

Ecological Risk Screening Summary for Maryland:
Candiru (*Vandellia cirrhosa*)



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Department of Natural Resources
Resource Assessment Service



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Foreword

The following document summarizes a risk assessment for the Candiru (*Vandellia cirrhosa*) conducted by staff of the Maryland Department of Natural Resources. The risk assessment tools used in this analysis were developed elsewhere but adopted to assess potentially invasive animals in Maryland by the Maryland Department of Natural Resources' Invasive Species Matrix Team in 2020 (Kilian and Harbold 2020). The AS-ISK screening tool is one of the most widely applied, tested, and calibrated tools available for assessing invasive risk (Vilizzi et al. 2019). It has been adapted to assess various taxa including amphibians, reptiles, marine and freshwater fishes, and marine and freshwater invertebrates in a wide range of environments. The Invasive Species Matrix Team also adopted the Great Lakes Assessment Framework (Fusaro et al. 2017) as a more comprehensive assessment to be used in conjunction with the AS-ISK screening tool when appropriate. The results of both tools are summarized below along with a climate suitability analysis using the CLIMATCH model (Australian Bureau of Rural Sciences 2010). The ecological risk screening summary format used in this report was adapted from the Ecological Risk Screening Summary template developed by the U.S. Fish and Wildlife Service (USFWS 2018a).

1. Background and Description

There are six species in the genus *Vandellia*. All appear to be fish blood parasites, and the common name “Candiru” has been applied to more than one of them. (Schmidt 1987). *Vandellia cirrhosa* is most commonly described using the “Candiru” common name, but there could be some confusion as to exactly what species is being discussed when using that name. The Candiru is native to the Amazon and Orinoco River Basins in South America and no known introductions outside its native range have been reported (Froese and Pauly 2019). *Vandellia cirrhosa* is parasitic to fish, searching for hosts using chemosensory and visual cues (Spotte 2001). Once a host is found it attacks the gills where it stays for no more than a few minutes to feed from. Recent evidence suggests they attack the major gill arteries of a host fish, relying on the host's blood pressure to pump blood into its gut, rather than sucking blood directly (Zuanon and Sazima 2004). *Vandellia cirrhosa* is not an interest in human utilization, consumption or for use in fisheries (Froese and Pauly 2019). There are reports of this species attacking humans but they are lacking documentation of any modern/verified occurrences (Bauer 2005).

2. Distribution



Figure 1. Known global distribution of *Vandellia cirrhosa*. Locations in Bolivia, Brazil, Columbia, Ecuador, and Peru. Map from GBIF Secretariat (2019).

Native Range

The candiru is native to the Amazon and Orinoco River Basins in South America. Countries where it has been reported include Bolivia, Brazil, Columbia, Ecuador, and Peru. (Froese and Pauly 2019)

Nonnative Range

Outside the United States

There are no records available that indicate it has been introduced outside of its native range. (GBIF.org (25 September 2019) GBIF Occurrence Download <https://doi.org/10.15468/dl.a8vjst>)

Within the United States

Candiru is currently not found in the United States.

3. Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to Fricke et al. (2025) *Vandellia cirrhosa* (Cuvier & Valenciennes 1846) is the current valid name for this species. It was originally described as *Vandellia cirrhosa* (Cuvier & Valenciennes 1846). From ITIS (2019):

From ITIS (2019):

Kingdom Animalia

Subkingdom Bilateria

Infrakingdom Deuterostomia

Phylum Chordata

Subphylum Vertebrata

Infraphylum Gnathostomata

Superclass Actinopterygii

Class Teleostei

Superorder Ostariophysi

Order Siluriformes

Family Trichomycteridae

Subfamily Vandelliinae

Genus *Vandellia*

Species *Vandellia cirrhosa* Valenciennes in Cuvier and Valenciennes, 1846:

The current taxonomic status is valid.

Size, Weight, and Age

Candiru have a torpedo-like body measuring 5 to 8 cm in length with a max standard length of 17.0 centimeters. The diameter is 4 to 6 millimeters (Herman, 1973, de Pínna and Wosiacki, 2003 as cited in Froese and Pauly, 2019).

Preferred Climate and Habitat

Candiru is a tropical, freshwater, and demersal species of fish. Past studies have collected *Vandellia cirrhosa* in the shallows of a 30 degrees Celsius blackwater river around submerged rocks and sand banks (Spotte et al. 2001) and in shallow water over mud and sand bottoms (Zuanon and Sazima 2004).

Biology

Vandellia cirrhosa resides buried in soft muddy/sandy bottoms when inactive and forages for blood at night and day when active (Zuanon and Sazima 2004). It finds hosts in muddy, turbulent waters using chemosensory and visual cues (Spotte 2001). Once a host is found, *Vandellia cirrhosa* forces itself into the gill chamber where it primarily bites a major gill artery, relying on the host's blood pressure to pump blood into its gut. The process takes 30 to 145 seconds from engorging to leaving the host (Zuanon and Sazima 2004). Some host species have been observed displaying defensive mechanisms by tightening its gill cover, slowing ventilation, and “using its pectoral fin to press it against its own flank or to sweep it from the gill cover edge.” (Zuanon and Sazima 2004, Froese and Pauly 2019)

Human uses

Vandellia cirrhosa is not an interest for human utilization, consumption or for use in fisheries (Froese and Pauly (2019). There are mentions of keeping this species and other congeners as pets on online aquarium forums (MyFishEatYourFish 2011).

Diseases

There are no reports available of diseases or parasites carried by this species. It is a parasite of fish itself.

Threat to humans

Vandellia cirrhosa is listed as “Traumatogenic” in FishBase (Wheeler 1977, as cited in Froese and Pauly 2019). There are reports of this species attacking humans but they are lacking documentation of any modern/verified occurrences (Bauer 2005).

4. Introductions

Outside the United States

No records of introductions outside of its native range have been found.

Within the United States

There is no data available on introductions of Candiru in the United States. Either introductions have not occurred, or they have gone unreported. If introductions were to occur it seems most likely that the pathway would be via the aquarium fish trade.

