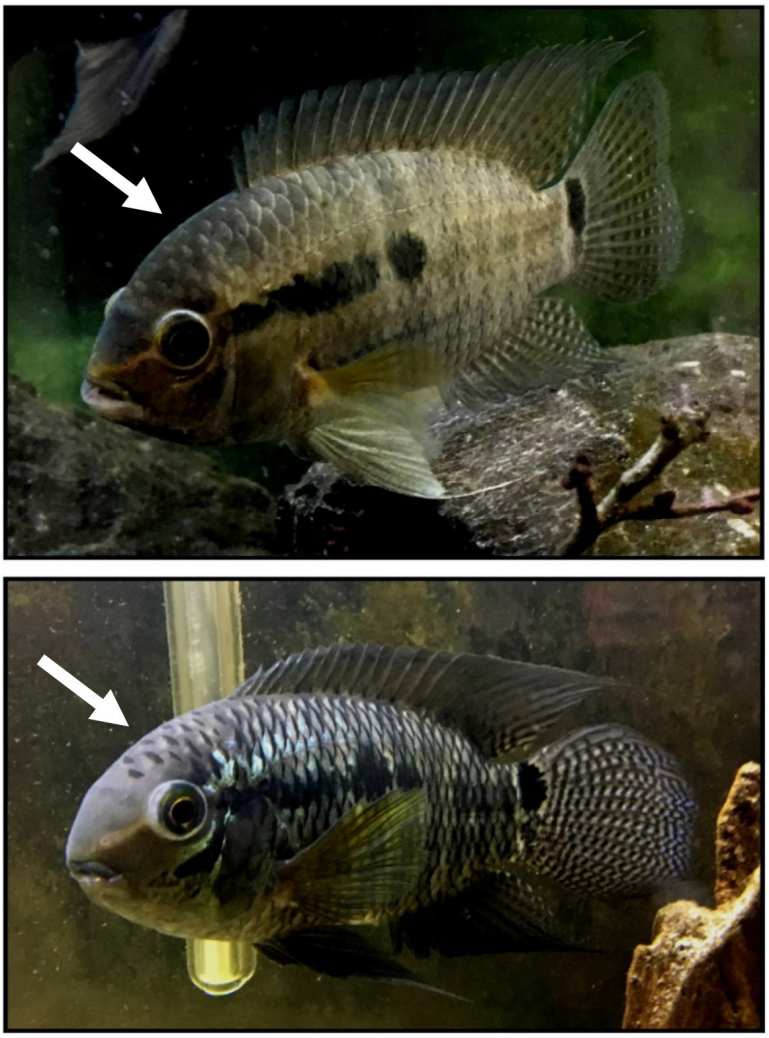

Figure 4. Scale rimming of the head, nape and anterior-upper flank in two species of acara. Top: Black Acara, *Cichlasoma bimaculatum*, ditch, Broward County, FL, Everglades drainage; scale rimming absent or faint. Bottom: Chanchita, *Cichlasoma dimerus* retention pond, Pinellas County, FL, Tampa Bay drainage; scale rimming dark, thick, and uneven. Photographed in aquaria. Photos by Robert Robins.

and at times uneven; when uneven the pigment was thickest at the center of the scale edge. The darkest and thickest rimming was found on the scales of the head and nape.

In Black Acara, scale rimming was absent to light; when present the pigment was narrow and even along the scale edge. Scale rimming was nowhere more pronounced in any one area of the body. A comparison of scale rimming in Chanchita and Black Acara is presented in Figure 4.

Two of the Chanchita that had 4 anal-fin spines, UF 241328 (n = 2 of 5), were in all other respects typical of other Chanchita examined (body and fin color, caudal-fin pattern, and scale rimming). While UF 242256 (n = 1 of 6), a legacy collection, could not be examined for color, it was typical of other Chanchita examined in caudal-fin pattern and scale rimming. Two Black Acara specimens that had more or less than 4 anal-fin spines (UF 239097 (n = 1 of 9) and UF 238812 (n = 1 of 3) were in all other respects typical of other Black Acara examined.

