A survey on aquatic animal keeping practices for home aquariums during the COVID-19 pandemic

Een onderzoek naar het houden van waterdieren voor huisaquaria tijdens de COVID-19-pandemie

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ABSTRACT

Human–animal interactions can generate a variety of benefits for the psychological and physiological wellbeing of humans. Therefore, more people may prefer to keep pets (such as aquatic animals) during stressful events, like the COVID-19 pandemic. In this study, an international survey of aquarium keepers was conducted to assess their attitudes toward home aquariums during the COVID-19 pandemic. Over 80% of the respondents, irrespective of gender, age, employment status, number of owned aquariums, or aquarium maintenance experience, confirmed that aquariums have produced stress-relieving benefits during the COVID-19 pandemic. Approximately, one-quarter of home aquarium owners claimed to have bought more than 15 fish and 15 aquatic invertebrates since the beginning of the stay-at-home restrictions. The majority of the respondents confirmed that their aquarium(s) was/were properly maintained during these regulations, particularly compared to the years prior to the COVID-19 pandemic. To some extent, a shortage of supply of live foods affected the maintenance performance of home aquariums.

SAMENVATTING

Het houden van dieren kan verschillende voordelen opleveren voor het psychologische en fysiologische welzijn van de mens. Daarom houden mogelijk meer mensen huisdieren (zoals waterdieren) tijdens stressvolle gebeurtenissen, zoals de COVID-19-pandemie. In deze studie werd een internationaal onderzoek uitgevoerd onder aquariumhouders om hun houding ten opzichte van thuisaquaria tijdens de COVID-19-pandemie te beoordelen. Meer dan 80% van de respondenten, ongeacht geslacht, leeftijd, arbeidsstatus, het aantal eigen aquaria of ervaring met aquariumonderhoud, bevestigde dat aquaria stressverlichtende voordelen hebben opgeleverd tijdens de COVID-19-pandemie. Ongeveer een kwart van de eigenaren van een thuisaquarium beweerde meer dan 15 vissen en 15 ongewervelde waterdieren te hebben gekocht sinds het begin van de lockdownbeperkingen door de COVID-19-pandemie. De respondenten waren vooral van mening dat hun aquarium(s) tijdens deze reglementen goed onderhouden was/waren, zeker in vergelijking met de jaren voorafgaand aan de COVID-19-pandemie. Het tekort aan levend voedsel beïnvloedde in bepaalde mate het onderhoud van huisaquaria.

INTRODUCTION

Since 2019, the coronavirus disease 2019 (COVID-19) pandemic has been spreading alarmingly fast. By the spring of 2020, more than half the world's population had experienced so-called "stay-at-home" restrictions with stringent lockdown measures (Allain-Dupré et al., 2020). According to the results from a recent study, these restrictions have resulted in drastic adverse psychological outcomes in humans including, anxiety and loneliness (Tull et al., 2020).

Human-animal interactions generate various benefits for the psychological and physiological wellbeing of humans. Examples include a better psychological

health status in elderly people who own dogs (Knight and Edwards, 2008), a better balance in children with autism spectrum disorder who get acquainted with family horses (Harris and Williams, 2017), a more active daily life for elderly people who own cats (Raina et al., 1999), and greater perceptions of relaxation and enhanced mood in people who keep aquariums (Cracknell et al., 2016; Gee et al., 2019). These findings suggest that people may prefer to keep pets more often during stressful events like the COVID-19 pandemic, whereby animals that are easy to take care of at home (and which are not susceptible to infection by the novel coronavirus) may become more popular. This seems at least to be the case for aquatic animals. According to the magazine, The Japan Times, there has been a significant increase in aquarium fish and reptile sales in Japan since June 2020. The growing demand for pets has disrupted the supply chains in the short term (Anonymous, 2020).

From an environmental point of view, the increased demand for aquatic pets may lead to issues related to the introduction of non-native species. According to the results of a survey amongst aquarium owners in Canada (Marson et al., 2009), at least one in three invasive fish species are owned by 794 aquarium keepers. Aquarium trade may provide a vector for introducing invasive aquatic species into natural habitats (West et al., 2019; Marson et al., 2009). Over 50% of the fish species introduced to the United States originate from trade in aquarium fish (Della Venezia and Leung, 2020; Della Venezia et al., 2018; Courtenay Jr. and Stauffer Jr., 1990).