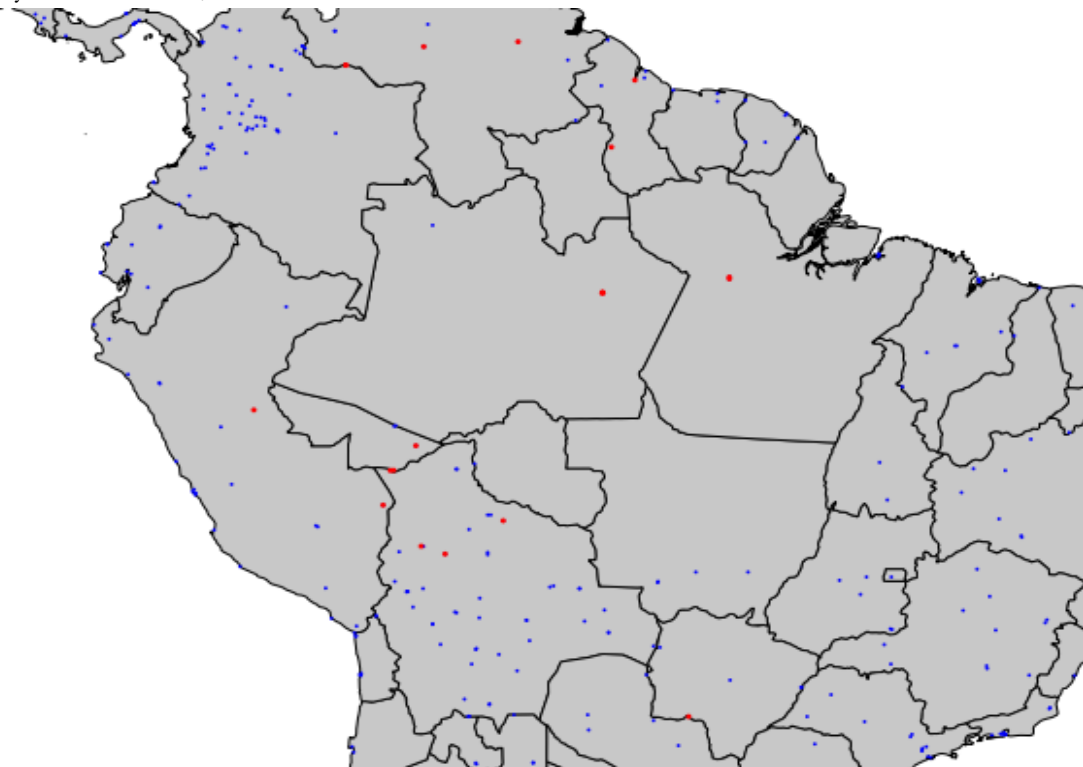
Impacts of Introduction

No records of introductions outside of its native range have been reported.

5. Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Australian Bureau of Rural Sciences 2010; 16 climate variables; Euclidean Distance) for Maryland was 0.006, Medium.



Figure

2: Climatch (Australian Bureau of Rural Science 2010) source map showing weather stations selected as source locations (red) and non-source locations (blue) for *Vandellia cirrhosa* climate matching. Source locations from GBIF.org (25 September 2019) GBIF Occurrence Download <https://doi.org/10.15468/dla8vjrs>.

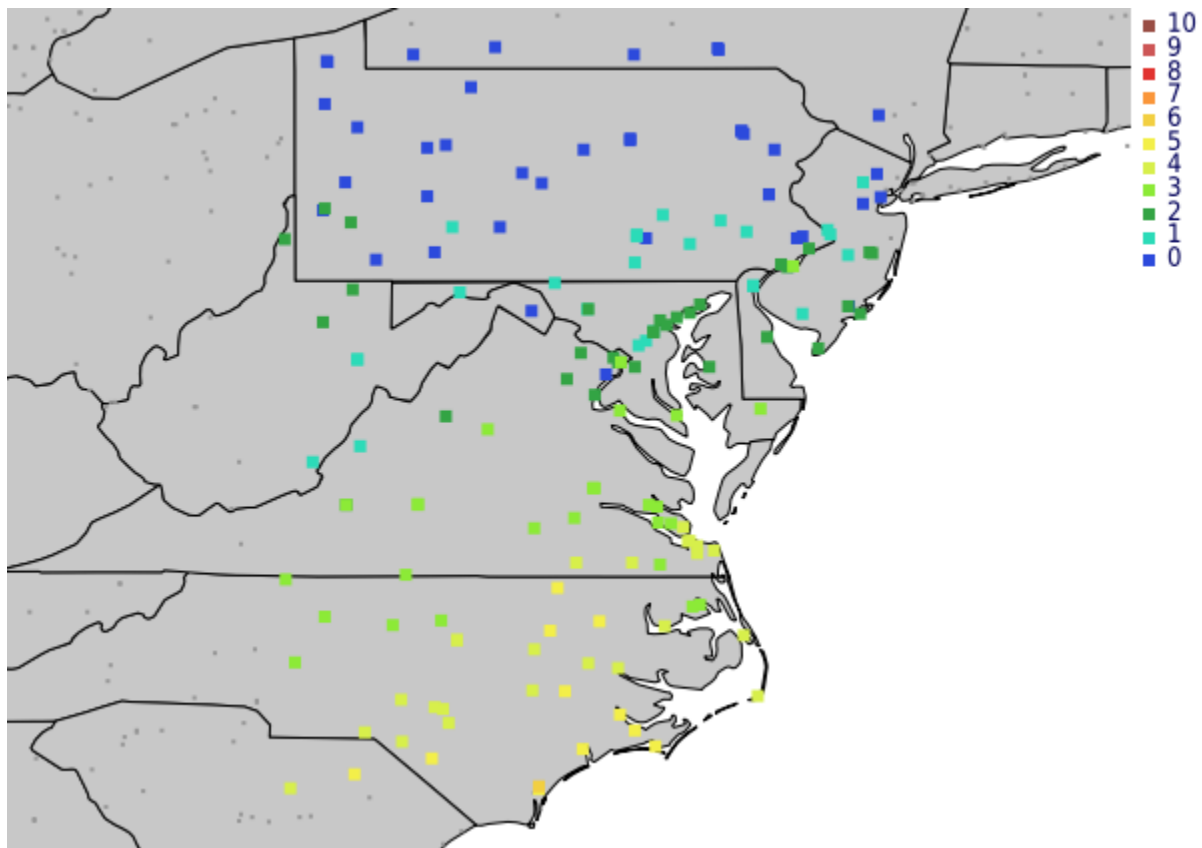


Figure 3: Map of Climatch (Australian Bureau of Rural Science 2010) climate matches for *Vandellia cirrhosa* in Maryland based on source locations reported by GBIF.org (25 September 2019) GBIF Occurrence Download <https://doi.org/10.15468/dl.a8vjsr>. 0= Lowest match, 10=Highest match.

Table 1: Climatch (Australian Bureau of Rural Science 2010) climate match scores for *Vandellia cirrhosa* for Maryland.

Climate Match	0	1	2	3	4	5	6	7	8	9	10
Count	39	25	33	26	24	11	1	0	0	0	0
Climate 6 Proportion = (Sum of Climate Score 6-10) / (Sum of Total Climate Scores) = 0.006 : Medium											

Table 2: Basis for High, Medium, and Low Climate Match Categories.

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
$0.000 < X < 0.005$	Low
$0.005 < X < 0.103$	Medium
> 0.103	High

6. Risk Assessment

Summary of Risk to the Contiguous United States

Candiru (*Vandellia cirrhosa*) is a parasitic catfish that is native to South America in the Amazon and Orinoco river basins. It has been reported from Bolivia, Brazil, Columbia, Ecuador, and Peru. *Vandellia cirrhosa* inhabits freshwater rivers and is typically found over soft mud or sand bottoms in shallow water. The history of invasiveness is uncertain since it has not been documented anywhere outside of its native range. The overall climate match for the mid-Atlantic United States was medium. Southern North Carolina had one medium match while most of the remainder of the region and all of Maryland had a low match. The certainty of assessment is low. The overall risk assessment category for *Vandellia cirrhosa* is low.

Assessment Elements

- **History of Invasiveness (Sec. 3):** Uncertain
- **Climate Match (Sec.6):** Medium (Low in Maryland only)
- **Certainty of Assessment (Sec. 7):** Low
- **Remarks/Important additional information:** Fish parasite Rare and largely unsubstantiated reports of attacks on humans
- **Overall Risk Assessment Category:** Low

7. Certainty of Assessment

The certainty of assessment for *Vandellia cirrhosa* is low. There is minimal information available for this species. *Vandellia cirrhosa* has not been introduced anywhere outside of its native range, and therefore, there are no impacts of introduction.

8. References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

- Baskin, J.N., T.M. Zaret & F. Mago-Leccia. 1980. Feeding of reportedly parasitic catfishes (Trichomycteridae and Cetopsidae) in the Rio Portuguesa Basin, Venezuela. *Biotropica* 12:182–186.
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Herman, J. 1973. Candiru: urinophilic catfish. *Urology*. 1: 265–267.

