A CONSERVATION ACTION PLAN FOR CHINESE GIANT SALAMANDERS

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ASG IUCN SSC Amphibian Specialist Group

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OPCF Hong Kong 香港海洋公園保育基金 Ocean Park Conservation Foundation Hong Kong

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FOREWORD

The Chinese giant salamander (*Andrias davidianus*) belongs to the Family Cryptobrachidae in the Order Caudata of the Class Amphibia, it is endemic to China and commonly known as "wawa yü" in China. They are called "living fossils" since their body structure has undergone no distinct changes in over 160 million years. The Chinese giant salamander plays the role of a top predator in the freshwater ecosystem because it sits at the top of the food chain, and therefore has important top-down effects on the ecosystem and maintains the stability and balance of the ecosystem. Meanwhile, the Chinese giant salamander is a state protected animal (grade II); in 1995, it was included on CITES appendix I; it is the Critically Endangered species (CR) in the Red Book of Endangered Animals in 1998, and the Red List of Vertebrates in 2016 and 2021. Therefore, the Chinese giant salamander is a flagship for amphibian conservation.

The Chinese giant salamander is strongly affected by multiple factors, including habitat destruction, climate change, over exploration, pathogens, environmental contamination and low genetic diversity. There are small populations in the field, but high abundance in the hatchery. The creation of natural reserves and reintroduction are the two main approaches to protect them. However, the effectiveness of these approaches is not so obvious, so we need improve our actions. Of which, greater collaboration between the different stakeholders is critically important. First, there is a need to carry out further surveys of populations in the field and those held on farms to know the status of these populations. This is the key basic work to support the protection of the Chinese giant salamander. The second is to understand the genetic relationships between populations and identify their lineages. The Chinese giant salamander is now known to be comprised of seven different lineages, and some of them have been described as new species, including *A. sligoi*, *A. jiangxiensis*, and *A. cheni*. Where each of these occur in nature needs to be clarified. Apparently, different lineages need be conserved separately. The third is to strengthen the protection of wild populations and standardize the artificial breeding work in farms and conservation breeding. For this to occur, we need the creation of mechanisms to facilitate the appropriate release of giant salamanders acknowledging that there are recommendations in place but no complete guidance on implementation.

I hope and believe that the new action plan will improve the effects of work to protect the Chinese giant salamanders.

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August 4, 2024
In Chengdu

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1. INTRODUCTION

Chinese giant salamanders (*Andrias* spp.) are the world's largest amphibians. These salamanders are economically important and are extensively farmed in China for their meat. Whilst Chinese giant salamanders were consumed historically across China, a large-scale farming industry was established in the early 2000s and giant salamanders were collected from the wild to stock these farms. Populations of Chinese giant salamanders have declined across China, and these declines have primarily been driven by overexploitation as well as habitat loss and degradation. Giant salamanders in China were once considered to be a single widespread species (*Andrias davidianus*) but genetic analyses have revealed that there are multiple species (likely at least seven) and that populations across central, eastern and southern China represent genetically distinct, local populations. Currently four species are formally named and recognised by the scientific community, and it is likely more will be described in future. China's government has supported releases of farmed giant salamander as a conservation measure, but this has resulted in the release of non-native giant salamanders across China and there is a risk that wild populations could hybridise with released non-native species. An urgent, large scale conservation response is required if Chinese giant salamanders are to persist in the wild, and this will require a collaborative and coordinated strategy with all stakeholders.

Figure 1. A Chinese giant salamander in captivity in Europe, rescued from the illegal wildlife trade © Benjamin Tapley / ZSL

2.1 Overview of species

2.1.1 Taxonomic background

The Chinese giant salamander has traditionally been interpreted as a single geographically wide-ranging species that occurred across multiple river basins and montane ecoregions. In 1924 a second species of Chinese giant salamander was described (*Megalobatrachus sligoi*, Boulenger 1924) based on a single specimen that was found in the Hong Kong Botanic Gardens. It is thought that this specimen was likely brought to Hong Kong from the nearby Chinese mainland (Liu, 1950). This species was subsequently synonymised with *A. davidianus* with little justification (Thorn, 1968).

Several studies utilising molecular tools have explored the population structuring of Chinese *Andrias* (Murphy et al. 2000; Tao et al. 2005; Wang et al. 2017; Yan et al., 2018; Liang et al., 2019; Turvey et al., 2019; Chai et al., 2022; Marr et al, In Press). Studies conducted by Murphy et al. (2000), Tao et al. (2005) and Wang et al. (2017) all concluded that populations of *Andrias* across southern, eastern and central China represent local populations that are genetically distinct from one another. A more comprehensive study using mitochondrial DNA (mtDNA) and single nucleotide polymorphisms (SNPs) from both wild and farmed salamanders found compelling evidence for the existence of five to seven distinct species-level clades, some of which were only known from individuals sampled on giant salamander breeding farms (Yan et al., 2018). These clades were not consistently associated with specific geographical regions due to the human-mediated transport and release of giant salamanders across China (Yan et al., 2018). A subsequent study that utilised additional mtDNA data recovered the same seven clades and was able to associate these with specific geographical locations, demonstrating that different clades had largely discrete distributions that were associated with different watersheds and ecoregions (Liang et al., 2019). Most recently, species delimitation analyses using tree-based and alignment-based models using 30 mitogenomes found support for at least seven statistically-resolved Chinese species-level clades and most models provided support for nine species-level clades (Marr et al., In Press).

Table 1. Overview of how different studies have referred to species level clades

Species	Clade according to Yan et al. (2018)	Clade according to Liang et al. (2019)
Andrias cheni	E	E
Andrias davidianus	B	G
Andrias jiangxiensis	U2	D
Andrias sligoi	D	B
Not currently named	A	A
Not currently named	C	F
Not currently named	U1	C

Attempts have been made to draw taxonomic conclusions from these and additional data. Turvey et al. (2019) used near-complete mitogenomes from historical museum specimens that were collected prior to the establishment of the large-scale farming industry and human-mediated movement of different *Andrias* clades between watersheds and ecoregions. In this study, the authors were able to associate the specimen that had been described as *Megalobatrachus sligoi* by Boulenger (1924) with one of the clades identified by both Yan et al. (2018) and Liang et al. (2019), and thus resurrected *A. sligoi* as a valid species. In 2022

Andrias jiangxiensis was described from wild specimens collected from within a protected area in northwest Jiangxi Province (Chai et al., 2022). Most recently, *Andrias cheni* was described from Huangshan, Anhui Province (Xu et al., 2023). Both *Andrias jiangxiensis* and *Andrias cheni* can be assigned to clades reported by Yan et al. (2018) and Liang et al. (2019). It is likely that further clades will be described as species new to science in the future.

Figure 2. The holotype of *Andrias sligoi* (after Turvey et al., 2019)

2.1.2 General biology

Chinese giant salamanders are the largest extant amphibians, growing to almost 2 m in total length, and can weigh more than 50 kg (Wang et al., 2004). All *Andrias* species have large, broad flattened heads and small lidless eyes, flattened bodies with obvious longitudinal folds, sturdy limbs, and a large compressed tail. They are extremely variable in colouration from black to dark red to numerous shades of brown, often with blotches (Sparreboom, 2004). Colour morphs are also reported from farms.

