Sahyadria denisonii: Report addressing the Department of Agriculture, Water and the Environment terms of reference for proposed amendments to the *List of Specimens taken to be Suitable for Live Import* (Live Import List)

Submitted by the Aquarium Industry Association of Australia

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Summary

Consideration of the Department of Agriculture, Water and the Environment (DAWE) terms of reference for proposed amendments to the List of Specimens taken to be Suitable for Live Import (Live Import List) against information available for the Torpedo barb (*Sahyadria denisonii*) indicates the risk of allowing the importation of the species would pose minimal biosecurity risk to Australia. Notably, *S. denisonii* is not reported to have established breeding populations outside its natural range overseas despite being traded internationally for over 30 years and similar species such as *Dawkinsia filamentosa* have not established self-maintaining wild populations in Australia despite decades of importation. Captive breeding populations of *S. denisonii* currently exist in the Australian hobby supplying a limited domestic trade ─ these populations have not led to the establishment of feral populations in Australia.

S. denisonii would be a welcome addition to the species permitted live importation, especially given the growing popularity of the hobby in Australia and the significant economic and social benefits of the aquarium fish trade to Australia. Furthermore, the addition of *S. denisonii* would be a common-sense decision given that the species is present in Australia and given that it is closely related to and shares a similar environmental risk profile with other species currently permitted live importation to Australia.

A structured risk assessment of *S. denisonii* based on the methodology of Bomford (2008) estimated a 'moderate' risk, generally consistent with the risk that would be posed by most of the species currently permitted live importation to Australia. It is recommended that *S. denisonii* is added to the Live Import List.

DAWE terms of reference

1. *Provide information on the taxonomy of the species.*

   - Denison barb or Torpedo barb *Sahyadria denisonii* Day 1865.
   - Actinopterygii (ray-finned fishes); Cypriniformes (Carps); Cyprinidae (Minnows or carps); Sub-family Barbinae.
   - Synonyms: *Labeo denisonii*; *Puntius denisonii* (Day 1865).
   - Common names: Denison Barb, Torpedo Barb, Red Line Torpedo Barb, Miss Kerala, Red Comet Barb, Redline Barb, Roseline Shark, Denison's Flying Fox and Bleeding Eye Barb (Page 2020).

2. *Provide information on the status of the species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). For example, is the species listed on CITES Appendix I, II or III, and if so, are there any specific restrictions on the movement of this species? Include information on the conservation value of the species.*

   - *S. denisonii* is not CITES listed.

- The species is listed on the IUCN's Red List of Threatened Species (Endangered category) and has some conservation value in the wild (Ali *et al.* 2015).

- The species is native to southern India (Western Ghats) where wild populations are under pressure from collection to supply the aquarium trade. The low abundance, gregarious and aggregating nature, easy location of habitats and/or aggregating locations, together with an increasing market demand and popularity, make *P. denisonii* vulnerable to overfishing and possible endangerment (Raghavan *et al.* 2009).

- Mercy *et al.* (2015) noted that 'measures to minimise the likelihood of imported specimens being source from the wild, i.e. ensuring that imports are captive bred, would negate this risk to conservation value. Indeed, encouraging the trade in captive Red List fish will reduce the risk of fish being sourced internationally from the wild'.

- Mercy *et al.* (2015) documented the first success of captive breeding and early developmental studies of *S. denisonii*. Over recent years captive breeding methods have been developed and commercial numbers of captive bred specimens are sold internationally.

- The species has been traded internationally as an aquarium species for 30 years (Jared Patrick, Premier Pet, pers. com.).

3. *Provide information about the ecology of the species.*

   - *Lifespan of the species*: 5 years (Sharpe 2020).

   - *Size and weight range*: Sizes in the wild populations range from 33mm up to a maximum of 162 mm in total length, with the most common length being 50-60 mm (Sajan *et al.* 2015). Studies of the species in different river systems indicate stock-specific variation in population structure (Sajan *et al.* 2015).

   - *Natural geographic range*: The species is a stenotherm (18-26 ºC) endemic to Kerala and south Karnataka in southern India (Malabar Coast) (Sharpe 2020). The species has an estimated range of less than 9,000 km^2 and a fragmented area of actual occupancy of less than 300km^2 (Ali *et al*. 2015).

