Export volume trends and the conservation status of commonly targeted ornamental fishes from Malawi

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Abstract The export of ornamental fishes from Malawi has received limited attention regarding its sustainability or the conservation status of any threatened species involved in this trade. To identify any species that require specific management actions, we used a negative binomial regression model to examine the relationship between the number of exported fish and year of export, adjusted for fish prices and the number of fish exporters. We also examined the correlation between export volume trends and the conservation status of fish species. We identified three groups of fish species based on their export volume trends: species with no trends, with decreasing trends and with increasing trends. There was no significant correlation between export volume trends and the conservation status of fish species. The export volume trends of individual species appear to be related to the number of exporters, price and, potentially, anthropogenic factors affecting fish populations. Based on our findings we recommend the inclusion of ornamental fishery management issues in a revised Fisheries and Aquaculture Policy. This should include strategies to control overexploitation of species with declining export volume trends, and conservation of threatened species and a ban on their export. We recommend further research to establish the population status of the exploited fish species and to identify any other factors linked to the volume trends of ornamental fish exports.

Keywords Export trends, IUCN conservation status, Lake Malawi, Malawi, negative binomial regression, ornamental fish species, threatened fish species

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Introduction

The global ornamental fish trade is a multibillion-dollar industry involving > 125 countries, with > 2,500 species traded, 60% of which are from freshwater (Dey, 2016). One major challenge of managing the ornamental fish trade is the difficulty of quantifying fish populations because of limited application of conventional fish stock assessment approaches for ornamental fisheries (Dee et al., 2014; Fujita et al., 2014; Leal et al., 2016). In addition, most global ornamental fish production statistics are based on inaccurate historical estimates of the value of exports (Watson & Roberts, 2015; Biondo & Burki, 2020). These challenges affect both freshwater and marine ornamental fisheries, and therefore it can be difficult to conserve and manage ornamental fish species effectively (Monteiro-Neto et al., 2003; Maceda-Veiga et al., 2016; Evers et al., 2019).

The export of ornamental fishes from Malawi, which affects > 700 wild taxa, predominantly cichlid fishes (Msukwa, 2020; Msukwa et al., 2021, 2022), also faces some of these management challenges. This trade started operating in Malawi in the early 1970s, and since then the number of licensed fish exporters has fluctuated between one and four. All four current exporters are based in Salima District, a lakeshore district in the Central Region (nearly all ornamental fish exported are from Lake Malawi, with only a small per cent from the inlet and outlet streams and rivers of the lake; Msukwa et al., 2022). The exporters employ SCUBA diving teams to capture ornamental fishes using small nets. Individual exporters have close connections with their regular clients in importing countries and export fish based on the species and quantities specified by their clients. The exploited ornamental fish species have varying abundance and distribution patterns in Lake Malawi (Konings, 2016), and most are also targeted by commercial and artisanal fisheries for food, increasing their vulnerability to overexploitation (Msukwa et al., 2021, 2022). For every ornamental fish export consignment, the exporters submit details of the exported fish (including a species list, quantities exported and invoices specifying the selling price and total value of the consignment) to the Government of Malawi through the Department of Fisheries (Msukwa, 2020). However, the Department has never undertaken a detailed analysis of this information, nor used it for the management of the ornamental fishery.

Sayer et al. (2019) highlighted the need to devise a system for monitoring the collection and export of live ornamental fishes from Malawi to prevent the overcollection of popular species with restricted distribution ranges. Such a strategy could involve monitoring the exploited ornamental fish populations and/or the quantities of individual ornamental fish species exported, which could facilitate the identification of species that have been overexploited so that appropriate management actions can be taken. Msukwa et al. (2022) reported increasing volumes of ornamental fish exports during 2008–2019. In addition, ornamental fish

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exporters have reported that the fishes their clients demand are becoming scarcer and more difficult to catch (Msukwa, 2020; Msukwa et al., 2022). One unique characteristic of global ornamental fisheries is that exporters target both abundant and rare fish species (Rhyne et al., 2012b).

Here we examine export trends of individual ornamental fish species from Malawi, taking into account temporal variation in fish prices and the number of fish exporters. We also examine any potential correlation between export trends and the IUCN Red List status of the fishes (IUCN, 2024). We anticipate that our findings will provide insights into the status of the exploited ornamental fish species and be a guide for remedial action for species that show evidence of overexploitation. In addition, our findings could contribute to the development of an appropriate strategy for the management of the ornamental fishery in Malawi, which is not yet included in the Fisheries and Aquaculture Policy (Msukwa et al., 2022).