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MyFishEatYourFish. “Candiru Asu.” *MonsterFishKeepers*, 24 Feb. 2011, <https://www.monsterfishkeepers.com/forums/threads/candiru-asu.396487/>

Schmidt, R. E. 1987. Redescription of *Vandellia beccarii* (Siluriformes: Trichomycteridae) from Guyana. *Copeia*. 1: 234-237.

Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, *Vandellia* cf. *plazaii*. *Environmental Biology of Fishes*. 2001; 60:459–464.

Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus *Vandellia* (Trichomycteridae) feed on major gill arteries of host fishes. *Journal of Ichthyology and Aquatic Biology*. 8: 31-36.

9. References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

de Pínna, M.C.C. and W. Wosiacki, 2003. Trichomycteridae (pencil or parasitic catfishes). p. 270-290. In R.E. Reis, S.O. Kullander and C.J. Ferraris, Jr. (eds.) *Checklist of the Freshwater Fishes of South and Central America*. Porto Alegre: EDIPUCRS, Brasil.

Wheeler, A., 1977. *Das grosse Buch der Fische*. Eugen Ulmer GmbH & Co. Stuttgart. 356 p.

10. Appendices

1. AS – ISK Risk Assessment Screening
2. Great Lakes Assessment Framework

AS-ISK Risk Screening Assessment- Candiru

Taxon and Assessor details	
Category	Fishes and Lampreys (freshwater)
Taxon name	<i>Vandellia cirrhosa</i>
Common name	Candiru
Assessor	William Harbold
Risk screening context	
Reason and socio-economic benefits	Candiru is being evaluated to determine if its prohibited status in Maryland is warranted.
Risk Assessment Area	Maryland, the Mid-Atlantic Region
Taxonomy	Actinopterygii (ray-finned fishes) > Siluriformes (Catfish) > Trichomycteridae (Pencil or parasitic catfishes) > Vandelliinae
Native range	South America: Amazon River basin.
Introduced range	None currently. There are no available records of introduction outside its native range.
URL	https://www.fishbase.se/summary/8811

			Response	Justification (references and/or other information)	Confidence
A. Biogeography/Historical					
1. Domestication/Cultivation					
1	1.01	Has the taxon been the subject of domestication (or cultivation) for at least 20 generations?	No	There are no records of cultivation or domestication of Candiru. Laboratory experiments have used wild caught specimens. Spotte et al. 2001, Zuanon & Sazima 2004.	High
2	1.02	Is the taxon harvested in the wild and likely to be sold or used in its live form?	No	There are no records of wild/commercial harvest of Candiru.	High
3	1.03	Does the taxon have invasive races, varieties, sub-taxa or congeners?	No	There are no known introductions or invasions of Candiru or other Vandellia species. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Medium
2. Climate, distribution and introduction risk					
4	2.01	How similar are the climatic conditions of the Risk Assessment (RA) area and the taxon's native range?	Low	The Amazon Basin is tropical, Maryland is largely temperate. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr , Climatch	Very high
5	2.02	What is the quality of the climate matching data?	High	Ran Climatch climate matching software. There are 15 climate stations within Candiru native range to compare with climate in Maryland.	High
6	2.03	Is the taxon already present outside of captivity in the RA area?	No	There are no published records of Candiru in MD or anywhere else outside of its native range	High
7	2.04	How many potential vectors could the taxon use to enter in the RA area?	One	There are no commercial uses for candiru and it seems unlikely to be transported as a hitchhiker in ballast water/with other fish. The only conceivable vector would be intentional importation for aquariums/research. (Guess/conjecture)	Low
8	2.05	Is the taxon currently found in close proximity to, and likely to enter into, the RA area in the near future (e.g. unintentional and intentional introductions)?	No	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
3. Invasive elsewhere					
9	3.01	Has the taxon become naturalised (established viable populations) outside its native range?	No	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
10	3.02	In the taxon's introduced range, are there known adverse impacts to wild stocks or commercial taxa?	Not applicable	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
11	3.03	In the taxon's introduced range, are there known adverse impacts to aquaculture?	Not applicable	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
12	3.04	In the taxon's introduced range, are there known adverse impacts to ecosystem services?	Not applicable	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
13	3.05	In the taxon's introduced range, are there known adverse socio-economic impacts?	Not applicable	There are no records of Candiru outside its native range. GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr	Very high
B. Biology/Ecology					
4. Undesirable (or persistence) traits					
14	4.01	Is it likely that the taxon will be poisonous or pose other risks to human health?	No	There are numerous historical reports of this species accidentally attacking humans. There are no modern documented cases. It seems that the attacks may be a product of folklore. Bauer 2005	Low
15	4.02	Is it likely that the taxon will smother one or more native taxa (that are not threatened or protected)?	Yes	As a parasite, Candiru could suppress the growth of native fishes that it would prey on if introduced.	Low
16	4.03	Are there any threatened or protected taxa that the non-native taxon would parasitise in the RA area?	Yes	There are multiple species of rare, threatened, or endangered freshwater fish in Maryland that could conceivably be parasitized by Candiru should it be introduced.	Very high
17	4.04	Is the taxon adaptable in terms of climatic and other environmental conditions, thus enhancing its potential persistence if it has invaded or could invade the RA area?	No	Adaptability is largely unknown, as there are no records of invasion outside the native range and no available studies on survivability thresholds at different temperatures/water quality parameters. (guessing here)	Low
18	4.05	Is the taxon likely to disrupt food-web structure/function in aquatic ecosystems if it has invaded or is likely to invade the RA area?	No	There is no evidence of introduction outside the native range. As an apparently non-lethal parasite (Zuanon and Sazima 2003) it does not seem likely to disrupt food webs or ecosystem structures.	Low
19	4.06	Is the taxon likely to exert adverse impacts on ecosystem services in the RA area?	No	There is a wide-held belief that this species can attack humans. If it were to be introduced it could negatively impact aquatic recreation in the water bodies where it became established. Breault 1991	Low
20	4.07	Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are endemic in the RA area?	No	Candiru do not seem particularly mobile and would likely be restricted to certain specific habitats (temperature requirements). It is unlikely that they would be an effective vector for infectious agents. (guess/conjecture)	Low
21	4.08	Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are absent from (novel to) the RA area?	No	Candiru do not seem particularly mobile and would likely be restricted to certain specific habitats (temperature requirements). It is unlikely that they would be an effective vector for infectious agents. (guess/conjecture)	Low
22	4.09	Is it likely that the taxon will achieve a body size that will make it more likely to be released from captivity?	No	Candiru remain small as adults. Max size 170cm https://www.fishbase.se/summary/8811	Very high
23	4.10	Is the taxon capable of sustaining itself in a range of water velocity conditions (e.g. versatile in habitat use)?	Yes	There are reports of Candiru being collected from a variety of aquatic habitats: blackwater, rapids, submerged sand banks, rocks... Zuanon and Sazima 2003, Spotte et al. 2001	Medium
24	4.11	Is it likely that the taxon's mode of existence (e.g. excretion of by-products) or behaviours (e.g. feeding) will reduce habitat quality for native taxa?	No	Candiru are a fish parasite. They do not engineer their ecosystem.	Low

