U.S. Fish & Wildlife Service

Quilted Melania (*Tarebia granifera*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, March 2023
Revised, March 2023
Web Version, 8/2/2024

Organism Type: Mollusk
Overall Risk Assessment Category: High

Photo: Takaaki Hattori. Licensed under: CC BY-NC 4.0. Available: https://www.inaturalist.org/observations/61837173 (March 2023).

1 Native Range and Status in the United States

Native Range

From Morningstar and Benson (2023):

"Native to India west to Japan, south through southeast Asia (Madhyastha and Dutta 2012)."

From Madhyastha and Dutta (2012):

"NATIVE
Extant (resident)
Bangladesh; Bhutan; Cambodia; China (Guangdong, Hainan); Hong Kong; India (Orissa, Madhya Pradesh, Meghalaya, Tripura, West Bengal, Andhra Pradesh, Bihar); Indonesia (Papua, Sumatera); Japan; Malaysia (Peninsular Malaysia); Myanmar (Myanmar (mainland)); Nepal; Philippines; Singapore; Sri Lanka; Taiwan, Province of China; Thailand; Viet Nam"

"Extant & Origin Uncertain (resident)
Madagascar; Papua New Guinea (Papua New Guinea (main island group))"

From Fofonoff et al. (2018):

"It is native to regions of Southeast Asia and Oceania, including India and Sri Lanka east to Indonesia, the Philippines, and Papua New Guinea."

Status in the United States

According to Morningstar and Benson (2023), nonindigenous occurrences of *Tarebia granifera* have been reported in the following U.S. States and territories. Range of observation years, number of watersheds (8-digit hydrologic unit), and population status where reported (one or more watersheds) are given in parentheses.

- Colorado (1989-2015; 2; established)
- Florida (1949-2020; 9; established)
- Hawaii (1997-2022; 2; established)
- Idaho (1991; 1; unknown)
- Puerto Rico (2007-2009; 4; established)
- Texas (1963-2020; 5; established)
- U.S. Virgin Islands (1987-1993; 1; collected)

From Fofonoff et al. (2018):

"*Tarebia granifera* occurs in Coral Gables and Miami, on the East Coast of Florida (Chaniotis et al. [1980]), but has not been reported from tidal waters."

"In North America, *Tarebia granifera* was reportedly first imported by an aquarium dealer in 1937 in Tampa, Florida (FL). In 1947, it was collected in Lithia Springs, Hillsborough County, FL in headwaters of the Alafia River. It subsequently spread into tidal waters, where it can occur in high abundances in fresh-oligohaline tributaries (Poss 1999; Baker et al. 2004; Gulf States Marine Fisheries Commission 2009). It has been collected in interior springs and streams in nine Florida counties and in central Texas (Karatayev et al. 2009; Florida Museum of Natural History 2013; USGS Nonindigenous Aquatic Species Program 2013)."

"This snail occurs widely in fresh waters of Pacific Islands, including Guam […] and Hawaii, where populations may have been introduced by early Polynesians (Abbott 1952; Cowie 1998; Myers et al. 2000)."

"It is now found in streams of all the major Hawaiian Islands (Cowie 1998; Carlton and Eldredge 2009). On Oahu, it is abundant in two brackish streams at 15 and 30 PSU (Englund et al. 2000)."

"*Tarebia granifera* was first found in Puerto Rico in 1945 (Chaniotis et al. [1980]) and is now widespread (USGS Nonindigenous Aquatic Species Program 2013)."

From Oglesby (1977):

"On 6 March 1976, many snails were observed by an aquatic biology class from Pomona College in Whitefield Creek, a brackish-water creek located in the headquarters area of the Salton Sea State Recreation Area, Riverside County [California], at an elevation of 68.6 m (225 ft) below sea level. […] Collected specimens were identified by Dwight W. Taylor, University of the Pacific, as *Thiara* (*Tarebia*) *granifera mauiensis* (Lea) […]"

Tarebia granifera is available for purchase from some vendors in the aquarium trade in the United States, though no estimates of overall abundance in trade were found.

From eBay (2023):

"8 Live freshwater Quilted Melania Snails (*Tarebia granifera*) […] $14.99"

Regulations
Possession or importation of *Tarebia granifera* has been prohibited or regulated in three U.S. States: Arkansas (Arkansas Game and Fish Commission 2022), Colorado (CPW 2022), and Utah (Utah DWR 2020). While every effort has been made to list all applicable State laws and regulations pertaining to this species, this list may not be comprehensive.

Means of Introductions within the United States
From Morningstar and Benson (2023):

"This species is spread through the aquarium trade (Abbott 1952). The first specimens known in the United States were found in San Francisco in 1935, when an aquarium dealer had discovered them and sent the specimens to the National Museum (Murray, 1971). It is possible that the species is moved between close waterbodies via waterfowl, as reported by Appleton et al. (2009)."

From Abbot (1952):

"An aquatic-plant and fish dealer in Tampa related that he acquired specimens in 1937 while on a visit to California. Since that time, his plant vats have been stocked with this mollusk which, as an oddity, had been sold over a hundred times in a year as the 'Philippine horn of plenty.' It was his opinion that the snails were probably accidentally introduced to the spring [Lithia Spring, Florida] around 1940, when improperly washed tubs were used to gather native plants."

From Oglesby (1977):

"[…] it seems likely that *T. granifera* was also introduced into Whitefield Creek [California] by aquarists or escapements from nearby tropical fish farms."

From Fofonoff et al. (2018):

"*Tarebia granifera* was collected in Maui in 1856, but it could have been introduced in Prehistoric times by Polynesian settlers as food or in the roots of cultivated Taro plants."

Remarks

This ERSS was previously published in March 2018. Revisions were completed to incorporate new information and conform to updated standards.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2023):

Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Protostomia
      Superphylum Lophozoa
        Phylum Mollusca
          Class Gastropoda
            Order Neotaenioglossa
              Family Thiaridae
                Genus *Tarebia*
                  Species *Tarebia granifera* (Lamarck, 1822)

According to MolluscaBase (2023), *Tarebia granifera* is the current valid name for this species. Over 30 other names have been used for this species (MolluscaBase 2023). In preparing this ERSS, both the valid scientific name, *Tarebia granifera*, and the common synonym *Thiara granifera* were used to search for information.

Size, Weight, and Age Range

From Morningstar and Benson (2023):

"6 to 40 mm; average 25 mm shell length (Abbott 1952)"

Environment

From Morningstar and Benson (2023):

"This species is found from a range of environments; large rivers to small springs, in mountains and valleys, and silty or sand bottoms, riffles as well as pools (Abbott 1952; Prentice 1983)."

From Lachner et al. (1970):

"This small snail prefers the shallow riffles of fast-flowing freshwater streams."

From Appleton et al. (2009):

"In common with other Thiaridae, *T. granifera* is primarily a benthic species and in South Africa has been collected on a variety of substrata in both natural and artificial waterbodies, *e.g*. sand, mud, rock, concrete bridge foundations and the concrete walls and bottoms of reservoirs, irrigation canals and ornamental ponds. Many of these habitats were vegetated and the associated vegetation included many types of emergent monocotyledons [. . .] Where densities are high, *T. granifera* may also occur on marginal, trailing vegetation and the floating *Eichhornia crassipes* (Mart.) Solms as well. It favours turbulent water and tolerates current speeds up to $1.2 m.s^{-1}$ and possibly greater."