Figure 3. A Chinese giant salamander encountered during ecological surveys in Shaanxi Province © Benjamin Tapley / ZSL.

Due to recent taxonomic changes and limitations associated with small sample sizes, it is difficult to summarise the key morphological differences between all described and undescribed *Andrias* species. Only a limited number of specimens of known provenance can be reliably associated with the clade that corresponds to *A. davidianus*, and *A. sligoi* was described and subsequently resurrected based on a single museum specimen. In their revision of *A. sligoi* as a valid species, Turvey et al. (2019) therefore refrained from describing diagnostic morphological characters for either species based on such a small sample size. The largest published account of a giant salamander is an individual that measured five feet and nine inches in length.

Andrias jiangxiensis is reported to differ from other *Andrias* species by the combination of the following characters: 1) head length almost equal to head width; (2) head and lower jaw relatively smooth, with

small tubercles arranged irregularly; (3) lateral neck fold discontinuous with body fold at forelimb insertion; (4) finger III distinctly longer than finger I; and (5) dorsum red-brown or yellow-brown in life, with large, irregular black patches (Chai et al., 2022). The type series consists of animals with total lengths ranging from 55.4-58.9 cm, but larger individuals up to 85 cm length were observed at the collection site (Chai et al., 2022).

Andrias cheni is reported to differ from other *Andrias* species by the combination of the following characters: 1) head and torso flat, head slightly longer than wide, and head width / head length ratio 0.80-0.98; (2) head and lower jaw relatively smooth, with small tubercles arranged irregularly; (3) lateral neck fold discontinuous with body fold at forelimb insertion; (4) finger III longer than finger I, finger lengths formula I < IV < III < II; (5) limbs are thick and short, with hind limbs longer than forelimbs, and forelimb length /posterior limb length ratio 0.78-0.96; (6) muscular tail, thick at base and gradually flattening posteriorly and distally, with tail length about 1/3 of total length (Xu et al., 2023). The type series includes one specimen (the holotype) that has a total length of 97.4 cm (Xu et al., 2023).

2.1.3 Breeding behaviour

Note that the following information is not attributable to a specific Chinese *Andrias* species.

Figure 4. Chinese giant salamander larvae from a farm in Guizhou Province © Benjamin Tapley / ZSL

Chinese giant salamanders are thought to be sexually mature at 5-6 years of age (Cheng, 1998, Browne et al., 2014). The reproduction cycle is seasonal, and gonad maturation occurs from spring to summer when water temperatures increase, food is more abundant and water flow decreases (Zhang et al., 2006; Browne et al., 2014). Chinese giant salamanders breed via external fertilisation in the aquatic environment, and spawning occurs in late summer in August and September (Zhang et al., 2006; Browne et al., 2014). They typically spawn in dens under large rocks or cavities in the banks of streams and subterranean caves, with dens typically having a single entrance (Wang et al., 2004; Luo et al., 2018; Liang et al., 2019). Male Chinese giant salamanders prepare the nesting sites by clearing away sand and are known to court females. Once a female enters a den, behaviours include head exposing, nest inspection, trailing, cloacal scenting, mouth contact and mounting the female's back (Wu et al., 2010; Browne et al., 2014; Luo et al., 2018). Males will mate with more than one female in a single den and clutches can exhibit multiple paternities but are guarded by and attended by a dominant male known as a den master (Browne

et al., 2014). Eggs are 5-8mm when laid and increase to 15-20 mm when fully hydrated (Cheng, 1998, Browne et al., 2014) and clutch size ranges from 300-560 eggs (Ge & Zheng 1994; Xiao et al., 2006; Liu et al., 1999; Browne et al., 2014). Eggs are guarded by the male, and during brooding the male stops feeding (Wu et al., 2010; Browne et al., 2014). Brooding and larval development occur until early winter and the larvae hatch at 3.0 cm in length (Ge and Zheng 1990). Larvae remain in the den until the coldest period of winter is over and yolk sacs have been absorbed, at which point they leave the den (Wu et al., 2010; Browne et al., 2014). Larvae retain external gills until they are 20 cm in length or approximately three years old in the wild (Ge & Zheng 1994). Chinese giant salamanders have been known to survive for over 55 years (Ye et al., 1993). Generation length is estimated to be 15 years (Liang et al., 2012).

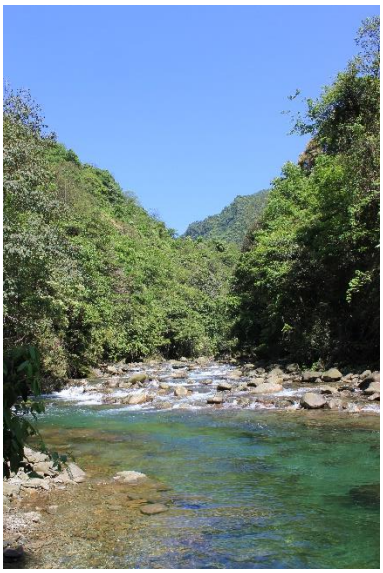
2.1.4 Diet and ecological role

Chinese giant salamanders are apex predators of stream and river environments (Song, 1994). Although the diet of wild Chinese giant salamanders is poorly known, they have been documented to consume crabs, shrimp, frogs, fish, invertebrates, snakes, waterbirds and water shrews (Hu, 1987; Song, 1994; Luo and Kang; 2009). Chinese giant salamanders are also known to be cannibalistic (Song, 1994).

2.1.5 Habitat requirements and resource assessment

Chinese giant salamanders are aquatic, and are known to inhabit clear, cool, slow to swift-flowing streams in well-vegetated, typically steep-sided valleys (Wang et al., 2004; Chen et al., 2018). Many remaining populations are associated with cave systems, often in karst landscapes (Wang et al., 2017; Liang et al., 2019). Streams inhabited by Chinese giant salamanders have caves and rocky banks and a pH of 6-7 (Wang et al., 2004; Chen et al., 2018; Tapley et al., 2021). A study at a single site on released Chinese giant salamanders found that male salamanders exhibited a preference to deep microhabitats with low alkalinity whereas females preferred microhabitats with high water conductivity, low dissolved oxygen and ammonium-nitrogen, and slow water movement (Zhao et al., 2023). Juveniles occupied microhabitats that had low ammonium-nitrogen (Zhao et al., 2023). Forest cover and nitrates are other known predictors of cryptobranchid salamander distribution in the USA (Pugh et al., 2016; Jachowski and Hopkins, 2018), but it is not known how important these parameters are for Chinese giant salamanders. Rocky cryptobranchid microhabitats are detrimentally impacted by siltation in the USA (Fobes, 1995) but the impact of siltation on Chinese giant salamanders has not been quantified.

Chen et al. (2018) developed a habitat suitability model using elevation (190–1,330 m a.s.l.), forest cover, mean annual precipitation (≥732.6 mm mean annual precipitation) and mean annual temperature (12.7–16.8°C mean annual temperature), which was broadly congruent with the estimated historical IUCN range map for *Andrias davidianus* (Liang et al., 2004).




Figures 5 & 6. Chinese giant salamander habitat, Fanjingshan, Guizhou Province © Benjamin Tapley / ZSL.

Table 2. Mean (and range) for water and environmental parameters collected at sites where live Chinese giant salamanders were collected during ecological surveys (after Tapley et al., 2021).