Methods

Data sources

From packing lists of species and quantities of ornamental fish export consignments from Malawi during 1998–2021, we extracted data on ornamental fish exports. Consignments are inspected and certified by the Department of Fisheries before export. One copy of the packing list for each consignment is submitted to the Department of Fisheries, and the other accompanies the consignment to the importing countries (Msukwa et al., 2021). We extracted data from the packing lists for > 700 species but analysed export trends only for the 135 most commonly exported species (i.e. those with > 500 specimens each exported during 1998–2021), with 113 described by their full scientific names and 22 only known by their informal trade names (Tables 1 & 2, Supplementary Table 1). The extracted data include the numbers exported by species, date of export, the unit price of each species and the number of licensed fish exporters in each year. We estimated the mean annual unit price for each fish species by dividing the total export value for all individuals of a particular species by the total number exported each year. We did this after converting the value of various export currencies into the USD equivalent using historical annual average currency exchange rates (OFX, 2024) and adjusting the USD values to purchasing power in 2021 using an inflation calculator (CoinNews, 2024). We based the total export value only on the price of fish, without the freight, insurance and other charges as some exporters did not provide this information in the export returns they submitted to the Department of Fisheries.

Compilation of species names and conservation status

The exporters of ornamental fish use either trade or scientific names (A.V. Msukwa, pers. obs., 2017). The exporters

Table 1 Ornamental fish species from Lake Malawi showing increasing export volume trends during 1998–2021, adjusted for the price of fish and the number of exporters, with the negative binomial regression model coefficients ± SE for year, price and number of exporters, and IUCN Red List status of assessed species (IUCN, 2024). The two species without a Red List status have not been fully scientifically named and are known only by their informal trade names.

Species	Intercept	Year	Price	Number of exporters	Red List status[1]
Champsochromis caeruleus	−215.800 ± 83.320**	0.108 ± 0.042**	0.007 ± 0.010	0.670 ± 0.215**	LC
Chiloglanis neumanni	−416.467 ± 133.895**	0.207 ± 0.067**	0.845 ± 0.139***	0.505 ± 0.350	DD
Chilotilapia rhoadesii	−197.500 ± 86.390*	0.099 ± 0.043*	0.007 ± 0.058	0.542 ± 0.257*	LC
Chindongo minutus	−334.313 ± 117.878**	0.167 ± 0.058**	0.337 ± 0.135*	−0.327 ± 0.240	LC
Copadichromis geertsi	−345.628 ± 42.896***	0.173 ± 0.021***	0.082 ± 0.012***	−0.247 ± 0.092**	LC
Cynotilapia aurifrons	−286.586 ± 149.035	0.146 ± 0.075*	−0.363 ± 0.280	−0.420 ± 0.352	LC
Labeotropheus trewavasae	−188.941 ± 45.729***	0.097 ± 0.023***	−0.050 ± 0.046	0.130 ± 0.155	LC
Lethrinops sp. 'yellow collar'	−279.502 ± 103.877**	0.142 ± 0.052**	−0.084 ± 0.060	−0.429 ± 0.265	
Metriaclima fainzilberi	−194.000 ± 90.680*	0.099 ± 0.045*	−0.004 ± 0.242	−0.151 ± 0.306	LC
Metriaclima koningsi	−361.300 ± 81.830***	0.182 ± 0.041***	−0.006 ± 0.041	−0.237 ± 0.196	CR
Metriaclima sp. 'elongatus chailosi'	−252.511 ± 102.186*	0.127 ± 0.051*	0.497 ± 0.202*	−0.120 ± 0.220	
Petrotilapia tridentiger	−325.344 ± 127.532*	0.164 ± 0.063**	0.197 ± 0.107	−0.542 ± 0.325	LC
Placidochromis milomo	−227.506 ± 74.679**	0.114 ± 0.037**	0.050 ± 0.031	0.335 ± 0.253	LC
Pseudotropheus perspicax	−343.266 ± 158.767*	0.171 ± 0.079*	0.248 ± 0.107*	0.403 ± 0.371	LC
Tramitichromis lituris	−178.678 ± 61.618**	0.091 ± 0.031**	−0.017 ± 0.045	−0.085 ± 0.178	LC
Trematocranus placodon	−155.100 ± 40.740***	0.079 ± 0.020***	−0.002 ± 0.024	0.252 ± 0.114*	LC

*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$.