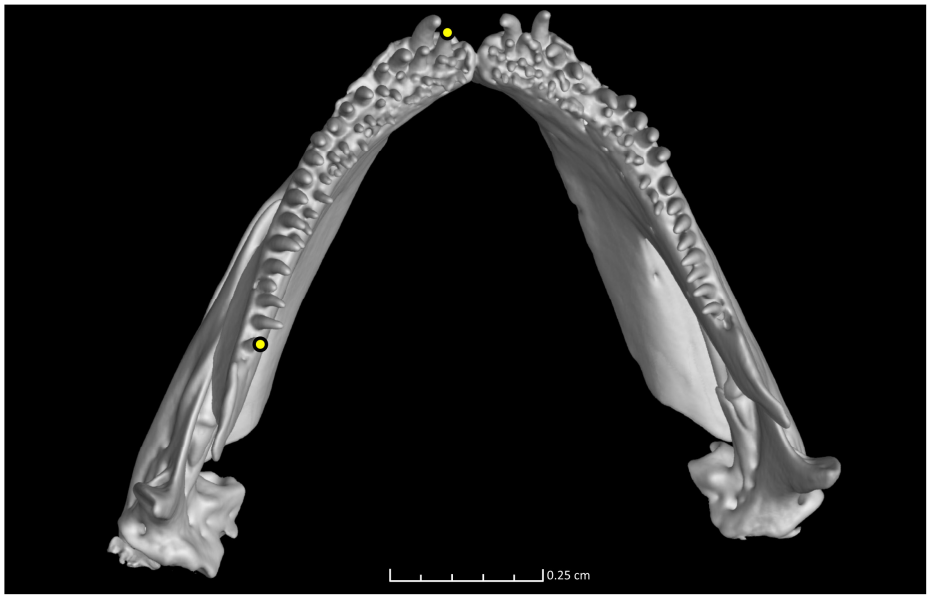

Figure 5. CT scan of lower jaw. Chanchita, *Cichlasoma dimerus*, Sweetwater Creek, Hillsborough County, Tampa Bay drainage, UF 241009, specimen 3. Uppermost yellow dot marks position of tooth number 1 in outer hemi-series (lower left jaw). Lowermost yellow dot marks position of tooth number 18, final tooth in outer hemi-series (lower left jaw).

CT scans of two specimens of Chanchita, UF 241009 (specimen numbers 2 and 3 in a series of 3), yielded lower-jaw tooth counts of the outer hemi-series of: specimen 2, left side = 17, right side = 17; specimen 3, left side = 18, right side = 21 (Figure 5). The presence of micro-gill rakers on the inner fourth branchial arch could not be determined clearly from CT scans and follow up dissections were performed on the right side of the specimens. These dissections revealed the presence of micro-gill rakers on the inner fourth branchial arch, numbered as follows: specimen 2 = 8 (uppermost micro-gill raker bicuspid and counted as one); specimen 3, damaged during right side inner fourth arch removal, micro-gill rakers present appear as n = 8; left side inner fourth arch removed for confirmation, n = 10. A single specimen of Black Acara (UF 239097 (n = 1 of 6)) had eleven micro-gill rakers on the inner fourth branchial arch of the right side.

Discussion

Species Identification

Chanchita, *Cichlasoma dimerus*, are readily distinguished from Black Acara, *Cichlasoma bimaculatum*, by the presence of 3 anal-fin spines (95% of specimens examined), brilliant metallic-green to light-blue body and fin color on larger individuals, strongly asymmetric caudal-fin pattern, and heavy head and nape scale-rim pigment. With respect to species of acara with three anal-fin spines, half possess features that do not appear in Chanchita: *Cichlasoma paranaense* Kullander, 1983 and *Cichlasoma araguaiense* Kullander, 1983 have an immaculate caudal fin (no pattern) and *Cichlasoma boliviense* Kullander, 1983 has spots on the scale bases of

the lower sides in the majority of adults. The three remaining species, the Chanchita, *Cichlasoma dimerus*, *C. portalegrense,* and *C. pusillum* Kullander, 1983 form a species group characterized by the most asymmetrically patterned caudal fins within *Cichlasoma* and the darkest, most extensive scale rimming (Kullander 1983). Within this group, the presence or absence of micro-gill rakers on the inner fourth branchial arch and counts of lower-jaw teeth were the most instructive features for diagnosing acara from Central Florida as the Chanchita, *Cichlasoma dimerus*. A discussion of a number of these features and their relative value for diagnosing the species of acara in Central Florida follows here.

