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Jason C. Chaney

David L. Bechler
Valdosta State University, dbechler@valdosta.edu

THE OCCURRENCE AND DISTRIBUTION OF *HETERANDRIA FORMOSA* (TELEOSTEI, POECILIIDAE) IN LOWNDES COUNTY, GEORGIA

Jason C. Chaney[1] and David L. Bechler[2*]
[1]1305 Dean Lane
Remerton, Georgia 31601

[2]Department of Biology
Valdosta State University
Valdosta, Georgia 31698-0015
*dbechler@valdosta.edu

ABSTRACT

Heretofore in the literature, *Heterandria formosa* had not been reported from Lowndes County, Georgia. Based on a survey of Lowndes County; we discovered eight localities from the southeastern portion of the county that collectively produced 30 specimens of *H. formosa*. The southeastern portion of the county is primarily flatwoods with numerous wetlands and low gradient streams compared to the remainder of the county, which is typified by a more upland habitat with greater relief and greater stream gradients. It is postulated that the greater stream gradients inhibited the migration of *H. formosa* into the southwestern and northern portions of the county.

Key Words: *Heterandria formosa*, Distribution, South Georgia, Flatwoods

INTRODUCTION

Heterandria formosa, the smallest fish in North America, is one of three members of the family Poeciliidae occurring naturally in Georgia (1). *Heterandria formosa* is the only North American representative of its genus; all others occurring from the Yucatan peninsula south into Central America (2). It is distinguished form other members of the family found in Georgia by a dark horizontal bar with smaller dark vertical bars along the body and a dorsal fin with a distinct ocellus surrounded by red (3). Heterandria formosa occupies well vegetated shallow, lentic waters and is known to occur in both fresh and brackish waters along the periphery of creeks, ponds, swamps, and lakes (4, 5). Other than the entire peninsula of Florida, the distribution of *H. formosa* is restricted to the Atlantic and Gulf Coastal Plains ranging from the Sabine River, Orange County, Texas (6) to the Cape Fear River, North Carolina (1). Heretofore, it was not known to be found more than 161 km inland (7).

Prior to this report, no populations were known form Lowndes County, Georgia. Here we report newly discovered populations in Lowndes County, Georgia, which also represent the western-most distribution of the species in southern Georgia. Analyses of population structure and geophysical and hydrological factors that may limit the species distribution are also provided.

MATERIALS AND METHODS

Thirty-seven locations (Appendix) were sampled in Lowndes County, Georgia, from 21 February to 13 April 2003. Locations sampled were at the junctions of creeks and roads. Sample sites were as uniformly distributed across the county as possible. Sites were sampled by dip netting along the edges of the creeks in areas with or without vegetation. Mesh sizes of the nets ranged from 1.5 to 4.0 mm. When present, one to 11 specimens were collected from each site. Specimens were immediately preserved in a 10% formalin solution, washed in water for 20 hours and preserved in 55% isopropyl alcohol. All specimens were archived in the Valdosta State University ichthyology collection. Standard length (SL) to the nearest 0.1mm and sex were determined for all specimens collected.

DeLorme 3-D TopoQuads (8) maps for the state of Georgia were used to determine longitude, latitude, and elevation to the nearest meter for all collection sites. DeLorme 3-D TopoQuads (8) were used to determine variations in topographic relief between the southeastern portion of the county compared to the southwestern and northern portions of the county. These determinations in topographic relief were made by determining the elevations along transect lines that followed longitudinal lines N 83° 10', N 83° 15', N 83° 20', and N 83° 25' at each point where they crossed latitudes W 31° 0', W 30° 55', W 30° 50', W 30° 45', W 30° 40", and the Florida state line. The southeastern portion of the county was defined as the area south of latitude W 83° 12' 53" and east of longitude N 30° 46' 3".

