Pet or Pest? Public Perception on Invasive Alien Fish in Malaysia

Lavanya Malini Vythalingam[1,4] Maivizhi Rajendram[1], Vishalache Balakrishnan[3], M.A. Motalib Hossain[4], Viviana Syra Theraviam[1], Subha Bhassu[1,2]

[1]Animal Genetics and Genome Evolutionary Lab (AGAGEL), Division of Genetics and Molecular Biology, Faculty of Science, Institute of Biological Sciences, University of Malaya, Kuala Lumpur, Malaysia

[2]Centre for Research in Biotechnology for Agriculture (CEBAR), University of Malaya, Kuala Lumpur, Malaysia

[3] Faculty of Education, University of Malaya, Kuala Lumpur, Malaysia

[4]Nanotechnology and Catalysis Research Centre (NANOCAT), Institute of Graduate Studies, University of Malaya, Kuala Lumpur, Malaysia

DOI: https://dx.doi.org/10.47772/IJRISS.2025.908000040

Received: 15 July 2025; Accepted: 25 July 2025; Published: 27 August 2025

ABSTRACT

Understanding public views on invasive ornamental fish in Malaysia will provide authorities with the tools needed to plan eradication or control protocols that account for stakeholder concerns. This study surveyed 200 respondents to investigate the perception levels of Malaysians towards invasive ornamental fish versus local fish and examine the community's role as a vector of introducing alien species into natural ecosystems. This study comprised of four sections examining socio-demography, fish ownership habits, awareness of fish handling practises, and human wellbeing when keeping fish. Based on this survey, there was a bias exhibited by the public that treated invasive fish better than local fish in terms of pet care (changing water and feeding frequency), the type of pet chosen (invasive or local), pet perception, and attachment towards their pet (naming, way to get rid of fish). Significant relationships were observed between the type of fish and where it was obtained, between gender and type of fish obtained, gender and naming their fish, gender and fish upkeep and lastly gender and ways to rid of fish ($p < 0.05$). Around 46.5% of respondents opted to get rid of their fish into the nearest river or drain, showing that Malaysians are one of the vectors for the introduction of alien fish into our ecosystem. Awareness campaigns that target specific age groups and education levels must be carried out to increase understanding of invasive pets. This study can help authorities plan invasive management programs that are effective for our community.

Keywords: invasive alien species, conservation, public perception, public awareness, exotic species, education outreach

INTRODUCTION

In Malaysia, the establishment of invasive alien fish has dated back to several decades starting as early as the 1950s by the Department of Fisheries and private sectors for economic purposes (Ang et al., 1989; Khairul et al., 2013). Since its establishment in the 1950s, the aquarium fish industry has significantly increased in the last 20 years due to high demand (DOF, 2006). Nevertheless, limited research has been conducted on the direct implications of the aquarium trade industry and its role in introducing invasive alien fish in Malaysia. With an estimate of two million people both directly and indirectly (Dominguez & Botella, 2014; King, 2019) involved in this industry, the aquarium fish industry is projected to further increase over the years. In 2018, the National Committee on Invasive Alien Species in collaboration with the Malaysia National Library printed published a catalogue (ISBN 978-983-047-243-0) on a list of invasive alien species present in Malaysia and the affected sectors.

In Malaysia there have been various studies on the presence of invasive fish in lakes, rivers and other ecosystems throughout Malaysia (Khairul Adha, 2021; Kavanagh, 2002; Khairul Adha, 2006; Shafiq et al.,2014; Alias et al.,2019; Aqmal-Naser et al.,2019; Khaleel et al.,2020). Nonetheless, limited studies have been carried out to determine the introduction pathway of invasive aquarium fish into the wild. The impacts of invasive species are rarely studied and receives limited attention (Othman & Hashim, 2003), especially studies pertaining the distribution patterns and pathways of introduction.

According to the International Union for Conservation of Nature (IUCN), an alien species is defined as an organism whose introduction is done outside of its natural geographic range and that is likely to cause economic, environmental, or harm to human well-being. The introduction of an alien species can be done intentionally or accidentally. Such introduction into our native ecosystem is seen through the aquaculture, aquarium trade industry, and recreational fishing. Freshwater ecosystems are vulnerable to invasions by alien fish as they are biogeographic islands with low densities of native fish. This makes it an ideal condition for the invasion of alien fish (Strayer, 2010).

In 2012, 64.3% of alien fish were introduced for aquaculture development in Malaysia (Khairul Adha, 2013). The establishment of invasive fish in Malaysia has dated back to several decades starting as early as the 1950's by the Department of Fisheries and private sectors for economic purposes (Ang et al., 1989; Khairul Adha et al., 2010; Khairul Adha et al., 2013). It was noted that the reproduction rate of alien fish was much higher than native fish species in the last 40 years. This was mainly due to the improvement of large-scale artificial breeding and culture of a variety of alien fishes, leading to increased number of introduced aquaculture fish species as well as fish fry production in Malaysia (Hanafi et al., 1995; Khairul Adha et al., 2011). Furthermore, carp species from India and China do not breed naturally in Malaysia, were stocked for aquaculture demand through artificial reproduction (Ang et al.1989). Although it was unable to establish a population and does not breed locally, the Fisheries Department of Malaysia continued to release a huge number of these invasive fish into the local water bodies through recurrent stocking with artificial reproduction (https://www.dof.gov.my/).

Turbelin et al.'s (2017) study elucidated a comprehensive study to map out the pathways of invasive alien species using Global Invasive Species Database (GISD) and the CABI Invasive Species Compendium (CABI ISC). This study indicated that the aquarium trade and intentional release through recreation or smuggling were the second and third largest pathways for intentional introduction of invasive alien species into a country

Experiences throughout the world have shown that several problems may arise following the introduction of a new species into Malaysian waters. These include disruption of the receiving environment; predation and interspecific competition; overcrowding and stunting; genetic degradation; introduction of viruses and disease; and the extinction of many native species (Zaret & Paine, 1973; Ross, 1991; Crowl, Townsend & McIntosh, 1992; Amundsen et al., 2009). Conversely, over time the alien fish reproductivity and scavenging activities would change the native fish ecosystem (Taylor, et al., 1984; Flecker and Townsend 1994).

The aquarium trade industry plays a pivotal role in the introduction of invasive alien fish into Malaysia. With globalization, social media has also become another avenue for this industry to trade exotic fish that are banned in Malaysia. Although there have been studies done to prove both how invasive fish is brought into the country and their current locations in Malaysia, there is lack of understanding on how invasive aliens go from the aquariums into the direct freshwater ecosystem. Furthermore, the role of the community as a proxy for the introduction of invasive alien fish into our ecosystem has been rarely studied and should be examined to address the accidental release issues. Consequently, this study aimed to investigate the perception bias among Malaysians towards invasive ornamental fish against local fish and establish the community's role as a vector of introducing alien species into the environment. This study can assist fisheries management to further optimize awareness efforts to educate the public on the harms of invasive alien species.

MATERIALS AND METHOD

Study area

The study was primarily conducted in Universiti Malaya area, around Klang Valley. The target community was randomly selected, with no specific age group in focus. Due to COVID-19 restrictions at the time, the study was

conducted online. As a result, participation from all over the country was recorded. The population size of Klang valley of 5.59 million was used as a reference when collecting survey respondents to ensure the results could accurately reflect the population view.