On the other hand, the COVID-19 pandemic may adversely affect pet owners' attitudes to animal welfare. According to a recent survey of pet owners commissioned by the not-for-profit, non-governmental organization "HealthforAnimals", pet owners' attitudes during the COVID-19 pandemic resulted in delayed or missed care for cats and dogs in Brazil, France, the UK and the US and mainly included delays in seeking veterinary contact, hesitation in consenting to medical treatment, and inadequate pet care due to fear of the pets getting infected with the coronavirus (HealthforAnimals, 2021). Aquarium animals are no exception, and their welfare is also expected to be affected by pandemic-related changes; for example, the possible misconception of aquarium owners that seeking (emergency) advice from veterinarians during the stay-at-home restrictions would not be possible or would only be possible via remote calling, thus creating barriers for seeking help.

In this study, a survey of aquarium keepers was conducted to assess the maintenance performance of home aquarium owners during stay-at-home restrictions. The results are discussed in terms of (a) changes in time and money spent by owners on their aquariums, (b) potential effects of restrictions on the welfare of animals (for example: disease prevalence, water quality issues, feeding), and (c) environmental issues related to high demand.

MATERIALS AND METHODS

The aquarium-keeping survey (Fish Keeping Survey, 2021) was produced as an online questionnaire using the Google Forms platform. The survey comprised 22 questions in English, which were in single-/multiple-choice or open-ended format. Initially, the respondents were asked to declare their willingness to keep aquariums by responding to dichotomous questions or rating their responses to statements on a 5-point scale Likert scale (anchors: "strongly agree" to "strongly disagree"):

(1) "I believe my aquarium(s) had stress-relieving benefits during the COVID-19 pandemic."

(2) "I have thought about or decided to give up my pets other than aquarium animals because they are more vulnerable to coronaviruses."

(3) "I believe I spent a lot of money on my aquarium(s) in the last year."

The next part of the survey consisted of questions regarding the number of fish or invertebrates purchased during the a one-year period of restriction regulations, methods of ordering animals, and the proportion of overall expenditure on exotic aquatic animal purchases.

In the third part, the performance of home aquarium owners in maintaining their aquariums during the COVID-19 pandemic stay-at-home restrictions was assessed by asking questions about changes in:

- Feeding frequency, quantity (closed-ended question), and food type (open-ended question)
- Conducting partial water changes (closed-ended question)
- Disease incidence or prevalence (closed-ended questions)
- Mortality (closed-ended question)

The questions dealing with the animal welfare issues (i.e. water supply and quality, stocking density, feeding and disease) were to some extent in line with the parameters described in section B- Annex III (i.e. requirements for establishments and the care and accommodation of fish) of Directive 2010/63/EU (Anonymous, 2010). The data were collected by self-reports obtained from the survey participants. Still, they were initially asked if they performed water monitoring in their aquariums (as a mandatory criterion to participate).

Finally, the respondents were asked how they disposed of unwanted (i.e. they have become an inconvenience) animals. Additional data on gender, age, nationality, employment status, aquarium-keeping experience, and the type, number, and size of aquariums owned were also collected.

The survey was distributed online using the Telegram (Telegram FZ LLC and Telegram Messenger Inc., 2021), Discord (Discord Inc. 2021) and several Reddit channels (i.e. r/Aquariums, r/Fishkeeping, r/PlantedTank, r/SaltwaterAquariumClub, r/Shrimptank) after gaining permission from the channel administrators. Informed consent was obtained from

each respondent before the survey was conducted. Participants were eligible to complete the survey if they were fifteen years or older. The survey was available from March to April 2021. The research was given ethical approval by the Iranian National Institute for Oceanography and Atmospheric Sciences (INI-OAS-ET-018).The time to complete the online survey was approximately seven minutes.

Pearson's chi-square statistics were used to test for significant association between responses and demographic/socio-economic status. Bivariate tabulations were conducted to analyze the relationships between responses. The Fisher's Exact Test was used as an alternative to a chi-square test in those cases where expected counts were below 5.

RESULTS

Overall, 168 home aquarium owners from 22 countries participated in this study. The demographic and socio-economic profiles of the respondents are presented in Table 1.