25	4.12	Is the taxon likely to maintain a viable population even when present in low densities (or persisting in adverse conditions by way of a dormant form)?	Yes	Information on this aspect of the Candiru's biology is unknown.	Low
5. Resource exploitation					
26	5.01	Is the taxon likely to consume threatened or protected native taxa in the RA area?	No	Candiru parasitize other fish but do not kill/consume them.	High
27	5.02	Is the taxon likely to sequester food resources (including nutrients) to the detriment of native taxa in the RA area?	No	Candiru is a parasite. It takes nutrients directly from other (native) species.	Low
6. Reproduction					
28	6.01	Is the taxon likely to exhibit parental care and/or to reduce age-at-maturity in response to environmental conditions?	No	There was no data available on the reproductive habits of Candiru.	Low
29	6.02	Is the taxon likely to produce viable gametes or propagules (in the RA area)?	No	As a tropical species, Candiru would be unlikely to survive year-round in Maryland, making successful reproduction unlikely. (a guess) Climate matching shows that Maryland's climate is not hospitable.	Medium
30	6.03	Is the taxon likely to hybridise naturally with native taxa?	No	There are no native fish in the same family as Candiru living in Maryland. There are no sources in the literature discussing hybridization for this species.	High
31	6.04	Is the taxon likely to be hermaphroditic or to display asexual reproduction?	No	No sources were available that documented hermaphroditic or asexual reproduction	Low
32	6.05	Is the taxon dependent on the presence of another taxon (or specific habitat features) to complete its life cycle?	No	There were no sources available documenting dependence on other taxa or habitat features to complete the Candiru life cycle.	Low
33	6.06	Is the taxon known (or likely) to produce a large number of propagules or offspring within a short time span (e.g. <1 year)?	No	Reproductive habits are not documented.	Low
34	6.07	How many time units (days, months, years) does the taxon require to reach the age-at-first-reproduction? [In the Justification field, indicate the relevant time unit being used.]	1	Reproductive habits are not documented.	Low
7. Dispersal mechanisms					
35	7.01	How many potential internal vectors/pathways could the taxon use to disperse within the RA area (with suitable habitats nearby)?	>1	natural dispersal, bait bucket introductions, aquarium releases. All guesses	Low
36	7.02	Will any of these vectors/pathways bring the taxon in close proximity to one or more protected areas (e.g. MCZ, MPA, SSSI)?	Yes	If released/introduced Candiru could enter state parks, WMA's, refuges or other protected areas.	Low
37	7.03	Does the taxon have a means of actively attaching itself to hard substrata (e.g. ship hulls, pilings, buoys) such that it enhances the likelihood of dispersal?	No	Candiru do not have a means of attachment to hard substrates.	Very high
38	7.04	Is natural dispersal of the taxon likely to occur as eggs (for animals) or as propagules (for plants: seeds, spores) in the RA area?	No	Reproductive habits are unknown	Low
39	7.05	Is natural dispersal of the taxon likely to occur as larvae/juveniles (for animals) or as fragments/seedlings (for plants) in the RA area?	No	reproductive and dispersal habits are unknown	Low
40	7.06	Are older life stages of the taxon likely to migrate in the RA area for reproduction?	No	There is no documented evidence of migration.	Low
41	7.07	Are propagules or eggs of the taxon likely to be dispersed in the RA area by other animals?	No	Breeding habits are unknown.	Low
42	7.08	Is dispersal of the taxon along any of the vectors/pathways mentioned in the previous seven questions (7.01–7.07; i.e. both unintentional or intentional) likely to be rapid?	No	There are no known introductions. Ability for dispersal is unknown.	Low
43	7.09	Is dispersal of the taxon density dependent?	No	There are no known introductions. Ability/characteristics for dispersal is unknown.	Low
8. Tolerance attributes					
44	8.01	Is the taxon able to withstand being out of water for extended periods (e.g. minimum of one or more hours) at some stage of its life cycle?	No	Candiru are described as being delicate. It is unlikely that they could survive desiccation. Spotte et al. 2001	Medium
45	8.02	Is the taxon tolerant of a wide range of water quality conditions relevant to that taxon? [In the Justification field, indicate the relevant water quality variable(s) being considered.]	Yes	Water quality tolerance is largely unknown. In lab experiments aquariums were kept well aerated. Spotte et al. 2001, Zuanon and Sazima 2003	Low
46	8.03	Can the taxon be controlled or eradicated in the wild with chemical, biological, or other agents/means?	Yes	There is no documented evidence, but Candiru should be susceptible to the same chemicals used to kill other fish species.	Low
47	8.04	Is the taxon likely to tolerate or benefit from environmental/human disturbance?	Yes	Increasing water temperatures (climate change or power/treatment plants) could make Maryland more hospitable for Candiru	Low
48	8.05	Is the taxon able to tolerate salinity levels that are higher or lower than those found in its usual environment?	Yes	Candiru is a freshwater fish. It is not likely to be particularly salt-tolerant.	Low
49	8.06	Are there effective natural enemies (predators) of the taxon present in the RA area?	Yes	The small size of the candiru should make it susceptible to a range of native/established piscivores in Maryland.	High
C. Climate change					
9. Climate change					
50	9.01	Under the predicted future climatic conditions, are the risks of entry into the RA area posed by the taxon likely to increase, decrease or not change?	No change	climate change is not likely to alter the pathways available for candiru's entry into Maryland	Low
51	9.02	Under the predicted future climatic conditions, are the risks of establishment posed by the taxon likely to increase, decrease or not change?	Increase	A warming climate would cause Maryland to come closer to the tropical climate in the Candiru's native range.	Low
52	9.03	Under the predicted future climatic conditions, are the risks of dispersal within the RA area posed by the taxon likely to increase, decrease or not change?	Increase	A warming climate would cause Maryland to come closer to the tropical climate in the Candiru's native range.	Low
53	9.04	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on biodiversity and/or ecological integrity/status?	No change	Candiru are not likely to impact biodiversity or ecological integrity in MD, regardless of climate.	Low
54	9.05	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem structure and/or function?	No change	Candiru are not likely to impact ecosystem structure or function, regardless of climate.	Low
55	9.06	Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem services/socio-economic factors?	No change	Candiru are not likely to impact ecosystem services. If established in a warmer climate they could have impacts on tourism due to their reported potential to attack swimmers.	Low

A risk assessment of potential Great Lakes aquatic invaders, adapted to Maryland/the Mid-Atlantic

Scientific Name:	Vandellia cirrhosa
Common Name:	Candiru

Reviewed By:	Jay Kilian and William Harbold
Date:	28-Feb-20

Scoring		Confidence Level
Potential for Introduction:	Unlikely	Low
Potential for Establishment:	Low	Moderate
Potential for Impact:		<i>unknowns/uncertainty are incorporated in impact potential scoring</i>
Environmental:	Unknown	
Socio-Economic:	Moderate	
Beneficial:	Unknown	

INTRODUCTION POTENTIAL

POTENTIAL INTRODUCTION VIA DISPERSAL

POTENTIAL INTRODUCTION VIA DISPERSAL				Score
1a	Does this species occur near waters (natural or artificial) connected to Maryland/the Mid-Atlantic* (e.g., streams, ponds, canals, or wetlands)? (*Maryland/the Mid-Atlantic = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)	Yes, this species occurs near waters connected to Maryland/the Mid-Atlantic and is mobile or able to be transported by wind or water.	100	Multiplier 0.25
		No, this species does not occur near waters connected to Maryland/the Mid-Atlantic and/or is not mobile or able to be transported by wind or water.	0	
		Unknown	U	
1b	What is the proximity of this species to Maryland/the Mid-Atlantic?	This species occurs in waters within 20 kilometers of Maryland/the Mid-Atlantic, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1	
		This species occurs in waters within 20 kilometers of Maryland/the Mid-Atlantic, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of Maryland/the Mid-Atlantic, and no barrier to dispersal is present.	Score x 0.75	
		This species occurs in waters within 100 kilometers of Maryland/the Mid-Atlantic, but dispersal to the basin is blocked.	Score x 0.5	
		This species occurs in waters >100 kilometers from Maryland/the Mid-Atlantic.	Score x 0.25	
		Unknown	U	
Notes	Candiru is native to the Amazon River Basin and has not been introduced outside of its native range.			
References	Froese, R. and D. Pauly. Editors. 2019. <i>Vandellia cirrhosa</i> Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019) (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dla8vjsr			GBIF.org