   - *Habitat*: *S. denisonii* is a stream dwelling fish with an affinity towards rocky pools and stream edges with thick overhanging vegetation along banks (Ali *et al*. 2015). However, the species has also been observed from riverine habitats including run, glide and riffles with sand, gravel, cobble and boulder substrates (Ali *et al*. 2015).

   - *Diet, including potential to feed on agricultural plants*: *S. denisonii* is a herbivore feeding on filamentous algae, diatoms and plant matter (Raghavan *et al.* 2009). There are no reports of the species posing a threat to agricultural crops.

   - *Social behaviour and groupings*: *S. denisonii* is a gregarious species, often appearing in shoals. The species is known to spawn during the North East Monsoon in the months of November-January (Ali *et al*. 2015).

- *Territorial and aggressive behaviours*: There are no reports of territorial or aggressive behaviours in this species.

- *Natural predators*: Not reported in the scientific literature but the species would likely be prey to piscivorous birds, mammals or fish in their natural habitat. As a relatively small species with conspicuous patterning and coloration, the young and adults of the species would be prone to predation by many Australian predatory freshwater fish species such as such as barramundi, grunters, tarpon, Eleotrids, Apogonids and gudgeons.

- *Characteristics that may cause harm to humans and other species*: No characteristics that may cause harm to human or other species have been reported in this species.

4. *Provide information on the reproductive biology of the species.*

Mercy *et al.* (2015) classified the life history of *S. denisonii* into embryonic, larval, juvenile, subadult and adult stages with fecundity varying depending on the size and age of breeding pairs. Under laboratory conditions hatching takes place 36 h after fertilisation at a water temperature of 27.5±0.5ºC. At hatching, mean larval length was approximately 3.5 mm with the yolk sac remaining up to 3-4 days. Organogenesis of larvae was completed 15-20 days after hatching. The fertilised eggs of *S. denisonii* are heavily yolked, transparent, spherical and yellow in colour. The eggs are adhesive similar to other *Puntius* species, the genus in which the species was historically classified.

The spawning season of *S. denisonii* is reported to correspond more or less with the regional monsoon (June–August) and associated seasonal cues, since mature specimens have been observed in the wild from May, with peak maturity seen in June and continuing until July (Raghavan *et al.* 2009). The sex ratio in aggregations of mature fish is highly skewed favouring males (1:25) (Raghavan *et al.* 2009).

- *Age at maturity (first breeding)*: Solomon *et al.* (2011) reported size at first maturity to be 95 mm for females and 85 mm for males, approximating to 1+ year class fish (12-18 months old).

- *How frequently breeding occurs*: Mercy *et al.* 2015 observed spawning season of the species in the wild is from November to March ─ others have reported a narrower season from November-January, more closely aligned to India's North East Monsoon (Ali *et al.* 2015)

- *Can the female store sperm*: Females are not reported to store sperm. Fertilisation is external ─ all fish in this family are egg-layers and like most cyprinids this species does not build nests or guard the eggs.

- *How many eggs or live-born young are produced at each breeding event*: Mercy *et al.* (2015) reported absolute fecundity of *S. denisonii* ranging from 293 to 967ova per female, while Solomon *et al.* (2011) recorded a range of 76 to 1098; extremely low when compared to other cyprinids such as *Systomus* (*Puntius*) *sarana* (Chandrasoma and de Silva 1981) and *Rasbora daniconius* (Nagendran *et al.* 1981). Similar to this species, three endemic cyprinids threatened by aquarium collections in

Sri Lanka, *Pethia* (*Puntius*) *nigrofasciatus*, *Pethia* (*Puntius*) *cumingi* and *Systomus* (*Puntius*) *pleurotaenia* are also known to have a low absolute fecundity (151–638 for 46–64 mm TL) (Solomon *et al.* (2011).

- *Has the species hybridised with other species (both in the wild and in captivity) or has it the potential to hybridise with any other species*: the species is not reported to have hybridised with any other species.
- *If the species can hybridise, are the progeny fertile*: Not applicable.