Over 40% of the participants were experienced aquarium keepers (with more than five years of experience), and less than 20% were new in the hobby (with less than one year of experience) (Figure 1). Approximately 34% of the respondents owned two aquariums, 20% owned only one, and 16% had more than five (Figure 1). There was no significant association between the number of owned aquariums and aquarium keeping experience ((LR)= 24.66, N= 165,

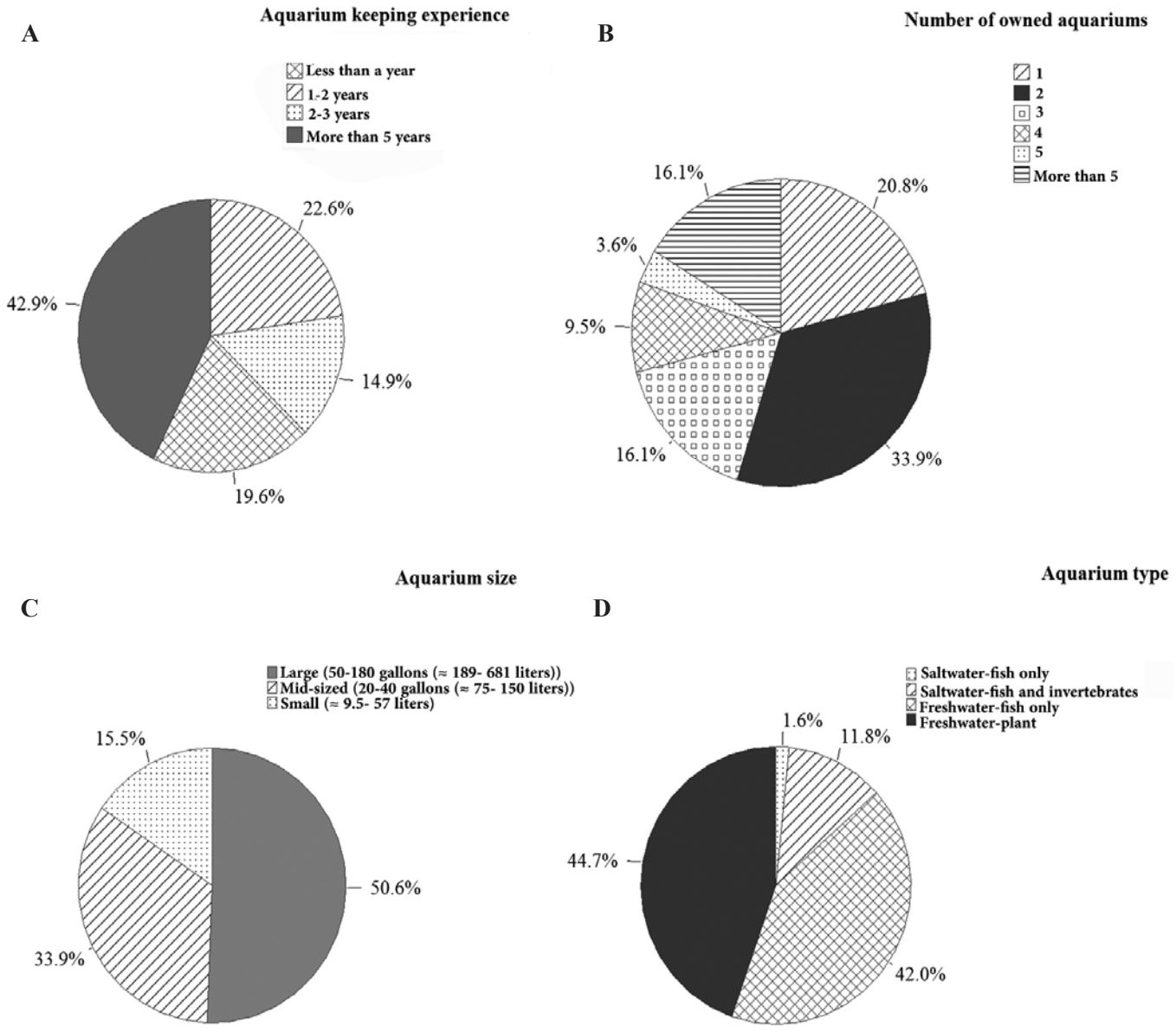

Figure 1. Distribution of home aquarium owners in terms of A. the reported level of experience, B. the number, C. size of owned aquariums and D. aquarium types. Total number of respondents = 168.

Table 1. Demographic and socio-economic profile of home aquarium owners surveyed. Total number of respondents = 168.

