Journal of Sustainability Science and Management
Volume 14 *Number* 6, December 2019: 51-65

eISSN: 2672-7226

REGIONAL TINFOIL BARB IMPORTS CAN ALTER ITS NATIVE SPECIES GENETIC MAKEUP

MAISARAHADIBAH JAFFAR[1,2], NORFATIMAH MOHAMED YUNUS[1] AND BRYAN RAVEEN NELSON*[2,3]

[1]Faculty of Applied Science, Universiti Teknologi Mara Shah Alam, 40000 Shah Alam, Selangor, Malaysia. [2]Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia. [3]Association for Biodiversity Conservation and Research, Devine Colony, Balasore, 756001 Odisha, India.

**Corresponding author: bryan.nelson@umt.edu.my*

Abstract: Tinfoil barb, *Barbonymus schwanfeldii* is part of Malaysian inland fish commodity and being trade as ornamental fish, alternative protein and aquaculture industries. It is now within transboundary demand-supply chains of Indonesia, Singapore, Malaysia and Thailand. An inquest on gene hybridization from the trade used morphometric, meristic and phylogenetic tree construction. Mitochondrial cytochrome c oxidase 1 gene codes of three fish, each acquired from five different ornamental traders are revealed some degree of native gene dilution. As such, bootstrap values above 90 were produced after comparison with Indonesian fish, whereas it was below 90 when compared to Malaysian fish. This finding suggests that Malaysian *B. schwanfeldii* may have cross-bred with same species of non-native origin when held in captivity and it diluted the filial genetic make-up. Dilution of native genetic information cause gene hybridization and this adaptable individuals (an alternative perspective of natural selection) could become invasive. In-line with invasive alien species management, Convention on Biological Diversity has asserted the need for good practices that abide to Transnational Policy Network on Invasive Alien Species. It is suggested that alike-species transboundary exports should forgo ornamental intentions and focus instead on the sustainable alternative protein supply to compensate regional transboundary food security.

Keywords: Sustainable, tropical fish, Malaysia, hybrid, phylogenetic, ecology.

Introduction

Food security is always been an unresolved issue as market demands are rising exponentially (Seufert *et al*., 2019). Presently, agriculture practices support global, cross border and local food demands. Agriculture promotes cultivation techniques and this reduces pressure from the traditional wild population harvest (Gu *et al*., 2019). Diversified food production is one of the solutions to achieve United Nations Development Programme of Sustainable Development Goal 2, in particularly to eradicate hunger. Adopting an identical heed, Food and Agriculture Organisation resolves global food issues through innovative supply-demand chains and diversified economy (Magrini et al., 2019; Stančová & Cavicchi, 2019). Chain-reaction from food diversifications made fin- and shell-fisheries follows guiding principles for safe harvest (Nelson *et al*., 2015; Nelson *et al*., 2016a; Shaari *et al*., 2016; Manan *et al*., 2017) and eventually saw ornamental and trash aquatic life becoming part of food security commodity (Fairuz-Fozi *et al*., 2018; Aubin *et al*., 2019). In particular, the once side-lined inland fish *Barbonymus schwanenfeldii* or commonly called tinfoil barb is now part of the protein supply (Arifin *et al*., 2017; Ng *et al*., 2017).

The tinfoil barb congregates in flooded forest, grassland and also found in lakes where water flow (or current) is close to negligible. Commonly sighted in shallow waters (Muthmainnah & Gaffar, 2017), *B. schwanenfeldii* usually occupies water fringes, and this eases encounter as well as their attaining from the wild. Thus, the tinfoil barb is now part of inland capture fisheries and sold in local wet markets as protein resource (Sultana *et al*., 2018). Inclusion of *B. schwanfeldii* into protein supply did not completely divert local demands. In fact, *B. schwanenfeldii* is an important for ornament, commercial aquaculture, subsistence farming, and bait industry (Frasca *et al*., 2018). As a tropical fish, *B. schwanenfeldii* may be recovered from Mekong and Chao Phraya basins (Cambodia, Laos, Thailand and Vietnam) (Krailas *et al*., 2016), the Malay Peninsula, Borneo (Ng *et al*., 2017) and Sumatran regions (Batubara *et al*., 2018). Wild adult fish may reach beyond 240 mm whereas its juveniles ranges 25 mm to 70 mm depending on water body carrying capacity (Radhi *et al*., 2018). Like every fish having economic importance, the tinfoil barb culture was received well by locals because meat of this fish is tasty regardless the cooking technique (Idris *et al*., 2017).