Sampling strategy and questionnaire design

The questionnaire for the survey targeting the community was designed using Google Forms (https://docs.google.com). This survey was open for public response over a period of six months (September 2019 to February 2020) and was shared on social media platforms such as Instagram, Facebook, WhatsApp, and Telegram. This survey was also distributed in person to the University Malaya community as well as fish hobbyists around the Klang Valley to obtain a broader response. The questionnaire was internally reviewed by the research team to ensure question clarity, consistency and relevance prior to distribution.

This survey included questions intended on investigating the perception levels among Malaysian about invasive fish and fish handling methods using open-ended and dichotomous survey questions. This survey contained four sections: (1) socio-demographic information, (2) fish ownership habits, (3) awareness of fish handling practises and (4) maintenance and wellbeing as shown in Figure S1. The first section comprises of basic information such as name, age, education level, nationality, occupation and gender. Next, section two comprised of questions regarding the history of their pet fish, species of fish, place of purchase/ attained, reasons for keeping a pet fish. The third section explored the awareness of fish handling practices such as feeding, frequency of water changing and the emotional attachment towards their pet fish. Lastly, section four concentrates on fish and human well-being.

Data analysis

The results from the survey were collected and analysed using SPSS 17.0 statistical program (SPSS Inc., Chicago, USA). The results with $p < 0.05$ were considered significant. Word clouds were created using Tag Crowd (http://tagcrowd.com/) to visualize the responses given by survey participants.

RESULTS

Respondents Demographic and Background Information

The respondents' background information is summarised in Table 1. Based on the survey outreach, at a confidence level of 95%, the margin error was determined to be 6.89% (Taherdoost, 2017). Most respondents were female (66.5%), while 33.5% were male. Analysis of the gender and type of fish preferred showed no significant relationship ($p = 0.44$) with little to moderate association. Next, the respondent's age was examined. Most respondents (35.5%) were between 26 to 33 years old, followed by 11.0% (34 – 50 years old), 3.5% (51 years and above), and only 2% of respondents were 12 and below. Nevertheless, this study does not generalise the age-related findings due to sampling bias on the 26 to 33 age group. Future studies can rectify this issue by widening the study population towards schools and perform more social media-based sampling strategies.

Based on the results, most respondents were aged 26 to 33, with a mean age of 29 and a median of 30. Most of the respondents in this age group were working professionals. The respondents purchased fish for several reasons: i) partner to overcome loneliness, ii) stress relief, and iii) to cultivate a sense of responsibility. Accordingly, 31% of respondents kept fish for companionship and 16.5% of respondents viewed their pet fish as a way of relieving stress. This study did not find any association between the species of fish in relation to age.

A large percentage of respondents have had tertiary education (83.0%), while 10.0% of respondents have a secondary school education background, 2.5% had primary school education, and 4.5% of respondents have had other forms of education. This demographic only represents a small percentage of society and not sufficient to be generalised across the broader population. There was no significant relationship between education level and the species of pet fish. Similarly, there was no correlation between education level and reasons for keeping fish.

Table 1: Respondents Demographic Information

Category	Frequency (n)	Percentage (%)
Gender		
Male	67	33.5
Female	133	66.5
Age		
7-12	4	2.0
13-17	9	4.5
18-25	87	43.5
26-33	71	35.5
34-50	22	11.0
51-70	7	3.5
Education		
Primary School	5	2.5
Secondary School	20	10.0
Diploma	57	28.5
Degree	83	41.5
Postgraduate	26	13.0
Other	9	4.5

Fish Care and Handling Practices among Malaysian Respondents

Several questions regarding feeding patterns, changing of water, as well as place of acquisition of fish, were included to establish a baseline about fish handling practices in Malaysia (Table 2). Firstly, it was observed that 97.5% of respondents had previously kept pet fish before while only 2.5% of respondents have not. To elucidate the types of fish popular amongst survey respondents, a word cloud was created (Figure 1). There was no significant relationship observed between gender and the type of fish kept as pets (p = 0.052).

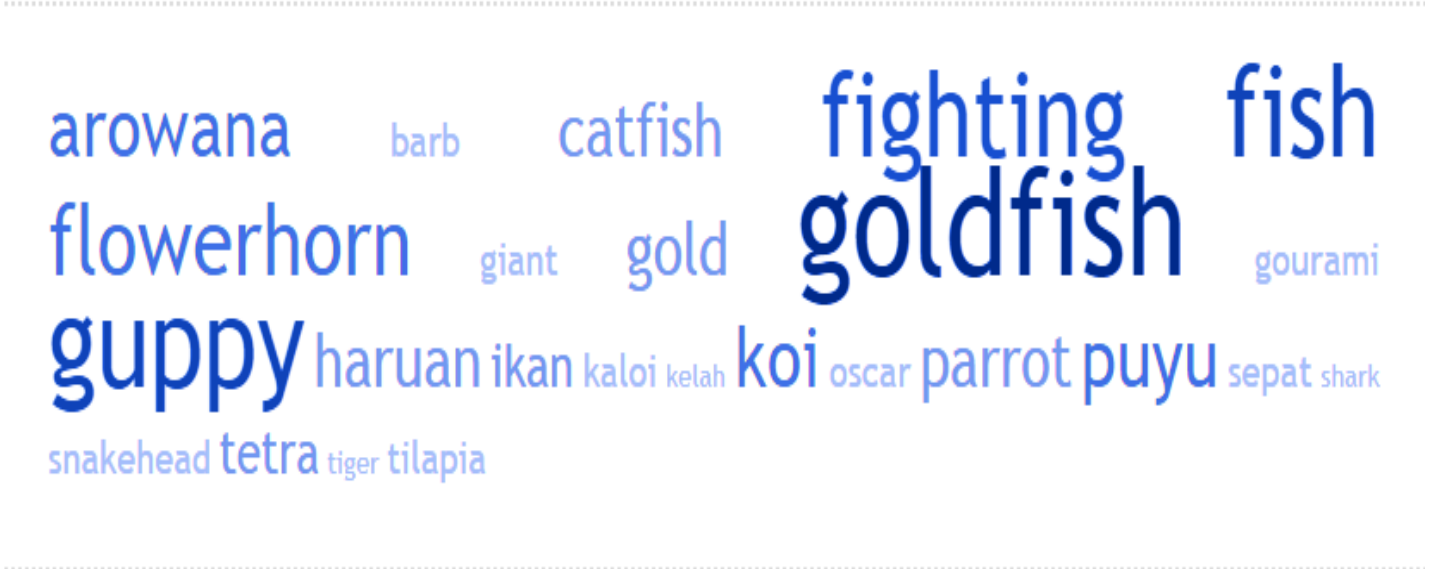


Figure 1: **Word cloud on types of fish kept by respondents. The size of the words represents the frequency of fish mentioned by the respondents**

From these results, approximately 85% of respondents kept invasive fish such as Goldfish, Koi and Siamese fighting fish, 10 % kept local fish such as Lampang, Kaloi and Haruan while 5% of respondents were unsure of the origins of the fish.