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

				Score
2a	2a) Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering Maryland/the Mid-Atlantic?	Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering Maryland/the Mid-Atlantic.	100	Multiplier 0
		No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering Maryland/the Mid-Atlantic.	0	
		Unknown	U	
2b	2b) What is the proximity of this species to Maryland/the Mid-Atlantic?	This species occurs in waters within 20 km of Maryland/the Mid-Atlantic.	Score x 1	Multiplier 0.1
		This species occurs in waters within 100 km of Maryland/the Mid-Atlantic.	Score x 0.5	
		This species occurs in waters >100 km from Maryland/the Mid-Atlantic.	Score x 0.1	
		Unknown	U	

Notes	Candiru does not adhere to hard surfaces. Although it is a parasite of larger fishes it does not remain attached long enough to act as a hitchhiker
References	Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. <i>Journal of Ichthyology and Aquatic Biology</i> . 8: 31-36.

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

				Score
3a	Is this species sold at aquarium/pet/garden stores (“brick & mortar” or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into Maryland/the Mid-Atlantic?	Yes, this species is available for purchase.	100	Multiplier 0.1
		No, this species this species is rarely/never sold.	0	
		Unknown	U	
3b	How easily is this species obtained within the Mid-Atlantic region?	This species is widely popular, frequently sold, and/or easily obtained within the Mid-Atlantic region.	Score x 1	
		This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Mid-Atlantic region.	Score x 0.5	
		This species is not very popular or is not easily obtained within the Mid-Atlantic region.	Score x 0.1	
		Unknown	U	
Notes	The only known potential vector of this species to the Risk Assessment area is the aquarium/pet trade. However, this species is not widely available. Similar species are available, but only on specialty websites (e.g., monsterfishkeepers). See this link: https://www.aqua-imports.com/shop/product/leopard-candiru-catfish-ituglanis-amazonicus/			
References	https://www.aqua-imports.com/shop/product/leopard-candiru-catfish-ituglanis-amazonicus/ https://www.monsterfishkeepers.com/forums/threads/candiru-as-pet.570465/			

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

				Score
4a	Is this species being stocked/planted to natural waters or outdoor water gardens around Maryland/the Mid-Atlantic region?	Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in Maryland/the Mid-Atlantic region.	100	Multiplier U
		No, this species cannot be stocked/planted or there is not enough interest to do so in Maryland/the Mid-Atlantic region.	0	
		Unknown	U	
		This activity is authorized and/or is occurring directly in Maryland/the Mid-Atlantic.	Score x 1	Multiplier U
		This activity is occurring in Maryland/the Mid-Atlantic tributaries or connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin.	Score x 0.75	

4b	What is the nature and proximity of this activity to Maryland/the Mid-Atlantic basin?	This activity is likely to occur within 20 km of Maryland/the Mid-Atlantic basin because of its popularity/value and there are no widespread regulations against stocking/planting. This activity is occurring in waters >20 km from Maryland/the Mid-Atlantic basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value. Unknown	Score x 0.5 Score x 0.25 U
Notes	Candiru could potentially enter Maryland as an aquarium fish/research specimens, but there is market or purpose for stocking them in outdoor water in Maryland		
References	Conjecture here. Seems to reason that there is no incentive to stock a small Amazonian catfish with no real commercial value		

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

			Score
5a	Is this species known to be commercially cultured in or transported through Maryland/the Mid-Atlantic region?	Yes, this species is being commercially cultured in or transported through Maryland/the Mid-Atlantic region. No, this species is not commercially cultured in or transported through Maryland/the Mid-Atlantic region. Unknown	100 0 U
			Multiplier
5b	5b) What is the nature and proximity of this activity to Maryland/the Mid-Atlantic basin?	This activity is unregulated or minimally regulated and is occurring directly in Maryland/the Mid-Atlantic. This activity is unregulated or minimally regulated and is occurring in Maryland/the Mid-Atlantic tributaries or connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin. This activity is strictly regulated but occurs directly in Maryland/the Mid-Atlantic, and/or this activity involves transport of live organisms on/across Maryland/the Mid-Atlantic. This activity is strictly regulated but occurs in Maryland/the Mid-Atlantic tributaries, connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin, and/or this activity involves transport of live organisms within 20 km of Maryland/the Mid-Atlantic basin. This activity occurs >20 km from Maryland/the Mid-Atlantic basin and typically does not involve transport of live organisms closer to the basin. Unknown	Score x 1 Score x 0.75 Score x 0.5 Score x 0.25 Score x 0.1 U
Notes	There is little evidence that this species is cultured, harvested, and used or sold commercially. However, it may be available at times on specialty websites for aquarists. There is no known transportation of this species through Maryland.		
References	https://www.monsterfishkeepers.com/forums/threads/candiru-as-pet.570465/		

POTENTIAL INTRODUCTION VIA SHIPPING

POTENTIAL INTRODUCTION VIA SHIPPING				Score
6a	Is this species likely to be taken up in ballast, and capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/flushing (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?	Yes, this species is able to survive in ballast tank environments for weeks at a time and is not substantially impacted by current regulatory requirements (e.g., exchange, flushing).	100	Multiplier 0
		Yes, this species is able to survive in ballast tank environments for weeks at a time, but survival is substantially impacted by current regulatory requirements.	80	
		No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40	
		No, this species is unlikely to be taken up in ballast, not able to survive adverse environments, does not foul transoceanic ship structures, or is unable to survive current ballast water regulations.	0	
		Unknown	U	
6b	Does this species occur in waters from which shipping traffic to Maryland/the Mid-Atlantic originates?	Yes, and this species has been observed in ballast of or fouling ships entering Maryland/the Mid-Atlantic.	Score x 1	U
		Yes, and this species has been observed in ports that have direct trade connections with Maryland/the Mid-Atlantic (e.g., Baltic Sea).	Score x 0.5	
		Yes, but this species has neither been observed in ballast/fouling ships entering Maryland/the Mid-Atlantic nor in ports in direct trade with Maryland/the Mid-Atlantic.	Score x 0.1	
		No, this species does not occur in waters from which shipping traffic to Maryland/the Mid-Atlantic originates.	Score x 0	
		Unknown	U	
Notes	It seems unlikely that a benthic fish that lives in shallow water and burrows in the substrate would be subject to getting drawn into ballast tanks.			
References	Largely a guess- habits and habitat described here: Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, <i>Vandellia</i> cf. <i>plazaii</i> . <i>Environmental Biology of Fishes</i> . 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus <i>Vandellia</i> (Trichomycteridae) feed on major gill arteries of host fishes. <i>Journal of Ichthyology and Aquatic Biology</i> . 8: 31-36. Froese, R. and D. Pauly. Editors. 2019. <i>Vandellia cirrhosa</i> Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019)			

ESTABLISHMENT POTENTIAL

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

1)	How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?	This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30° C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9	U
		This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6	
		This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3	
		Unknown	U	
Notes	Candiru tolerance is unknown. In its native range it lives in freshwater tropical rivers and streams. It has not been reported outside its native range.			
References	Froese, R. and D. Pauly. Editors. 2019. <i>Vandellia cirrhosa</i> Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019) GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
2)	How likely is it that any life stage of this species can overwinter in Maryland/the Mid-Atlantic (survive extremely low levels of oxygen, light, and temperature)?	Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9	0
		Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6	
		Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3	
		Unlikely	0	
		Unknown	U	
Notes	Candiru tolerance is unknown. In its native range it lives in freshwater tropical rivers and streams. It has not been reported outside its native range, and although the climate match analysis indicated a 'medium' risk to Maryland, there are no reported populations of this species in a temperate climate. All occurrences of this species worldwide are in tropical regions (GBIF 2019). As a neotropical species, it would be unlikely to survive a Maryland winter (judgement).			