From Miranda et al. (2010):

"In South Africa, *T. granifera* was first recorded in an estuarine environment in the St Lucia Estuary. […] this snail survives high salinity for a relatively long time, as LS_{50} (lethal salinity for 50% of the population) was reached at 30 psu over 65–75 days. However, higher salinity adversely affected the *T. granifera* population. Snails acclimated to freshwater conditions and suddenly transferred to 30 psu experienced 100% mortality within 48 h. Snail activity also declined with increasing salinity."

Climate

From Fofonoff et al. (2018):

"It is typically found in warm-temperate to tropical regions […]."

From Miranda et al. (2010):

"*T. granifera* can tolerate temperatures between 0 ºC and 47.5 ºC, allowing it to survive high temperature extremes. The species may also survive cold snaps and invade higher altitude areas."

Distribution Outside the United States

Native

From Morningstar and Benson (2023):

"Native to India west to Japan, south through southeast Asia (Madhyastha and Dutta 2012)."

From Madhyastha and Dutta (2012):

"NATIVE
Extant (resident)
Bangladesh; Bhutan; Cambodia; China (Guangdong, Hainan); Hong Kong; India (Orissa, Madhya Pradesh, Meghalaya, Tripura, West Bengal, Andhra Pradesh, Bihar); Indonesia (Papua, Sumatera); Japan; Malaysia (Peninsular Malaysia); Myanmar (Myanmar (mainland)); Nepal; Philippines; Singapore; Sri Lanka; Taiwan, Province of China; Thailand; Viet Nam"

"Extant & Origin Uncertain (resident)
Madagascar; Papua New Guinea (Papua New Guinea (main island group))"

From Fofonoff et al. (2018):

"It is native to regions of Southeast Asia and Oceania, including India and Sri Lanka east to Indonesia, the Philippines, and Papua New Guinea."

Introduced

From Madhyastha and Dutta (2012):

"Extant & Introduced (resident)
Cuba; French Polynesia (Society Is.); South Africa; […] Venezuela, Bolivarian Republic of"

"The species has been very widely introduced in North (Abbott 1952), Central ([…] Mexico and Venezuela), and South America, as well as Cuba and throughout the Caribbean islands, to Africa (South Africa, and likely to be more widespread within southern Africa), and is likely to have a wider introduced range than presented here."

From Fofonoff et al. (2018):

"This snail occurs widely in fresh waters of Pacific Islands, including […] French Polynesia, […] where populations may have been introduced by early Polynesians (Abbott 1952; Cowie 1998; Myers et al. 2000)."

"It also occurs in Cuba, Jamaica (by 1988), […] Martinique (in 1991), Haiti (by 1979), the Dominican Republic (in 1968), Trinidad (by 1944), the Gulf Coast of Mexico (by 2007), and the Caribbean coast of Guatemala and Venezuela (in 1975) (Chanitois 1980b; Pointier et al. 1994; Pointier 2001; López-López et al. 2010; Florida Museum of Natural History 2013). In two Mexican rivers, its range extends to the upper estuarine zone (López-López 2010)."

"*Tarebia granifera* was discovered near Durban, South Africa, in a freshwater reservoir in 1996 (Appleton and Nadasan 2002). It has now colonized freshwater drainages, lagoons, and estuaries along ~330 km of coastline, from Durban, nearly to the border with Mozambique (Appleton et al. 2009). In 2005, it was found in a freshwater stream flowing into the St. Lucie estuary in Kruger National Park, and soon established dense populations at salinities of 10-20 PSU

(Appleton et al. 2009; Miranda et al. 2010). In 2004, *T. granifera* was found at several sites along the Jordan River estuary [Israel] (Ben-Ami 2008)."

Means of Introduction Outside the United States

From Fofonoff et al. (2018):

"The aquarium industry is probably the primary vector of introduction, but some of its later spread in the Caribbean region has resulted from its use for biocontrol of the native snail *Biomphalaria glabrata*, a host of the disease-causing trematode *Schistosoma mansoni* (blood-fluke) (Pointier et al. 1994; Pointier 2001)."

From Appleton et al. (2009):

"It is probable that dispersal of *T. granifera* from one waterbody or river catchment to another occurs passively via birds, notably waterfowl, which eat them and void them later, perhaps in another habitat. Evidence for this comes from the finding of many small *T. granifera* 5-7 mm in height and still containing the soft parts in unidentified bird droppings from the bank of the Mhlali River. […] Passive dispersal may also occur via weed on boats and boat trailers and via water pumped from one waterbody to another for industrial and irrigation purposes. In the Nseleni River [South Africa] juvenile *T. granifera* were commonly found with another invasive snail, *Lymnaea columella* Say, 1817, on floating clumps of water hyacinth *Eichhornia crassipes* which provide a vehicle for rapid downstream dispersal."

Short Description

From Abbott (1952):

"The shell is rather elongate with a straight-sided, pointed spire and is sculptured with several spiral rows of beads or blunt tubercles. The aperture of the shell is obliquely ovate, and the apertural lip is sharp. The color of the shell and its thin periostracal covering is generally a light brown to yellowish brown, which sometimes is flecked with small, dark, red-brown color spots. The operculum is about two-thirds the size of the aperture, opaque, and colored a dark blackish brown. The animal and operculum may be withdrawn into the shell completely from view. When fully extended the head and foot are, together, about one-fourth the length of the shell. The foot is relatively small and square to oblong. The proboscis is rather large and flattened. The two tentacles are round and slender and extend slightly beyond the anterior limits of the proboscis. The mantle, which lines the interior of the last shell whorl, is bordered by several prominent, fleshy papillae, which may be seen projecting beyond the shell lip on the left (or outer lip) side. In mature and gravid specimens a brood pouch is present on the back of the animal just behind the head. In some individuals the shells of the small, living young may be seen through the thin dorsal wall of the pouch."

Biology

From Morningstar and Benson (2023):

"Sexual maturity is reached around 8-12mm in shell height, or typically 6-12 months (Abbott 1952). This species is parthenogenic (capable of self-fertilization), […] the species is also ovoviviparous, meaning their eggs hatch within the body and live young are birthed (Abbott 1952; Appleton et al. 2009). It has been documented that females can birth one offspring every twelve hours (Abbott 1952)."

From Fofonoff et al. (2018):

"This snail has separate sexes, but reproduces primarily by parthenogenetic reproduction (without fertilization), with only occasional sexual reproduction, resulting in populations that are largely or completely clonal. Males are rare or absent (Abbott 1952; Myers et al. 2000; Miranda et al. 2010). Reproduction is ovoviviparous, with eggs being incubated in the female's brood pouch in the last (largest) whorl of the shell and hatching out as small snails, 2.0 - mm in length with 4-5 shell whorls. Estimated annual fecundity is 213 embryos per year (Keller et al. 2007). The snails reach maturity at about 6 mm shell length in 3-6 months (Abbott 1952; Chaniotis et al. [1980])."

"*Tarebia granifera* has a generalist diet, but feeds mostly on filamentous microlalgae [sic] (Miranda and Perissinotto 2012)."

From Oglesby (1977):

"Observations in the field and laboratory indicate that *T. granifera* feeds on microscopic algae, other micro-organisms, and small particles of organic matter."

From Appleton et al. (2009):

"In Florida Tucker Abbott (1952) recorded an 'extraordinary' *T. granifera* density of 4444 m^{-2} which falls within the range of densities measured with a Van Veen grab in a number of sites in northern KwaZulu-Natal […] Typically half or more of these snails were buried in the sediments and were not visible from the surface."