Variable	Mean (range)
Altitude (m)	923 (716–1,076)
Water temp. (°C)	18.7 (14.2–20.9)
Dissolved O_2 (mg/l)	8.04 (7.50–8.68)
Salinity (ppt)	0.03 (0.00–0.09)
pH	7.53 (6.46–7.94)
Ammonia (ppm)	0.125 (0.00–2.00)
Nitrite (ppm)	0.40 (0.0–2.0)
Nitrate (ppm)	1.8 (2.0–5.0)
dKH	2.83 (0.3–3.8)
Flow rate (m/sec)	0.54 (0.09–0.93)

2.2 Distribution, abundance and population trends

2.2.1 Historical and current distribution

The Chinese government has supported releases of farmed giant salamander as a conservation measure. This has resulted in the release of non-native giant salamanders across China and greatly confuses the interpretation of geographical range data for individual species (Turvey et al., 2018, 2019; Yan et al., 2018; Liang et al., 2019; Shu et al., 2021). In some cases, *Andrias* have been translocated outside of the genus' natural geographical range (Shu et al., 2021) and up to four different species-level clades have been detected at a single site (Shu et al., 2021).

Chinese *Andrias* are known to be invasive in Japan and readily hybridise with Japanese giant salamander (*Andrias japonicus*); mtDNA specific to Chinese *Andrias* has been detected in environmental DNA surveys

of Japanese rivers, and some individuals exhibit intermediate morphology between Japanese and Chinese species (Matsui et al., 2005; Fukumoto et al., 2015; Hara et al., 2023). Captive individuals of *A. sligoi* were recently discovered in Japan (Nishikawa et al., 2024) and *A. davidianus* has been found in rivers around Kyoto (Nishikawa et al., 2024). Clade U1 of Yan et al. (2018)/ Clade C of Liang et al. (2019) has also been found in a river in Komatsushima (Nishikawa et al., 2024). This indicates that the Chinese giant salamanders found in Japan have multiple origins. There are also unconfirmed records of the species in Taiwan, Province of China, but these have not been confirmed. However, Chinese giant salamanders that were due to be illegally exported to Taiwan have been confiscated in Fujian Province (IUCN SSC Amphibian Specialist Group, 2023b).

Andrias cheni (Clade E of Yan et al., 2018 / Clade E of Liang et al., 2019)
The description of *A. cheni* is based on individuals that were collected from Qimen County, Anhui Province prior to 1995 (Xu et al., 2023). This species is also reported from Xiuning, County, Anhui Province and Qingyuan County, Zhejiang Province (Liang et al., 2019).

Andrias davidianus (Clade B of Yan et al., 2018 / Clade G of Liang et al., 2019)
This species is only known to occur with certainty from Mabian Yi autonomous County, Meishan and Ya'an in Sichuan Province (Liang et al., 2019; Turvey et al., 2019).

Andrias jiangxiensis (Clade U2 of Yan et al., 2018; Clade D of Liang et al., 2019)
Currently this species is only known to occur with certainty in Jiulingshan National Nature Reserve, Jing'an County, Jiangxi Province (Chai et al., 2022). This species has been recorded from Jing'an County and Maoping township in Jiangxi Province, and Lianzhou in Guangdong Province (Liang et al. 2019).

Andrias sligoi (Clade D of Yan et al., 2018; Clade B of Liang et al., 2019)
Turvey et al. (2019) were unable to reliably associate this species with a specific region in China, but Liang et al. (2019) indicate that *A. sligoi* has been recorded from Chongqing Municipality and Guizhou and Hunan Provinces. The elevation range of this species is thought to be between 390–1,300 m asl (Liang et al. 2019).

Andrias "Guangxi Pearl River" (Clade A of Yan et al., 2018; Clade A of Liang et al., 2019)
Reported from Xing'an County, Guangxi Province (Liang et al., 2019).

Andrias "Gansu" (Clade C of Yan et al., 2018; Clade F of Liang et al., 2019)
Reported from Qinzhou County, Gansu Province (Liang et al., 2019).

Andrias "Hunan" (Clade U1 of Yan et al., 2018; Clade C of Liang et al., 2019)
Reported from Longhui County, Hunan Province (Liang et al., 2019).

Andrias "Qinghai"
In 1966, a giant salamander specimen was reportedly collected from the headwaters of the Yangtze River in Qumalai County, Qinghai Province, at an elevation of 4,200 m. If this record is correct, it could represent a disjunct isolated salamander population or species occurring at an elevation >2,000 m higher than any other known population (Chen, 2011; Fei et al., 2012; Pierson et al., 2014). The existence or continued survival of giant salamanders in Qinghai has not been confirmed in relatively recent small-scale survey efforts (Pierson et al., 2014), and the taxonomic status of this population remains uncertain.

2.2.2 Abundance and population trends

Chinese giant salamanders, even in areas of good-quality habitat have probably been declining since at least the 1980s due to local consumption and/or exploitation for trade (Turvey et al., 2021). A further escalation in the decline of wild populations in the early 2000s was driven by the development of the giant salamander farming industry, and populations declined due to extraction of wild animals across China to stock farms (Cunningham et al., 2016; Turvey et al., 2018). In some places, surviving populations may now be restricted to caves due to high levels of exploitation in accessible non-subterranean habitats (Liang et al., 2019). Conversely, millions of individuals exist in farms (Cunningham et al., 2016).

There is an inferred dramatic population decline of at least 80% across the range of Chinese giant salamanders. Interviews conducted with freshwater resource users from 2013-2016 recorded that 46.9% of over 2,900 people living within 1 km of the 97 field survey sites had seen a giant salamander in their lifetime, but across China, the mean time of last giant salamander sightings was 18.96 years earlier (Turvey et al., 2018). Only 24 salamander individuals were detected at just four sites during extensive ecological surveys conducted in 2013-2016. These surveys took place in suitable habitat (and often at sites with local historical records) across the known range of Chinese giant salamanders (Turvey et al., 2018). Evidence of electrofishing or the use of poison (known methods for harvesting giant salamanders) was observed at 25% of the study sites (Turvey et al., 2018; Tapley et al., 2021). Surveys for Chinese giant salamanders in Qinghai Province from June and July 2017 found no direct evidence of the species, although there were unverified reports of sightings by local people, the most recent dating from 2012 (Pierson et al., 2014).

Chinese giant salamander populations are severely fragmented, and more than 50% of populations are inferred to occur in patches with no natural dispersal between them (IUCN SSC, 2023a, b). Wild populations of Chinese giant salamanders are now critically depleted or extirpated across large areas of suitable habitat (Turvey et al., 2018; Xu et al., 2018; Tapley et al., 2021).