Table 2: Fish Ownership and Fish Care Practices

Category	Frequency (N)	Percentage (%)
Have Pet Fish Before		
Yes	195	97.5
No	5	2.5
Type of Fish		
Local	21	10.5
Invasive alien fish	170	85
N/A	9	4.5
Where They Obtained Fish		
Aquarium/pet shop	160	80
River/pond	17	8.5
Family/Friends	21	10.5
N/A	2	1
Why Keep Fish		
Companionship	62	31.0
Curiosity	35	17.5
Easy to care for	39	19.5
Others	31	15.5
Gives Peace/ Calming	33	16.5
Where Fish is Kept		
Fish Tank	177	88.5
Pond at home	21	10.5
Other	2	1
Change water of aquarium		
Everyday	9	4.5
Once a week	123	61.5
Once a month	41	20.5
When I feel like it	22	11.0
Never	5	2.5
Frequency of feeding		
Once a day	92	46.0
Twice a day	85	42.5
Three times a day	16	8.0
More than three times a day	5	2.5
Never	2	1.0

Out of 200 respondents, only 8.5% had caught their fish from rivers and ponds while 81% of fish were obtained from aquariums or pet shops. Conversely, a small fraction (10.5%) of respondents obtained their pets from family and friends. These results showed that aquarium and pet shops were the main medium for the sale and acquisition of pet fish. There was a significant relationship between the type of fish (invasive or local) and where it was obtained: $\chi^2\ (4, \mathrm{N} = 200) = 36.539$, p= 0.00. Interestingly, three-way crosstabulation done on gender, type of fish and where it was obtained also showed significant relationship $\chi^2\ (4, \mathrm{N} = 200) = 20.127$, p = 0.000.

Around 88.5% of respondents disclosed that they keep their fish in aquariums or fish tanks while 10.5% tend to keep their fish in ponds at home. These results indicate a consensus of keeping pets in aquariums. There was no significant relationship between the type of fish and where it was kept ,nor between gender and where fish was kept.

Respondents were also asked about the frequency of changing the water in the fish aquarium. The survey results indicated that many respondents (61.5%) preferred to change the water in their fish tank once a week. Surprisingly, around 1.0% of respondents admitted to never changing the water in their fish tank or aquariums. With closer introspection, female respondents indicated that they would change the water in the fish aquarium once a week regardless of the type of fish owned, local (70.0%) or invasive (65.0%). When the relationship

between females and the frequency of changing the aquarium water was tested using the chi-square test of independence, there was a significant relationship observed $\chi^2\,(8, N = 200)$ = 28.7, p = 0.000 while no significance was found between males and changing the aquarium water.

To further clarify how attached respondents were to their pet fishes, they were asked if they had named their pets. Based on the results, 54.0 % of them had named their pet fish while 46.0 % had not. There was significance between the type of fish (invasive or local) and whether it was named: χ^ (2) (2, N=200) = 7.649, p= 0.020. Looking closer, it was noted that 42.2% of females and only 12.1 % of males named their pet fish. Interestingly, there was a significant relationship between gender and naming their fish $\chi^2\,(1, N = 200)$ = 13.404, p= 0.000 based on a chi-square test of independence.

Furthermore, the results indicated that there was significance between the type of fish and whether it was named: χ^ (2) (2, N=200) = 7.649, p= 0.020, Cramer's V= 0.196, small effect size. It was shown by crosstabulation that 81.8 % of male respondents tended to not name their local fish while only 57.7 % of invasive fish were not named. Meanwhile, in females, the opposite pattern was observed where a majority of them (56.4%) named their pet fish. Notably, females named their fish regardless of the type where 80.0% of local fish and 64.1 % of invasive fish were named.

Awareness about Fish Handling Practices

Several questions were posed to determine how attached respondents were to their pet fish and to note how responsible pet owners were as shown in Table 3. Overall, there was a mass consensus of respondents that felt responsible and attached to their pet fish (85.0 %). There was only a small percentage of respondents that felt negatively and were not attached to their pets (15.0%). There was no significant relationship between gender and feeling responsible for their fish χ^ (2) (2, N=200) = 1.097, p= 0.578 based on a chi-square test of independence.

Table 3: Fish Owner Responsibility and Perception towards Disposing of Unwanted Fish

Category	Frequency (N)	Percentage (%)
Responsible and attachment		
Yes	170	85.0
No	30	15.0
Named pet fish		
Yes	108	54.0
No	92	46.0
No longer want their pet fish		
Yes	76	38.0
No	124	62.0
Ways to get rid unwanted fish		
Release in drain	9	4.5
Release in river or pond	84	42.0
Kill fish	3	1.5
Give family or friend	100	50.0
Food source	4	2.0

When asked if respondents ever wanted to get rid of their fish, 38.0 % had agreed that they have once not wanted their pet fish while 62.0 % of respondents have always wanted their fish. The proportion of people that reported not wanting their pet fish were not significant based on gender, $\chi^2\,(1, N = 200)$ = 0.028, p= 0.868 based on a chi-square test of independence. Cramer's V= 0.12 indicates a small effect size in this study.

Based on the analysis, it was noticed that males did not want local fish more (54.5%) compared to invasive fish (45.5%). Among female respondents, local fish were slightly more unwanted (70.0 %) compared to invasive at 30.0%. However, statistically at $p<0.05$, there was no significant relationship between the type of fish, respondents gender and not wanting their pet fish.

Lastly, the respondents were asked about how they would dispose of their unwanted pets. Out of 200 respondents, 50% of people answered that they would give their pet fish to family or friends when they no longer wanted it. Collectively, 46.5% of responses stated that they would release their fish into the nearest drain, river or pond regardless of the locality of fish. In addition, 1.5% of respondents said they would kill their pet fish and 2.0% of people would make their pets into a food source if they no longer wanted it. There was no significant relationship between gender and how respondents chose to get rid of unwanted pet fish, $\chi^2\ (4, N = 150) = 7.734$, p= 0.102 based on a chi-square test of independence. The response was then evaluated to see if there was a difference in how respondents chose to get rid of unwanted fish based on fish type. Based on the data obtained, when it came to local varieties of fish, 81.8% male respondents and 60.0% female respondents were more likely to release it into the river or pond. For invasive fish, both male (47.2%) and female (54.7%) respondents would give away their pets to family or friends. Interestingly, there was a significant relationship between the type of fish and how they get rid of their fish pet, χ^ (2) (8, N = 200) = 16.065, p = 0.041 based on a chi-square test of independence. Cramer's V= 0.2 indicating a small effect size in this study.

A word cloud was created to elucidate why respondents decided to release fish into the drain, river or ponds (Figure 2).

Figure 2: Word cloud on why respondents would release their unwanted pet fish into the drain, river or pond. The size of the words represents the frequency of reasons mentioned by the respondents

Many respondents also believed that local rivers or water bodies were a habitat for their ornamental invasive pets (18.28%). Furthermore, respondents frequently cited words such as 'love my pet' (11.83%), 'freedom for my pet' (24.73%), 'pity' (9.68%) and 'want my fish to have friends' (6.45%). This showed that respondents linked releasing their fish into local water bodies as helping the fish to survive and live on freely. Conversely, respondents also cited 'too big' (2.15%), 'easy' (11.83%), and 'no reason or unsure of alternatives' (15.05%) as reasons for releasing their pet fish into the drain and rivers as shown in Figure 3. This indicated that there are not many alternatives when it comes to disposing of unwanted pets, and the respondents would rather take the easier method of disposing them into the nearest water body. These responses suggest a blend of emotional reasoning and misconceptions, where many of the respondents view local waterways as natural habitats for their pet fish or believing releasing their fish is an act of kindness.