Human Uses

From Fofonoff et al. (2018):

"It is a popular aquarium species […]. In some areas, it has been introduced to control native snails which host disease-causing trematode parasites."

"[…] *T. granifera* came to be regarded as a parasite fighter in the Caribbean, against the Blood Fluke *Schistosoma mansoni*, by competition with the native host snail *Biomphalaria glabrata*. It has been introduced to many streams as a biocontrol agent (Perez et al. 1991; Pointier et al. 1994)."

From Oglesby (1977):

"These snails are used by tropical fish aquarists to keep down algal growth and to prevent accumulation of organic debris in aquaria."

Diseases

No information was found associating *Tarebia granifera* with any diseases listed by the World Organisation for Animal Health (2023).

From Morningstar and Benson (2018):

"This species is a host to the parasite *Centrocestus formosanus*, which parasitizes fish gills (Appleton et al. 2009)."

From Fofonoff et al. (2003):

"Many trematode species and many more undescribed larval forms have been reported from this snail (Abbott 1952; Appleton et al. 2009)."

From Abbott (1952):

"Family HETEROPHYIDAE
1. *HAPLORCHIS TAICHUI* (Nishieorl. 1924).
2. *DIORCHITREMA FORMOSANUM* Kataata. 1932.
3. *METAGONIMUS YOKOGAWAI* Katsorada, 1912."

"Gastropod mollusks serve as the obligatory first intermediate host of all digenetic trematodes or flukes. While in several cases the relationship between the parasitic fluke and the host snail is restricted to one species in certain areas, on the whole there does not appear to be any set pattern for certain snails to serve as hosts to any particular species or even genus of trematode."

"In all likelihood *Thiara granifera* may be considered a potential host of the American *Paragonimus kellicottii* on epidemiological and ecological grounds."

From Appleton et al. (2009):

"*Tarebia granifera* serves as the first intermediate host for a variety of trematodes in its native south east Asia. Amongst these are several species of the family Heterophyidae some of which have been reported as opportunistic infections in people (Watson, 1960), and another, *Centrocestus formosanus* (Nishigori, 1924), is an important gill parasite of fish. […] *T. granifera* also serves as intermediate host for the philopthalmid eyefluke *Philopthalmus gralli* Mathis & Ledger, 1910 which has recently been reported affecting ostriches on farms in Zimbabwe (Mukaratirwa et al., 2005). The snail host implicated in this outbreak was *Melanoides tuberculata* (Müller, 1774) but the rapid spread and high population densities achieved by *T. granifera*, which appears to be replacing *M. tuberculata* in South Africa, may exacerbate the problem in the future. For many years *T. granifera* was believed to be an intermediate host for the Asian lungfluke *Paragonimus westermani* (Kerbert, 1878), but Michelson showed in 1992 that this was erroneous."

Threat to Humans

From Morningstar and Benson (2023):

"*Tarebia granfiera* was thought to be an intermediate host for the Asian lung fluke *Paragonimus westermani*, but this is not actually the case; however, this species still hosts other trematode parasites of the family Heterophyidae (Appleton et al., 2009)."

From Appleton et al. (2009):

"*Tarebia granifera* serves as the first intermediate host for a variety of trematodes in its native south east Asia. Amongst these are several species of the family Heterophyidae some of which have been reported as opportunistic infections in people (Watson, 1960) […]"

3 Impacts of Introductions

From Morningstar and Benson (2023):

"This species is known to outcompete, extirpate and replace native snail species, making the species an effective biological molluscicide used to remove native snails that carry parasites (Prentice 1983)."

"In Texas, *T. granifera* feeds on the eggs of the endangered fountain darter *Etheostoma fonticola* (Phillips et al. 2010)."

"Species has blocked pipes in large industrial plants and ponds in a fish hatchery in introduced areas in Africa, due to its tendency to become very dense (Appleton et al., 2009)."

From Fofonoff et al. (2018):

"*Tarebia granifera* is known to compete with, and sometimes replace, native gastropods in its introduced range. In the West Indies and Venezuela, it, together with *M. tuberculata*, spread rapidly and replaced the native *Biomphalaria glabrata*, a major host of *Schistosoma mansoni* (Perez et al. 1991; Pointier et al. 1994; Pointier 2001)."

"In Trinidad streams, the snail was much more abundant (2-8 X) in open areas, with direct sunlight and denser algal populations, compared with forested areas. The high snail abundance and intense grazing led to a 3-9-fold increase in nitrogen export, contributing to eutrophication downstream (Moslemi et al. 2012). An unusual habitat effect was found at the mouth of streams in Tobago, where abundant shells of *M. tuberculata* (Red-Rim Melania) and *Tarebia granifera* were washed down streams into coastal waters during storms, providing a new empty-shell resource for hermit crabs (*Clibanarius tricolor* and *C. vittatus*) and drastically changing the patterns of shell use (van Oosterhout et al. 2013)."

The importation, possession, or trade *Tarebia granifera* is regulated by the following states: Arkansas (Arkansas Game and Fish Commission 2022), Colorado (CPW 2022), Utah (DWR 2020).

4 History of Invasiveness

The History of Invasiveness for *Tarebia granifera* is classified as High. Established populations of *T. granifera* have been documented outside of its native range. Negative impacts of introduction have been documented in the scientific literature, including extirpation of native snails, infrastructure fouling, and river eutrophication.

5 Global Distribution

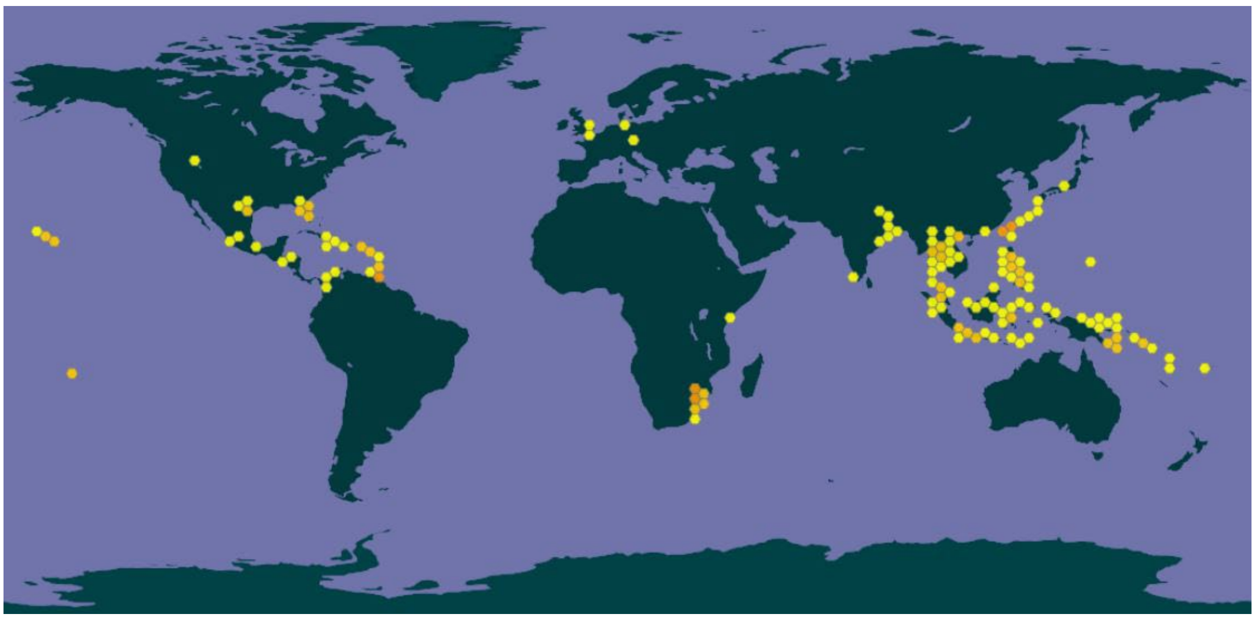

Figure 1. Known global distribution of *Tarebia granifera*. Map from GBIF Secretariat (2023). Points located in Idaho, Europe, and Kenya were not used to select source points for climate matching as they do not represent known established populations of *T. granifera*.