2.3 Threats, potential threats and limiting factors

2.3.1 Releases, hybridisation and disease

Since 2002, farmed Chinese giant salamanders have been released across China as part of a well-intentioned ongoing programme by Chinese national and provincial governments. The aim of this release programme is to restock wild populations. From 2002 to 2019 at least 287,840 farmed salamanders were released across China (Shu et al., 2021). However, these releases have not been informed by genetic screening, and the wide-scale transportation and release of giant salamanders across China has already resulted in the genetic homogenisation of some local populations (Yan et al., 2018) and introduction of non-native species with as many as four non-native species-level clades have been detected at some sites (Shu et al., 2021). At least 10% of Chinese giant salamander releases are thought to have occurred outside suitable habitat and some individuals have even been released in Beijing, more than 600km northeast of

native Chinese *Andrias* range (Shu et al., 2021). Hybrids between Chinese and Japanese giant salamanders are now invasive in parts of Japan (Fukumoto et al., 2015; Nishikawa et al., 2024). Given that *Andrias* spp. from China are more closely related to each other than *A. japonicus*, it is likely that different species of giant salamanders in China are able to hybridise. It is therefore likely that hybridisation with both described and undescribed congeners is a threat to this species. China's Aquatic Wildlife Conservation Association (CAWCA) has acknowledged that there are at least five species of giant salamanders in China and recommend that releases of giant salamanders from farms should be prohibited unless animals are genetically screened to confirm species identity. Unfortunately, there is no centralised mechanism in place to ensure that genetic screening is undertaken, that results are correctly interpreted, and appropriate release sites for each species are identified.

Figure 7. The corpse of a Chinese giant salamander found at a site where farmed animals had been recently released © Jay Redbond / ZSL

Ranavirus is known to cause disease in farmed Chinese giant salamanders (Geng et al., 2011; Cunningham et al., 2016). There is a risk that pathogens that cause disease in farmed giant salamanders could be inadvertently released with released salamanders, and this poses a threat to wild amphibians (Daszak et al., 2003; Cunningham et al., 2016). Disease is likely a low threat to Chinese giant salamanders in the wild, however it has been a historic driver for wild collection to repopulate farms depopulated by ranavirosis outbreaks (). Pathogens released with salamanders could cause disease in conspecifics or in different species present at release sites or even impact ecosystem processes, human health and livelihoods. The

International Union for the Conservation of Nature has published guidelines for reintroductions and other conservation translocations (IUCN SSC, 2013), which require that diseases are considered in any translocation or release.

Unfortunately, there is no current evidence that the widespread and deliberate releases of farmed individuals as a conservation measure have resulted in the establishment of viable populations (Shu et al., 2021). However, dead giant salamanders have been reported at release sites (Fig. 7; Turvey et al., 2018).

2.3.2 Overexploitation

The range-wide decline of giant salamanders across China has been attributed to overexploitation for various food markets (Wang et al., 2004; Feng et al., 2007; Dai et al., 2009; Cunningham et al., 2016; Turvey et al., 2018, 2021; IUCN SSC, 2023a,b), and to habitat loss and degradation resulting from anthropogenic modification of freshwater habitats, including pollutant emissions and alteration of flow regimes and water turbidity from damming (Wang et al., 2004; Dai et al., 2009).

Figure 8. A Chinese giant salamander (likely farm bred) being sold in a supermarket in Guiyang © Benjamin Tapley / ZSL

Figure 9. Electrofishing in Chinese giant salamander habitat © Thomas Brown / ZSL (left).
Figure 10. A bow hook targeting Chinese giant salamanders in a protected area in Guizhou Province © Benjamin Tapley / ZSL (right)

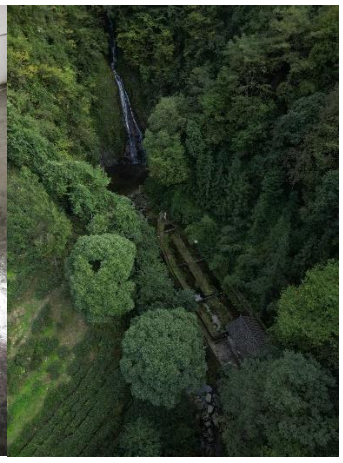


Figure 11. Industrial-style Chinese giant salamander farm in Gansu Province © Benjamin Tapley / ZSL (left)
Figure 12. Industrial-style Chinese giant salamander farm in Shaanxi Province © Benjamin Tapley / ZSL (middle)
Figure 13. A farm using "wild type" farming methods in Gansu Province © Chenhaojia Liu (right)

In recent years there have been several reported cases of illegal international trade in Chinese giant salamanders, and animals have been seized from the illegal wildlife trade in the United States of America, United Kingdom, Philippines, South Korea, Vietnam and Singapore.

Giant salamander populations in areas of good-quality habitat have probably been in decline from at least the 1980s, due to local consumption and/or exploitation for trade; this is several decades before the development of the Chinese giant salamander farming industry (Turvey et al., 2021). Overall, 15.4% of 2,932 respondents in rural communities had consumed giant salamanders, with dates of last consumption ranging from the 1940s to 2010 (Turvey et al. 2021). Since the farming industry was established there has been a major escalation in levels of exploitation (Turvey et al., 2018, 2021), including the illegal collection of wild giant salamanders to stock farms, which was still occurring as recently as 2016 (Cunningham et al., 2016; Turvey et al., 2021). A study on the Chinese giant salamander farming industry undertaken between 2013 and 2016 estimated that there were at least 42,000 wild-caught breeding adult giant salamanders and 164,000 wild-caught subadults in farms across China at the time of the survey (Turvey et al., 2021).

Interviews with both urban and rural user groups demonstrate wide-scale and largely unregulated illegal hunting to stock farms at a country-wide scale to support demand by urban consumers for high-prestige rare meat (Turvey et al., 2021). Evidence for hunting during the same survey was widespread, with bow hooks, electrofishing and evidence of poisoning observed across the range of the Chinese giant salamanders, even within protected areas (Turvey et al., 2018, 2021; Tapley et al., 2021).

2.3.3 Habitat loss and degradation

Habitat loss and fragmentation are highly likely to have a detrimental impact on remaining Chinese giant salamanders. The top five Chinese provinces for broad-scale deforestation are all within the range of Chinese giant salamanders (Ren et al., 2015), and giant salamanders are known to be associated with forest cover (Wang et al., 2004). Good-quality aquatic habitat for Chinese giant salamanders has declined across China in recent decades due to water development projects, pollution, industrialisation and urbanisation (Dai et al., 2009). Much of the surveyed habitat for salamanders in Qinghai Province was deemed unsuitable for giant salamanders due to turbidity resulting from mining and erosion (Pierson et al., 2014), and it is believed that *Andrias davidianus* has been extirpated from its type locality due to similar aquatic habitat degradation (Dai et al., 2009). However, Chinese giant salamanders do occur in approximately different protected areas. In some cases, these protected areas have been relatively effective at protecting wild populations (e.g. Chai et al., 2022).

2.3.4 Climate change

Chinese giant salamanders are vulnerable to the impacts of climate change. Species distribution modelling predicts that more than two thirds of currently predicted suitable habitat will be lost in all modelled climate change scenarios (Zhang et al., 2019). Furthermore, approximately 25% of existing national and provincial nature reserves that currently have suitable Chinese giant salamander habitat are thought to become unsuitable by 2050 due to the impact of climate change (Zhang et al., 2020). Climate change is also known to impact amphibian pathogen disease dynamics (e.g. Price et al., 2019). However, none of the studies on the potential impacts of climate change on Chinese giant salamanders have attempted to look at the impacts on individual Chinese giant salamander species.