Variable	Category (percentage)
Gender	Males (56.5%), 68 females (38.7%), non-binary (4.8%)
Age group	Youth 15-24YO (44.6%), adults 25-64YO (55.4%)
Country	USA (63.7%), UK (6%), Singapore (6%), Canada (5.4%), Other (< 5%)
Employment status	Full-time (53.9%), part-time (6%), self-employed (6.6%), retired (1.2%), unemployed (15.5%), student (16.8%)

P 0.055), gender (LR= 13.16, N= 168, P= 0.21), age (LR= 3.41, N= 165, P= 0.63), or employment status (LR= 28.80, N= 160, P= 0.34).

Over 50% of the respondents owned large (i.e. 50-180 gallons ≈ 189- 681 liters) aquariums and 15.5% had small (i.e. 2.5-15 gallons ≈ 9.5- 57 liters) ones (Figures 1). Approximately 97% of the respondents kept one or two types of aquariums. Freshwater-plant (i.e. community) aquariums were the most popular types (> 40%), followed by freshwater-fish only (> 40%), saltwater-fish and invertebrates (> 10%), and saltwater-fish only aquariums (< 2%) (Figure 1). The interest in aquarium type was significantly (chi-squared test, Eta= 0.85, N= 165, P= 0.009) dependent on aquarium keeping experience. The saltwater-fish and invertebrate aquariums and freshwater-plant (community) aquariums were more likely to be chosen by experienced aquarists.

Overall, 83.3% (140/168) of the respondents, irrespective of gender (LR= 3.90, N= 168, P= 0.41), age (LR= 5.65, N= 165 P= 0.22), employment status (LR= 9.75, N= 160, P= 0.46), number of owned aquariums (LR= 4.33, N=168, P = 0.93), or aquarium keeping experience (LR= 11.98, N= 165, P= 0.060) believed that aquariums have stress-relieving benefits during the COVID-19 pandemic. Moreover, 79.2% (133/168) of the participants declared they had not been thinking about giving up their pet(s) other than fish since the beginning of the pandemic, probably indicating that their interest in fish was due to the fear of COVID-19 incidence in other animals. The rest of the respondents marked the question as "not applicable" in the assumption that no other pets than fish were considered in this survey.

In terms of the maintenance performed during the restrictions, 73.3% (99/135) of the aquarists (excluding those with less than one year of experience) generally agreed (or strongly agreed) that their aquariums were properly maintained during the last year compared to the previous years. A percentage of 20.7% (28/135) of the participants were neutral, and 6% (8/135) claimed that they did not maintain their