In body and fin color, Chanchita from Florida compare favorably with the description provided by Kullander of the scales on the head and flanks as "opalescent blue (blue-green to greenish)" with the same color, but fainter, filling the spaces "between dark dots in the unpaired fins (pg. 204)." Kullander noted further: "The blue or green flank and head color of living *C. dimerus* is unique to this species, among those for which color is known (pg. 205)." While not the metallic green to light blue of Chanchita examined during the present study, these differences in observed color likely reflect the qualitative way in which color is perceived and described. Observing fish in laboratory aquaria, Pandolfi et al. (2009) characterized the appearance of Chanchita as "greenish to light or dark grey...also golden-yellow and light blue reflections" and attributed color variation to mood or social ranking. According to Alonso et al. (2007) color in captive Chanchita changed with behavior, social status, and reproductive condition with gregarious, non-reproductive individuals having a "pale body color", territorial individuals "bright body color" and non-territorial individuals "opaque gray."

Kullander was unable to observe live color in *Cichlasoma portalegrense* and *Cichlasoma pusillum*. A color photo of a live *C. portalegrense* collected within its natural range appears in Corrêa et al. (2010) and shows a fish with a light green to yellow sheen on the body and pelvic fins with all other fins dusky to yellowish. This appearance, though less metallic green and light blue than Chanchita from Florida is not so substantially different as to eliminate *C. portalegrense* from consideration as the species in Florida. Images of preserved *C. portalegrense* appear in Abrahão et al. (2015), Azevedo and Bertaco (2016), and Honorio and Martins (2018) but are not informative with respect to body and fin color. No color photos of live *C. pusillum* that could be reliably traced to the known range of the species were available to this study. It is likely *C. pusillum* also exhibits a blue, green, or yellow sheen on its body and fins and that blue, green, and yellowish body and fin color is a shared feature of the *Cichlasoma dimerus* species group. Accordingly, body and fin color would appear unreliable for diagnosing species of acara within this group.

A diagnostic character in Kullander's description of *C. pusillum*, "irregularly arranged dark spots on gill-cover" (pg. 221), described elsewhere within the same work as "scattered dark dots on operculum, suboperculum, and corner of preoperculum" (pg. 225), is absent from acara in Central Florida, eliminating *C. pusillum* as the species introduced to Central Florida. It should be noted, however, that the image of *C. portalegrense* in Honorio and Martins (2018; pg. 5, figure 4) shows extensive spotting on the gill cover of a fish from the Una River, tributary to the Paraiba do Sul River, in the state of São Paulo. This locality is north of the known range of *C. portalegrense* in Brazil, where it is reported only from the states of Rio Grande do Sul and Santa Catarina (Kullander 1983; Abrahão et al. 2015). It is also outside the known range of *C. pusillum*, which was described from the Upper Rio Paraná and Rio Uruguay system of Paraguay (Kullander 1983; Ottoni 2011) and southern Brazil but is more definitively known from the Yguazú reservoir and the Rio Monday (Kullander and Santos de Lucena 2013).

The presence of micro-gill rakers on the inner surface of the fourth branchial arch is typical of *Cichlasoma*, though variably present in Chanchita, *Cichlasoma dimerus*, and absent in *Cichlasoma portalegrense* (Kullander 1983). CT scans of 2 specimens of Central Florida acara (UF 241009 n = 2 of 3) were inconclusive in revealing the presence of these structures (see results). Because micro-gill rakers of the fourth gill arch in *Cichlasoma* are nowhere illustrated in the literature available to this study, the fourth gill arch was removed from a large Black Acara (UF 239097) in order to visualize these structures (see results). Micro-gill rakers detected on the inner surface of the fourth gill arches dissected from two scanned specimens of Central Florida acara are instructive in eliminating *C. portalegrense*.

The number of lower jaw teeth in outer hemi series is an additional discriminating character between *Cichlasoma dimerus* (16–24 teeth) and *Cichlasoma portalegrense* (11–15 teeth) (Kullander 1983). All four outer hemi-series examined having > 17 teeth (see results) also eliminates *C. portalegrense*.