[1]DD, Data Deficient; LC, Least Concern; CR, Critically Endangered.

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TABLE 2 Ornamental fish species from Lake Malawi showing decreasing export volume trends during 1998–2021, adjusted for the price of fish and the number of fish exporters, with the negative binomial regression model coefficients ± SE for year, price and number of exporters, and IUCN Red List status of assessed species (IUCN, 2024). The three species without a Red List status have not been fully scientifically named and are known only by their informal trade names.

Species	Intercept	Year	Price	Number of exporters	Red List status
Aulonocara saulosi	257.865 ± 119.183*	−0.124 ± 0.059*	−0.373 ± 0.117**	0.034 ± 0.296	LC
Aulonocara sp. 'yellow collar'	433.216 ± 117.086***	−0.214 ± 0.058***	0.009 ± 0.087	0.345 ± 0.337	
Aulonocara stuartgranti	191.628 ± 62.683**	−0.092 ± 0.031**	−0.126 ± 0.095	0.351 ± 0.151*	LC
Copadichromis melas	211.347 ± 67.336**	−0.105 ± 0.034**	0.089 ± 0.033**	0.874 ± 0.234***	LC
Copadichromis quadrimaculatus	229.147 ± 114.277*	−0.113 ± 0.057*	−0.028 ± 0.077	0.514 ± 0.395	LC
Dimidiochromis kiwinge	336.800 ± 147.058*	−0.165 ± 0.073*	−0.089 ± 0.034**	0.064 ± 0.314	LC
Labidochromis freibergi	292.320 ± 80.808***	−0.144 ± 0.041***	0.080 ± 0.109	−0.031 ± 0.268	LC
Labidochromis joanjohnsonae	419.116 ± 76.170***	−0.207 ± 0.038***	0.106 ± 0.141	0.588 ± 0.217**	NT
Melanochromis auratus	262.602 ± 78.836***	−0.128 ± 0.040**	0.154 ± 0.163	0.430 ± 0.179*	LC
Melanochromis chipokae	279.670 ± 75.982***	−0.137 ± 0.038***	0.045 ± 0.080	0.184 ± 0.253	CR
Metriaclima barlowi	190.095 ± 55.645***	−0.093 ± 0.028***	0.188 ± 0.238	0.553 ± 0.207**	LC
Metriaclima callainos	162.889 ± 59.725**	−0.078 ± 0.030**	0.095 ± 0.109	0.165 ± 0.172	LC
Metriaclima sp. 'lime'	156.086 ± 64.794*	−0.074 ± 0.033*	−0.242 ± 0.065***	−0.380 ± 0.329	
Pseudotropheus cyaneorhabdos	254.646 ± 102.345*	−0.124 ± 0.051*	−0.089 ± 0.054	0.344 ± 0.237	CR
Pseudotropheus johannii	210.326 ± 66.951**	−0.103 ± 0.034**	0.450 ± 0.235	0.284 ± 0.231	LC
Pseudotropheus sp. 'elongatus ornatus'	219.717 ± 82.241**	−0.108 ± 0.041**	0.042 ± 0.099	0.463 ± 0.277	

*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001.

[1]NT, Near Threatened; LC, Least Concern; CR, Critically Endangered.

and the SCUBA divers employed to catch the fish are experienced in identification, having handled the same species for many years (A.V. Msukwa, pers. obs., 2018). Moreover, owners of two of the exporting companies formerly worked for the first established export company before establishing their own ornamental fish export companies (D. Nkhwazi, pers. comm., 2018), and most of the SCUBA divers commonly move between exporters (H. Ngwira, pers. comm., 2018). We validated the scientific names of the exported fish species using Konings (2016, pp. 422–431), which provides detailed information of both the trade and scientific names of the fish species of Lake Malawi. We extracted information on the conservation status of the fish species from the IUCN Red List of Threatened Species (IUCN, 2024).

Data analysis

Export trends We first employed a Poisson regression to model the fish export trend data for each fish species by fitting the number of exported ornamental fish as a response variable and year as an explanatory variable, with price and the number of exporters as covariates. We considered this model appropriate because ornamental fish export data involved counts that cannot have a negative value, have increasing variance as the mean increases and have errors that are not normally distributed (Crawley, 2007). However, the overdispersion parameter of the Poisson regression was > 1, and therefore we used a negative binomial regression model instead to fit the relationship between the number of exported ornamental fish of each species as a response variable and year of fish export as an explanatory variable, adjusting for average price of fish and number of exporters each year. We fitted the negative binomial regression model using the *glm.nb* function in the package *MASS* (Venables & Ripley, 2002) in *R 4.3.1* (R Core Team, 2023).