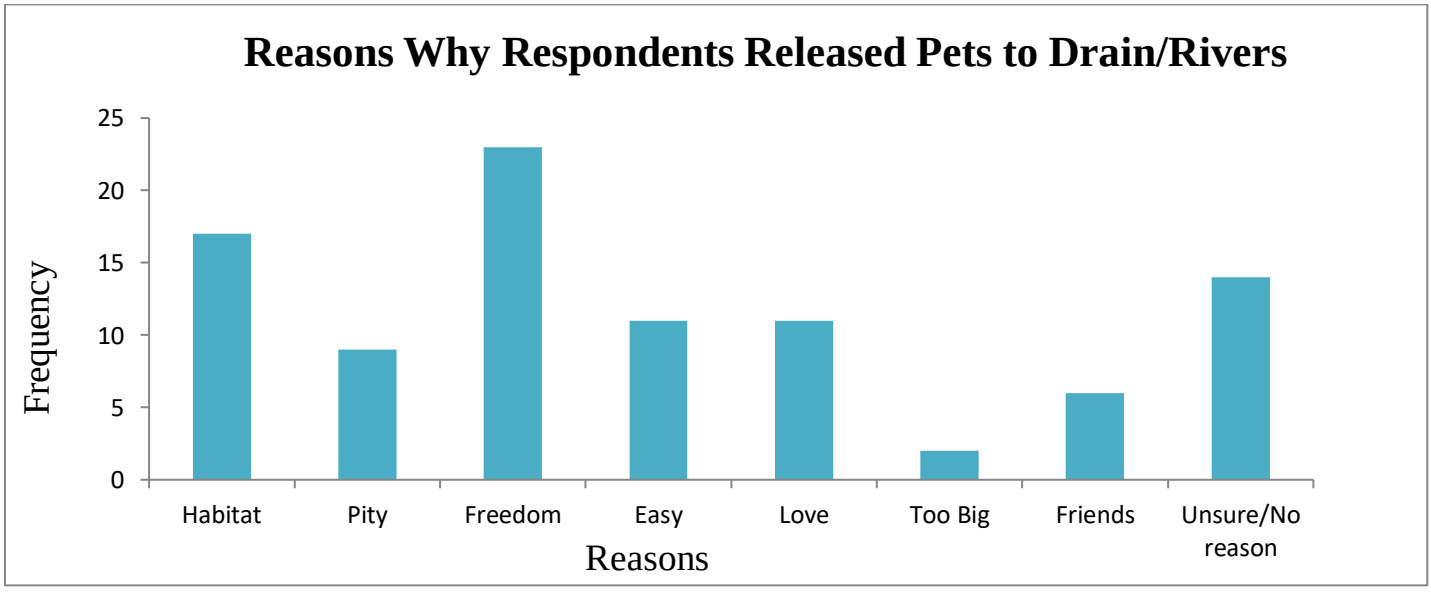


Figure 3: Graph on the reasons why respondents release unwanted pet fish into the drain, river or pond.

DISCUSSION

This survey was carried out to set a benchmark to gauge how popular invasive fish were in Malaysia. The information received through this survey serves as missing pieces of the puzzle in understand the bigger picture of the invasive alien species in our native waters.

Perception on Invasive Fish

Based on the data collected from the survey, it can be observed that there is a preponderance of people that preferred keeping invasive alien fish, particularly ornamental fish as pets. The popularity of invasive ornamental fish as a household pet can be contributed to the high "charisma" of these fish. Studies describe "charisma" by the presence of attractive physical attributes such as body size, vibrant coloration on the body; its responsiveness to external stimulation as well as a peculiar appearance (Shackleton et al., 2019; Jaric et al., 2020). Interestingly, the study determined that gender and education played a role in how the respondents chose what fish to keep and where to buy these fish from. Shackleton et al.'s (2019) study inferred that the public's outlook on invasive species is prejudiced by their upbringing and societal views including their occupation, the authority in charge as well as the species of concern. Unquestionably, gender roles need to play a vanguard part when authorities create frameworks to manage alien fish. This is corroborated by Saba et al.'s (2021) study that found women were more knowledgeable about invasive fish compared to men and a higher level of knowledge about invasive fish was reported by those with tertiary education. With an increase in educational levels, society becomes more open and exposed to information on invasive alien species. Those with higher awareness levels tended to support and be more open to invasive species management (Verbrugge et al., 2013).

This study also highlights the biases shown by respondents that favour invasive fish more than local fish. Males changed the water of local fish less frequently than invasive fish. While in females, aquarium water was changed once a week regardless of the type of fish. There was significance in the relationship between the females, type of fish as well as water change frequency indicating there is a pattern of biasness when it came to caring for their pets.

In Malaysia, these alien fish are perceived positively as companions and beloved more than local fish. The survey showed that overall respondents perceived invasive fish as good companions while local fish were kept due to curiosity (males) and ease of care (females). It can be postulated that society perceives local fish as hardier and needs less care compared to invasive fish. Studies done show that people allocate more time, food and love for charismatic invasive animals compared to animals they perceive to be less charismatic (Jaric et al., 2020). Overall, it was observed that there is awareness amongst the community about the right ways to of handling an unwanted pet. Around 50% of the respondents said that they would give away their fish to a family or friend that would take better care of their pets. However, 46.5% of respondents said that they would release their pet fish into the nearest drain or river. Almost half of the total respondents believed that release a fish into the nearest water body was a viable option. To further clarify this, the reasons why the respondents thought releasing fish into the nearest water body were investigated. It was found that there were two polarizing perceptions on discarding fish into the local ecosystem, amongst the respondents mainly i) Good knowledge and understanding about invasive alien fish and ii) Misconception that all fish belong in local water bodies.

It was troubling to note that some respondents (18.28%) did not realize their pet fish were not native to Malaysia. Conceivably, they did not realise that fish from different countries of origin can behave differently in Malaysian freshwater. Conversely, Saba et al. (2021) observed higher awareness levels among Malaysians about invasive fish (76%), yet it does not reflect on the implications of alien fish onto the environment. Similar challenges have been reported in other Southeast Asian countries. In India, suckermouth catfish have invaded river systems due to public release with their spread confirmed using social media reports and genetics analysis (Verma et. al., 2024). Meanwhile in China, tilapia species have established dominant populations including over 160 freshwater sites in Guangdong and Hainan Provinces, mostly due to public misconceptions and weak enforcement of pet release regulations (Yongo et al., 2024). These regional findings reflect similar public misconceptions and release behaviour as observed in this study, particularly regarding the belief that invasive pet fish can thrive in local water bodies. Van de Waal et al. (2014) argued that while the origin of a species should not determine the need for conservation efforts, awareness about the origin of a particular species remains important and must be

spread among the public. Awareness and information about invasive fish within a community can reduce the impacts of accidental release into a new environment. Invasive fish have become a part of the local fauna in Malaysia due to change attributed to the shortage of awareness, recollection, personal experiences and historical data of the origin which had occurred over a steady change over time (Pauly, 1995; Beever et al., 2019; Shannon et al., 2020).

Authorities must consider public perception when dealing with popular invasive species. Fish that are beloved pets in the consumer's eye will cause conflict and resistance towards eradication efforts due to public outrage (Novoa et al., 2017; Shackleton et al., 2019). This study elucidated that ornamental invasive fish are beloved pets and can influence the response on how an invasive species should be treated thus, measures are taken to increase awareness about the dangers of invasive fish to the community.