Upscaling of aquaculture practices in lakes and reservoirs were required in order to meet local-community demands. Between years 2011 and 2013, countries like Malaysia (Adnan & Atkinson, 2011; Chatterji *et al*., 2012; Tan *et al*., 2015), Indonesia (Ward *et al*., 2013; Remondi *et al*., 2016) and Thailand (Nara *et al.*, 2014; Homdee *et al*., 2016) were experiencing reducing carrying capacities in large water bodies. In fact, reducing carrying capacities by harsh climate and weak land management were not limited to surface water networks (Nelson *et al*., 2016b; Nelson *et al*., 2019; Zauki *et al*., 2019a; Zauki *et al*., 2019b) but also, being witnessed at terrestrial territories (Fakhrul-Hatta *et al*., 2018; Khalib *et al*., 2018; Nelson *et al*., 2018). With regard to deleterious environments, tinfoil barb habitats are deteriorating from unregulated logging and damming (Hashim *et al*., 2014; Jutagate *et al*., 2016). Sharp decline of local fish populations in Southeast Asia were noticed after anthropic impacts onset the 1990s (Bartley *et al*., 2015; Lynch *et al*., 2016). As means to overcome the supply, transboundary trade was stimulated to secure fish population from declining. Many enthusiasts carried out local population revival through home-culture from which supply became ever ready to compensate regional demands (Sudasinghe, 2016).

Unknowingly, the endeavour by local enthusiasts and opportunists were leading towards a biological crisis where native fish populations were mixed with same species from foreign origin (Nguyen *et al*., 2006; Lima *et al*., 2018). It may be suitable if fishes from Malaysia are crossbred with local populations but, geographically distinct intra-species cross breeding may be developing into unforetold conundrums. These conundrums revolve around vigour and speciation from which native fish undergo genetic leakage to become aliens, hybrids or even exhibit invasive behaviours (Glover *et al*., 2017; Moy *et al*., 2019). Such were experienced after introduction of Australian mosquitofish into local environments through aquarium suppliers. The release of untreated wastewater introduced the non-native mosquitofish eggs into drains and streams. Mosquitofish cross-breeding between different geographically distinct populations had caused genetic assimilation and hybridization (Norazmi-Lokman *et al*., 2016; Walton *et al*., 2016). Similar practices were also carried out to improve tilapia culture in Malaysia (Nguyen *et al*., 2017) where fish are accidentally release into the wild and capable to reproduce into invasive populations (Zharif *et al*., 2016). Another ecological instability were witnessed with Malaysian Mahseer where *Tor tambra* and *Tor Tambroides* (Tan *et al*., 2018) begun to complicate phylogenetic attempts with bootstrapping values due to hybridization (Walton *et al*., 2017).

With regard to wild tinfoil barb, they may have also experienced genetic makeup change through crossbreeding and farming (Dewantoro *et al*., 2018). The once sensitive native tinfoil barb is now easily recovered in large populations at reservoirs and lakes that are impacted by surge storms, deforestations and extreme heat (Ng *et al*., 2018). Aligned with the present approach, there is a need to ascertain whether native *B. schwanenfeldii* have hybrid genetic constituents from the ill-practices of mass culture and inter-population breeding.

The idea to use mitochondrial cytochrome c oxidase 1 arise from fruitful attempts to DNA barcode freshwater fish (Ng *et al*., 2017; John *et al*., 2018a). While tinfoil barb improved its resistance to acidic waters, its gene pool begun to mix after different life stages of the fish were recovered from geographically segregated sections in Mekong River (Nyanti *et al*., 2017; Nyanti *et al*., 2018). Since it is bias to solely rely on genetic barcodes and the comparison with DNA database, the use of morphology and meristic measurements are included as the aims of this study. In fact, genetic make-up are best compared with visual properties when applied for fish identifications (Jamniczky *et al*., 2015; Michel *et al*., 2017).