6 Distribution Within the United States

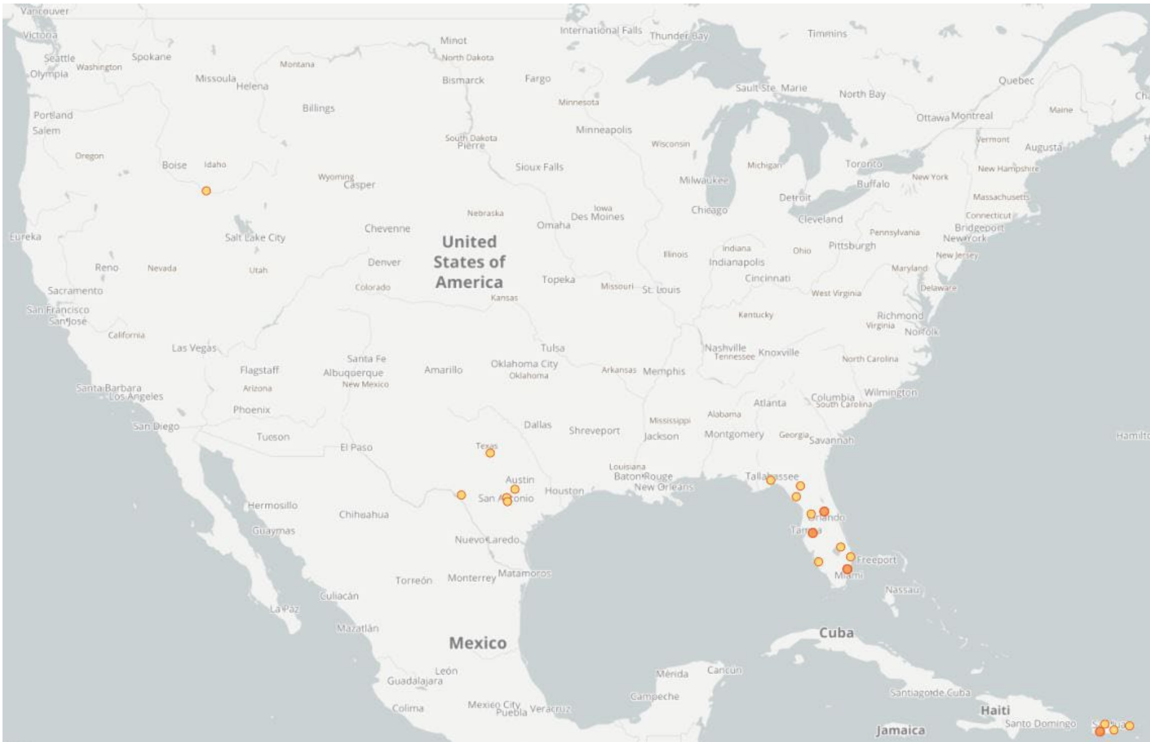

Figure 2. Reported distribution of *Tarebia granifera* in the contiguous United States and Puerto Rico. Map from GBIF-US (2023). Observations reported from Idaho, Texas, Florida, and Puerto Rico. The point in Idaho was not used to select source locations for climate matching because it does not represent a known established population.

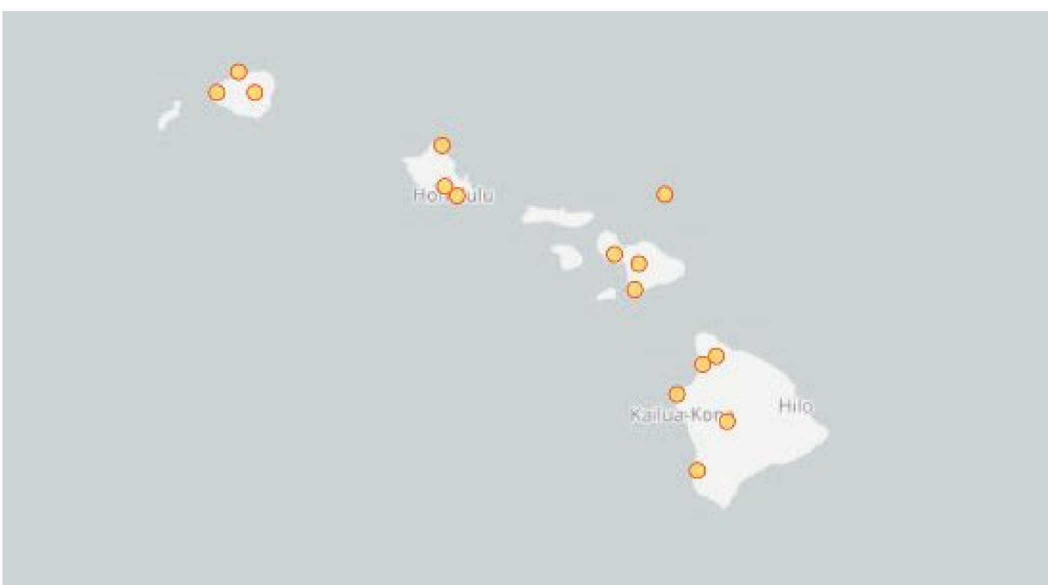

Figure 3. Reported distribution of *Tarebia granifera* in Hawaii, United States. Map from GBIF-US (2023).

Figure 4. Reported distribution of *Tarebia granifera* in the U.S. territory of Guam. Map from GBIF-US (2023).

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Tarebia granifera* in the contiguous United States was highest in peninsular Florida and central Texas, where the species is already established. Other areas of high match included other portions of Texas into central Oklahoma, parts of New Mexico and Arizona, the Gulf Coast, and the southern Atlantic coast from Georgia to North Carolina. Medium matches were found in a broad band stretching from the Mid-Atlantic region across the southern Midwest and the central Plains. Other areas of medium match were found in the Southwest, along the southern and central California coast, and scattered across the Great Basin. Low matches were found in the Pacific Northwest, the Rocky Mountains, the Cascade-Sierra Mountain Range, the Northern Plains into the northern Great Lakes, and the Northeast. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.401, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Tarebia granifera* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