Authorities should consider three steps when devising a framework to deal with invasive alien fish; invasion risk analysis, feasibility analysis, and priority-setting (D'hondt et al., 2015). This survey provides a valuable resource to management on which invasive species would be deemed a high priority due to likability and should be addressed carefully to ensure public support. According to the results, goldfish, guppy and beta fish were preferred as pets. Additionally, the results infer that these invasive fish were obtained through pet shops and aquariums. Invasive ornamental fish that are household names such as guppy and goldfish are easily available without restriction. The authorities must act on illegal breeding of invasive fish for retailing purposes and employ firmer and thorough checks on live fish imports, particularly for ornamental fish.

The authorities should utilise this information by converting this data into educational awareness projects. This survey elucidates the perception levels of different age groups and education levels about invasive fish. This valuable data should be incorporated as a part of the education syllabus. If this awareness is assimilated into the younger generation, the number of accidental invasive fish release can be reduced if not prevented.

Role of Aquarium Industry in Influencing Public Perception of Invasive Fish

The aquarium industry promotes charismatic alien fish fervently which has contributed to society thinking that alien fish is more popular and wanted compared to local counterparts (Chucholl and Wendler, 2017; Kutlvašr et al., 2019). About 80% of respondents obtained their pet fish from aquariums and pet shops. This result further proves the impact of the aquarium trade industry on championing non-native fish in Malaysia. The booming of the aquarium trade industry hence has caused breeders to reproduce invasive alien fish in Malaysia to sell and make profits. The popularity of ornamental invasive fish in Malaysia due to the aquarium trade industry is identical to the prominence of the alien fish in many Asian countries such as India (Hussan et al., 2018), China (Liang et al., 2020) and Bangladesh (Mukul et al., 2020). The study showed that local fish were most likely to be obtained from local rivers, and alien fish were most likely to be picked up from aquariums. With them being the main distributor for the alien fish species, stricter licensing must be carried out to reduce illegal breeding or distributors. Conversely, the importing quantity must be reported accurately, and a maximum number of fish imports must be capped to ensure a safer amount of ornamental fish influx.

The ornamental fish plays a huge role in shaping public perception of invasive species, as retailers often serve as the primary contact between hobbyist and aquatic animals. In Malaysia, this pathway is especially important, with surveys showing that over 85% of freshwater species sold in Klang Valley pet stores are non-native, some with a high invasion risk (Saba et al., 2021). However, traders often do not provide proper guidance on specific risks or responsible pet care. In Singapore, the National Parks Board (NParks) has implemented public campaigns such as "No Release" (NParks, n.d.) and supports policy enforcement under the Parks and Trees Act (Cap. 216, 2006 Rev. Ed., Singapore) to penalize animal release in nature areas. Additionally, studies from Singapore also have suggested mandatory species labelling along with retailer-led educational outreach for customers to reduce unintentional introductions into local waterways (Chan et al., 2019). In Indonesia, gaps in regulatory enforcement and public awareness have prompted efforts for community-based surrender programs and outreach interventions through trade channels (Surya et al., 2020). This is supported by formal regulation from Indonesia's Ministry of Marine Affairs and Fisheries (MMAF) enforces Regulation No. 16/2024, which prohibits the import, cultivation or release of species designated as "endangering or harmful", which includes the invasive fish taxa.

Based on these regional examples above, Malaysia could benefit from adopting similar policy mechanisms. Building on the earlier discussion of public education and management frameworks, potential interventions could include introduction of return-to-store programs for unwanted fish, organizing pet amnesty days by the government, retailer licensing and training, especially for vendors selling non-native species and mandating public education within the aquarium retail sector. These preventive efforts could potentially help reduce intentional and unintentional release of fish by offering hobbyist practical and informed alternatives to disposal in natural waterways.

The Role of e-Learning in Increasing Awareness on Invasive Fish

This study showed that there is high awareness among those aged 18 to 25 years old that were predominantly doing their tertiary education. This showed that youths had higher awareness about this issue compared to other age groups due to being exposed to various awareness programs and environmental programs in universities. Within the viewpoint of environmental issues, it can be said that youths, with access to the internet and social media, are better equipped with the understanding and awareness on invasive alien species compared to the other age levels in this study. This is supported further by Shannon et al. (2020) w showed how effective e-learning through the internet was to increase perception level and understanding on matters pertaining to invasive alien species.

The e-learning method can be executed in various modes, such as through course-based, video-based, app-based, article-based, and in traditional classrooms. Through these different modes, awareness campaigns that target specific age groups and education levels can be developed. Specific modes can be designed to cater the specific groups so that the knowledge imparted onto them can be absorbed and applied properly. This is in line with provisions set by the Convention on Biological Diversity in 2004, to interact with the public to effectively deal with the invasive alien problem faced worldwide. Many studies have noted that while awareness campaigns provide the public with information on invasive species, many people struggle to apply the knowledge learnt and change preconceived behaviour and thoughts effectively (McKenzie-Mohr and Schultz, 2014; Shannon et al., 2020). Furthermore, Estevez et al.'s (2015) study postulated that the awareness levels in the younger generation can be enhanced by appealing to them through educational activities, social media, and training programs. Nonetheless, several short educational videos can be made into games and social media advertisements to reach a wider audience. This e-learning project can help seed awareness from a young age about invasive fish and its impact on the ecosystem.

The Role of Face-to-Face Learning in Increasing Awareness on Invasive Fish

Awareness and understanding about invasive fish can also be cultivated through face-to-face campaigns. Although e-learning is appealing particularly to youths, face-to-face awareness campaigns comprising of impact education, behavioural and perception change should also be continued to target a wider range of the community. A successful awareness outreach must aid participants to obtain knowledge, skills, and equip them with the attitude to sustainably cultivate responsible behaviour over a period (Salas et al., 2006).

Hands-on training programs are a stepping stone to develop sustainable skills using the knowledge obtained and applying it to real-world decision making. Studies have found that knowledge alone is not sufficient to change the perception of society and stimulate behavioural changes (Hungerford and Volk 1990; Rothlisberger et al. 2010; McKenzie-Mohr and Schultz 2014). According to Michie et al.'s (2011) study, educating the community must focus on both dissemination of knowledge and helping the participants comprehend the knowledge attained. Consequently, face-to-face awareness programs must be concurrently carried out along with hands-on programs that promote the application of knowledge.

The government must work hand in hand with educators, researchers, and conservationists to develop awareness modules that target a wide range of the community as well as develop awareness campaigns that specifically target specific demographics. Face-to-face learning opportunities can utilise the citizen scientist programs to aid society in increasing awareness and alter their behaviour and perception on invasive species (Phillips et al., 2021). Citizen science programmes can assist the public to directly learn about the types of invasive fish in Malaysia as well as witness first-hand the impacts of releasing aquarium bought fish into the ecosystem. This

can be applied to a wide set of demography as knowledge and apprehensions have no boundaries. Additionally, these citizen science programs can help the government to better understand the spatial distribution of invasive fish in Malaysia, empower the public to care about the environment and increase awareness on invasive fish.

Limitations and Caveats

While the importance of this study is to establish a baseline of the perception in Malaysians about invasive alien fish as pets, there were some limitations and caveats in this approach. Firstly, this survey did not represent the full population of Malaysia accurately. Due to the low sample size of respondents of this survey, there was a 6.8% margin of error. In addition, since the dissemination of this survey was mostly online based, there was a possibility of perception bias occurring. This questionnaire focused on mutual social connections found on social media. This can attract people from a similar mindset or point of view thus impacting the results slightly (Duffy et al., 2005). This sample was also highly similar with a bigger response from women. Future research could include a more diverse sample to include older age groups, less-educated respondents and rural populations to ensure more representative insights into the Malaysian population. Additionally, incorporating more advanced statistical methods such as regression or multivariate analysis could help identify key behavioural predictors of problematics pet disposal practices.