Methodology

Fish body measurements

Tinfoil barb, *B. schwanenfeldii* were gathered from five ornamental fish traders situated in Shah Alam, Selangor on the western coast of Peninsular Malaysia (Figure 1). A total of three (3) fish (~0.5 kg live weight, 33-35 days old juvenile fish) were randomly removed from each of the five (5) ornament fish trade premises, transferred into chilled water (10 °C to 15 °C) to calm the fish before cerebral-pithed (euthanized) with scalpel. Each of the fish's body dimensions were distinguished using 11-point morphometric measurements (Caillon *et al*., 2018) that include total length, standard length, fork length, pre-anal length, pre-dorsal length, pre-pelvic length, pre-pectoral length, body depth, head length, eye diameter and pre-orbital length. Apart from dimensions, taxonomic traits were ascertained using 8-point meristic counts that include lateral lines, scales in lateral series, dorsal fin spines, dorsal fin soft rays, anal fin spines, anal fin soft rays, pectoral fin spines, pectoral fin spines and pectoral fin soft rays. All meristic characteristics (average values) were sub-divided according to its stocking premises (S1-S5, Figure 1) after *bis* counting. Fins and flesh of *B. schwanenfeldii* were removed *in situ* and stored in an ice box (0 °C to 4 °C) before long-term storing in -20 °C top loader freezer. Remaining portions of

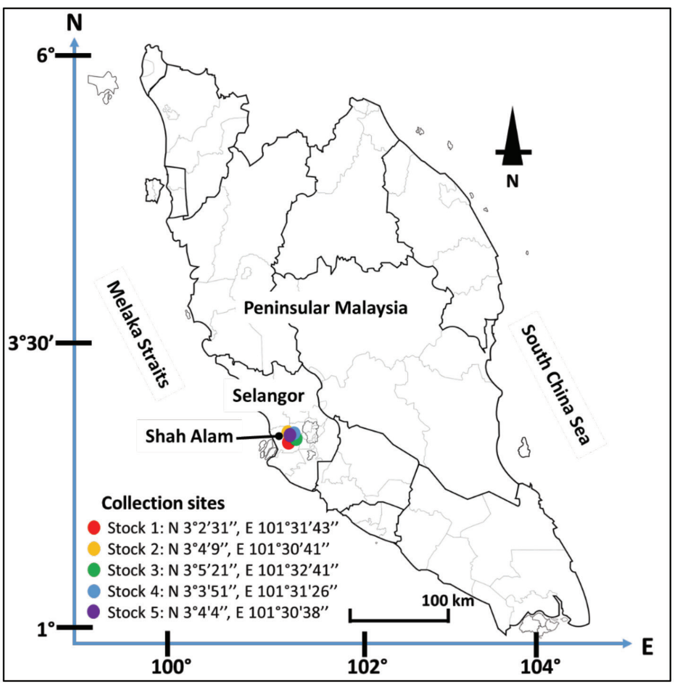

Figure 1: Sites for *Barbonymus schwanenfeldii* acquisition from ornamental traders in Shah Alam, Selangor.

the fish including its bones were recycled into production fish feed.

Extraction of genetic information

Fins and flesh of tinfoil barb were digested with DNeasy Blood & Tissue Kit using the manufacturer's suggestions for maximum DNA yield. An acceptable quantity of 2 % pure DNA were then, amplified using mitochondrial cytochrome c oxidase 1 gene through primers FishF1 and FishR1. The amplification steps used 50 µl polymerase chain reaction (PCR) reagents prepared from 30.5 µl of sterilised distilled water, 5.0 µl of 10X PCR buffer, 1.0 µl of dNTP (10 mM), 2.5 µl of each primer (10 µM), 0.5 µl of Taq polymerase, and 5 µl of DNA template. Then, *forward* (Fish F1: 5'TCAACCAACCACAAAGACATTGG CAC3') and *reverse* (Fish R1: 5'TAGACC TTCTGGGTGGCCAAAGAAT CA3') primers were used for DNA replication. Incubation involved thermal cycles that begun with 2 min. exposure at 95 °C, 0.5 min. at 94 °C, 0.5 min at 54 °C, 1 min. at 72 °C, 10 min at 72 °C, and then held at 4 °C. Immediately, the PCR products were added into 1.5 % agarose gel and SYBR Green I before visualized in Gel Doc™. Viable DNA bands are purified and the sequences (between around 500 kDa) were amplified through external hire (FirstBase).