References	Froese, R. and D. Pauly. Editors. 2019. <i>Vandellia cirrhosa</i> Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019) GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr		
3)	If this species is a heterotroph, how would the flexibility of its diet be described?	This species is a dietary generalist with a broad, assorted, AND flexible diet. 9 This species is moderately a dietary generalist with a broad, assorted, OR flexible diet. 6 This species is a dietary specialist with a limited and inflexible diet. 3 This species is an autotroph. 0 Unknown U	3
Notes	Candiru is a fish parasite. It feeds exclusively on blood from larger fishes, but does not seem selective on the types of fish it preys on		
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, <i>Vandellia cf. plazaii</i> . <i>Environmental Biology of Fishes</i> . 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus <i>Vandellia</i> (Trichomycteridae) feed on major gill arteries of host fishes. <i>Journal of Ichthyology and Aquatic Biology</i> . 8: 31-36.		
4)	How likely is this species to outcompete species in Maryland/the Mid-Atlantic for available resources?	Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in Maryland/the Mid-Atlantic). 9 Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in Maryland/the Mid-Atlantic) 6 Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in Maryland/the Mid-Atlantic) 3 Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in Maryland/the Mid-Atlantic) 0 Unknown U	0
Notes	Candiru competitive abilities are not documented. There are no other parasitic fish in Maryland waters for Candiru to compete with. It is possible that parasitism by candiru could reduce the competitive abilities of the native/established fish they would potentially feed on if introduced/established.		

References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, <i>Vandellia</i> cf. <i>plazaii</i> . <i>Environmental Biology of Fishes</i> . 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus <i>Vandellia</i> (Trichomycteridae) feed on major gill arteries of host fishes. <i>Journal of Ichthyology and Aquatic Biology</i> . 8: 31-36.			
5)	How would the fecundity of this species be described relative to other species in the same taxonomic Class?	Very high High Moderate Low Unknown	9 6 3 0 U	0
Notes	Fecundity is largely unknown for candiru. Some reports of 4-5 eggs per spawning. Other species in the same family spawn multiple times throughout the season.			
References	Gustavo Chiang, G., K. R. Munkittrick, M. F. Saavedra, F. Tucça, M. E. McMaster, R. Urrutia, G. Tetreault & R. Barra. 2011. Seasonal changes in reproductive endpoints in <i>Trichomycterus areolatus</i> (Siluriformes: Trichomycteridae) and <i>Percilia gillissi</i> (Perciformes, Perciliidae), and the consequences for environmental monitoring, <i>Studies on Neotropical Fauna and Environment</i> , 46:3, 185-196 Manríquez A, Huaquín L, Arellano M, Arratia G. 1988. Aspectos reproductivos de <i>Trichomycterus areolatus</i> Valenciennes, 1846 (Pisces: Teleostei: Siluriformes) en río Angostura, Chile. <i>Stud Neotrop Fauna Environ</i> . 23(2):89–102. (www.animaldiversity.org , accessed December 2019, https://animaldiversity.org/accounts/Vandellia_cirrhosa/#A1DE78B8-827E-11E2-AEFF-002500F14F28).			
6)	How likely are this species’ reproductive strategy and habits to aid establishment in new environments, particularly Maryland/the Mid-Atlantic (e.g., parthenogenesis/self-crossing, self-fertility, vegetative fragmentation)?	Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in Maryland/the Mid-Atlantic based on these attributes) Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in Maryland/the Mid-Atlantic based on these attributes) Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in Maryland/the Mid-Atlantic based on these attributes) Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments) Unknown	9 6 3 0 U	3
Notes	If Candiru spawns more than once in a season, as some other species in the family do, it increases the likelihood that some offspring would survive. Largely unknown.			

References	Gustavo Chiang, G., K. R. Munkittrick, M. F. Saavedra, F. Tucça, M. E. McMaster, R. Urrutia, G. Tetreault & R. Barra. 2011. Seasonal changes in reproductive endpoints in <i>Trichomycterus areolatus</i> (Siluriformes: Trichomycteridae) and <i>Percilia gillissi</i> (Perciformes, Perciliidae), and the consequences for environmental monitoring, <i>Studies on Neotropical Fauna and Environment</i> , 46:3, 185-196 Manríquez A, Huaquín L, Arellano M, Arratia G. 1988. Aspectos reproductivos de <i>Trichomycterus areolatus</i> Valenciennes, 1846 (Pisces: Teleostei: Siluriformes) en río Angostura, Chile. <i>Stud Neotrop Fauna Environ</i> . 23(2):89–102.
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ENVIRONMENTAL COMPATIBILITY

7)	How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in Maryland/the Mid-Atlantic region?	Very similar (The climatic conditions are practically identical to those of Maryland/the Mid-Atlantic region) 9 Similar (Many of the climatic conditions are similar to those of Maryland/the Mid-Atlantic region) 6 Somewhat similar (Few of the climatic conditions are similar to those of Maryland/the Mid-Atlantic region) 3 Not similar 0 Unknown U	3
Notes	Although the climate match analysis indicated a 'medium' risk to Maryland, there are no reported populations of this species in a temperate climate. The species is neotropical and is likely not to be very tolerant to the temperate climate of Maryland (J). However, If introduced during late spring and summer in Maryland when conditions may be more suitable for this neotropical species, it is likely that this species could survive and spawn - though recruitment would be expected to be unsuccessful (J).		
References	https://climatch.cp1.agriculture.gov.au/climatch.jsp		
8)	How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in Maryland/the Mid-Atlantic?	Very similar (These factors are practically identical to those of Maryland/the Mid-Atlantic region) 9 Similar (Many of these factors are similar to those of Maryland/the Mid-Atlantic region) 6 Somewhat similar (Few of these factors are similar to those of Maryland/the Mid-Atlantic region) 3 Not similar 0 Unknown U	3
Notes	Similar habitat types exist between the native range of the Candiru in the Amazon and Maryland. That said, temperature is likely to be limiting.		

References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, <i>Vandellia cf. plazaii</i> . Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus <i>Vandellia</i> (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.		
9)	How abundant are habitats suitable for the survival, development, and reproduction of this species in Maryland/the Mid-Atlantic area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?	Abundant (Suitable habitats can be easily found and readily available) Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present) Somewhat scarce (Suitable habitats can be found occasionally) Scarce (Suitable habitats are rarely found) Unknown	9 6 3 0 U
Notes	Temperature is likely to limit Candiru success in Maryland. The only areas where year-round survival may be possible are warm water discharges from powerplants and treatment plants. The habitat for this species is shallow, slow moving waters with muddy and sandy bottoms. This catfish remains burrowed in sediments and emerge to feed and mate. Suitable habitat (as based on this limited description) would be somewhat abundant in Maryland, especially in the Coastal Plain physiographic province (J).		
References	(www.animaldiversity.org, accessed December 2019, https://animaldiversity.org/accounts/Vandellia_cirrrosa/#A1DE78B8-827E-11E2-AEFF-002500F14F28)		
10)	How likely is this species to adapt to or to benefit from the predicted effects of climate change on Maryland/the Mid-Atlantic freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?	Likely (Most of the effects described above make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances) Somewhat likely (Several of the effects described above could make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species) Somewhat unlikely (Few of the effects described above would make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species) Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of Maryland/the Mid-Atlantic unsuitable) Unknown	9 6 3 0 U
Notes	Warmer water temperatures due to climate change would bring Maryland closer to the tropical climate where candiru is native.		