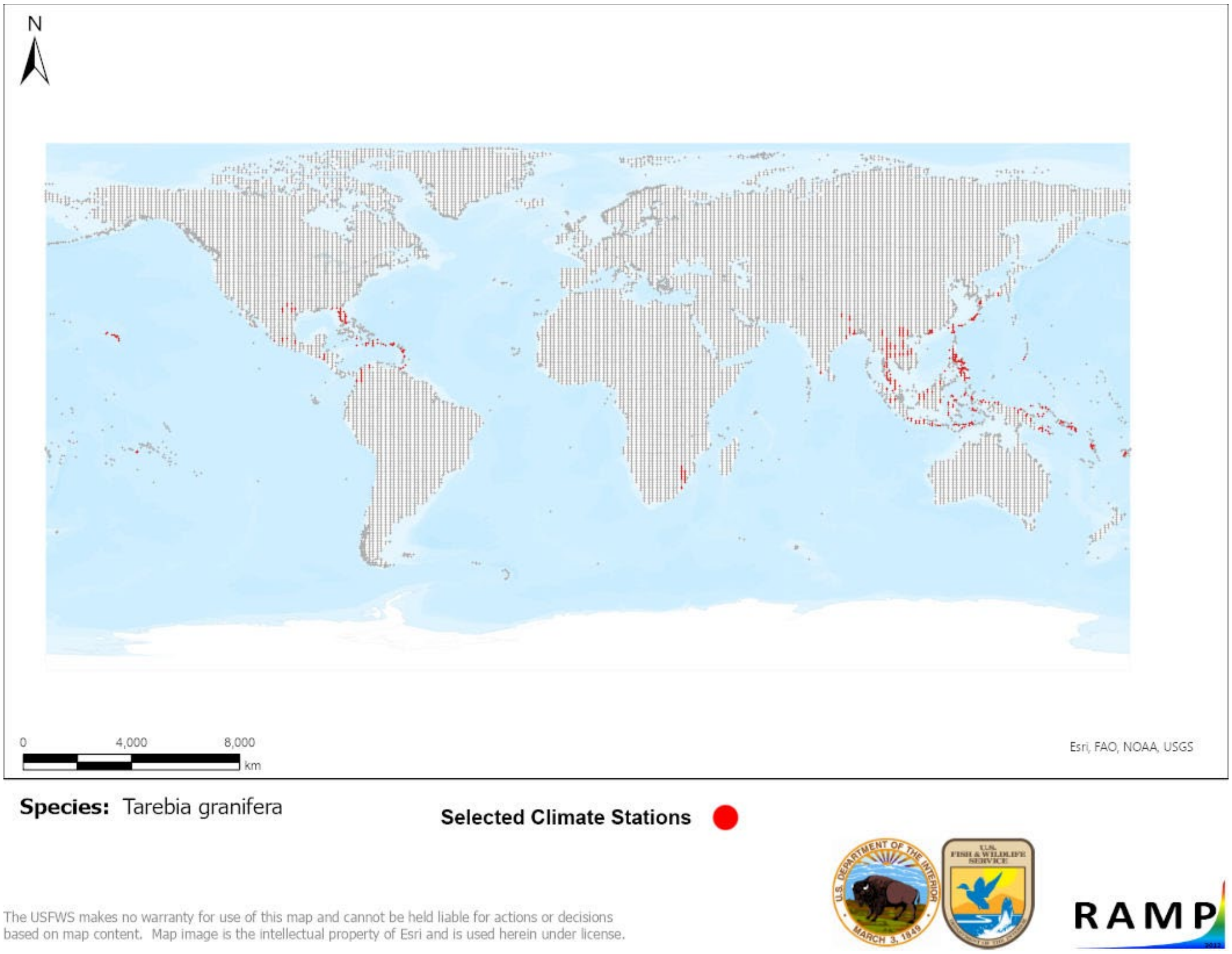

Figure 5. RAMP (Sanders et al. 2023) source map showing weather stations selected as source locations (red; contiguous United States, Venezuela, much of Central America and the Caribbean, South Africa, much of South and Southeast Asia, the Solomon Islands, Vanuatu, Fiji, Guam, French Polynesia, Hawaii) and non-source locations (gray) for *Tarebia granifera* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

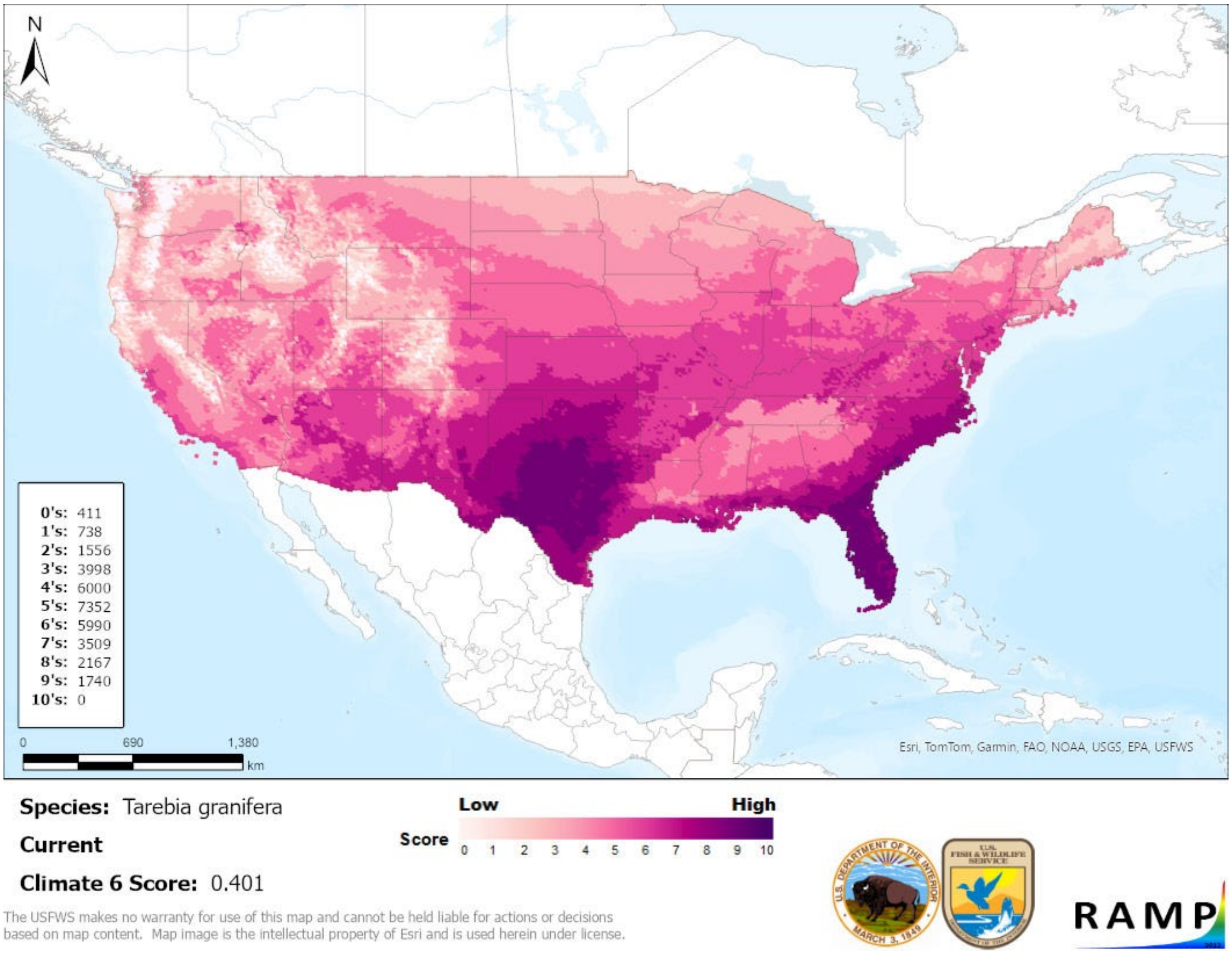

Figure 6. Map of RAMP (Sanders et al. 2023) climate matches for *Tarebia granifera* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Tarebia granifera* is classified as High. Information is readily available on the biology, ecology, and distribution of *T. granifera*. In addition, information is available documenting negative impacts of *T. granifera* introduction from several scientific literature sources.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Tarebia granifera, Quilted Melania, is a warm-temperate to tropical snail native to Southeast Asia and Oceania regions. It can be found in a variety of aquatic habitats, from small springs to large rivers, lakes, and estuaries, and feeds mostly on filamentous algae. *T. granifera* reproduces primarily by parthenogenesis with occasional sexual reproduction. The History of Invasiveness for *T. granifera* is classified as High because established populations of *T. granifera* have been found outside of its native range and there are several documented negative impacts from these introductions, including extirpation of native snails, infrastructure fouling, and river eutrophication via increased nitrogen concentrations. Most introductions have been attributed to the aquarium trade, including in the United States, and three U.S. States regulate possession, collection, transport, or aquaculture of this species (Arkansas, Colorado, and Utah). The Overall Climate Match to the contiguous United States is classified as High, with High matches in the Southern region up to the southern Midwest region of the United States. The Certainty of Assessment for this ERSS is classified as High because information is readily available on the biology, ecology, distribution, and impacts of introduction of *T. granifera*. The Overall Risk Assessment Category for *Tarebia granifera* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): High**
- **Remarks, Important additional information: Often reproduces via parthenogenesis.**
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