Data Analysis

Mitochondrial cytochrome c oxidase 1 sequences from *B. schwanenfeldii* were snipped using MEGA (Molecular Evolutionary Genetic Analysis) 7.0 (Yamamoto, 2019). Then, the sequences were inserted into Barcode of Life Data System, attached with reference number and find matching species. The edited sequences (via 1000 bootstrap replications) in MEGA 7.0 were aligned with *B. goniotus*, *B. altus* and external groups (*Puntius binotatus, Rasbora sumatrana, Danio choprai, Systomus orphoides* and *Barbodes binotatus*) in Genbank NCBI using Neighbour-Joining trees of Kimura two-parameter (K2P) distances in ClustalW (Michel *et al*., 2017; Moy *et al*., 2019) to construct *B. schwnenfeldii* phylogenetic tree.

Results

Tinfoil barb shape and built

Visits to the five (5) ornamental trade premises in Shah Alam revealed active *B. schwanenfeldii* distribution within the supply-demand trade chain. While this movement may be seen as Malaysian-local, generations of captivity and breeding (of tinfoil barb in Shah Alam ornamental trade premises) have produced *B. schwanenfeldii* filial with different meristic properties. Morphometric measurements (11-point indicators) for the tinfoil barb's head, anterior and posterior body regions were having size disparities (Table 1). Growth proportions of head (0.1 cm to 0.6 cm) and posterior body (0.2 cm to 0.8 cm) segments made the captive tinfoil barb appear in different shapes, from proportional to elongated. However, the fish's body plan is not limited to the supplier's reserve but instead, the genetic material it carried. For instance, *B. schwanenfeldii* were only having pre-anal length with variations ±2 cm whereas for remaining 10 indicators, it was ranging between 0.2 cm and 1.3 cm.

In light of the change to body plan, tinfoil barb from the stock-holding premises are juvenile between 33 and 35 days old (Figure 2). Standard length of fish from Shah Alam were almost three-folds smaller than the adult *B. schwanenfeldii* retrieved from Aceh, Indonesia (Table 1). Comparatively, the Malaysian *B. schwanenfeldii* were not only smaller in size, their head regions and posterior body were smaller than the appearance of Indonesian tinfoil barbs. Under these circumstances, 8-point meristic features revealed that the Indonesian tinfoil barb to have disproportional number of scales on lateral line as well as number of anal, caudal and pectoral fin rays (Table 2). It is interesting to note that all *B. schwanenfeldii* from the Shah Alam stock-holding premises have almost identical meristic features and, their differences do not exceed one count (for scales and rays). However, fish from Iberian Peninsula,

Table 1: The 11-point morphometric measurements of *Barbonymus schwanenfeldii* collected from stock-holding premises in Shah Alam, Selangor.