5. *Provide information on whether this species has established feral populations, and if so, where those populations are. Include information on whether this species has been introduced to other countries, even if it has not established feral populations.*

   The species has not been reported as having established feral population outside of their natural geographic distribution, despite being traded internationally for the aquarium trade for the past 30 years in volumes in the order of 3 million per year (Jared Patrick, Premier Pet, pers.com.).

6. *Provide information on, and the results of any other environmental risk assessments undertaken on the species both in Australia and overseas, including any Import Risk Analyses undertaken.*

   A search of the scientific literature did not identify any previous environmental risk assessment of this species. The species is not on the BRS 'grey list' of ornamental fish species, i.e. non-native species that are present in Australia through historical imports that are not on the Live Import List, nor is it one of the species of non-native freshwater fish that are reported to have established self-sustaining populations in the wild in Australia (Corfield et al. 2008).

   However, the species is known to be captive bred and traded domestically in Australia (Jared Patrick, Premier Pet, pers. com.). It is unknown how the first individuals arrived in Australia ─ it is plausible that they may have been shipped to Australia inadvertently as they resemble some closely related species on the current Live Import List (Anthony Ramsey, Pet Industry Association of Australia, pers. com.).

   The addition of *S. denisonii* to the Live Import List would be generally consistent with Australia's biosecurity arrangements for live fish given that the species is present in Australia and given that it is closely related to and shares a similar environmental risk profile with several species currently permitted live importation to Australia.

7. *Assess the likelihood that the species could establish a breeding population in the Australian environment should it ever be released from effective human control.*

   Assessing the risk of the potential of introducing a new organism into the environment involves assessing the risk of it becoming established and spreading and the likely impacts if establishment occurred. The risk assessment method 'Exotic Freshwater Fish Model 1' developed by Mary Bomford has been adopted by DAWE for its freshwater fish risk assessments (Bomford 2008). The following considers each of the risk factors

considered by Bomford to be applicable to freshwater fish and is guided by the recent Australian Government risk assessment of glass catfish (DAWE 2020a). The specific criteria in the DAWE template terms of reference are also covered. The potential impacts of established feral populations are addressed in the next term of reference (#8). A structured risk assessment based on the Bomford methodology is at Appendix A.

- *Propagule pressure*—the release of large numbers of animals at different times and places enhances the chance of successful establishment: As a schooling species S. denisonii has a higher likelihood of establishing than non-schooling species. However, the species is not territorial, and any inadvertent or deliberate releases into water ways would likely disperse. A moderate to high probability of establishing a self-sustaining population would require deliberate release into very specific waterways – it is unlikely therefore to happen at random (DAWE 2020a). The possible locations where establishment may occur are generally remote from populated areas; this includes areas in Arnhem Land and far Northern Australia. It is highly unlikely that enough fish would be accidently or deliberately released into a suitable receiving environment to establish a breeding population.

- *Climate match*—introduction to an area with a climate that closely matches that of the species' original range: Climatch (original v1.0) was run with the source region set to circumscribe nine stations in the Western Ghats ranges of India including the location of sampling sites (in and around 75ºE, 12ºN) used by Solomon *et al.* (2011) and the broader 'extant and probably extant' geographical range described in the IUCN species assessment (Ali *et al.* 2015). A climate match prediction was generated using the Euclidian algorithm applied to the 'world stations' data set. Climatch calculated a 'value X' (Climate Euclidian Sum Level 5) of 655, equating to a climate match score of 5, increased to 6 because there were less than 12 meteorological stations used in the prediction. DAWE (2020a) suggested the need for some caution in predicting climate suitability for freshwater aquatic species because Climatch is based on terrestrial climate measurements. The new upgraded version of Climatch (v2.0) was not used in this assessment because its improved mapping resolution results in higher output values that are yet to be calibrated for purposes of applying the Bomford methodology.

- *Overseas range:* The species is a stenotherm (18-26ºC) endemic to Kerala and south Karnataka in southern India (Malabar Coast) (Sharpe 2020). It has an estimated range of 8,805 km^2 and is conservatively estimated to occupy a total 6, 1^o latitude x 1^o longitude grid squares (Bomford 2008).

- *History of establishment elsewhere—previous successful establishment:* There have been no recorded establishment of wild populations of *S. denisonii* outside its natural range, despite likely inadvertent or deliberate introductions as an internationally traded aquarium species. The species is considered to have been "introduce but never established" (Bomford 2008).