CONCLUSION

This study highlights a public bias among Malaysians that prefer invasive fish compared to local fish without awareness of ecological risks if alien fish were released into local waterways. Findings show that the public tends to treat their invasive pet with greater care in terms of feeding, tank cleaning and emotional attachment levels. Awareness of invasive fish remains divided as some members of the public are aware about the impacts of alien fish while others mistakenly believe that certain invasive fish are native to Malaysia. These findings offer an important benchmark for understanding the perception of Malaysian about invasive fish and provide insight into how the public may react to potential invasive management protocols including eradication or regulation efforts. As for future policies, the results emphasize the need of integrating public perception into invasive species governance to ensure strategies are both effective and socially acceptable. This research also supports the design of targeted outreach campaigns that bridges knowledge gaps and shift public attitudes towards more sustainable and responsible pet ownership. Ultimately, this studies baseline date and actionable insights for future conservation planning, public behaviour research and invasive species management.

Note: All data pertaining to the manuscript is available as supplement to the manuscript.

REFERENCES

1. Akmal, S. G., Zámečníková-Wanma, B. P., Prabowo, R. E., Khatami, A. M., Novák, J., Petrtýl, M., ... & Patoka, J. (2020). Marine ornamental trade in Indonesia. Aquatic Living Resources, 33, 25, https://doi.org/10.1051/alr/2020026
2. Alias, M. I. M., Hambali, K., Amir, A., Fauzi, N., Hassin, H., & Yin, S. A. (2019). Checklist of Fishes at Pergau Lake, Jeli, Kelantan, Malaysia. Tropical life sciences research, 30(1), 161. https://doi.org/10.21315/tlsr2019.30.1.10
3. Amundsen, P. A., Siwertsson, A., Primicerio, R., & Bøhn, T. (2009). Long-term responses of zooplankton to invasion by a planktivorous fish in a subarctic watercourse. Freshwater Biology, 54(1), 24-34, https://doi.org/10.1111/j.1365- 2427.2008.02088.x
4. Ang KJ (1989) The status introduced fish species in Malaysia. Exotic Aquatic Organism in Asia: 71–82
5. Aqmal-Naser, M., Fahmi-Ahmad, M., & Ahmad, A. B. (2019). Inland Fishes of Pulau Pangkor, Perak, Peninsular Malaysia. The Malaysian Forester, 82(1), 297-302. https://www.researchgate.net/publication/331035405_Inland_fishes_of_Pulau_Pangkor_Perak_peninsular_Malaysia
6. Beever EA, Simberloff D, Crowley SL, Al-Chokhachy R, Jackson HA, Petersen SL (2019) Social–ecological mismatches create conservation challenges in introduced species management. Frontiers in Ecology and the Environment 17(2): 117–125, https://doi.org/10.1002/fee.2000

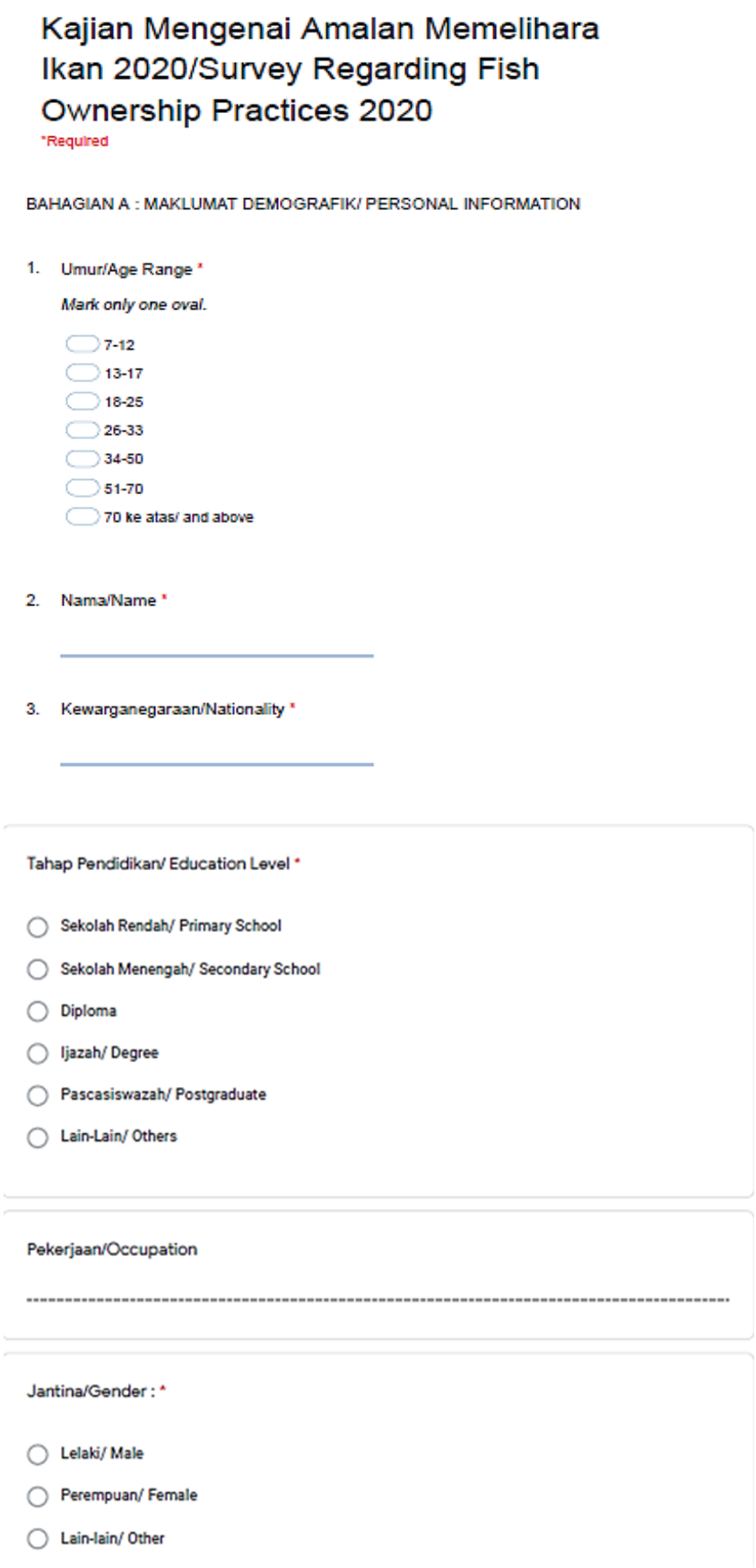
7. Chan, F. T., Beatty, S. J., Gilles Jr, A. S., Hill, J. E., Kozic, S., Luo, D., ... & Copp, G. H. (2019). Leaving the fish bowl: the ornamental trade as a global vector for freshwater fish invasions. Aquatic Ecosystem Health & Management, 22(4), 417-439, https://doi.org/10.1080/14634988.2019.1685849
8. Chucholl C, Wendler F (2017) Positive selection of beautiful invaders: long-term persistence and bio-invasion risk of freshwater crayfish in the pet trade. Biological Invasions 19(1): 197–208, https://doi.org/10.1007/s10530-016-1272-5
9. D'hondt B, Vanderhoeven S, Roelandt S, Mayer F, Versteirt V, Adriaens T, Branquart E (2015) Harmonia+ and Pandora+: risk screening tools for potentially invasive plants, animals and their pathogens. Biological Invasions 17(6): 1869–1883, https://doi.org/10.1007/s10530-015-0843-1
10. DOF (2006) Department of Fisheries. List of Registered Ornamental Fish Exporters. https://www.dof.gov.my (Accessed 30 July 2021)
11. Duffy B, Smith K, Terhanian G, Bremer J (2005) Comparing data from online and face-to-face surveys. International Journal of Market Research 47(6): 615–639, https://doi.org/10.1177%2F147078530504700602
12. Estevez-Menendez M, An H, Strasser J (2015) The effects of interactive multimedia iPad E-books on preschoolers' literacy. In Tablets in K-12 education: Integrated experiences and implications. IGI Global, pp. 139–155, https://doi.org/10.4018/978-1-4666-6300-8.ch010
13. Hungerford HR, Volk TL (1990) Changing learner behavior through environmental education. J Environ Educ 21: 8–21, https://doi.org/10.1080/00958964.1990.10753743
14. Hussan A, Chakrabarti PP, Sundaray JK, Das A, Mohapatra BC, Ananth PN (2018) Status and future of aquaculture development in Mizoram, India. International Journal of Fisheries and Aquatic Studies 6(4): 42–48
15. Indonesia. (2024). Ministerial Regulation No. 16/2024 on the authority to control endangering or harmful fish. Jakarta: Ministry of Marine Affairs and Fisheries. Retrieved from https://nusantaralegal.com/artikel/indonesia-third-quarter-regulatory-updates-2020.html
16. Jaric I, Courchamp F, Correia RA, Crowley SL, Essl F, Fischer A, Jeschke JM (2020) The role of species charisma in biological invasions. Frontiers in Ecology and the Environment 18(6): 345–353, https://doi.org/10.1002/fee.2195
17. Kavanagh K (2000) Fishes from mountain streams in the Crocker Range Park Sabah, Malaysia. ASEAN Review of Biodiversity and Environmental Conservation (ARBEC), 1–4.
18. Khairul AA. R, Yuzine E, Aziz A (2013) The Influence of Alien Fish Species on Native Fish Community Structure in Malaysian Waters. Kuroshio Science 7(1): 81–93
19. Khaleel AG, Ismail N, Ahmad-Syazni K (2021) Introduction of Invasive Peacock Bass (Cichla spp.), Its Rapid Distribution and Future Impact on Freshwater Ecosystem in Malaysia. Croatian Journal of Fisheries 79(1): 33–46, http://dx.doi.org/DOI:%2010.2478/cjf-2021-0004
20. King TA (2019) Wild caught ornamental fish: A perspective from the UK ornamental aquatic industry on the sustainability of aquatic organisms and livelihoods. Journal of Fish Biology 94(6): 925–936, https://doi.org/10.1111/jfb.13900
21. Kutlvašr J, Pergl J, Baroš A, Pyšek P (2019) Survival, dynamics of spread and invasive potential of species in perennial plantations. Biological Invasions 21(2): 561–573, https://doi.org/10.1007/s10530-018-1847-4
22. Liang SH, Walther BA, Shieh BS (2020) Determinants of establishment success: Comparing alien and native freshwater fishes in Taiwan. PloS one 15(7): e0236427, https://doi.org/10.1371/journal.pone.0236427
23. McKenzie-Mohr D, Schultz PW (2014) Choosing effective behavior change tools. Social Marketing Quarterly 20(1): 35–46, https://doi.org/10.1177/1524500413519257
24. Michie S, Van Stralen MM, West R (2011) The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci 6:42, https://doi.org/10.1186/1748-5908-6-42
25. Mukul SA, Khan MASA, Uddin MB (2020) Identifying threats from invasive alien species in Bangladesh. Global Ecology and Conservation e01196, https://doi.org/10.1016/j.gecco.2020.e01196
26. National Parks Board (NParks). (n.d.). Invasive species in Singapore. Retrieved July 26, 2025, from https://www.nparks.gov.sg/nature/invasive-species-singapore