2.4 Extinction risk

Currently, only *A. davidianus* and *A. sligoi* have been assessed by the IUCN (IUCN SSC Amphibian Specialist Group, 2023a, b). However, all described and putative species would likely qualify for being assessed as Critically Endangered, as data for all species other than *Andrias sligoi* were incorporated into the IUCN Red List assessment for *A. davidianus* due to the taxonomic uncertainty at the time the *Andrias* Red List workshop took place.

Andrias cheni	NOT EVALUATED	*"Listed as Critically Endangered because of an observed drastic population decline, estimated to be more than 80% over the last three generations (the generation length is estimated to be 15 years), due to a decline in the extent of occurrence and habitat quality, over-exploitation which has extirpated subpopulations from areas of remaining suitable habitat, and the possible effects of introduced pathogens and hybridisation from salamander farming operations. Despite the uncertainty surrounding its true distribution and further taxonomic work needing to be carried out, there are sufficient data that demonstrates widespread, severe declines across all Andrias species populations within China due to extensive harvesting for food and habitat loss".*
Andrias davidianus	CRITICALLY ENDANGERED	
Andrias jiangxiensis	NOT EVALUATED	
Andrias sligoi	CRITICALLY ENDANGERED	

Box 1. Extinction risk for different *Andrias* species according to the IUCN Red List.

2.5 Cultural Values

Figure 14. Pottery vases dated from 5,000-6,000 years B.P. depicting Chinese giant salamander designs, unearthed in Gansu Province © Benjamin Tapley / ZSL

Chinese giant salamanders have been depicted and used in China for more than 5,000 years, with some of the earliest images of these animals associated with pottery from the Yangshao culture of the Yellow River region. Chinese giant salamanders are perceived to have a wide range of benefits in traditional medicine (He et al., 2018) and have been used for this purpose for at least 2,000 years (Strassberg, 2002). However, a recent study of local communities living alongside Chinese giant salamanders found that whist Chinese giant salamanders were used in traditional medicine (specifically for skin ailments), no one reported using salamanders for this purpose this century. They have also a long history of being exploited for meat, with the first record of human consumption dating back more than 3,500 years ago (Ebrey, 1996;

Browne et al., 2020). Chinese texts also suggest that two entwined Chinese giant salamanders could have inspired the Taoist yin-yang symbol.

Some research has reported cultural taboos associated with Chinese giant salamanders and the perception that salamanders were 'dirty' or 'bad luck', which could have limited exploitation historically (Cunningham et al., 2016; Turvey et al., 2021). Chinese giant salamanders are well known by the human communities that live alongside them, with 27 different names or name variants reported for giant salamanders across their range in China, and with local traditions, stories and legends reported in 12 provinces (Turvey et al., 2021). Giant salamanders have a reported association with children due to their general appearance and the reported crying sound they are said to make, with associated local stories of babies (especially dead or illegitimate babies) turning into salamanders. There are also local stories that salamanders eat children, especially dead children; and that they are bad luck and that it is forbidden to eat them because they had transformed from dead babies (Turvey et al., 2021). Use of salamanders varied across different ethnic groups (Turvey et al., 2021). However, the widespread reported consumption of Chinese giant salamanders indicates that these taboos or negative associations are insufficient in limiting their exploitation.

2.6 Conservation Management

2.6.1. Protection status

Chinese giant salamanders were designated as a Class II state key protected wildlife species in China in 1988, which makes hunting or collection illegal without an official permit (Dai et al., 2009), although this legislation only applies to *A. davidianus.* All *Andrias* species have been included on CITES Appendix I since 1975 a. The genus is considered a global priority for conservation due to its evolutionary history and global endangerment (Isaac et al., 2012). In 2012, President Xi Jinping initiated an ongoing nation-wide anti-corruption campaign aimed at reducing the consumption of rare animal products at official banquets, and demand for consumption of Chinese giant salamanders at banquets declined as a result (Turvey et al., 2021). The COVID-19 pandemic led to further restrictions on national trade in wild animal products in China, although these restrictions do not apply specifically to giant salamanders (Borzée et al., 2021).

Since 2002, the Chinese government has been carrying out a national action plan for Chinese giant salamander reintroduction into the wild, but this reintroduction plan has not considered the phylogeography of the genus (Yan et al., 2018). There is no published evidence to indicate that these release programmes have resulted in the establishment of viable populations (Turvey et al., 2018; Shu et al., 2021).

Chinese giant salamanders are reported to occur in over 50 national, provincial and county-level nature reserves, and in some cases giant salamanders are the main conservation target of the protected area. Determining whether these reserves are effective in protecting Chinese giant salamanders is challenging. Releases of farmed individuals are known to occur in protected areas (e.g., Luo et al., 2009), and these releases could include species of Chinese giant salamander that are locally non-native. It has been reported that releases of Chinese giant salamanders into protected areas have decreased in recent years (IUCN SSC Amphibian Specialist Group, 2023a). However, Chinese giant salamander poaching has been

recently reported to occur in protected areas relatively recently (Tapley et al., 2015, 2021). Conservation breeding efforts are reportedly underway for both *A. sligoi* and *A. davidianus* at the Hunan Giant Salamander Rescue Centre (IUCN SSC Amphibian Specialist Group, 2023a) and there have been calls for the establishment of more facilities in China for the conservation breeding for all species of Chinese giant salamander (Turvey et al., 2018, 2019).

3. Long Term Recovery Strategy 2024 – 2044

3.1 Justification

Chinese giant salamanders occur over a large geographical area and the threats posed to them are diverse, and addressing these will require the active participation of many different stakeholders. There is now a sufficient evidence-base on which to act to prevent the imminent extinction of the named and unnamed giant salamanders. To this end two NGOs, Green Camel Bell and the Zoological Society of London, worked with the Chinese Academy of Science to organise a workshop on the conservation of Chinese giant salamanders (Mao et al., 2024), which was held in Lanzhou in October 2023. This multi-stakeholder workshop brought together 32 stakeholders with expertise in giant salamanders from across China, including from regional and national governments, business, NGOs and academia (including genetic, ecological and conservation research), together the IUCN SSC Amphibian Specialist Group. Of these 32 participants, 29 were Chinese nationals, thus ensuring that the action plan is locally led.

Figure 15. Participants at the Conservation Action Plan Workshop for Chinese giant salamanders held in October 2023, Lanzhou © Green Camel Bell.

3.2 Conservation of Chinese giant salamanders: barriers, challenges and difficulties

Table 3. Results of the group discussion on current barriers, challenges and difficulties in conserving Chinese giant salamanders.