RESULTS

Heterandria formosa was collected form eight localities in the southeastern portion of the county (Table I, Figure 1) to include one site from within the City of Valdosta. Except for the city, this area is typified by flatwoods habitats (9, 10) with numerous wetlands scattered throughout and low steam gradients along Mud, Knights and Grand Bay creeks, which converge to form the Alapahoochee River. Elevations in this area as determined by transect lines ranged form 34m to 62m with a standard deviation of 9.1m (n=8). In contrast, the remainder of the county is drained by the Withlacoochee River with wetlands lying primarily along the river (8). Elevations along transect lines in the southwestern and northern portions of the county ranged from 23m to 72m with a standard deviation of 16.9m (n=14). Stream gradients between the southeastern portion of the county and the rest of Lowndes County were significantly different with collecting sites in the southeastern portion of the county having a mean elevation of 49.4m with a variance of

43.3 (n=18, S.D=6.6m) compared to the rest of the county where elevations averaged 52.7m with a variance of 126.6 (n=19, S.D.=11.3m) (Two-sample Test of Variances; N=37; df=17, 18; F=0.342, p=0.015).

Table I. Localities by Description and Longitude and Latitude. All localities are within the southeastern portion of Lowndes County as defined in the main text. Sites 1, 2 and 3 are within the Withlachoochee River drainage. All other localities are within the Alapahoochee River Drainage. Zero (0) specimens listed for Site 1 are due to the fact that they were the first collected and maintained alive in the laboratory and not used to determine sex or size ranges.

Site	Lowndes County Locations: Description, Longitude and Latitude	No. of Specimens	Sex Ratio	
			M	F
1	One-mile Branch Cr at Gordon St. and Melody Ln. N 30° 50' 22.4", W 83° 18' 29.2"	0	-	-
2	Bevel Creek (Browns Pond) at Loch Laurel Road N 30° 43' 18.5", W 83° 14' 48.5"	6	0	6
3	Creek at Loch Laurel andDasher Roads N 30° 42' 36.8", W 83° 18' 29.2"	11	2	9
4	Mud Creek at Hickory Grove Road N 30° 50' 39.7", W 83° 15' 1.9"	1	0	1
5	Knights Creek at US Highway 84 N 30° 50' 22.4", W 83° 18' 29.2"	5	1	4
6	Knights Creek at Howell Road N 30° 49' 15.4", W 83° 18' 45.6"	2	0	2
7	Knights Creek at Park Avenue (Hwy 221) N 31° 51' 42.5", W 83° 15' 14.9"	2	2	0
8	Enoch Creek at County Road 102 N 30° 41' 52.8", 2 83° 9' 0.8"			
	Totals	30	5	25