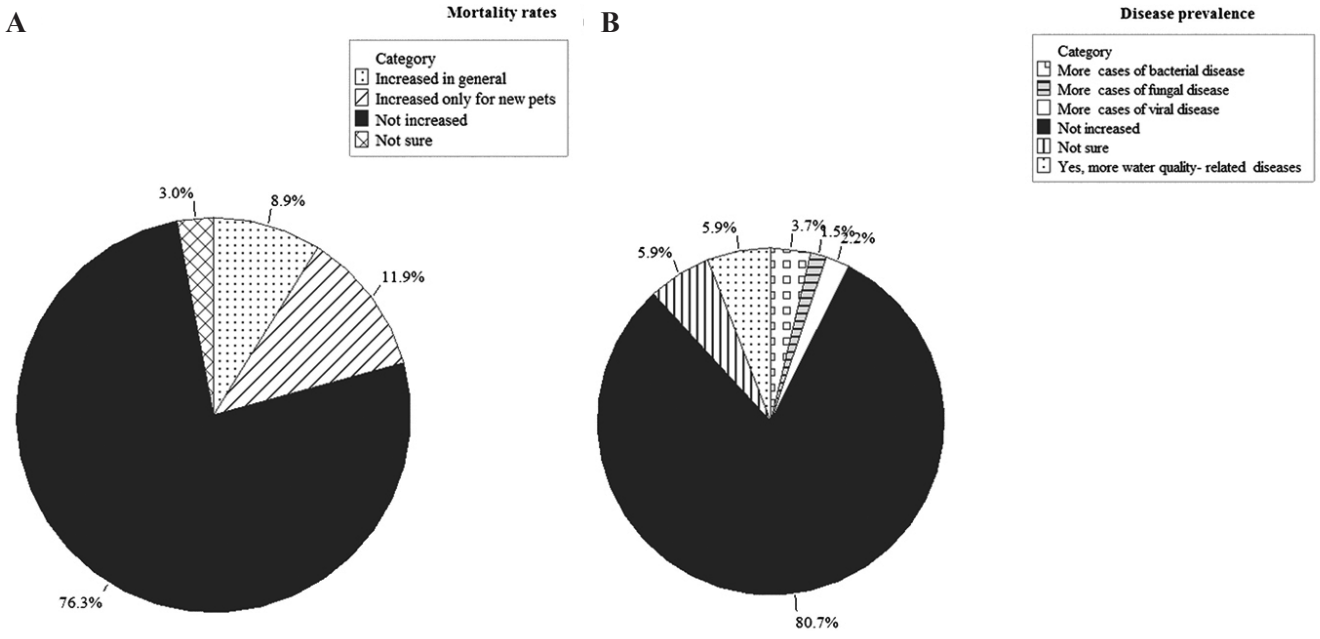

Figure 2. Changes in A. reported mortality rates and B. disease prevalence since the beginning of the COVID-19 stay-at-home restrictions (compared to previous years). Total number of respondents = 135.

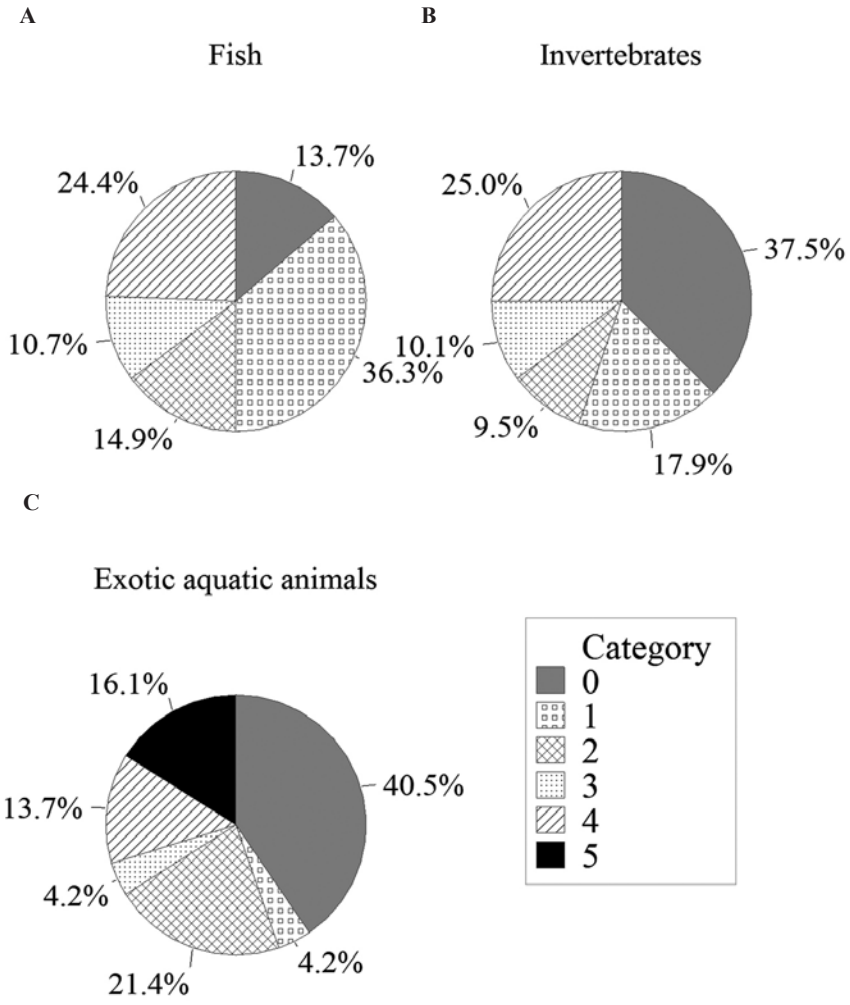

Figure 3. Distribution of home aquarium owners in terms of the reported number of purchased fish, invertebrates, and exotic aquatic animals since the beginning of the COVID-19 stay-at-home restrictions. Total number of respondents = 168.

aquariums properly. The agreement level was not dependent on the respondent's gender (LR= 5.75, N= 135, P= 0.067), age (LR= 12.30, N= 135, P= 0.13), employment status (LR= 25.10, N= 135, P= 0.19), number of owned aquariums (LR= 24.10, N= 135, P= 0.23), or aquarium keeping experience (LR= 12.61, N= 135, P= 0.39). 82.7% (111/135) of the respondents, nearly equally distributed between employed and unemployed statuses, also claimed they spent relatively more money maintaining their aquariums.