Species delimitation	The identification of the different Chinese giant salamander species is challenging, as they have extremely similar morphology and there are no well-established guidelines for being able to distinguish between them without genetic analysis
	Need for simplified morphological definitions and simplified species identification to facilitate conservation and management
	Conservation should be at the species level or subspecies if these are identified in future.
	Delimitation of new species has an impact on the protection that a new species will receive.
	Not all species currently receive legal protection, so laws need to be updated to include protection for all species of *Andrias* native to China
Releases from farms	Standardised guidelines for the releases of farmed salamanders exist at the national level but these are not followed or enforced.
	Improving the effectiveness of releases
	How should animals be selected for release?
	Where is the best place to release animals?
	How should animals be screened for diseases and which pathogens should be screened for?
	How should post release monitoring be undertaken?
Management of habitat	Irrational delineation of boundaries and functional areas of protected areas, conflicts with neighbouring communities, and failure to enable communities to take an active role in conservation management
	Are existing laws good enough in their wording, coverage and goal to be effective?
	Illegal fishing and illegal trade could still occur within some protected areas, unknown efficacy of legal enforcement?
	The habitat in the range of the Chinese giant salamanders is not adequately protected
	The habitat and environmental requirements of different Chinese giant salamander species are not adequately understood
Impacts of farming	Preservation of natural populations in the wild as far as possible, retaining their natural attributes (which may be lost in aquaculture releases)
	How to differentiate between farmed and wild stocks for management
	Huge losses in the farming sector and the need to promote rational utilisation of remaining farm animals
	We do not know enough about the current state and dynamics of the market; is there still a market demand for farmed salamanders, and/or is there still a demand for illegal collection from the wild?
	Unknown what will happen to the existing farmed salamanders if there is no longer a

	huge market demand for farmed salamanders. Improper disposal may become a new threat to conservation in the future.
LOW CONSERVATION PROFILE	Lack of professional conservation institutions, professional capacity to promote giant salamander conservation
	Lack of adequate social attention on the conservation of giant salamanders
RESEARCH GAPS	We do not know enough about the distribution, ecological requirements, status and threats to wild populations. There is a need for careful collection of data on ecological characteristics and behaviour of wild populations.
	Taxonomy
	There is a need for need for both ecological and social-science research programmes, to understand both the biological/ecological and human dimensions of social-ecological systems in which giant salamanders survive in China
	There needs to be more research on the impact of global climate change

3.3 VISION AND OBJECTIVES

Vision: To effectively conserve China's wild giant salamanders and their habitats as a global model for wildlife conservation.

Objective: By 2043, each Chinese giant salamander species will occupy suitable and stable habitat within its natural range, that support healthy, viable wild populations and genetic diversity.

3.4 UNDERSTANDING AND RANKING THREATS

Workshop participants reviewed the existing knowledge of Chinese giant salamanders and the different threats they face and were tasked with analysing these threats and ranking them in order.

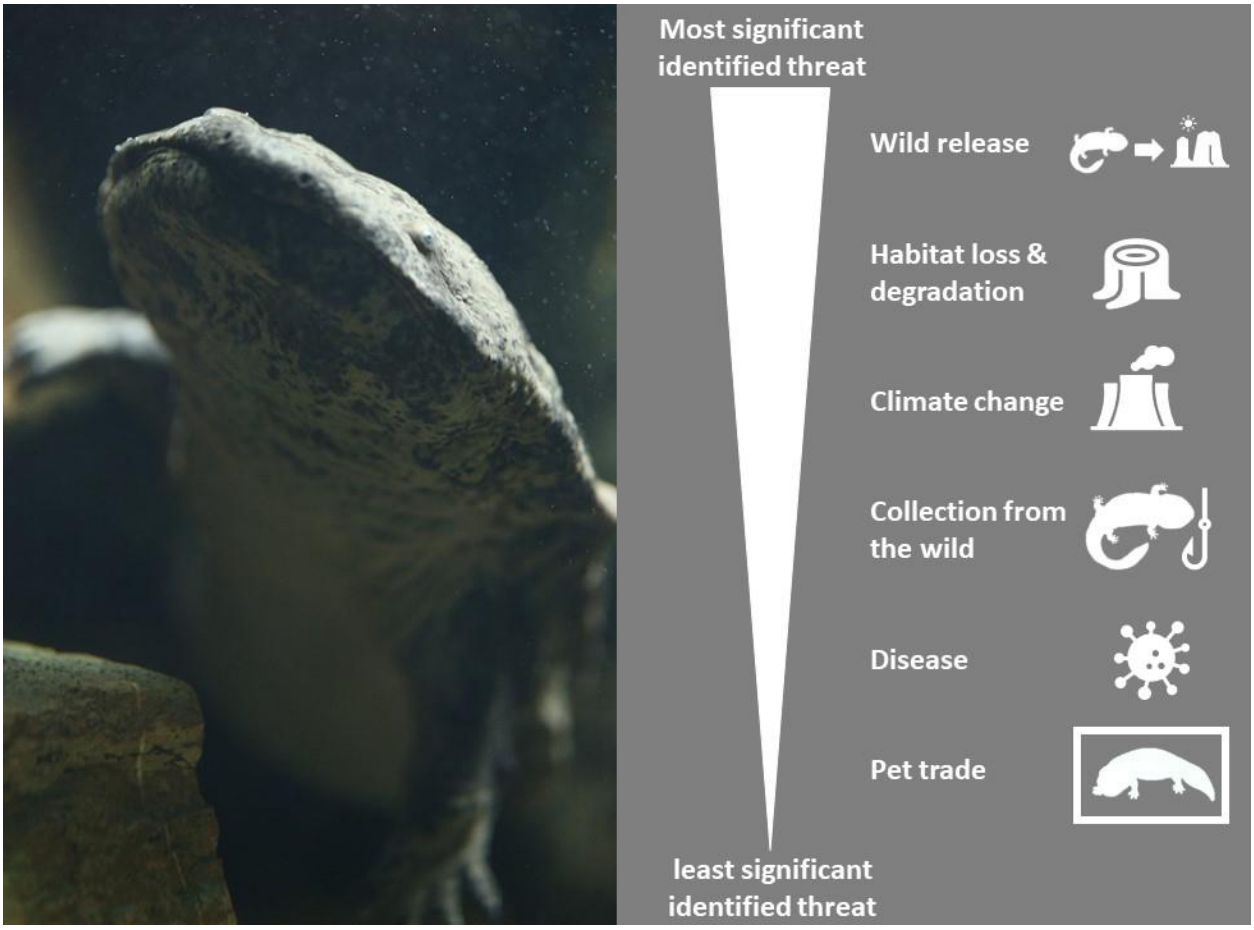


Figure 16. Ranked threats for Chinese giant salamanders

Workshop participants were then tasked with delving deeper into analysing the four threats that were considered to pose the greatest risk to Chinese giant salamanders.

Table 4. The threat of wild release

Name of threat: Wild release
Description of the threat: • Unreasonable stock enhancement • Deliberate release of adults and larvae • Accidental escape from farms
Impact of the threat: • Genetic contamination • Diseases transfers • Exceeding environmental carrying capacity
Causes of the threat: • Inadequate stock enhancement / release protocols (not managed by national regulations, inadequate

supervision, standards need to be improved and enforceable)
- Release: poor public awareness of wild salamander conservation requirements
- Escape: poor management of farmed populations, natural disasters

- **What we know:** Standardised guidelines exist for the release of Chinese giant salamanders from farms but these guidelines are not enforced and could be improved. Releases are not undertaken following national regulations, and there is inadequate monitoring
- The need to release only locally-occurring species is not always known or appreciated
- The identity of locally-occurring species also presumably isn't known by the people doing the release
- High number of releases
- The environment is sometimes assessed at the time of release, but subsequent monitoring of individual releases is inadequate
- Post release screening for genetics and disease does not always occur

What we assume:
- Partial releases are successful (definition: stable populations in the wild with natural reproduction)
- Most of the released individuals are native species