27. Novoa A, Dehnen-Schmutz K, Fried J, & Vimercati G (2017) Does public awareness increase support for invasive species management? Promising evidence across taxa and landscape types. Biological Invasions 19(12): 3691–3705, https://doi.org/10.1007/s10530-017-1592-0
28. Othman, M. H., & Hashim, A. K. A. (2003). Prevention and Management of Invasive Alien Species. In Proceedings of a Workshop on Forging Cooperation throughout South-Southeast Asia. Global Invasive Species Programme, Cape Town, South Africa. https://www.doi.gov/sites/doi.gov/files/uploads/invasive_alien_species_in_south_southeast_asia.pdf
29. Pauly D (1995) Anecdotes and the shifting baseline syndrome of fisheries. Trends in ecology & evolution 10(10): 430, https://doi.org/10.1016/s0169-5347(00)89171-5
30. Phillips TB, Bailey RL, Martin V, Faulkner-Grant H, Bonter DN (2021) The role of citizen science in management of invasive avian species: What people think, know, and do. Journal of Environmental Management 280: 111709, https://doi.org/10.1016/j.jenvman.2020.111709
31. Rothlisberger JD, Chadderton WL, McNulty J, Lodge DM (2010) Aquatic invasive species transport via trailered boats: what is being moved, who is moving it, and what can be done. Fisheries 35:121–132, https://doi.org/10.1577/ 1548-8446-35.3.121
32. Saba, A. O., Ismail, A., Zulkifli, S. Z., Ghani, I. F. A., Halim, M. R. A., Ibrahim, M. A., ... & Amal, M. N. A. (2021). Invasion risk and potential impact of alien freshwater fishes on native counterparts in Klang Valley, Malaysia. Animals, 11(11), 3152, https://doi.org/10.3390/ani11113152
33. Saba, AO, Ismail A, Zulkifli SZ, Shohaimi S, Amal MNA (2021) Public knowledge and perceptions of the impacts and importance of alien fish species in Malaysia: implications for freshwater biodiversity and conservation. Management of Biological Invasions 12(2): 441, https://doi.org/10.3391/mbi.2021.12.2.15
34. Salas E, Wilson KA, Priest HA, Guthrie JW (2006) Design, delivery, and evaluation of training systems. In: Salvendy G (ed) Handbook of human factors and ergonomics. Wiley, Florida, pp 472–512, https://psycnet.apa.org/doi/10.1002/0470048204.ch18
35. Shackleton RT, Richardson DM, Shackleton CM, Bennett B, Crowley SL, Dehnen-Schmutz K, Marchante E (2019) Explaining people's perceptions of invasive alien species: a conceptual framework. Journal of Environmental Management 229: 10–26, https://doi.org/10.1016/j.jenvman.2018.04.045
36. Shafiq, Z. M., Ruddin, M. S. A. S., Zarul, H. H., Syaiful, M. M., Khaironizam, M. Z., Khaled, P., & Hamzah, Y. (2014). An annotated checklist of fish fauna of Bukit Merah Reservoir and its catchment area, Perak, Malaysia. Check List, 10(4), 822-828, http://dx.doi.org/10.21315/tlsr2016.27.3.11
37. Shannon C, Stebbing PD, Quinn CH, Warren DA, Dunn AM (2020) The effectiveness of e-Learning on biosecurity practice to slow the spread of invasive alien species. Biological Invasions 22: 2559–2571, https://doi.org/10.1007/s10530-020-02271-z
38. Singapore. (2006). Parks and Trees Act (Cap.216, 2006 Rev. Ed.). Retrieved from Singapore Statutes Online: https://sso.agc.gov.sg/Act/PTA2005
39. Strayer DL (2010) Alien species in fresh waters: ecological effects, interactions with other stressors, and prospects for the future. Freshwater biology 55: 152–174, https://doi.org/10.1111/j.1365-2427.2009.02380.x
40. Turbelin, A. J., Malamud, B. D., & Francis, R. A. (2017). Mapping the global state of invasive alien species: patterns of invasion and policy responses. Global Ecology and Biogeography, 26(1), 78-92. https://doi.org/10.1111/geb.12517
41. Verbrugge LN, Van den Born RJ, Lenders HR (2013) Exploring public perception of non-native species from a vision of nature perspective. Environmental management 52(6): 1562–1573, https://doi.org/10.1007/s00267-013-0170-1
42. Verma, C. R., Pise, M., Khare, T., Kumkar, P., & Kalous, L. (2024). Social media and genetic evidence demonstrate the expansion of an invasive fish in India. Journal of Vertebrate Biology, 73(23087), 23087-1, https://dx.doi.org/10.25225/jvb.23087
43. Yongo, E., Zhang, P., Mutethya, E., Zhao, T., & Guo, Z. (2023). The invasion of tilapia in South China freshwater systems: A review. Lakes & Reservoirs: Research & Management, 28(1), e12429, http://dx.doi.org/10.1111/lre.12429
44. Zaret, T. M., & Paine, R. T. (1973). Species introduction in a tropical lake: A newly introduced piscivore can produce population changes in a wide range of trophic levels. Science, 182(4111), 449-455, https://doi.org/10.1126/science.182.4111.449