- *Introduction success:* The species is not known to have been released or established. However, after decades of trade worldwide it can be assumed it has been released into non-native areas on many occasions. The *introduction rate* is conservatively considered to be less than 0.25 or 25%.

- *Taxonomic group—belonging to a family or genus which has a high establishment success rate: S. denisonii* belongs to the family Cyprinidae (freshwater fish that includes the carps, the true minnows, and their relatives such as barbs and barbels) and the subfamily Barbinae ─ the taxonomy of the Barbinae is uncertain as some genera historically considered within it are still considered *incertae sedis* (Wikipedia n.d.─a). There are four ornamental cyprinid species that are reported to have established self-maintaining populations in Australian waters; namely goldfish (*Carassius auratus*), rosy barb (*Puntius conchonius*), Sumatra barb (*Puntius tetrazona*) and white cloud mountain minnow (*Tanichthys albonubes*) (Corfield *et al.* 2008). However, there is limited value in assigning a level of invasiveness risk to the family as a whole because the Cyprinidae is the largest and most diverse fish family and the largest vertebrate animal family in general, with about 1750 valid species, representing about 150 genera (Fricke *et al*. 2020) (Froese and Pauly n.d.─a)

  At a genus level, since there are only two species in the genus *Sahyadria*, all species currently in the genus *Puntius* (to which the species previously belonged) plus the two species of *Sahyadria* may be considered as a single group for risk assessment purposes. According to FishBase (Froese and Pauly n.d.─b), of a total 52 species (50 *Puntius* and 2 *Sahyadria*), 11 (10 *Puntius* and 1 *Sahyadria*) are traded as ornamental species, and of these 11, there are seven records (representing only two species) on FishBase of *Puntius* species being found to have established wild populations outside the countries to which they are native. As internationally traded species, it is reasonable to assume that these 11 species have been introduced to non-native environments many times over the past several decades of international trade – conservatively assumed to be 50 introductions for the purposes of this risk assessment. This assumed level of introductions has resulted in 7 established populations of two species. The 'genus level' taxa risk is therefore 7/50 (14%).

- *Ability to find food sources*: As a herbivore feeding on filamentous algae and plant matter, the species is expected to find food sources in the unlikely event it is introduced into the wild.

- *Ability to survive and adapt to different climatic conditions (e.g. temperatures, rainfall patterns)*: *S. denisonii* is a benthopelagic stenotherm endemic to the Achenkovil, Pamba and Chaliyar rivers; specifically in four locations — Cheenkannipuzha (a major tributary of Valapattanam River), the Achankovil river, the Chaliyar river and near Mundakayam town (Wikipedia n.d.─b). The species thrives in a subtropical climate in water with a 6.8-7.8 pH, a water hardness of 5-25 dGH and a temperature range of 18 to 26°C. This climatic range together with its stream habitat requirements limits the potential geographical range where the species could theoretically (Wikipedia 2020b).

- *Ability to find shelter*: As a stream dwelling fish with an affinity towards rocky pools, edges with thick overhanging vegetation along its banks (Wikipedia n.d.─b), opportunity to find shelter in the event of deliberate or inadvertent release into the wild would be limited.

- *Rate of reproducing*: Solomon *et al.* 2011 reported absolute fecundity of *S. denisonii* to be extremely low, compared to other cyprinids such as *Systomus* (*Puntius*) *sarana*

and *Rasbora daniconius*. Similar to this species, three endemic cyprinids threatened by aquarium collections in Sri Lanka, *Pethia* (*Puntius*) *nigrofasciatus*, *Pethia* (*Puntius*) *cumingi* and *Systomus* (*Puntius*) *pleurotaenia* are known to have a low absolute fecundity (151–638 for 46–64 mm TL). The net reproductive rate (the number of offspring that a female produces during its lifetime) is therefore considered relatively low compared to other cyprinids.

- *Any characteristics that the species has which could increase its chance of survival in the Australian environment*: The species is not considered to have any characteristics that would increase its likelihood of survival in the wild in Australia.