Abbott RT. 1952. A study of an intermediate snail host (*Thiara granifera*) of the oriental lung fluke (*Paragonimus*). Proceedings of the United States National Museum 102(3292):71–116.

Appleton CC, Forbes AT, Demetriades NT. 2009. The occurrence, bionomics and potential impacts of the invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) (Gastropoda: Thiaridae) in South Africa. Zoologische Mededelingen 83:525–536.

Arkansas Game and Fish Commission. 2022. Certain exotic species prohibited. Arkansas Game and Fish Commission Code Book 26.13.

[CPW] Colorado Parks and Wildlife. 2022. Possession of aquatic wildlife. 2 Code of Colorado Regulations 406-0, Article VIII #012.

eBay. 2023. 8+ Live freshwater Quilted Melania Snails (*Tarebia granifera*) great algae eaters. eBay. Available: https://www.ebay.com/itm/285138146848?hash=item42638ed620:g:l8UAAOSwhi5i5EHb&amdata=enc%3AAQAHAAAA4Mk%2F1n2j%2F9%2BMEmXRTO61MrQixSCkQ9WiQQPLpEcuHnTltnmIr2tGUvyv%2FHob22PR6f68zExf98LMZX03QqXbXVFaLB0QbZ6lHSOXC4ufpsvQLdI6mkb6GWeRezw0Hl8R%2Bc8sO21My%2FGu1JbdGgyMs%2Fu2fzGPK0WPdZ1Sg1IwSmV9W3BVuTsV1sl7%2FjLaTjiPMyYwDAxRFkChOLI%2B4mp4UxftyrXjkh5t0BQV%2BCRmHyJjFAgs9HNd72SCXom15PMdoLSgxvJeNBDuq

0aWfR75v5%2BeP1yaLBnQ3EHXrSjnogES%7Ctkp%3ABk9SR47J_83ZYQ (March 2023).

Fofonoff PW, Ruiz GM, Steves B, Simkanin C, Carlton JT. 2018. *Tarebia granifera*. National Exotic Marine and Estuarine Species Information System. Edgewater, Maryland: Smithsonian Environmental Research Center. Available: https://invasions.si.edu/nemesis/species_summary/71539 (March 2023).

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Tarebia granifera* (Lamarck, 1816). Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/2300928 (March 2023).

GBIF-US. 2023. Species occurrences: *Tarebia granifera*. Available: https://www.gbif.us/data/?taxonKey=2300928&view=MAP (March 2023).

[ITIS] Integrated Taxonomic Information System. 2023. *Tarebia granifera* (Lamarck, 1822). Reston, Virginia: Integrated Taxonomic Information System. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=71539#null (March 2023)

Lachner EA, Robins CR, Courtenay WR Jr. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contributions to Zoology 59:1–29.

Madhyastha A, Dutta J. 2012. *Tarebia granifera*. The IUCN Red List of Threatened Species 2012. Available: https://www.iucnredlist.org/species/165813/1102513 (March 2023).

Miranda NAF, Perissinotto R. 2012. Stable isotope evidence for dietary overlap between alien and native gastropods in coastal lakes of northern Kwazulu-Natal, South Africa. PLOS ONE 7:e31897.

MolluscaBase editors. 2023. *Tarebia granifera* (Lamarck, 1816). World Register of Marine Species. Available: https://www.marinespecies.org/aphia.php?p=taxdetails&id=397189 (March 2023).

Morningstar CR, Benson AJ. 2023. *Tarebia granifera* (Lamarck, 1822). Gainesville, Florida: U.S. Geological Survey, Nonindigenous Aquatic Species Database. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1039 (March 2023).

Oglesby LC. 1977. A newly introduced, brackish-water snail in the Salton Sea Basin, California. California Fish and Game 63:180–182.

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.

Utah [DWR] Division of Wildlife Resources. 2020. Collection, importation, possession (CIP). Administrative rule R657-3.

[USFWS] U.S. Fish and Wildlife Service. 2024. Standard operating procedure: how to prepare an "Ecological Risk Screening Summary." Version 3.

World Organisation for Animal Health. 2023. Animal diseases. Paris: World Organisation for Animal Health. Available: https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/ (March 2023).

11 Literature Cited in Quoted Material

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.

Appleton CC, Nadasan DS. 2002. First report of *Tarebia granifera* (Lamarck, 1816) (Gastropoda: Thiaridae) from Africa. Journal of Molluscan Studies 68:399–402.

Baker P, Baker SM, Fajans J. 2004. Nonindigenous marine species in the greater Tampa Bay ecosystem. Tampa, Florida: Tampa Bay Estuary Program.

Ben-Ami F. 2008. First report of the invasive freshwater snail *Tarebia granifera* (Lamarck, 1816) (Gastropoda : Thiaridae) from Israel. Nautilus 120:156–161.

Carlton and Eldredge. 2009. [Source did not provide full citation for this reference.]

Chaniotis BN, Butler JM Jr, Ferguson FF, Jobin WR. 1980. Bionomics of *Tarebia granifera* (Gastropoda: Thiaridae) in Puerto Rico, an Asiatic vector of *Paragonimus westermanni*, Caribbean Journal of Science 16(1-4):81–90.

Cowie RH. 1998. Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands. Biodiversity and Conservation 7:349–368.

Englund RA, Arakaki K, Preston DJ, Coles SL, Eldredge LG. 2000. Nonindigenous freshwater and estuarine species introductions and their potential to affect sportfishing in the lower stream and estuarine regions of the south and west shores of Oahu, Hawaii. Honolulu: Hawaii Biological Survey, Bishop Museum.

Florida Museum of Natural History. 2013. Invertebrate zoology master database. Available: http://www.flmnh.ufl.edu/scripts/dbs/malacol_pub.asp.

Gulf States Marine Fisheries Commission. 2009. [Source did not provide full citation for this reference.]

Karatayev AY, Burlakova LE, Karatayev VA, Padilla DK. 2009. Introduction, distribution, spread, and impacts of exotic freshwater gastropods in Texas. Hydrobiologia 619:181–194.

Keller RP, Drake JM, Lodge DM. 2007. Fecundity as a basis for risk assessment of nonindigenous freshwater molluscs. Conservation Biology 21:191–200.

López-López E, Sedeño-Díaz JE, Vega PT, Oliveros E. 2010. Invasive mollusks *Tarebia granifera* Lamarck, 1822 and *Corbicula fluminea* Müller, 1774 in the Tuxpam and Tecolutla rivers, Mexico: spatial and seasonal distribution patterns. Aquatic Invasions 5:435–450.