Correlation between export trends and conservation status We coded the conservation status and export trend values for the 111 fully named ornamental fish species in an ordinal scale to determine their relationship using Kendall's rank correlation tau, in *R*. We excluded two of the 113 fully named species (*Chiloglanis neumanni* and *Copadichromis mloto*) from this analysis because they are categorized as Data Deficient on the IUCN Red List. The conservation status codes were 1 for species of Least Concern, 2 for Near Threatened species and 3 for threatened species (i.e. categorized as Vulnerable, Endangered or Critically Endangered). The export trend codes were −1 for decreasing, 0 for no trend and 1 for increasing. We used Kendall's rank correlation because, in addition to offering a distribution-free test of independence and a measure of the strength of dependence between two variables, it is easier to interpret than Spearman's correlation (Dalgaard, 2008). We determined the significance of the Kendall's rank correlation analysis at an α level of 0.05.

Results

Export trends

Using the negative binomial regression model, we identified three export trends for the 135 fish species: increasing export volumes (Table 1), decreasing export volumes (Table 2) and no apparent export volume trend (Supplementary Table 1). Export price and the number of exporters significantly affected the annual export volumes of some of the fish species.

Species with increasing export volume trends Sixteen species of 14 genera had significant increasing export volume trends (Table 1), with all but one genus (*Chiloglanis*, family Mochokidae) of the Cichlidae family. Three of these genera (*Copadichromis*, *Metriaclima* and *Pseudotropheus*) were represented in all three export volume trend types (Tables 1 & 2, Supplementary Table 1), and five genera (*Chilotilapia*, *Chindongo*, *Cynotilapia*, *Labeotropheus* and *Placidochromis*) were also common in the group with no apparent export volume trends. Fourteen of the species with increasing export volume trends are fully named, and two only have trade names (Table 1). Of the fully named species, *Metriaclima koningsi* is Critically Endangered, *Chiloglanis neumanni* is Data Deficient and the others are Least Concern (IUCN, 2024). Export volumes of five of the species in this group were positively influenced by fish prices, and export volumes of three and one fish species were positively and negatively influenced, respectively, by the number of exporters (Table 1).

Species with decreasing export volume trends Sixteen species of seven genera (*Aulonocara*, *Copadichromis*, *Dimidiochromis*, *Labidochromis*, *Melanochromis*, *Metriaclima* and *Pseudotropheus*, all of the family Cichlidae) had significant decreasing export volume trends (Table 2). Four of the genera (*Aulonocara*, *Dimidiochromis*, *Labidochromis* and *Melanochromis*) were also common in the group with no apparent export volume trends (Supplementary Table 1). Thirteen of these species are fully named, and three only have trade names (Table 2). Of the fully named species, two are Critically Endangered, one is Near Threatened and 10 are Least Concern (IUCN, 2024). Export volumes of one and three species in this group were positively and negatively influenced, respectively, by fish prices, and export volumes of five species were positively influenced by the number of exporters (Table 2).

Species with insignificant export volume trends One hundred and three species (86 fully named and 17 with only trade names) of 34 genera (32 of the family Cichlidae, *Synodontis* of the family Mochokidae and *Mastacembelus* of the family Mastacembelidae) did not have significant export trends (Supplementary Table 1). Of the fully named species, three are Critically Endangered, one Vulnerable, 10 Near Threatened and the others Least Concern (IUCN, 2024). Export volumes of eight and 16 species in this group were positively and negatively influenced, respectively, by fish prices, and 17 and two species were positively and negatively influenced, respectively, by the number of fish exporters (Supplementary Table 1).

Correlation between export trends and conservation status

Of the 111 fully named species, seven are categorized as threatened (six Critically Endangered, one Vulnerable), 11 as Near Threatened and 93 as Least Concern (Supplementary Table 1). Of the seven threatened species, two (29%) had decreasing export volume trends, one (14%) an increasing export volume trend and four (57%) no significant export volume trends. Of the 11 Near Threatened species, one (9%) had a decreasing export volume trend and 10 (91%) no significant export volume trend. Of the 93 Least Concern species, 10 (11%) had decreasing export volume trends, 12 (13%) increasing export volume trends and 71 (76%) no significant export volume trend (Fig. 1). Kendall's tau correlation analysis showed no statistically significant correlation between species conservation status and export trends (tau = −0.09848178, P = 0.2791).