	Body measurements (cm)	**Stock-holding premises**					**Aceh, Indonesia**
		S1	**S2**	**S3**	**S4**	**S5**	**Batubara *et al.*, 2018**
Body (overall)	Total Length	19.7±0.4	19.8±0.6	19.4±0.3	20.1±0.3	20.2±0.3	-
	Standard Length	15.3±0.4	15.0±0.6	14.8±0.1	15.2±0.2	15.0±0.1	72.0-77.6
Head	Pre-orbital Length	0.8±0.1	0.9±0.1	0.8±0.2	1.1±0.2	1.1±0.1	-
	Eye Diameter	1.4±0.1	1.3±0.2	1.3±0.1	1.4±0.2	1.4±0.1	3.9-4.4
	Head Length	3.4±0.2	3.2±0.3	3.2±0.1	3.5±0.1	3.4±0.1	17.8-18.2
Anterior body	Pre-dorsal Length	7.8±0.6	7.6±0.1	8.1±0.3	7.9±0.4	7.9±0.3	-
	Pre-pectoral Length	3.9±0.6	3.7±0.2	4.2±0.3	4.3±0.4	3.7±0.2	-
	Body Depth	6.6±0.3	6.9±0.2	6.6±0.1	6.6±0.1	6.8±0.2	33.1-33.6
	Pre-anal Length	11.1±0.3	9.9±0.8	10.1±0.4	11.1±0.2	11.0±0.2	-
Posterior body	Pre-pelvic Length	7.4±0.8	6.7±0.2	6.9±0.4	7.2±0.3	7.4±0.5	-
	Fork Length	16.4±0.3	15.9±0.8	15.2±0.3	16.1±0.3	16.2±0.4	-

Note: The tinfoil barb from collection sites S1 to S5 are measured individually. However, fish body measurement values are described as mean ± standard deviation where, n = 3 fish. The hyphen '–' is used to represent unavailable information.

Figure 2: Tinfoil barb, estimated between 33 and 35 days old. The *B. schwanenfeldii* retrieved from an ornamental trader (Stock 2) within Shah Alam, Selangor.

Spain possessed reduced (-3 to -4) number of scales in lateral series (11.5) compared to the standard 14 to 15 scales. Tinfoil barb from Sri Lanka possessed reduced number of scales on lateral line (-2), increased number of pre-pelvic scales (+1), reduced number of caudal fin rays (-3>) and, varying number of pectoral fins (-1 to +2).

Phylogeny assessment on tinfoil barb

Neighbour-Joining trees were used to construct the phylogenetic tree (Fig. 3) that implored 1000 bootstrap replicates. While all fish from the stock-holding premises in Shah Alam have genetic affinity to *B. schwanenfeldii*, fish from ornamental trader S5 contained 25 % genetic similarities to *B. gonionotus* (KU692338, 39, 41 & 43) from East Java. Also, *B. schwanenfeldii* from ornamental trader S2 contained 42 % genetic resemblance with *B. schwanenfeldii* from Laos (JQ346171). In addition, fish from ornamental traders S4, S1 and S3 contained 48 % (HM156340, 41, 42, 43 & 44), 93 % (HM156340) and 99 % (FJ464385) genetic similarities to *B. schwanenfeldii* from Peninsular Malaysia. The higher genetic similarities (depicted by bootstrap values) are suggesting native gene preservation within the Malaysian tinfoil barb. Since not all information were declared in GenBank (National Center for Biotechnology Information), it were difficult to ascertain tinfoil barb place of capture in Peninsular Malaysia (other than Negeri Sembilan) (Fig. 3). With this limitation, it became difficult to identify the fish's filial, but, we now know that *B. schwanenfeldii* involved in ornamental trade (from Shah Alam, Selangor) are carrying some degree of non-native genes. Thus, there is possibility that DNA hybridization might dilute expression of native genes upon cross-breeding with the wild *B. schwanenfeldii* populations.

Discussions

Tinfoil barb genetic make-up

Tinfoil barb, *B. schwanenfeldii* is familiarised with the appearance of red pectoral, pelvic and anal fins, black blotched dorsal fin tips and, white and black margins on its caudal fin. Although *B. schwanenfeldii* is distributed across wide geographies in Asia (Sabarudin *et al*., 2017), the fish's morphology varies with its distribution (Kamarudin & Esa, 2009; Ng *et al*., 2017). In particular, *B. schwanenfeldii* from Malaysia (Esa *et al*., 2012), Indonesia (Nugroho *et al*., 2016) and Sri Lanka (Sudasinghe, 2016)

Table 2: The 8-point meristic features used to distinguish *Barbonymus schwanenfeldii* from different populations.