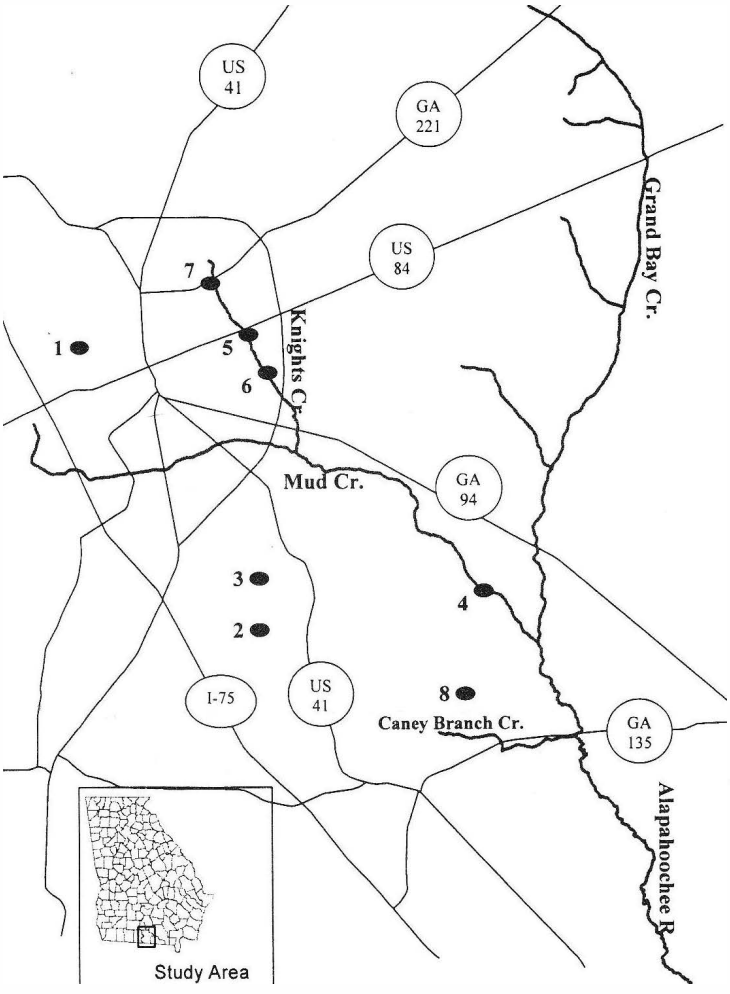

Figure 1. *Heterandria formosa* collecting sites, Lowndes County, Georgia. Site numbers are indicated by solid black oval and correspond to those described in Table I and the text. Only the southeastern portion of Lowndes County is within the boundaries of the figure. The above map was produced with ESRI software using Tele Atlas map layers, and permission for publication is granted by Tele Atlas, http://www.tele-mart.com/ and http://www.tele-mart.com/esri.php.

No specimens of *H. formosa* were collected at sites sampled in the southwestern and northern portions of the county. With the exception of sites 1, 2 and 3 (Table I, Figure 1), which are in the Withlacoochee River drainage, all other sites where *H. formosa* was collected lay in the Alapahoochee River drainage, which is part of the Alapaha River drainage. In addition Site 3, which flows into Brown's Pond, and Site 2 are drained by Bevel Creek, so are actually in the same hydrologic system. Sites 1, 2, and 3

while lying in the Withlacoochee drainage, lie on its eastern most edge with site 2 and 3 lying in flatwoods habitat that is contiguous with the flatwoods habitat in the southeastern portion of the county. Both the Withlacoochee and the Alapahoochee rivers are part of the Suwannee River basin. All the sites where *H. formosa* were collected were typified by lentic to nearly lentic waters with most being shallow and well vegetated with submergent and emergent vegetation.

Of the 30 specimens collected and preserved, female length was 17.3mm (n=25, S.D.=2.6) with a range of 12.8 to 20.8 mm compared to an average length of 12.5mm for males (n=5, S.D.=0.5) with a range of 12.0 to 13.4 mm. Differences in average length were significantly different (N=30, df=28, t=8.002, P<0.0001).

DISCUSSION

Our understanding of the biology of *H. formosa* has been enhanced through this study with respect to the following two points: (1) the dynamics of a range extension of *H. formosa* westward in Georgia, and (2) a test of factors possibly limiting the distribution of *H. formosa*.

The occurrence of *H. formosa* in Lowndes County, Georgia, represents a range extension of 118.0 km (1, 8) east of it present published range along the eastern edge of the Okeefenokee swamp, Glynn County. With respect to its nearest distribution in the Suwannee River basin in Florida, the range extension is northward by about 56.0 km (1). With the occurrence of *H. formosa* being common along the Gulf of Mexico coast and common throughout the peninsula of Florida, migration inland along the Suwannee River and its presence in Lowndes county should have been expect; however *H. formosa* was not discovered until a dip netting survey by the first author was undertaken in One-mile Branch Creek. Prior to this survey, collecting throughout Lowndes, Echols and Brooks counties had been conducted over a seven-year period without *H. formosa* having been collected. The small size and microhabitat preference of *H. formosa* for shallow lentic waters with aquatic vegetation (4, 5) may account for the failure to have discovered it prior to this time. Mesh size of seines used and seining techniques may have precluded the capture of *H. formosa*.