López-López. 2010. [Source did not provide full citation for this reference.]

Miranda NAF, Perissinotto R. 2012. Stable isotope evidence for dietary overlap between alien and native gastropods in coastal lakes of northern Kwazulu-Natal, South Africa. PLOS ONE 7:e31897.

Moslemi JM, Snider SB, MacNeill K, Gilliam JF, Flecker AS. 2012. Impacts of an invasive snail (*Tarebia granifera*) on nutrient cycling in tropical streams: the role of riparian deforestation in Trinidad, West Indies. PLOS ONE 7:e38806.

Mukaratirwa S, Hove T, Cindzi ZM, Maononga DB, Taruvinga M, Matenga E. 2005. First report of an outbreak of the oriental eyefluke *Philopthalmus gralli* (Mathis & Ledger, 1910), in commercially reared ostriches (*Struthio camelus*) in Zimbabwe. Onderstepoort Journal of Veterinary Research 72:203–206.

Murray HD. 1971. The introduction and spread of Thiarids in the United States. The Biologist 53(3):133–135.

Myers MJ, Meyer CP, Resh VH. 2000. Neritid and thiarid gastropods from French Polynesian streams: how reproduction (sexual, parthenogenetic) and dispersal (active, passive) affect population structure. Freshwater Biology 44:535–545.

Perez JG, Vargas M, Malek E, Emile A. 1991. Displacement of *Biomphalaria glabrata* by *Thiaria granifera* under natural conditions in the Dominican Republic. Memorias do Instituto Oswaldo Cruz Rio de Janeiro 88:341–347.

Phillips CT, Alexander ML, Howard R. 2010. Consumption of eggs of the endangered fountain darter (*Etheostoma fonticola*) by native and nonnative snails. Southwestern Naturalist 55:115–117.

Pointier JP, Incani RN, Balzan C, Chrosciechowski P, Prypchan S. 1994. Invasion of the rivers of the littoral central region of Venezuela by *Thiara granifera* and *Melanoides tuberculate* (Mollusca: Prosobranchia: Thiaridae) and the absence of *Biomphalaria glabrata*, snailhost of *Schistosoma mansoni.* Nautilus 107(4):124–128.

Pointier JP. 2001. Invading freshwater snails and biological control in Martinique Island, French West Indies. Memorias do Instituto Oswaldo Cruz Rio de Janeiro 96:67–74.

Poss SG. 1999. Nonindigenous species in the Gulf of Mexico. [Source did not provide full citation for this reference.]

Prentice MA. 1983. Displacement of *Biomphalaria glabrata* by the snail *Thiara granifera* in the field in habitats in St. Lucia, West Indies. Annals of Tropical Medicine and Parasitology 77:51–59.

USGS Nonindigenous Aquatic Species Program. 2013. Nonindigenous aquatic species database. Gainesville, Florida: U.S. Geological Survey. Available: http://nas.er.usgs.gov.

van Oosterhout C, Mohammed RS, Xavier R, Stephenson JF, Archard GA, Hockley FA, Perkins SE, Cable J. 2013. Invasive freshwater snails provide resource for native marine hermit crabs. Aquatic Invasions 8(2):185–191.

Watson JM. 1960. Medical helminthology. London: Baillière Tindall & Cox.

Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Tarebia granifera* was projected to occur in Southern Florida and along the Southern Atlantic Coast of the contiguous United States. High match was also widespread in Texas at the 2055 time step but covered much less of Texas at the 2085 time step. Areas of low climate match were projected to occur in the Northern Pacific Coast region and in parts of the Western Mountains, Colorado Plateau, and California. The band of medium to high match across the southern Midwest was narrow at the 2055 time step but expanded northward into the southern Great Lakes at the 2085 time step, especially under the SSP5 scenario. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.473 (model: GFDL-ESM4, SSP3, 2055) to a high of 0.643 (model: MRI-ESM2-0, SSP5, 2085). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.401, figure 6) falls below the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, primarily at time step 2085, areas within the Colorado Plateau, Great Lakes, Northeast, and Northern Plains saw a large increase in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Great Basin, Northern Pacific Coast, Southern Plains, and Western Mountains saw a moderate increase in the climate match relative to current conditions. Under one or more time step and climate scenarios, other areas within the Appalachian Range, Gulf Coast, Southeast, Southern Plains, and Southwest saw a moderate decrease in the climate match relative to current conditions. No large decreases were observed regardless of time step and climate scenarios. Additional, very small areas of large or moderate change may be visible on the maps (figure A3). The changes, particularly in the Great Lakes, Northern Plains, Southern Plains, and Northeast were most substantial under SSP5, 2085.

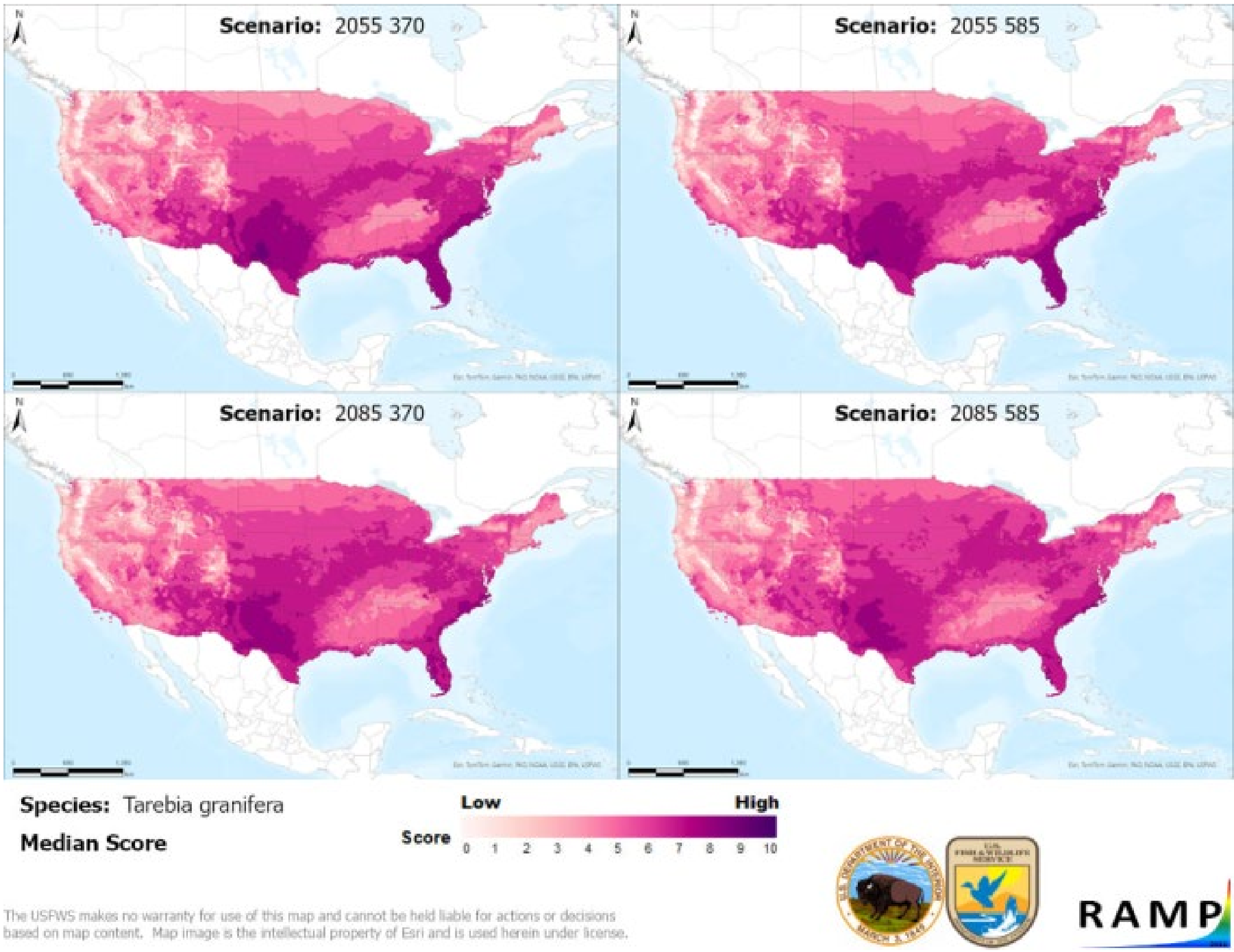

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Tarebia granifera* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