Meristic measurements (cm)	**Stock-holding premises**					**Indonesia[1]**	**Spain**	**Sri Lanka**	**Indonesia[2]**
	S1	**S2**	**S3**	**S4**	**S5**	Bleeker *et al*., 1853	Gante *et al*., 2008	Sudasinghe, 2016	Radona *et al*., 2017
Scales on lateral line	35	36	35	35	36	35-36	36	34	31-36
Scales in lateral series	14	15	14	14	15	14-15	11.5	14	-
Dorsal fin rays	9	9	9	9	9	8-9	9	8-9	9
Pre-pelvic scales	15	16	15	15	16	-	15	15-17	-
Pelvic fin rays	8	8	8	8	8	8	-	8	7-8
Anal fin rays	6	6	6	6	6	5-6	6	6	6-8
Caudal fin rays	18	19	18	18	19	19	18-19	16	15-17
Pectoral fin rays	14	14	14	14	14	14	14	13-16	11-13

Note: The tinfoil barb from ornamental traders S1 to S5 are measured individually but expressed as average from pool, n = 3 fish. References for Indonesia are divided into (1) Sumatra and (2) Aceh. The hyphen '– ' is used to represent unavailable information.

were compared and indicated minute (< 10 %) morphology and meristic differences. On the contrary, *B. schwanenfeldii* from Spain (Gante *et al*., 2008; Almeida *et al*., 2013) were showing >20 % physical trait differences after comparisons with the Malaysian fish species. In fact, anomalies for scale and ray count are present between tinfoil barbs in ornamental trade premises within Shah Alam, Selangor. Perhaps, parapatric speciation from sharing ecological niche with silver barbs of Laos (Baumgartner *et al*., 2012) and East Java (Batubara *et al*., 2018) and, the Malaysian populations in holding tanks may have diversified their genetic properties (Kamarudin & Esa, 2009; Jutagate *et al*., 2011). Wild fish introduced into confined-culture practices were having native gene dilutions after being fed with fixed dietary regime (Clavelle *et al*., 2019). This finding is also achieved in mass culture after fish are fed with formulated feed (Debnath *et al*., 2019). Secondly, ecological transitions from open space (wild) and then into confined space (domesticated) can alter genetic vigour of fish because of thermal and spatial limitations. Within this regard, passive environments are proven to alter genetic make-up of snakehead fish (Robert *et al*., 2019), to deduce that confinements and partitioning in rivers can alter fish genetic constituents over time (Aubin *et al*., 2019).

Episodes of natural selection allowed the *B. schwanenfeldii* from Laos and East Java to have heritable physical or behavioural traits. Perhaps, genetic vigour of whole population in stock-holding premises S2 and S5 converged to share common trait (extra one scale and ray counts) after foreign *B. schwanenfeldii* were introduced with Malaysian native *B. schwanenfeldii* from Negeri Sembilan. Since the fish stocks in ornament trade premises S2 and S5 were restricted to confined spaces, ecological tolerances may have developed (Butt *et al*., 2019; Kitada *et al*., 2019) and given the filial specialised body features. Fish acquisition from different sources may reproduce under favourable conditions to produce an adapted filial (Bergero *et al*., 2019). To highlight, random *B. schwanenfeldii* acquired from the five premises in Shah Alam were having 25 % genetic similarities to *B. gonionotus*, 48 % genetic similarities to *B. schwanenfeldii* from Laos, and East Java and >90 % genetic similarities to farmed populations from Negeri Sembilan. If compared to *B. schwanenfeldii*, *B. gonionotus* possesses shorter fins and reduced body depth. However, *B. schwanenfeldii* from stock-holding premises S2 and S5 possessed an extra lateral scale and caudal ray. Genetic assimilations occur because tinfoil barbs will reproduce under favourable temperature and water conditions despite being in captivity and origin from different population groups (Häkli *et al*., 2018). Thus with regard to fish, cross-population breeding have produced individuals with foreign genetic make-up or native fish with hybrid DNA assembly (Johnston, 2018; Puvanasundram *et al*., 2018). Overall, fish distributors in Shah Alam, Selangor have turned-the-other cheek by importing fish from various sources and stocking these different population fish together. It is also clear that tinfoil barb of Malaysia involved with ornament trade are no longer having pure (native) genetic make-up.