Discussion

The objective of this study was to examine the export trends of ornamental fish species from Lake Malawi, taking into account the effect of the unit prices of the fish and the number of fish exporters, and to examine whether there was any association between export trends and the conservation status of the species. Such information can improve understanding of any overexploitation and be used as a

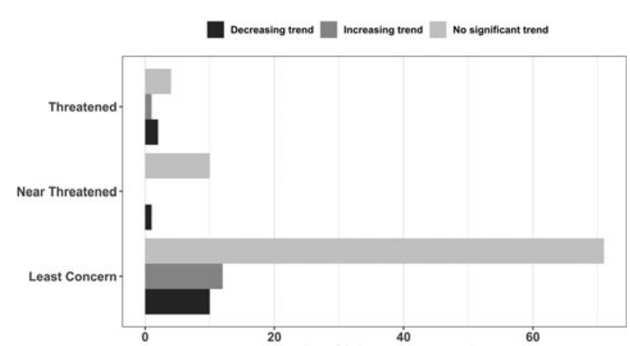

FIG. 1 The number of Lake Malawi ornamental fish species exported, by IUCN Red List status and export volume trend type (see text for details), during 1998–2021. Threatened species included species categorized as Vulnerable, Endangered and Critically Endangered (IUCN, 2024).

basis for instituting appropriate actions for conservation and sustainable exploitation.

Monitoring fish production trends is one of the recommended actions for sustainable management of ornamental fisheries (Rhyne et al., 2012a; Sayer et al., 2019; Biondo & Burki, 2020; Millington et al., 2022). Analysis of export/import trends of marine ornamental species has been used to monitor both exploitation and the challenges associated with supply (Rhyne et al., 2012a; Leal et al., 2016). Such trend analyses have also been used for marine capture fisheries landing data in relation to environmental and fishery variables (Zuur et al., 2003; Zuur & Pierce, 2004; Erzini, 2005), assessment of the status of the green sea turtle *Chelonia mydas* in New Caledonia (Fretey et al., 2023), analysis of the illegal harvest and trade of marine turtles (Lopes et al., 2022) and assessment of the population of the olive ridley sea turtle *Lepidochelys olivacea* in Guatemala (Morales-Mérida et al., 2023). Our analysis of trends in ornamental fish exports, adjusted for fish prices and number of exporters, shares many similarities with the monitoring of marine ornamental fish exports.

Although data presented previously (Msukwa et al., 2022) indicated an overall trend of increasing volumes of ornamental fish species exported from Malawi, we found no significant export volume trends for 103 of the 135 commonly exported fish species, an increasing trend for 16 species, and a decreasing trend for 16 species. The decreasing export volume trends for 16 species occurred despite an increase in the number of ornamental fish exporters, with 1–2 exporters during 1998–2009 and 3–4 exporters during 2010–2021 (except in 2011, when there was only one exporter; Msukwa et al., 2022), potentially indicating unsustainable collection and consequent declines in the populations of these species.

Inclusion of fish export prices and the number of fish exporters as covariates in the negative binomial regression model indicated how these contributed to the significance of the export volume trends of the individual species. Of the 33 species for which there was a significant relationship between export volumes and price, 14 (42%) and 19 (58%) were positively and negatively influenced, respectively. Of the 28 fish species for which there was a significant relationship between export volumes and the number of exporters, 25 (89%) and three (11%) were positively and negatively influenced, respectively, by the number of exporters. The positive relationship between fish export volumes and the numbers of exporters for some species is consistent with the linkages between specific individual exporters and the importers of ornamental fish from Malawi (Msukwa et al., 2022). These linkages are strong, and most importers would rather not import fish for a while than switch to a different exporter if they fail to renew their export licence (D. Nkhwazi, pers. comm., 2018).