In a more detailed response, approximately 77% (103/135) of the respondents (excluding those with less than one year of experience) reported no signs of increased fish/ invertebrate mortalities during the stay-at-home restrictions, irrespective of animal stocking density (LR= 14.83, N= 135, P= 0.25) (Figure 2). On the other hand, those cases of increased losses were more common for newly introduced animals (Figure 2). In terms of disease dynamics, more than 80% (109/135) of the aquarists responded that the disease prevalence/incidence had not been increased in their aquariums during the stay-at-home restrictions. On the other hand, water quality-related issues were the main cause of increased disease rates, followed by bacterial infections (Figure 2).

The survey results on feeding and water exchange practices revealed minor changes during COVID-19 restrictions. In general, the aquarists fed their pets once (37.5%, 63/168) or twice (49.4%, 83/168) per day, and approximately three-quarters of the respondents reported no change in feeding frequency since the beginning of the stay-at-home restrictions. Meanwhile, 23.7% (32/135) of the respondents tended to increase feeding frequency from once to twice per day. Also, most participants (i.e. 71.6%, 97/135) did not change the food quantity per meal, while 26.1% (36/135) reported increased food per meal. The increased amount of food was not associated with the incidence of more disease (LR= 1.07, N= 135, P= 0.3). Live (87%) and fresh (74%) foods were more

commonly used than dried, freeze-dried, or frozen foods. More than one type of food was used by 80% of the aquarium keepers.

A positive correlation was found between the number of food types used and the aquarium type (Pearson's correlation test, R= 0.21, N= 168, P= 0.004). Also, 79.8% (134/168) of the respondents indicated no change in food type since the beginning of the stay-at-home restrictions. The remainder 20.2% (34/168), declared to use less live foods due to the shutdown of live food stores in some countries. As an alternative, they decided to grind fresh foods with pellets to make homemade gel foods (15% (5/34) of the participants) or use more dried foods (5% (2/34) of the participants).

Approximately 60% (101/168) of the respondents declared no change in the partial water change frequency and/or schedule, while 20% (33/168) reported that they performed more frequent water changes and 10.6% (18/168) used lower frequency. The water change frequency was not associated with the disease prevalence (LR= 24.29, N= 168, P= 0.06).

According to the survey results, the respondents were more interested in buying more fish than invertebrates since the beginning of stay-at-home restrictions (Figure 3). Also, the demand for exotic aquatic animals was low, and 41% (68/167) purchased none (Figure 3). When the respondents were asked about their actions in case of unwanted fish/invertebrates, "giving to other aquarist(s)" and "returning to store" were the most common replies. Less than 10% (4/168) of the answers indicated disposal to the wilderness or drain.

DISCUSSION

In this survey, over 50% of the respondents from both the children/youth and adult groups agreed that aquariums have stress-relieving benefits. The results of a previous research indicated that only 10% of the respondents would choose aquariums to reduce tension in their daily lives under normal circumstances (Laskar et al., 2016). The spread of COVID-19 has had psychopathological effects on humans of all ages worldwide. Stress, anxiety and depression are amongst the main effects and these seem to be most prevalent in the category of ≤25 years old (Nwachukwu et al., 2020). The feeling of uncertainty is another essential psychopathological effect of COVID-19 on humans and may have long-lasting effects, such as trauma (Nieforth and O'Haire, 2020). Personal social contact is one of the best ways to cope with feelings of uncertainty; however, social networks have been restricted during the COVID-19 pandemic due to the stay-at-home restrictions. Instead, pets have become alternative options, acting as social support (Nieforth and O'Haire, 2020). Positive attitudes towards pets in stressful circumstances may be due to emotional support (e.g., biophilia and non-judgmental support) provided by these animals (Kellert and Wilson, 1995).

In the present study, the ratio between male and female aquarium owners was male-skewed. The same phenomenon has also been reported in previous studies (Laskar et al., 2016). Felsing et al. (2000) concluded that some cultural traditions and social limitations might result in females' lesser interest in keeping aquariums (Felsing et al., 2000). On the other hand, males may have less adaptive stress responses to COVID-19 (Yan et al., 2021) and therefore a greater need for companion animals.