APPENDIX

Supplementary Material

Figure S1: Survey Questions on public perception of IAS



Kajian Mengenai Amalan Memelihara Ikan 2020/Survey Regarding Fish Ownership Practices 2020

*Required

BAHAGIAN A : MAKLUMAT DEMOGRAFIK/ PERSONAL INFORMATION

1. Umur/Age Range *

Mark only one oval.

- 7-12
- 13-17
- 18-25
- 26-33
- 34-50
- 51-70
- 70 ke atas/ and above

2. Nama/Name *

3. Kewarganegaraan/Nationality *

Tahap Pendidikan/ Education Level *

- Sekolah Rendah/ Primary School
- Sekolah Menengah/ Secondary School
- Diploma
- Ijazah/ Degree
- Pascasiswazah/ Postgraduate
- Lain-Lain/ Others

Pekerjaan/Occupation

Jantina/Gender : *

- Lelaki/ Male
- Perempuan/ Female
- Lain-lain/ Other

BAHAGIAN B : AMALAN PEMELIHARAAN IKAN/ FISH OWNERSHIP HABITS

Pernakah anda memelihara ikan? /Have you had fish as a pet? *

- ◯ Ya/Yes
- ◯ Tidak/ No

Apakah jenis ikan yang dipelihara?/ What type of fish did you keep? *
Anda boleh menyenaraikan lebih dari satu jawapan/ You can list more than one answer

---

Dimanakah ikan tersebut?/ Where did you obtain the fish?: *
Anda boleh tanda lebih daripada satu kotak/ You can check more than one box

- ☐ Aquarium/Pet shop
- ☐ River/Pond
- ☐ Diberi oleh Keluarga atau Kawan/Given by family or friends
- ☐ Online Purchase
- ☐ Other: ---

Apakah sebab utama anda memelihara ikan/What are the reasons for choosing a fish as a pet? *
Anda boleh tanda lebih daripada satu kotak/ You can check more than one box

- ☐ Sebagai teman /Companionship
- ☐ Sifat ingin tahu /Curiosity
- ☐ Senang dijaga/ Easy to care for
- ☐ Memberi ketenangan / Calming
- ☐ Lain-lain/Others

Dimanakah anda menyimpan ikan ?/ Where do you keep your fish? *

- ◯ Tangki ikan/Fish tank
- ◯ Kolam dirumah/ Pond at home
- ◯ Other: ---

BAHAGIAN C: TAHAP KESEDARAN MENGENAI CARA PENGENDALIAN IKAN/AAWARENESS ABOUT FISH HANDLING PRACTICES

Adakah anda mempunyai rasa sayang dan bertanggungjawab terhadap ikan peliharaan anda? / Do you have a strong attachment and responsibility towards your fish?

- ◯ Ya/ Yes
- ◯ Tidak / No

Adakah anda menamakan ikan anda sebelum ini?Sila nyatakan nama. / Have you named your fish before? Please state the name. *

Berapa kerap anda menukar air di dalam akuarium? / How often do you change the water in the aquarium? *

- ◯ Setiap hari/ Everyday
- ◯ Seminggu sekali/ Once a week
- ◯ Sebulan Sekali/ Once a month
- ◯ Semasa saya suka/ When I feel like changing
- ◯ Tidak pernah/ Never

Berapa kerap anda memberi makanan kepada ikan peliharaan? / How often do you feed your fish? *

Mengapakah hal ini terjadi? / Why did this happen? *

Apakah yang akan anda lakukan sekiranya tidak mahu lagi ikan anda? / What will you do if you no longer want your fish? *

- ◯ Melepaskan ikan tersebut dalam longkang/ Release it into the drain
- ◯ Melepaskan ikan tersebut ke dalam sungai atau kolam/ Release it into the river or pond
- ◯ Membunuh ikan tersebut/ Kill the fish
- ◯ Memberi kawan atau keluarga / Give the fish to a friend or family member
- ◯ Mejadikanya sebagai sumber makanan / Become a source of food

Pernakah anda tidak lagi mahu haiwan kesayangan anda? / Have you no longer wanted your pet fish? *

- ◯ Ya/Yes
- ◯ Tidak/ No

Apakah sebab-sebab tindakan anda di atas?/What are your reasons for doing the action above ? *

Apakah perasaan anda apabila ikan peliharaan anda mati? / How will you feel if your pet fish died? *

- ◯ Sedih/ Sad
- ◯ Tiada perasaan/ Indifferent
- ◯ Gembira/ Happy
- ◯ Rasa Bersalah/ Guilty

Pemeliharaan Ikan dan Kesejahteraan Hidup / Fish and Well Being

Pernahkah anda duduk dan melihat ikan berenang di akuarium ? / Have you ever sat and watched the fish in your aquarium swim? *

- ◯ Ya/ Yes
- ◯ Tidak/ No

Bagaimanakah perasaan anda apabila berbuat demikian?/ How did that make you feel? *

- ◯ Tenang/ Calm
- ◯ Gementar/Nervous
- ◯ Seronok/ Happy
- ◯ Tiada apa -apa perasaan/ No feelings
- ◯ Sedih/Sad

Pernahkah anda berbual--bual atau main dengan ikan peliharaan ? / Have you ever spoken to or played with your pet fish? *

- ◯ Ya/ Yes
- ◯ Tidak/No

Adakah anda percaya bahawa pemeliharaan ikan boleh membawa ketenangan? / Would you believe that keeping fish can bring well being to humans ? *

- ◯ Ya/ Yes
- ◯ Tidak/No
- ◯ Tidak Pasti/ Unsure

Adakah anda mengesyorkan rakan anda untuk menyimpan ikan?/ Would you recommend your friend to keep fish as a pet? *

- ◯ Ya/ Yes
- ◯ Tidak/ No