In summary, *S. denisonii* is considered unlikely to establish, in main because the species is not reported to have established breeding populations outside its natural range despite being traded internationally as an ornamental species for the last 30 years, and because there are few areas in Australia expected to have habitat suitable for the species to establish. This conclusion can be ground-truthed to an extent by comparing *S. denisonii* with similar species such as *Dawkinsia filamentosa* that have not established self-maintaining wild populations despite decades of importation to Australia for the aquarium trade. Furthermore, there currently exists breeding populations of *S. denisonii* in the Australian hobby – these have not led to the establishment of feral populations in Australia.

The above information is presented as a structured Bomford (2008) risk assessment at Appendix A.

8. *Provide a comprehensive assessment of the potential impact of the species should it establish feral population/s in Australia. Include, but do not restrict your assessment to the impact of this species on:*

- *Similar niche species (i.e. competition with other species for food, shelter etc.)*: In the unlikely event this species establishes in the wild in Australia, it may compete for benthic algae and plant matter with other small herbivores and omnivores in tropical waters (17-28°C), typically in pebble, rock or boulder-substrate running water habitats. These niche species could include bottom feeders such as rainbowfishes (*Melanotaenia* spp.), *Pseudomugil* spp. and other small omnivores. *S. denisonii* is unlikely to compete with species that feed in the water column such as glassfishes/Agassiz's perchlet (*Ambassis agassizii*) (AKA Agassiz's glass fish), flyspecked hardyheads (*Craterocephalus stercusmuscarum*), unspecked hardyhead (*Craterocephalus fulvusgudgeons*) and other similar species.

- *Is the species susceptible to, or could it transmit any pests or disease*:
  No significant pests or diseases have been associated with this species, including any of the diseases to which there are disease-specific risk management measures applied for importation of ornamental fish to Australia. The barbs as a group are considered of low risk in terms of disease risk in that they are subject to the minimum one-week post arrival quarantine isolation on importation to Australia (DAWE 2020b).

- *Probable prey/food sources, including agricultural crops*: *S. denisonii* has not been reported to pose any threat to agricultural crops or pose a threat as a predator ─ it is a herbivore.

- *Habitat and local environmental conditions*: *S. denisonii* has not been reported to change its environment or habitat. It is a stream dwelling fish with an affinity towards rocky pools, edges with thick overhanging vegetation along its banks (Ali *et al*. 2015). It does not build nests and lays adhesive eggs that attach to the pebbly substrate of stream bottoms.

- *Control/eradication programs that could be applied in Australia if the species was released or escaped*: Potential controls measures include listing as a noxious species; eradication or containment programs (including movement controls) or broader education/awareness building campaigns such as the NAQS program for labelling fish bags in aquarium shops in northern Australia.

- *Characteristic or behaviour of the species which may cause land degradation i.e. soil erosion from hooves, digging*: There are no reports of this species exhibiting any behaviours that my cause habitat degradation.

- *Potential threat to humans*: The species is not reported as posing any threat to humans.

9. *What conditions or restrictions, if any, could be applied to the import of the species to reduce any potential for negative environmental impacts (e.g. single sex imports, de-sexing animal prior to import etc.).*

   Potential environmental impacts from importation of live animals into Australia can take the form of direct pest risks or indirect risks associated with the introduction of new diseases that may be carried in imported sock. In the case of *S. denisonii*, importation under Australia's current import conditions would reduce potential disease risks to an acceptable level, consistent with previous Australian Government disease risk analyses (AQIS, 1999, DOA, 2014).

10. *Provide a summary of the types of activities that the specimen may be used for if imported into Australia (e.g. pet, commercial, scientific).*

    - *Benefit of this species for these activities*: Permitting importation of this species will support the ornamental fish industry. In a broader context, the ornamental fish hobby is an important one. Aside from creating employment and contributing to the economy of all States and Territories, it has become especially important during the CoViD pandemic where individuals subject to movement restrictions are turning increasingly to the hobby for recreation – the hobby therefore plays a significant part in helping alleviate the stressors associated with the pandemic and post-CoViD recovery, both from economic and social perspectives.

      The direct and indirect economic benefits of ornamental fish importation carry through the aquarium industry supply chain and into the hobby. The economic beneficiaries include, but are not limited to, aquarium fish importers, wholesalers, aquarium hard goods distributors, retail pet and aquarium shops, commercial and

hobby breeders as well as freight and logistics providers and other associated vendors.