Awareness and Management

Malaysian aquatic-life trade is based on resource pool availability and market-demands (John *et al*., 2018a, b, c) and, stock-holding premises, like the ones in Shah Alam, Selangor are communal supply and distribution chains (Alafiatayo *et al*., 2019) for various types of ornament fin-fish. Inquiries with owners and workers revealed sourcing measures from local or cross-border (Thailand and Indonesia) during heavy market demands. Although the *B. schwanenfeldii* appear to have identical morphology, their genetic proportions vary by ecology, food and generation. Biotic genes notably alter with climate and distribution to produce geographically adapted individuals (Nelson *et al*., 2019b). In the appearance of negligence, some traders resort to out-of-country stock acquisition and, the DNA corruption conundrum begins (Ng, 2016). Gene flow between different population groups will lead to speciation, in which new adapted filial are produced (Leroy *et al*., 2019). However, when transferred into different confinements or spaces, portions of this hybridized DNA will converge with native constituents to produce an individual with completely fragmented genetic make-up. Studies have shown that intra-species cross breeding benefits culture practices to produce robust individuals but, having this capability does not favour the entire population (Giery & Layman, 2019; Mateos *et al*., 2019; Thomaz *et al*., 2019). Though natural selection may seem to take place where fittest survive, advantage to compete will limit distribution and occurrence of weaker individuals and result to population displacement.

Best practices should be observed so that wildlife splendour and vigour are kept at ambience. This exercise is essential to protect native species that occur in Malaysian environments which are now threatened by robust individuals from aquaculture. Though it is difficult to balance between economic importance, food security and conservation (Sharma, 2019) but, imposing workable standpoints are advantageous to reduce intensity of DNA hybridization with foreign gene. Aquaculture species like hybrid red tilapia and giant grouper are cross-bred to produce diploid and triploid individuals that cannot reproduce in the wild (Rimmer & Glamuzina, 2019). Production of sterile species were the aquaculture solution for escaped fish. However, there were some cases where 'the thought' sterile individuals were caught in different sizes and in large quantities (Baker, 2019; Pinheiro *et al*., 2019; Roy, 2019). As part of common resource pool good-practice, it would be ethical not to carry out multi-source purchases when supply depletes. However, extreme-crucial imports should ensure that ornament fish are neutered or sterile whereas, food fish are brought into the country as fillet. With all sanctions and practices in transboundary trade abiding to Bioinvasion and Global Environmental Governance of Convention on Biological Diversity, the Transnational Policy Network on Invasive Alien Species is achievable with good-practice by traders. Suggestively, same species transboundary trade should forgo ornamental intentions and focus instead, on sustainable alternative protein supply to compensate regional food security. Only then, Invasive Alien Species National Action Plan which is governed using Malaysian Fisheries Act 1984 can reduce incidences of genetic hybridization especially when dealing with non-native aquatic life.

Conclusions and Recommendations

The tinfoil barb, *B. schwanenfeldii* may be viewed as less important species for food and ornament but, standpoints and findings are revealing deleterious practices. Since this fish is a practical tool for genetic barcoding, its mitochondrial cytochrome c oxidase 1 were assessed. Every tinfoil barb population from ornament trade premises in Shah Alam, Selangor in West Peninsular Malaysia were discovered to contain minute degree of non-native genetic assimilations. At present, the tinfoil barb trade is much smaller than other species but, DNA hybridization is highlighting a weary that leads to succession and displacement between the Malaysian wild populations. Thus, continuation of these ill practices by traders within import-export chain should cause native genetic dilution. As a result, native species can no-longer thrive because natural selection favours populations with vigour and splendour. It would be preferable that foreign fish imports obligate neutering or sterility whereas, food security secured by processing imported protein diets. Only then, Invasive Alien Species National Action Plan can be in play with existing foreign genes diluted by native species to re-emerge their original DNA constituents.

Acknowledgements

The present initiative is supported by Faculty of Applied Sciences, Universiti Teknologi Mara Shah Alam through provision of laboratory facilities. The author (Jaffar, M.) extends appreciation to Abdullah, M. T., Director of Institute of Tropical Biodiversity and Sustainable Development for opportunity to pursue internship.

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