Although increases in fish prices were mostly associated with a decrease in export volumes, there were positive relationships between price and export volume for some fish species. These findings could reflect two potential situations. Firstly, there could be other factors influencing fish export volumes that were not accounted for by the negative binomial regression model. Secondly, ornamental fish species in high demand, in particular newly discovered or rare species, could command higher prices compared to other species (Biondo, 2017; Msukwa et al., 2022). Courchamp et al. (2006) demonstrated how the rarity of exploited species can cause an increase in both demand and price, resulting in their exploitation remaining profitable and potentially driving species to extinction. The influence of the rarity of individual species on price has previously been hypothesized in the trade of coral reef species (Rhyne et al., 2012a). As the value of the rare ornamental fish species of Lake Malawi increases, exporters may devote more time and resources to catching these species. This is evident for some exporters in Malawi, who pay bonuses to their fishers when they catch rare species (Msukwa, 2020). In addition, most of the ornamental fish species of Malawi have limited distribution patterns within small, rocky outcrops (Ribbink et al., 1983; Reinthal, 1993; Konings, 2016), which makes them easy to catch even at low densities. However, the extent to which rarity influences the export prices of the Lake Malawi ornamental fish species cannot be determined without data on the abundance of these species. Ribbink et al. (1983) conducted a comprehensive baseline study of the distribution and abundance of the rock-dwelling cichlid fishes of Lake Malawi, but although the study provided insights into the rarity of individual species, most of the information is now out of date because of subsequent taxonomic changes such as the splitting of some genera and species, the merging of some species and the description of new species (Hanssens & Snoeks, 2003; Konings, 2016). In addition, the populations of the targeted species could also have changed over time because of other anthropogenic factors such as subsistence fishing, localized water pollution, sedimentation and habitat destruction (IUCN, 2024). This demonstrates the need for a comprehensive resurvey of the status of exploited ornamental fish species as a basis for the management of this fishery.

Contrary to our expectation, we found no significant correlation between export volume trends and the conservation status of these ornamental fish species, suggesting that export volume trends alone are not a reflection of the population status of these fish species. All three export volume trend groups included threatened species. Exploitation of these threatened ornamental fish species, irrespective of their export trend, is a significant conservation concern (Raghavan et al., 2013). In addition to the 113 named fish species, 22 species known only by their trade names are also being exported and are represented within all three export

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trend groups. These species are potentially vulnerable to overexploitation and need to be fully named, to facilitate monitoring.

To ensure sustainability of the ornamental fishery of Lake Malawi, the Government of Malawi needs to incorporate aspects of ornamental fishery management when revising the Fisheries and Aquaculture Policy, which expired in 2021. The revised Policy should include strategies and measures such as encouragement of the preferential exploitation of ornamental fish species of Least Concern that have either increasing or no significant export volume trends, action to control overexploitation of the species with declining export trends, and a ban on the export of threatened ornamental species. Such a ban could be implemented both internationally and nationally. All threatened species should be included in the appendices of CITES, which regulates the international trade of species. Currently, none of the ornamental fish species exported from Malawi are included in the CITES appendices (CITES, 2024). Nationally, export bans could be enforced by the Department of Fisheries, which is responsible for the inspection and clearance of export consignments (Msukwa et al., 2022). To be effective, such a ban would require training of Fisheries Department staff in the identification of exported fish species. Additionally, a clause could be included in the Fisheries and Aquaculture Policy to allow the export of threatened species only if they have been propagated in aquaculture facilities. This could reduce pressures on threatened wild ornamental fish stocks (Brummett, 2005), increase employment and encourage the production of new strains of ornamental fish species by selective breeding (Teletchea, 2016). There is a general concern that breeding ornamental fish only benefits developed countries with the infrastructure to support aquaculture operations, at the expense of the countries from which the wild fish are sourced (Watson, 2000; Wood, 2001; Tlusty, 2002) and with captive rearing away from the exporting country resulting in negative economic impacts for that country (Gerstner et al., 2006).

Finally, we recommend further research to establish the current status of the populations of the exploited ornamental fish species of Malawi and to identify any other factors that influence the observed export trends of individual ornamental fish species. Information from such research would be valuable for the development of suitable strategies for managing this ornamental fishery sustainably.

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Author contributions Development of research concept, design of data collection tools: AVM; data collection and analysis, writing: both authors.

Conflicts of interest None.

Ethical standards This research was approved by the University of Hull (UK) Ethical Clearance Committee (SES Code 146 and Dept. Code H 79) and the Department of Fisheries in Malawi (Ref. No. 20/1/21, dated 13 September 2018). It did not involve working with live specimens of fish or human subjects, and abided by the *Oryx* guidelines on ethical standards.

Data availability A summary of the data used is provided in the Supplementary Material, without details that could lead to the identification of individual fish exporters, for ethical reasons.

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