Importantly, keeping ornamental fish fosters companion animal care which has benefits to society beyond the direct economic value of the trade. There are companionship as well as mental health benefits. There has never been a more important time for these benefits to flow through Australian society. The aquarium hobby also plays an often undervalued educational role, especially relevant to younger Australians. The benefits in this respect include, but are not limited to, an increased understanding of, and appreciation for, biology, chemistry, physiology as well as geography and natural history.

- *Potential trade in the species*: The species is routinely traded internationally (and to a much smaller extent, domestically) and would be a welcome addition to the species permitted importation. In the order of 3 million fish of the species are traded internationally and given the growing popularity of the hobby in Australia, the likely market demand in Australia for imported *S. denisonii* stock would represent about one percent of this (Jared Patrick, Premier Pet, pers. com.).

- *Why this species has been chosen*: Internationally, the species is in high demand by hobbyists because aquacultured specimens are very affordable to the average hobbyist. *S. denisonii* is prohibitively priced in Australia due to unavailability of imported stock and as a result, beyond the reach of most hobbyists. Permitting importation will mean that the species could be offered at a more affordable price, with associated benefits to the trade and the hobby. The species is not aggressive and compatible to keep in aquaria with other tropical species.

- *Provide detailed guidelines on the way in which the species should be kept, transported and disposed of in accordance with the types of activity that the species may be used for if imported into Australia.*

- *The containment (e.g. cage, enclosure) and management standards for this species to prevent escape or release. This should also talk about the security standards for this specimen*: The fish will be transported as per the International Air Transport Association (IATA) guidelines and the provisions of the *BICON Import Conditions for Freshwater Aquarium Fish: Effective 18 July 2020* (DAWE 2020b).

- *The disposal options for surplus specimens*: Fish will be imported for purposes of supplying the aquarium fish trade and as such no surplus specimens are expected. In the event of mortality, animals will be disposed as per the provisions of the *BICON Import Conditions for Freshwater Aquarium Fish: Effective 18 July 2020* (DAWE 2020b) and in accordance with the Pet Industry Association of Australia (PIAA) National Code of Practice (PIAA 2008).

11. Provide information on all other Commonwealth, state and territory legislative controls on the species, including:

    - *The species' current quarantine status*: The species is not currently on the permitted species list.

- *Pest or noxious status*: The species is not list on any state or federal pest or noxious species list.
- *Whether it is prohibited or controlled by permit or licence in any state or territory*: The species is not prohibited or controlled by permit or licence in any state or territory.

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Appendix A: Bomford model risk assessment: *Sahyadria denisonii*

Assessing the risk of the potential of introducing a new organism into the environment involves assessing the likelihood of it becoming established and spreading and the likely impacts if the species does establish. The following analysis applies the assessment method for determining the risk of establishment of exotic freshwater fish introduced to Australia (Model 1) described in Bomford (2008) and is guided by the recent DAWE risk assessment of glass catfish (DAWE 2020a).

Bomford (2008) identified a range of factors that determined establishment success of freshwater fish, including propagule pressure, climate match, history of establishment elsewhere, geographic range and taxonomic group. These risk factors together with potential impacts should *Sahyadria denisonii* (Day 1865) establish wild populations in Australia are discussed below, as are the outputs of applying the Bomford (2008) methodology. These findings should be considered together with information addressing the DAWE terms of reference for proposed amendments to the *List of Specimens taken to be Suitable for Live Import (Live Import List)* in the body of this submission.

Establishment success

Propagule pressure—the release of large numbers of animals at different times and places

As a schooling species *S. denisonii* has a higher likelihood of establishing than non-schooling species. However, the species is not territorial, and any inadvertent or deliberate releases into water ways would likely disperse. A moderate to high probability of establishing a self-sustaining population would require deliberate release into very specific waterways – it is unlikely therefore to happen at random (DAWE 2020a). The possible locations where establishment may occur are generally remote from populated areas; this includes areas in Arnhem Land and far Northern Australia. It is highly unlikely that enough fish would be accidently or deliberately released into a suitable receiving environment to establish a breeding population.