References	Inference		
11)	How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?	Likely (All possible nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are highly abundant and/or easily found) 9 Somewhat likely (Some nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are abundant and/or search time is low to moderate) 6 Somewhat unlikely (Few nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are abundant and/or search time is moderate to high) 3 Unlikely (All possible nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are relatively scarce and/or search time is high) 0 Unknown U	9
Notes	Candiru is a fish parasite and is not selective. In laboratory tests it attacked both native fish and non-native goldfish without discrimination. It would likely prey readily on any fish it encountered in Maryland.		
References	Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.		
12)	Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?	Yes, and the critical species (or one that may provide a similar function) is common in Maryland/the Mid-Atlantic and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed 9 Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of Maryland/the Mid-Atlantic 6 Yes, and the critical species (or one that may provide a similar function) is relatively rare in Maryland/the Mid-Atlantic AND/OR can only be found occasionally in environments suitable for the species being assessed 3 Yes, and the critical species (or one that may provide a similar function) is not present in Maryland/the Mid-Atlantic but is likely to be introduced 0 Yes, but the critical species (or one that may provide a similar function) is not present in Maryland/the Mid-Atlantic and is not likely to be introduced A (-80% total points at end) Unknown U	9

Notes	It is not documented whether Candiru requires another species for critical stages in its life cycle.		
References	no data available		
13)	How likely is the establishment of this species to be aided by the establishment and spread of another species already in Maryland/the Mid-Atlantic?	Likely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in Maryland/the Mid-Atlantic, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas) 9 Somewhat likely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in Maryland/the Mid-Atlantic) 6 Somewhat unlikely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established in Maryland/the Mid-Atlantic BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict) 3 Unlikely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species has not been established in Maryland/the Mid-Atlantic) 0 Unknown U	U
Notes	There is no data available on whether candiru benefits from any other specific species.		
References	no data available		
14)	How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy	Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in Maryland/the Mid-Atlantic) A (-80% total points at end) Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in Maryland/the Mid-Atlantic) B (-60% total points at end)	B

17)	this is already present in Maryland/the Mid-Atlantic and may preferentially target this species?	Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in Maryland/the Mid-Atlantic) Unlikely (Such a natural enemy is particularly rare or is not present in Maryland/the Mid-Atlantic) Unknown	C (-10% total points at end) 0 U
Notes	As a small fish, candiru are subject to predation by piscivores in their native range. It is assumed that any number of native or established piscivores in Maryland could and would prey upon any candiru that were introduced/established.		
References	Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36. Froese, R. and D. Pauly. Editors. 2019. Vandellia cirrhosa Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019)		

PROPAGULE PRESSURE

15)	On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)	Frequent, large inocula Frequent, moderate inocula Frequent, small inocula OR infrequent, large inocula Infrequent, small or moderate inocula Unknown	9 6 3 0 U	0
Notes	Availability of this species in the live trade is low and likely infrequent. Parasitic catfishes of different genera have been reported for sale by specialty online dealers. Propagule pressure in Maryland and the Mid-Atlantic is likely low and inoculations, if they ever occur, are rare (J).			
References	Educated guess			

HISTORY OF INVASION AND SPREAD

	Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9	0
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16)	How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?	Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range) Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other) Not extensively (no invasive populations of this species have been reported) Unknown	6 3 0 U	
Notes	There are no known successful introductions of this species resulting in established populations outside of its native tropical range (GBIF 2019).			
References	GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
17)	How rapidly has this species spread by natural means or by human activities once introduced to other locations?	Rapidly (This species has a history of rapid spread in introduced ranges) Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges) Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges) Slowly (This species has a history of slow to no spread in its introduced ranges) Unknown	9 6 3 0 U	0
Notes	This species has not spread beyond its native range			
References	GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
18)	Are there any existing control measures in Maryland/the Mid-Atlantic set to prevent	Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species) Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	A (-90% total points at end) B (-50% total points at end)	A

18)	the establishment and/or spread of this species?	Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread) No control methods have been set to prevent the establishment and/or spread of this species Unknown	C (-20% total points at end) 0 U
Notes	Candiru is currently banned in Maryland. MD DNR routinely includes messaging to remind pet owners not to release unwanted pets in its education/outreach efforts. This messaging is aimed at reducing pet release to Maryland waters. However, the effectiveness of this messaging may be limited given the relative high occurrence of non-native, released species (e.g., red eared slider, plecostomous sp., pacu, etc.) detected in Maryland waters each year.		
References			

IMPACT POTENTIAL

POTENTIAL ENVIRONMENTAL IMPACT

NOTE: In this section, a "Not significantly" response should be selected if the species has been studied but there have been no reports of a particular impact. An Unknown" response is appropriate if the species is poorly studied.

E1)	Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?	Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6	1
		Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru is a parasite but does not tend to kill its host. There are no known occurrences of this species outside of its native range (GBIF 2019). Candiru is a parasite, but its potential impact on the health of species within its native range is not well-documented. Potential impacts to Maryland native taxa are presumed minimal.			
References	Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.			
E2)	Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?	Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6	U
		Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru has not been introduced outside its native range. Thus, its impacts as an invader are unknown.			

References	GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
E3)	Does it alter predator-prey relationships?	Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6	U
		Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru has not been introduced outside its native range. Thus, its impacts as an invader are unknown.			
References	GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
E4)	Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?	Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6	U
		Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1	
		Not significantly	0	
		Unknown	U	

Notes	Candiru has not been introduced outside its native range. Thus, its impacts as an invader are unknown.			
References	GBIF.org (25 September 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.a8vjsr			
E5)	Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?	Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6	0
		Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1	
		Not significantly	0	
		Unknown	U	
Notes	The habits of candiru do not indicate that it would negatively impact water quality.			
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, Vandellia cf. plazaii. Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.			

E6)	Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?	Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6	0	
		Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1		
		Not significantly	0		
		Unknown	U		
Notes					
	There is no data to suggest that candiru has any impact on the physical components of its ecosystem within its native range.				
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, Vandellia cf. plazaii. Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.				

POTENTIAL SOCIO-ECONOMIC IMPACT

NOTE: In this section, a “Not significantly” response should be selected if there have been no reports of a particular impact. An “Unknown” response is appropriate if the potential for a particular impact might be inferred from a significant environmental impact but has not been explicitly reported or if there is an unresolved debate about a particular impact.

S1)	Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?	Yes, significant effects on human health have already been observed	6	1
		Yes, but negative consequences have not been widespread, long lasting, or severe	1	
		Not significantly	0	
		Unknown	U	
Notes	There are reports of attacks on humans by candiru. These reports are generally second hand and few are recent. It is possible the risk from this species has been exaggerated by myth/folklore.			

References	Bauer, I.L. 2005. Candiru- A Little Fish With Bad Habits: Need Travel Health Professionals Worry? A Reivew. Journal of Travel Medicine. 20: 119–124.			
S2)	Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?	Yes, it is known to cause significant damage	6	0
		Yes, but the costs have been small and are largely reparable or preventable	1	
		Not significantly	0	
		Unknown	U	
Notes	There is no evidence of Candiru damaging infastructure. Its habits and life history make it unlikely that it would cause any such damage.			
References	Inference. Also: Froese, R. and D. Pauly. Editors. 2019. Vandellia cirrhosa Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811. (11/2019)			
S3)	Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?	Yes, it has significantly affected water quality, and is costly or difficult to reverse	6	0
		Yes, but the effects are negligible and/or easily reversed	1	
		Not significantly	0	
		Unknown	U	
Notes	There is no evidence of Candiru impacting water quality. Its habits and life history make it unlikely that it would cause any such damage.			