What else do we need to know:
- The methods and standards that are needed to ensure adequate prerelease screening
- The status of any existing wild population at release sites
- How sites and animals are chosen for release
- Sources of released animals
- How to test the effectiveness of the release

What is currently done:
- Relevant standards have been developed in the agricultural sector but there is no mechanism to implement the standards
- We are developing a better understanding of Chinese giant salamander taxonomy to guide releases

What worked:
- Some suitable artificial enrichment releases have had an enrichment effect on wild populations (giant salamanders being seen more frequently or seen again after they have disappeared)
- Published research provides some guidance (e.g., site selection)

What hasn't worked:
- Failure to use genetic screening to identify animals that are suitable for release
- Failure to use health screening to identify animals that are suitable for release
- No organisation is coordinating or regulating the releases and their impacts

What actions can be taken to counter these threats:
- Improve post-release surveillance and monitoring
- Detection of origin and pathogen screening of all released individuals
- Ensure that provenance of released animals is known, fixed and traceable

What alternative actions exist:
- Establishment of dedicated local release centres (original seed farm or rescue station using animals of known provenance)
- Collecting wild founders for ex situ conservation

What are our goals in dealing with the threat:
- Ensuring the appropriate species is released at the site
- Ensuring that no diseases are introduced to wild populations during releases
- Reducing the number of accidental releases by identifying how these potentially occur and suggesting how these accidents might be mitigated in future
- Remove non native giant salamanders
- Ensuring that the native species in each locality is conserved, and that the maximum amount of species diversity is protected over the largest possible area
- Increased numbers of individuals of each species in the wild

Statement: Chinese giant salamanders are deliberately released from farms into the wild on a large scale. These releases are not well planned or coordinated and post-release monitoring is suboptimal. Some animals also escape from farms. This poses a threat to wild populations through genetic contamination and potentially pathogen pollution. These releases are not known to have resulted in the establishment of any self-sustaining giant salamander populations

Table 5. The threat of habitat loss and degradation

Name of threat: Habitat loss and degradation
Description of the threat: • Human-induced: mining, sand dredging, infrastructure construction, hydroelectric facilities, pollution, deforestation • Natural: increased intensity and frequency of floods, mudslides, droughts
The impact of the threat: • Reducing water quality, flow and other aquatic conditions directly affect habitat so that it can no longer support the survival of salamanders • Causes habitat fragmentation and disruption of habitat connectivity
Causes of the threat: • Anthropogenic: economic development and industrialisation • Destruction by natural disasters • Climate change
What we know: • Activities such as sand mining, dredging and pollution destroys habitat and / or cause habitat quality to decline • Hydropower facilities reduce habitat connectivity and water flow • Hydropower facilities result in a reduction in breeding sites (complete submersion or exposure) • Direct destruction of habitat by natural disasters
What we assume: • Noise and / or pollution caused by infrastructure development, such as reduced water quality, affects the survival and behaviour of salamanders
What else do we need to know: • The effectiveness of existing conservation legislation and management to protect salamander habitat and enforce bans against harmful activities in protected habitats • Hydrological and water quality requirements for salamander survival and reproduction • How noise and vibration might impact the behaviour and survival of giant salamanders
What is currently done: • Habitat protection through the establishment of nature reserves, prohibition of sand dredging in rivers, removal of small hydroelectric power stations, sewerage jurisdictions, fishing ban notices, prohibition on the use of poison for fishing
What worked: • Protected areas, prohibition of sand dredging, dismantling of small hydropower, sewage management, prohibition of fish poisoning at least in some areas
What hasn't worked: • Not all areas with giant salamander populations are protected. The scale and effectiveness of these mitigations (prohibition of sand dredging, dismantling of small hydropower, sewage management, prohibition of fish poisoning) is probably not sufficient?
What actions can be taken to counter these threats: • Better spatial assessment of the level and ecological impact of different anthropogenic threats, associated with spatial and population-level modelling to determine the likely impact they're having on habitat integrity and salamander population survival

• Centralised stockpiling and environmentally sound management of domestic waste • Artificial construction of deep pools and other suitable habitats (vegetation restoration along riverbanks to regulate small ecosystems) • Encourage urban migration to reduce impact to giant salamander habitats • Habitat diversity is retained in small watershed management
What alternative actions exist: • Improved waste management in rural areas • Largescale Chinese giant salamander habitat restoration • Spatial relocation of all harmful activities to landscapes that aren't priorities for salamanders
What are our goals in dealing with the threat: • Habitat restoration, improved habitat connectivity, improvement of breeding habitats, wild population recovery
Statement: Human-induced habitat loss and degradation such as sand mining, dredging, and water facilities disrupt giant salamander habitat quality and / or connectivity. Natural disasters have been identified as directly affecting salamander habitats and even the animals themselves. We need better spatial assessment of the level and ecological impact of different anthropogenic threats, associated with spatial and population-level modelling to determine the likely impact they're having on habitat integrity and salamander population survival. We need further research to provide evidence of any impact of noise and vibration on the physiological well-being and behaviour of Chinese giant salamanders

Table 6. The threat of climate change

Name of threat: Climate change
Description of the threat: • Changes in temperature, extremes, temperature differences, etc. • Changes in rainfall • Climate change driving the change in habitats (e.g. vegetation) • Changes in frequency and severity of extreme weather events that can damage salamander habitat (e.g. flooding, storms and associated forest loss and run-off)
The impact of the threat: • Temperature changes can affect the time and ability for salamander eggs to hatch and may impact larval development and food availability for giant salamanders • Increase in extreme weather events e.g., flooding or drought, which can directly or indirectly affect salamanders or their food and habitats • Salamanders will have to adapt to this climate change-induced habitat change to survive longer
Causes of the threat: • Global climate change caused by fossil fuel emissions, land use changes, food production and over consumption
What we know: • There have been increases in extreme weather events in China and elsewhere • Current research shows that future climate change scenarios will make many protected areas unsuitable for Chinese giant salamanders
What we assume: • Extreme weather events will continue to increase • That model predictions using China-wide data are locally relevant for each geographically restricted salamander species in different areas of China • It is possible to make meaningful predictions about aquatic habitat change and its varying future suitability for salamanders at local scales
What else do we need to know: • If there are particular species of giant salamander that may be impacted by climate change

• Whether giant salamanders can adapt to climate change
What is currently done: • Basic research on the impacts of global climate change on amphibian survival that has been done in China and abroad
What worked: • Currently unknown
What hasn't worked: • Currently unknown
What actions can be taken to counter these threats: • Identify and designate more protected areas that will be suitable for Chinese giant salamanders under future climate change scenarios • Further scientific research on environmental requirements and adaptability of giant salamanders, including research on changing environmental factors and temperature
What alternative actions exist: • In situ protection in the wild • If in situ conservation is not possible, develop conservation breeding programmes and undertake translocations • Assisted colonisation • Gene bank preservation
What are our goals in dealing with the threat: • To have populations of all Chinese giant salamanders occurring in the wild in at least some part of their natural range under all predicted future climate change scenarios
Statement: Global climate change could affect the survival of Chinese giant salamanders

Table 7. The threat of collection from the wild.