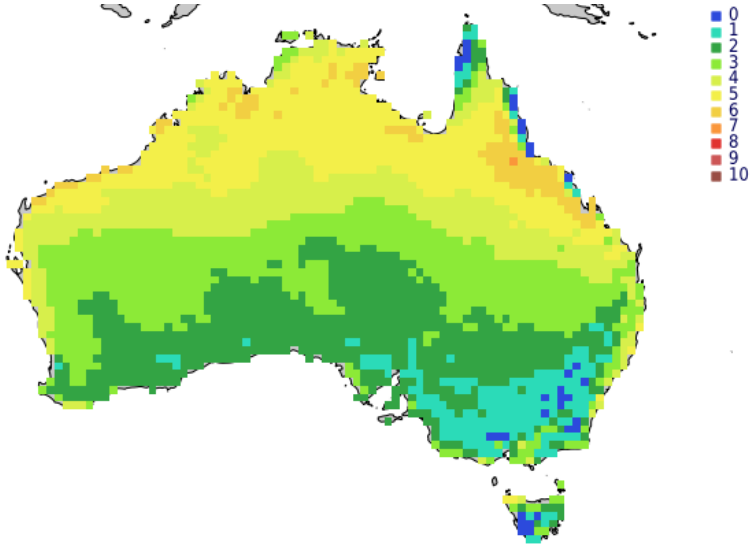
If permitted importation *Sahyadria denisonii* would be freely available in Australia through aquarium stores and retail at about $10-20 per fish. The species would be common enough in Australia that theft due to lack of availability is unlikely.

Only a very deliberate and planned release might result in establishment of the species, although the limited potentially suitable habitats and their remoteness from populated areas makes this scenario highly unlikely.

Climate match—introduction to an area with a climate that closely matches that of the species' original range:

Map coordinates of collection sites provided in Solomon et al. (2011) provides fairly precise data for climate matching purposes. Climatch (v1.0) was run with the source region set conservatively to circumscribe weather stations in the Western Ghats ranges of India including the location of sampling sites (in and around 75ºE, 12ºN) used by Solomon *et al.* (2011) and the broader 'extant and probably extant' geographical range described in the IUCN species assessment (Ali *et al.* 2015). A climate match prediction was generated using the Euclidian algorithm applied to the 'world stations' data set (Figure 1). Climatch calculated

a ‘value X’ (Climate Euclidian Sum Level 5) of 655, equating to a climate match score of 5, increased to 6 because there were less than 12 meteorological stations used in the prediction. DAWE (2020a) suggested the need for some caution in predicting climate suitability for freshwater aquatic species because Climatch is based on terrestrial climate measurements. The recently released upgraded version of Climatch (v2.0) was not used in this assessment because its improved mapping resolution results in higher output values that are yet to be calibrated for purposes of applying the Bomford methodology.



Score	0	1	2	3	4	5	6	7	8	9	10
Count	33	195	699	721	482	551	103	1	0	0	0

Figure 1 Climatch output for *Sahyadria denisonii*

History of establishment elsewhere—previous successful establishment:

There have been no recorded establishment of wild populations of *S. denisonii* outside its natural range, despite likely inadvertent or deliberate introductions as an internationally traded aquarium species. The species is considered to have been “introduce but never established” (Bomford 2008).

Overseas range:

The species is a stenotherm (18-26ºC) endemic to Kerala and south Karnataka in southern India (Malabar Coast) (Sharpe 2020). It has an estimated range of 8,805 km2 and is conservatively estimated to occupy a total 6, 1º latitude x 1º longitude grid squares (Bomford 2008).

Introduction success:

The species is not known to have been released or established. However, after decades of trade worldwide it can be assumed it has been released into non-native areas on many occasions. The introduction rate is conservatively considered to be less than 0.25 or 25%.