References	Froese, R. and D. Pauly. Editors. 2019. <i>Vandellia cirrhosa</i> Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019)			
S4)	Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?	Yes, it has caused significant damage to one or more markets or economic sectors	6	0
		Some damage to markets or sectors has been observed, but negative consequences have been small	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru's reputation as a danger to humans could reduce tourism and/or people's willingness to enter the waters where it lives			
References	Breault, J. L. 1991. Candiru- Amazonian parasitic catfish. <i>Journal of Wilderness Medicine</i> . 2: 304-312. Gudger, E.W. 1930. On the alleged penetration of the human urethra by an Amazonian catfish called candiru, with a review of the allied habits of other members of the family Pygidiidae. Part I. <i>Am. J. Sur. (N. S.)</i> 8: 170–188. Bauer, I.L. 2005. Candiru- A Little Fish With Bad Habits: Need Travel Health Professionals Worry? A Reivew. <i>Journal of Travel Medicine</i> . 20: 119–124.			
S5)	Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?	Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6	0
		Yes, but negative consequences have been small	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru's reputation as a danger to humans could reduce tourism and/or people's willingness to enter the waters where it lives			

References	Breault, J. L. 1991. Candiru- Amazonian parasitic catfish. Journal of Wilderness Medicine. 2: 304-312. Gudger, E.W. 1930. On the alleged penetration of the human urethra by an Amazonian catfish called candiru, with a review of the allied habits of other members of the family Pygidiidae. Part I. Am. J. Sur. (N. S.) 8: 170–188. Bauer, I.L. 2005. Candiru- A Little Fish With Bad Habits: Need Travel Health Professionals Worry? A Reivew. Journal of Travel Medicine. 20: 119–124.			
S6)	Does it diminish the perceived aesthetic or natural value of the areas it inhabits?	Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area’s value for future generations	6	1
		Yes, but negative consequences have been small	1	
		Not significantly	0	
		Unknown	U	
Notes	There remains a significant stigma surrounding Candiru and its supposed danger to humans. This stigma remains despite a lack of hard evidence of attacks on humans in the mordor era.			
References	Breault, J. L. 1991. Candiru- Amazonian parasitic catfish. Journal of Wilderness Medicine. 2: 304-312. Gudger, E.W. 1930. On the alleged penetration of the human urethra by an Amazonian catfish called candiru, with a review of the allied habits of other members of the family Pygidiidae. Part I. Am. J. Sur. (N. S.) 8: 170–188. Bauer, I.L. 2005. Candiru- A Little Fish With Bad Habits: Need Travel Health Professionals Worry? A Reivew. Journal of Travel Medicine. 20: 119–124.			

POTENTIAL BENEFICIAL EFFECT

NOTE: In this section, a “Not significantly” response should be selected if there have been no reports of a particular effect. An “Unknown” response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.

B1)	Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?	Yes, it has succeeded significantly as a control agent	6	U
		Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1	
		Not significantly	0	
		Unknown	U	

Notes	There have been no report of Candiru acting as a biological control agent			
References	No data			
B2)	Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?	Yes, it is economically important to at least one of these industries	6	0
		Yes, but its economic contribution is small	1	
		Not significantly	0	
		Unknown	U	
Notes	There is no data available indicating that Candiru could be commercially valuable. There is some interest in keeping Candiru and other members of its family as pets in aquaria, but the market and the commercial value would be very limited.			
References	https://www.monsterfishkeepers.com/forums/threads/candiru-as-pet.570465/			
B3)	Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?	Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6	1
		It is sometimes employed recreationally, but adds little value to local communities or tourism	1	
		Not significantly	0	
		Unknown	U	

Notes				
	There is very limited interest in keeping candiru as pets in aquaria. Members of its family are occasionally available for sale in pet the trade.			
References	https://www.aqua-imports.com/shop/product/leopard-candiru-catfish-ituglanis-amazonicus/ https://www.monsterfishkeepers.com/forums/threads/candiru-as-pet.570465/			
B4)	Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?	Yes, it has significant medicinal or research value	6	0
		It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1	
		Not significantly	0	
		Unknown	U	
Notes	Candiru has been used in research, but the research was focused on candiru itself/determining its feeding habits/life history and not on any benefits/uses it may provide.			
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, Vandellia cf. plazaii. Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36.			
B5)	Does the species remove toxins or pollutants from the water or otherwise increase water quality?	Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and	6	0
		Yes, but positive impact for humans or native species is considered negligible	1	
		Not significantly	0	
		Unknown	U	

Notes				
	Candiru is a fish parasite. It does not seem to have any impacts on water quality.			
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, Vandellia cf. plazaii. Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36. Froese, R. and D. Pauly. Editors. 2019. Vandellia cirrhosa Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019)			
B6)	Does the species have a positive ecological effect outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?	Yes, it significantly contributes to the ecosystem in one or more of these ways	6	0
		Yes, it provides some positive contribution to the ecosystem, but is not vital	1	
		Not significantly	0	
		Unknown	U	
Notes				
	Candiru is a fish parasite. It does not seem to have any positive ecological effects.			
References	Spotte, S., P. Petry & J. Zuanon. Experiments on the feeding behavior of the hematophagous Candiru, Vandellia cf. plazaii. Environmental Biology of Fishes. 2001; 60:459–464. Zuanon, J. & I. Sazima. 2004. Vampire catfishes seek the aorta not the jugular: candirus of the genus Vandellia (Trichomycteridae) feed on major gill arteries of host fishes. Journal of Ichthyology and Aquatic Biology. 8: 31-36. Froese, R. and D. Pauly. Editors. 2019. Vandellia cirrhosa Valenciennes, 1846 Candiru. https://www.fishbase.se/summary/8811 . (11/2019)			

INTRODUCTION POTENTIAL SCORING

Vector Potential Scorecard				
Vector	Raw Points Scored	Multiplier	Total Points	Potential for Introduction
POTENTIAL INTRODUCTION VIA DISPERSAL	0	0.25	0	Unlikely
POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING	0	0.1	0	Unlikely
POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE	0	0.1	0	Unlikely
POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE	0	U	U	Unknown
POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE	0	U	U	Unknown
POTENTIAL INTRODUCTION VIA SHIPPING	0	U	U	Unknown
Total Unknowns	3	Potential for Introduction (overall)		Unlikely
			Confidence Level	Low

Scoring	
Points per Vector	Probability for Introduction
80-100	High
40-79	Moderate
1-39	Low
0	Unlikely
# Unknowns (overall)	Confidence Level
0	High
1-2	Moderate
3-5	Low
>5	Very Low

ESTABLISHMENT POTENTIAL SCORING

Establishment Potential Scorecard				
Points	Probability for Establishment	A. Total Points (pre-adjustment)		36
>100	High	Adjustments		
		B. Critical Species (#12)	A*(1-__%)	36
51-99	Moderate	C. Natural enemies (#14)	B*(1-__%)	14.4
		Control measures (#18)	C*(1-__%)	1.44
0-50	Low	Probability for Establishment		Low
# of questions answered as "unknown"	Confidence Level			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very Low			

IMPACT POTENTIAL SCORING

Scoring		
Score	# U	Impact
>5	Any	High
2-5	Any	Moderate
0	0-1	Low
1	0	
0	≥2	Unknown
1	≥1	

Potential Impact Type	Score	# Unknowns	Impact
Environmental	1	3	Unknown
Socio-Economic	2	0	Moderate
Beneficial	1	1	Unknown