The results show that 40% of the respondents added one to five fish to their aquariums since the beginning of the stay-at-home restrictions, while 25% added more than 15 fish (i.e. more than one fish per month). The authors could not provide information on the net demand for aquatic animals since the beginning of the restrictions, because global data on per-unit demand are scarce in the literature. In Tripura (India), >50% of questioned aquarists were found to buy one fish every four to six months during 2015–2016 (totaling two to three fish per year), while only 5% claimed to purchase a fish per month (Laskar et al., 2016). An earlier study in the USA indicated that, on average, each freshwater/saltwater aquarist owned 7.7– 8.8 fish (Council, 1996), while in the present study, approximately 35% owned > 10 fish.

The respondents indicated that the lockdown periods negatively affected live food supplies, at least in ten countries, particularly during the initial phases of the regulations. In these cases, the respondents decided to produce homemade food by mixing pellets with fresh legumes (e.g. peas) and other vegetables to make gel food. The results of previous studies show that replacing fish meal with pea seed meal (as a protein source) may lead to poor growth and lower protein assimilation efficiency in omnivorous fish, e.g. Tilapia (El-Saidy and Saad, 2008) and Carp (Siddhuraju and Becker, 2001). However, adding vegetables to the fish food may improve disease resilience by restoring the gut microbiome in carnivorous fish (Piazzon et al., 2017). In terms of feeding frequency, approximately 20% of the home aquarists claimed that they had decided to increase fish feeding frequency from once to twice a day since the beginning of the restrictions. Feeding fish on a twotimes/day schedule is a standard practice in ornamental fish (e.g. *Symphysodon* spp.) culture (Chong et al., 2000). Increased feeding frequency during COVID-19 restrictions may have increased weight gain in fish (e.g., *Pterophyllum scalare*) (Kasiri et al., 2011), and to some extent, may have compensated for decreased growth in fish consuming vegetables.

In the present study, analysis of mortality and disease data revealed that mortality was more common among newly purchased animals. This result was probably due to the 'new tank syndrome', i.e., the incomplete establishment of filtration in aquari-

ums (Roberts and Palmeiro, 2008), since the ratio of beginners reporting new fish mortalities was higher than the ratio of experienced respondents (13% versus 6%). On the other hand, knockdown-related interruptions in pet supply chains and improper maintenance by pet shops may also cause increased mortality rates in obtained pets like dogs and cats (Applebaum et al., 2020). No mass mortalities were observed by the respondents; hence the reported problems associated with bacterial disease seemed not to be highly infectious.

Increased demands on aquarium fish during the COVID-19 stay-at-home restrictions may raise concerns about invasive fish species (Padilla and Williams, 2004). A previous study indicated that only 2% of home aquarium owners tend to release unwanted animals into the wild, and 16% would dispose of them in the garbage (Marson et al., 2009). The results of the present survey indicated nearly the same ratios for the cases of releasing into the wild and lower ratios for garbage/compost releasing. According to Kidd and Kidd (1999), fish can act as family pets, decorations and companion animals for home aquarium owners. Maintenance, disease and mortality, equipment setup and cleaning and algae are the main problems with home aquariums, which can be addressed by patience and giving time to aquariums to get balanced, spending more time and money, and increasing owner responsibility (Kidd and Kidd, 1999).

In conclusion, this study provides an international survey of aquarium keepers assessing their attitudes towards home aquariums during the COVID-19 pandemic. Although the survey provides valuable information for further studies, part of the results should be interpreted with care. Firstly, the USA-based respondents were over-represented in the survey, partially due to the fact that the discordapp.com traffic mostly comes from the visitors based in the USA (Anonymous, 2021). Secondly, the study did not include survey questions to retrieve information on the measurement of specific water quality parameters (e.g. ammonia, nitrite, pH). This keeps the questions very accessible for beginning aquarium owners, who might not possess all the necessary equipment to measure detailed water quality parameters. Instead, the participants were interrogated about regular checking of water quality parameters in their aquarium(s) and might have interpreted this differently, depending on the individual; it can hence be questioned whether diseases (as interpreted by the participants) were perhaps due to a deteriorated water quality or not (according to the replies received). Lastly, the respondents' reports on the incidence of different types of disease may not be as reliable as the reports by a professional veterinarian, as the exact determination of the disease agent may be difficult without appropriate clinical examinations and water quality parameter check-ups. Nonetheless, the authors believe the present study demonstrates that pet owners get strongly attached to companion animals in stressful conditions.

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