Taxonomic group—belonging to a family or genus which has a high establishment success rate:

S. denisonii belongs to the family Cyprinidae (freshwater fish that includes the carps, the true minnows, and their relatives such as barbs and barbels) and the subfamily Barbinae ─ the taxonomy of the Barbinae is uncertain as some genera historically considered within it are still considered incertae sedis (Wikipedia n.d.─a). There are four ornamental cyprinid species that are reported to have established self-maintaining populations in Australian waters; namely goldfish (*Carassius auratus*), rosy barb (*Puntius conchonius*), Sumatra barb (*Puntius tetrazona*) and white cloud mountain minnow (*Tanichthys albonubes*) (Corfield *et al.* 2008). However, there is limited value in assigning a level of invasiveness risk to the family as a whole because the Cyprinidae is the largest and most diverse fish family and the largest vertebrate animal family in general, with about 1750 valid species, representing about 150 genera (Fricke *et al*. 2020) (Froese and Pauly n.d.─a)

At a genus level, since there are only two species in the genus *Sahyadria*, all species currently in the genus *Puntius* (to which the species previously belonged) plus the two species of *Sahyadria* may be considered as a single group for risk assessment purposes. According to FishBase (Froese and Pauly n.d.─b), of a total 52 species (50 *Puntius* and 2 *Sahyadria*), 11 (10 *Puntius* and 1 *Sahyadria*) are traded as ornamental species, and of these 11, there are seven records (representing only two species) on FishBase of Puntius species being found to have established wild populations outside the countries to which they are native. As internationally traded species, it is reasonable to assume that these 11 species have been introduced to non-native environments many times over the past several decades of international trade – conservatively assumed to be 50 introductions for the purposes of this risk assessment. This level of assumed introductions has resulted in 7 established populations of two species. The 'genus level' taxa risk is therefore 7/50 (14%).

Potential impacts of established feral populations

Sahyadria denisonii is a schooling nonaggressive fish that is not reported to be territorial or to change its habitat. If a population did manage to become established in the wild in Australia it may compete for food resources with native fish, this would include small invertebrates and zooplankton. As there are no reports of any *Sahyadria* species establishing feral populations direct impacts are not certain but unlikely.

S. denisonii poses a minor impact risk to the Australian environment as they have been freely traded internationally for many years, with no evidence of establishment of feral populations or any detrimental impact in any other country.

Disease transmission to Australian fish and aquarium fish populations

No significant pests or diseases have been associated with this species, including any of the diseases to which there are disease-specific risk management measures applied for importation of ornamental fish to Australia. The barbs as a group are considered of low risk in terms of disease risk in that they are subject to the minimum one-week post arrival quarantine isolation on importation to Australia (DAWE 2020b).

Bomford 2008 Exotic Freshwater Fish Risk Assessment Model

Common name	Torpedo barb
Scientific name	*Sahyadria denisonii* Day 1865

Date assessed	10 October 2020
Literature Search Type and Date:	FishBase October 2020

Risk criterion	**Value**	**Explanation**
A. Climate Match Score (1–8)	6	Climatch (v1.0) Euclidian Sum Level 5 (Value X) = 655. This value equates to a climate match score of 5, which is increased to 6 because there were less than 12 meteorological stations used in the prediction.
B. Overseas Range Score (0–4)	1	Applying a conservative estimate of 6, 1-degree grid squares.
C. Establishment Score (0–3)	0	The species is considered to have been "introduce but never established", representing an establishment score of 0.
D. Introduction Success Score (0–4)	<1	Never known to be released or established. However, after decades of trade worldwide it can be assumed the species has been released into non-native areas. The introduction rate is conservatively considered to be <0.25, representing an introduction success score of <1.
E. Taxa Risk Score 1(0–5)	1	As an internationally traded aquarium species, it is reasonable to assume that there would have been many instances of inadvertent or deliberate introduction around the world of the 11 ornamental fish species currently or formerly belonging to the genus *Puntius.* Conservatively, 50 past introductions are assumed for the purposes of this risk assessment. There are only seven records (representing only two species) on FishBase of *Puntius* species being found to have established wild populations outside the countries to which they are native. The 'genus level' taxa risk is therefore 7/50 (14%). Notably, there are several species of barbs such as *Puntius vittatus* that are on the current Live Import List.

Summary	*Score*	*Rank*
Establishment Risk	9	Moderate

Conclusion

The estimated risk of 'moderate' using the Bomford (2008) methodology is generally consistent with the risk that would be posed by most of the species currently permitted live importation to Australia. It is recommended that *S. denisonii* is added to the Live Import List.