Name of threat: Collection from the wild
Description of the threat: • There is illegal collection and legal collection • There may be a need to replenish farm stocks, community needs, etc. • Farmers and consumers may have a preference for wild individuals • Enforcement may not be sufficient based on historical data, but the situation may have changed • Based on existing discussions, many stakeholders believe that wild collection/exploitation is now greatly reduced, there is evidence of a reduction in the number of farms, and it is assumed that legislation and enforcement is effective
The impact of the threat: • Decrease in effective population sizes of wild giant salamanders, inclusive local extirpation of many populations and potential extinction of some species in the wild
Causes of the threat: • Removal of wild animals to supply farms • Local use • Personal use • Community use • Farm reintroduced due to disease outbreak • Establishment of new farms • Preference for wild meat
What we know: • Substantial evidence to show that this was the most significant cause of decline in the salamander population in the recent past • Survey reveals city dwellers' preference for wild meat

• That there have been efforts to improve the legislation that protects China's threatened biodiversity
What we assume: • It was felt that the irrational use of such phenomena had declined • Fewer farms • Legislation is effective, enforcement is better
What else do we need to know: • Baseline for all current use and demand for freshwater resources in salamander habitats • What is the current demand for new stock on salamander farms • Consumer demand for salamanders • How effective is the current enforcement
What is currently done: • Legislation and protection of species by law was established • There are corresponding regulations in all parts of China, and there have been some cases of public interest prosecutions
What worked: • The effectiveness of the existing protection and the current dynamics and drivers of human-salamander interactions in natural habitats is not yet known
What hasn't worked: • As above
What actions can be taken to counter these threats: • List all *Andrias* as a State 1 protected species • Science-based recommendations to recognise multiple *Andrias* species in legislation • Further targeted research using multiple methods (ecological, social science), and effective communication of information to relevant policymakers and government agencies • Enhancement of the participation and oversight of civil society organisations in the conservation of giant salamanders • Promotion of law enforcement and enhancement of its effectiveness
What alternative actions exist: • Enhancement of law enforcement and enforcement effectiveness, as well as local community law enforcement • Citizen science monitoring • Educational and behaviour change campaigns, ideally fronted in ways that will be maximally receptive for target audiences e.g. by Chinese celebrities • Increased segregation between farmed and wild animals; distinguish between farmed and wild salamanders, and have a better understanding of both, as well as hybridization
What are our goals in dealing with the threat: • Promote legislation to include new species for protection; • Drive implementation efforts • Raise public awareness of protection
Statement: Wild harvesting used to be the most significant threat to Chinese giant salamanders. Although the dynamics of farming systems may have changed over the past decade, there is still a lack of evidence on whether utilisation remains a threat or not, the situation is further complicated by potential and a lack of enforcement of existing legislation

3.5 PROJECTS AND ACTIVITY TABLES

Table 8. Thematic conservation actions needed, relative urgency and suggested responsible parties

Themes for action	Action	Urgency of action (high, medium, low)	Responsible body
Wild capture / utilisation	Regulations and policies promote the development of conservation plans to include new species;	High	Government, NGOs, lawyers, democratic parties, news media, scholars
	Promote the strength and effectiveness of implementation;	High to Medium	Government, NGOs
	Promote behaviour change in consumers	High to Medium	Government, media, NGOs
	Raise public awareness of existing conservation legislation	Medium	Government, media, NGOs
Habitat loss and degradation	Reduce surface source pollution such as pesticides and fertilisers and reduce other directly harmful activities within salamander habitat e.g. mining, deforestation;	High	Government, community, NGOs (monitoring)
	Change local legislation to further protect giant salamander habitat	High	Government, protected area management agencies
	Establish new protected areas for giant salamanders;	High	Government, protected area management agencies, scientific research units, community
	Improved enforcement of existing legislation that protects giant salamanders;	High	Government, protected area management agencies
	Reduce human disturbance and destruction of habitats through public and community education;	High	Communities, NGOs, schools, governments, protected area management organisations, media
	Conduct presence / absence studies of suitable habitats and include key habitats for protection	High	Government, Protected Area Management Agencies, Research Institutions, NGOs
	Ensure environmental impact assessments of any development / industrial work are undertaken and that these require environmental offsetting/restoration;	High	Government, Protected Area Management Agencies, Research Institutions, NGOs
	Restore and rehabilitate suitable habitat;	Medium to high	Governments, protected area management organisations,

			businesses, research institutions
	Preserve the ecological integrity of habitats when treating small watersheds;	Medium	Government, protected area management agencies, scientific research units
	Implement centralised stockpiling and environmentally sound treatment of domestic, agricultural and industrial pollution;	Medium	Government, community, NGOs (monitoring)
	Where feasible, consider modifying microhabitats to help salamanders adapt to climate change (e.g. planting large trees along river channels to fix sand and regulate water; artificially modified caves and deep pools as potential habitats)	Low	Government, protected area management agencies, scientific research units
Wild Release	Modify and refine existing release protocols to make them more enforceable;	High	Government, research institutes, scholars, academic societies,
	Improve the supervision of the release. local assessment is needed to ensure suitable ecological conditions for released salamanders. Before release, conduct a comprehensive survey (inclusive of genetic analyses and disease screening) of the release area to clarify that the origin of individuals in the wild is consistent with those that should occur naturally at the release site; after release, assess the effects of enrichment and release, including impacts on the wild giant salamander population as well as on other species and the habitats in which they are found;	High	Media, NGO's, government, research units,
	Establish or screen professional, local release centres, such as original seed farms, or rescue stations, to specify the origin of released individuals and test for pathogens;	High	Government, Research Institutions, Enterprises
	Strengthen regulation to eliminate individual releases;	High	Government, media, religious groups,
	Strengthen farm management practices to reduce farm escapes (ecological farming requires even more attention to the breeding of individuals from local seed sources);	High	Government, farms, protected areas, NGOs

	Prerelease training for individual salamanders that are destined for release;	Low	Businesses, research institutions, governments,
Climate Change	Modelling predicts potential future habitats and unsuitable habitats in preparation for future relocation for conservation;	Medium	Scientific research institutions, protected area management institutions,
	Research climate change adaptation in giant salamanders;	Medium	Scientific research institutions, protected area management organisations, enterprises
	Develop contingency plans for dealing with extreme weather;	Low	Research institutes, governments, protected area management organisations, businesses
Management	Promote cross-sectoral coordination	High	NGO, government, media,
	Mobilise more funding for salamander conservation and research (push for government budgets)	High	Government, NGOs, enterprises, research institutes, media,
	Relocation Conservation Research and Practice	Low	Research institutes, governments, protected area management organisations, NGOs
Promotion of scientific research	Comprehensive surveys of wild populations: comprehensive surveys of historical distribution areas, surveys of extant populations, etc.	High	Government, research institutes, protected area management organisations, NGOs,
	Taxonomic studies of species (combining morphology and genetics);	High	Research institutes, enterprises, NGOs
	Comprehensive research into threats inclusive of social science and economic studies;	High	Research institutes, enterprises, NGOs
	Develop tools that reflect ecological health (rapid, collegiate assessment) based on an understanding of habitats, species, and ecosystems;	High	Government, Research Institutions, NGOs, protected area management organisations
	Research on epidemics, diseases, pathogens, and prevention and control of salamanders;	Medium to High	Government, Research Institutions, Enterprises, NGOs
	Conduct conservation breeding research on small populations with special genetic traits;	Medium to High	Scientific research units, protected area management organisations

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