Extensive collecting throughout Lowndes County showed *H. formosa* to be restricted to the southeastern region of the county, a region that is predominantly flatwoods. Compared to regions with greater geophysical relief, streams and wetlands associated with flatwoods are typified by low stream gradients, slower currents, and long retention times of water within flatwoods (9, 10). Lower stream gradients hold for the flatwoods of the southeastern region of Lowndes County and water retention is greater compared to the southwestern and northern regions of the county, which possess significantly greater stream gradients resulting form greater geophysical relief. The small size of *H. formosa* may preclude it from migrating into regions of the county where stream gradients and currents are greater (11).

Assuming that Sites 2 and 3, which are in the Bevel Creek drainage basin, represent one population, then the presence of two populations *H. formosa* in the Withlacoochee River drainage (Table I, Figure 1) rather than the Alapaha River drainage can be explained by two mechanisms: [1] historically *H. formosa* could have migrated up the Withlacoochee River when migration conditions such as low stream gradients were more suitable, or [2] possibly stream capture by drainages in close proximity to each other could also account for the presence of these two populations in the Withlacoochee drainage (11). Stream capture has been hypothesized to account for hybrids between *Cottus b. bairdi* and *C. caeruleomentum* in Willis Creek of the Potomac River drainage (12) and a unique halotype of *Etheostoma nigrum* in the upper Poor Fork of the Cumberland River (13). The headwaters of One-mile Branch Creek on which Site 1 lies are within 0.5 km of the wetlands surrounding the headwaters of Knights Creek on which sites 5, 6 and 7 are found. The location of Site 2 and 3, which lies well within the flatwoods that Mud and Knights creeks flow through, makes stream capture a plausible explanation.

Baer (14) has argued that a genetic analysis of gene flow in 34 populations of *H. formosa* along the Gulf of Mexico and Atlantic coasts is best explained by a two-dimensional model with gene flow occurring through southeast Georgia and across the Florida peninsula into the area of the Aucilla and Ochlockonee rivers. The presence of *H. formosa* in Lowndes County as well as the lower Suwannee River basin would facilitate such gene flow and further argues for stream capture across multiple river drainages between the east coast and the Gulf of Mexico.

The findings in this study coupled with Baer's (14) genetic analysis suggests that additional work needs to be done on the distribution of *H. formosa* and factors governing its distribution. The fact that flatwoods habitat exists from southeast Lowndes County east to the Okeefenokee Swamp, the origin of the Suwannee River, suggests that *H. formosa* should be found throughout the entire region. Inland flatwoods habitats associated with the Ochlockonee River in southwestern Georgia and the Satilla River in eastern Georgia might also hold populations of *H. formosa*. Additional genetic analyses similar to those of Baer (14), but on a finer scale might also be conducted so as to better understand the implications of gene flow across southeastern Georgia and the Florida Panhandle region.

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Appendix. Lowndes County Collecting Locations. Region designates the area of the county in which the sampling site is located. An asterisk (*) indicates that the sampling site is also listed in Table I and is a locality where *H. formosa* was collected. Elevation, listed in meters, and the names of creeks (Cr), roads (Rd), and State Highways (Hwy) are based on information provided by DeLorme 3-D TopoQuads (8).