The Chanchita, Cichlasoma dimerus *in Florida*

The first record from Florida of Chanchita, *Cichlasoma dimerus*, for which voucher specimens are available is six specimens from Lake Tarpon, north Pinellas County, Tampa Bay drainage, collected on July 27, 2000 (UF 242256). The species appears to have been firmly established by November/December 2001 in nearby Brooker Creek, northeast Pinellas County, Tampa Bay drainage (UF 160700, UF 160701, UF 160705, UF 160635, UF 160895, UF 160898 and UF 160900; n = 281 individuals total). A single specimen of Chanchita was taken in the Pithlachascotee River headwaters, Pasco County, Pithlachascotee River drainage on January 24, 2002 (UF 124513). The origin

Figure 6. Chanchita, *Cichlasoma dimerus*, Volusia Blue Spring, March 30, 2017. Photo by Kirsten Work.

of populations of Chanchita in Florida is unknown but based on these museum records would appear likely to be West-Central Florida, likely within northern Pinellas County, around the turn of the century. Chanchita have recently been collected or observed in Central Florida springs of the Upper St. Johns River system, including Rock Springs Run, Wekiva River, October 11, 2018 (UF 241318) and Volusia Blue Spring, March 30, 2017 (Figure 6; Kirsten Work *pers. comm.*; USGS 2019).

The Chanchita is native to the Paraguay and Paraná river basins, encompassing areas of northeastern Argentina, southern Brazil, eastern Paraguay, Uruguay, and eastern Bolivia where it prefers densely vegetated lentic waters (Kullander 1983; Alonso et al. 2007). Chanchita occupy the tropical and subtropical zone from approximately 19°S (CAS 14771) to 34.5°S (CAS 31728). The Black Acara, *Cichlasoma bimaculatum* is native to the upper Rio Branco drainage, Amazonas basin, in Brazil; Rio Cuyuni in Venezuela and isolated river basins of western French Guiana Suriname and Guyana. Black Acara are tropical, ranging from 3.28°N (CAS 78173) to 9.5°N (ROM 41511).

The extent to which Chanchita introduced to Florida will spread is unknown. Pandolfi et al. (2009) found Chanchita tolerate a wide variety of water conditions and temperatures between 10 to 30 °C. An ecological risk screening summary performed by the United States Fish & Wildlife Service, sourcing climate data from weather stations within the native range of Chanchita, yielded a high match for an area within the U.S., extending along the southeastern coast from the southern tip of Maryland to Texas (USFWS 2018a). The same risk screening process conducted for Black Acara yielded a high match for Florida and coastal Georgia (USFWS 2018b). Schofield and Huge (2011) found the average lower lethal limit for Black Acara collected from Florida to be 8.6 °C.

Captive Chanchita formed monogamous pair bonds, bred year round, and spawned on average every 29.4 days during the spring (Vázquez et al.

2012). Varela et al. (2017) found captive females ten days post spawn had ovarian histology comparable to that of pre-spawning females and concluded female Chanchita are functionally capable of a spawning interval equal to the shortest recorded for fishes under laboratory conditions. As is common to most substrate spawning cichlids, parent fish cooperatively guard and care for the eggs and developing larvae (Pandolfi et al. 2009); larvae are free swimming in approximately 174 hours and the juvenile stage is reached in 42 days at approximately 14.7 mm total length (Meijide and Guerrero 2000).

In asserting that Chanchita likely possess a strong capacity for dispersal, Kullander speculated that Chanchita possibly use the stomach for air breathing and cited the observations of Sucksdorff (1981), who reported on "small green cichlids" capable of overland migration during the rainy season in the Pantanal of the state of Mato Grosso do Sul, Brazil. A photo appearing in Sucksdorff of a live *Cichlasoma* on its side on a footpath in approximately 2 cm of water and partially exposed to the air is identified by Kullander as a Chanchita.

Conclusion

Effective invasive species management requires accurate species identification. The Chanchita, *Cichlasoma dimerus*, present in Florida waters for at least 19 years, has spread through several Central Florida river drainages and counties while misidentified as the Black Acara, *Cichlasoma bimaculatum*. Despite morphological similarity to Black Acara, the Chanchita is likely to tolerate a wider temperature range, as evinced by a latitudinally broader native range. Capable of breeding year round under optimal conditions, Florida's environments may facilitate higher levels of fecundity for Chanchita than their native range. Further attributes of the Chanchita's biology, including biparental care and a hypothesized capability for overland migration during wet periods and a tolerance for low oxygen environments may portend further colonization in the state. Environmentally sensitive areas including springs habitat, which has already been partially colonized, and those areas adjacent to them, could be monitored for the presence of Chanchita. Greater care is needed in the identification of nonindigenous species of fishes.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Florida Museum distribution records of acara in Florida.

Table S2. Morphometric and meristic feature counts taken of acara specimens (NT = not taken).

This material is available as part of online article from:
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