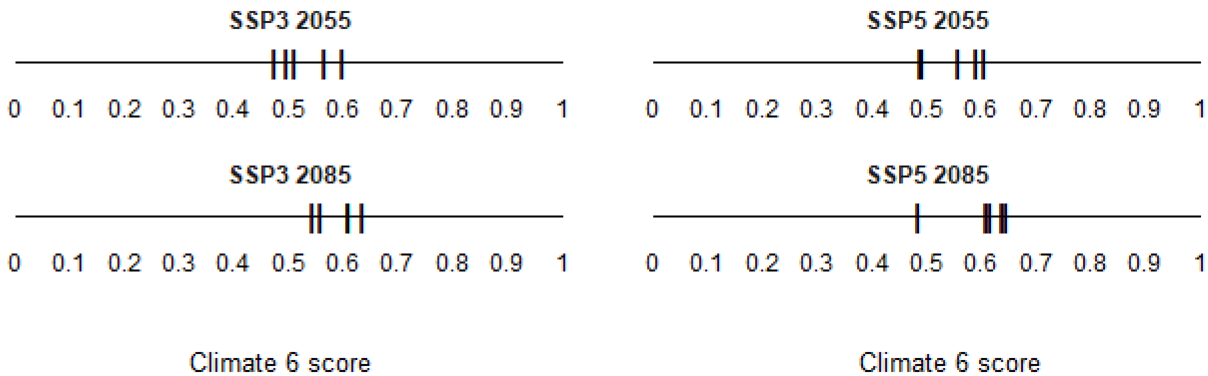

Figure A2. Comparison of projected future Climate 6 scores for *Tarebia granifera* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

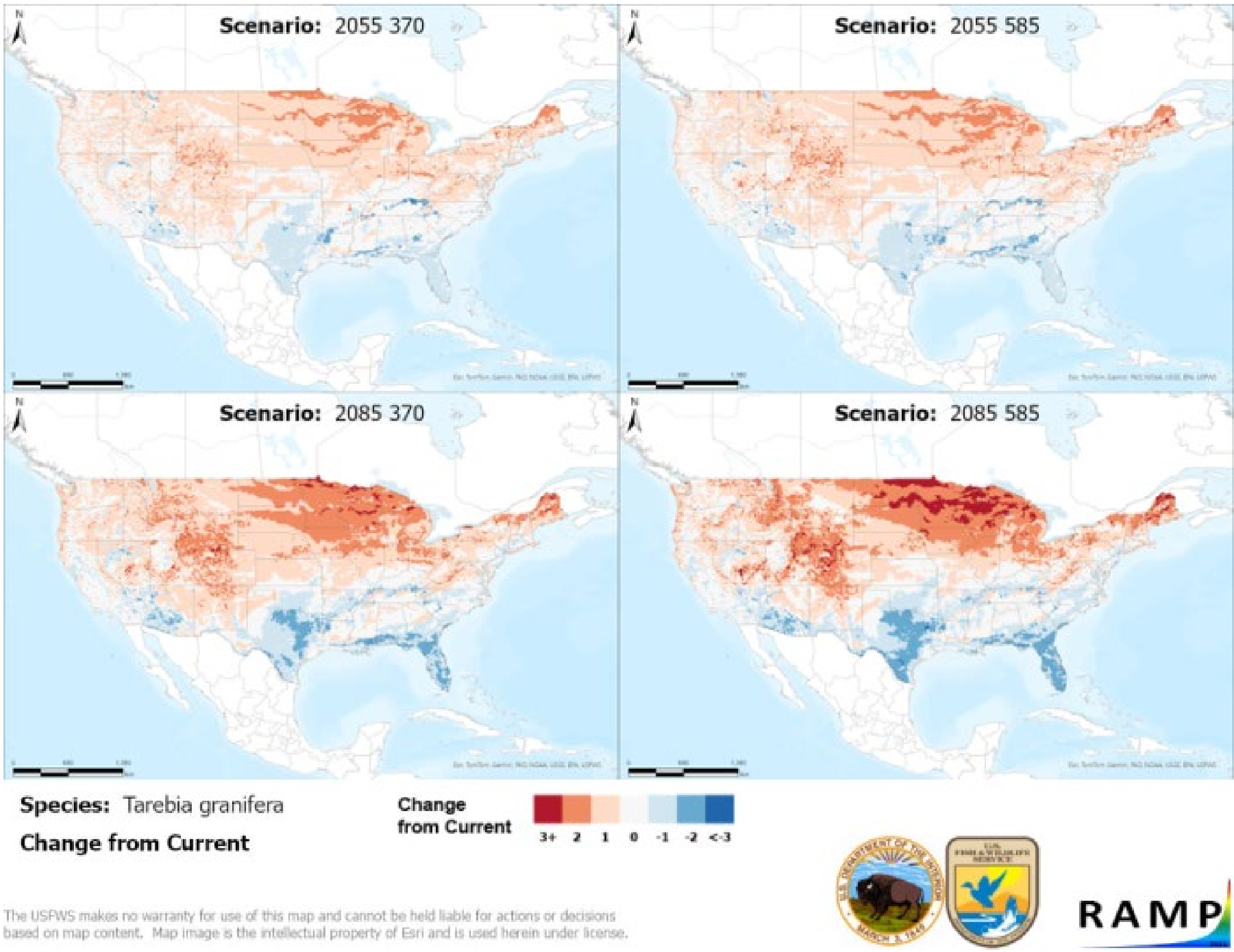

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 6) and the median target point score for future climate scenarios (figure A1) for *Tarebia granifera* based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

Literature Cited

GBIF Secretariat. 2023. GBIF backbone taxonomy: *Tarebia granifera* (Lamarck, 1816). Copenhagen: Global Biodiversity Information Facility. Available: https://www.gbif.org/species/2300928 (March 2023).

[IPCC] Intergovernmental Panel on Climate Change. 2021. Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder HP, Kessler M. 2018. Data from: Climatologies at high resolution for the earth's land surface areas. EnviDat. Available: https://doi.org/10.16904/envidat.228.v2.1.

Karger DN, Conrad O, Böhner J, Kawohl T, Kreft H, Soria-Auza RW, Zimmermann NE, Linder P, Kessler M. 2017. Climatologies at high resolution for the Earth land surface areas. Scientific Data 4:170122.

Sanders S, Castiglione C, Hoff M. 2023. Risk Assessment Mapping Program: RAMP. Version 5.0. U.S. Fish and Wildlife Service.