Region	Description, Longitude and Latitude	Elevation
S.E.*	One-mile Branch Cr at Gordon St. and Melody Ln; N 30° 50' 22.4", W 83° 18' 29.2"	49
S.E.*	Bevel Creek (Browns Pond) at Loch Laurel Rd; N 30° 43' 18.5", W 83° 14' 48.5"	49
S.E.*	Creek at Loch Laurel and Dasher Rds; N 30° 42' 36.8", W 83° 18'‘ 29.2"	51
S.E.*	Mud Creek at Hickory Grove Rd; N 30° 50' 39.7", W 83° 15' 1.9"	38
S.E.*	Knights Creek at US Hwy 84; N 30° 50' 22.4", W 83° 18' 29.2"	59
S.E.*	Knights Creek at Howell Rd; N 30° 49' 15.4", W 83° 18' 45.6"	59
S.E.*	Knights Creek at Park Avenue (Hwy 221); N 31° 51' 42.5", W 83° 15' 14.9"	61
S.E.*	Enoch Creek at County Rd 102; N 30° 41' 52.8", W 83° 9' 0.8"	43
S.E.	Mud Cr at Perimeter Rd; N 30° 48' 17.3", W 83° 14' 3.5"	50
S.E.	Unnamed Cr at County Rd; 20, N 30° 50› 22.4», W 83° 10› 15.0»	56
S.E.	Unnamed Cr at Howell Rd; N 30° 49' 246.9", W 83° 9' 6.0"	53
S.E.	Grand Bay Cr at Howell Rd; N 30° 49' 46.6", W 83° 48' 38.3"	46
S.E.	Unnamed Cr at Boring Pond Rd; N 30° 48' 38.3", W 83° 11' 04"	54
S.E.	Unnamed Cr at Vann Rd; N 30° 46' 40.9", W 83° 10' 48.2"	44
S.E.	Caney Cr at Hwy 376; N 30° 42' 4.4", W 83° 9' 0.8"	43
S.E.	Caney Cr at County Rd; 103, N 30° 4' 52.8", W 83° 9' 0.8"	42
S.E.	Unnamed Cr at Loch Laurel Rd; N 30° 42' 36.8", W 83° 15' 1.9"	49

S.E.	Cr from Bear Garden Swamp Cr at Jumping Gulley Rd; N 30° 38' 8.0", W 83° 15' 58.5"	25
S.W.	Unnamed Cr at Santa Clause Rd; N 30° ' ", W 83° ' "	59
S.W.	Lanes Mill Cr at Clyatteville-Nankin Rd; N 30° 41' 31.9", W 83° 21' 24.5"	41
S.W.	Perennial Cr at Ousley Rd; N 30° 41' 46.1", W 83° 22' 42.7"	40
S.W.	Perinnial Cr at Phillips Rd; N 30° 47' 42.0", W 83° 22' 50.8"	68
S.W.	Tiger Cr at Ousley Rd; N 30° 47' 24.2", W 83° 25' 43.3"	41
N.	Franks Cr at Morvan Rd; N 30° 59' 4.8", W 83° 23' 35.2"	56
N.	Franks Cr at Franks Cr Rd; N 30° 56' 58.5", W 83° 23' 0.0"	50
N.	Franks Cr at Shiloh Rd; N 30° 53' 41.0", W 83° 22' 4.4"	41
N.	Unnamed Cr at Hwy 122; N 30° 59' 39.5", W 83° 24' 37.2"	62
N.	Big Cr at Shilo Rd. N 30° 57' 55.6", W 83° 24' 11.3"	56
N.	Unnamed Cr at Thunderbowl Rd. N 30° 55' 0.1", W 83° 24' 6.9"	53
N.	Unnamed Cr at Union Rd. N 30° 56' 36.5", W 83° 22' 4.4"	56
N.	Unnamed Cr at Coleman Rd. N 30° 58' 51.3", W 83° 20' 58.2"	56
N.	Twin Cr at Hwy 122 N 30° 59' 32.0", W 83° 19' 51.9"	61
N.	Unnamed Cr at Old Pine Rd. N 30° 56' 0.0", W 83° 14' 53.7"	71
N.	Cherry Cr at Stallings Rd. N 30° 54' 2.0", W 83° 13' 57.4"	59
N.	Grand Bay Cr at Old State Rd. N 30° 56' 3.2", W 83° 6' 30.9"	56
N.	Copeland Cr at Old State Rd. N 30° 56' 5.6", W 83° 8' 18.9"	60
N.	Bay Branch Cr at Valdel Rd. N 30° 56' 27.9", W 83° 19' 44.8"	47

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