Comparing the status of Chinese giant salamanders between three nature reserves in Guizhou province using local ecological knowledge



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Abstract

Amphibians are suffering severe declines on a global scale but there has been little research into amphibian conservation in China. The Chinese giant salamander is an endemic and iconic animal that is classified as Critically Endangered by the IUCN. Currently, there are few published English papers on their status and they are rarely encountered during ecological surveys. Therefore the use of local ecological knowledge may be more effective. To investigate the Chinese giant salamander's status in Guizhou, we conducted 300 structured guestionnaires targeted at local inhabitants in three national nature reserves: Fanjingshan (FNNR), Leigongshan (LNNR) and Mayanghe (MNNR). Overall, there have only been three reported Chinese giant salamander sightings over the past two years. There were significantly fewer reported sightings in MNNR than in the other reserves: 43 from FNNR, 53 from LNNR, and 3 from MNNR. This suggests that FNNR and LNNR are better reserves for Chinese giant salamanders than MNNR. The local giant salamander population in MNNR may be functionally extinct. The results also highlight five rivers as potentially important giant salamander habitats. Although few respondents admitted to hunting giant salamanders illegally, questionnaire results indicate that poaching in Guizhou is part of a larger national scale trade network. The majority of respondents thought that Chinese giant salamanders should be protected. These results indicate that LEK can provide useful insights into a species' local distribution and status, as well as helping to understand the conservation attitudes of locals, which are useful for conservation purposes.

Keywords: *Andrias davidianus*, Chinese giant salamander, Guizhou province, local ecological knowledge, questionnaires

1) INTRODUCTION

Compared to other vertebrate groups, amphibians are threatened more severely and are being lost more rapidly around the world (Stuart *et al.*, 2004). Most conservation efforts in China have been concentrated on mammals, with little research into amphibian conservation (Feng *et al.*, 2007). Notably, salamanders are an order of amphibians that are particularly threatened by environmental changes, because they breed slowly and are less mobile than other amphibians (Welsh & Droege, 2004). Humans also exploit a large percentage of salamanders species found in China (Feng *et al.*, 2007).

The Chinese giant salamander (*Andrias davidianus*) is an endemic and iconic Chinese species. It is the largest amphibian in the world and can grow to 1.8 metres. Chinese giant salamanders are fully aquatic and nocturnal animals (Liang & Wu, 2010). As a carnivorous species, their main prey includes fish, frogs and crustaceans. They have high requirements for pristine and oxygenated habitats, inhabiting clear and fast flowing mountain streams in forest covered areas (Liang *et al.*, 2004).

The giant salamander's ancestors diverged from other amphibians during the Jurassic period, making it one of the oldest amphibian lineages and thus highly evolutionarily distinct (Tao *et al.*, 2004). Chinese giant salamanders can act as health indicators of freshwater ecosystems because they are extremely sensitive to water pollution (Luo *et al.*, 2009). Nevertheless, there are few published English papers on Chinese giant salamander conservation and little data on their local distribution patterns (Wang *et al.*, 2004).

Chinese giant salamanders are found in the tributaries of the Pearl, Yangtze and Yellow Rivers. In the past, they were widely distributed but numbers have declined rapidly in recent years (Zhang *et al.*, 2002) and many local populations are nearly extinct (Zhang & Wang, 2001). Major threats include over-extraction for consumption and for salamander farms, habitat loss and the use of destructive fishing methods (Wang *et al.*, 2004). The IUCN Red List has classified the Chinese giant salamander as Critically Endangered (IUCN, 2013) and it is a Class II state protected animal in China. In addition, the Zoological Society of London's EDGE of existence programme

has placed it as the number two global priority for amphibian conservation (Isaac *et al.,* 2012). Urgent conservation action is required to prevent the species' extinction.

Although hunting Chinese giant salamanders is illegal, legislation is not strongly enforced. They have been over-exploited by local inhabitants for many decades (Feng *et al.*, 2007). They are sold as luxury food or used in traditional Chinese medicines, and fetch extremely high prices. There are many commercial giant salamander farms to meet market demands. However, reproduction in farms has been unsuccessful and wild populations are often hunted to replenish farmed stock (Qiang *et al.*, 2005; Luo *et al.*, 2004). In the last thirty years, China's increasing economy has fuelled intensive agriculture and large scale deforestation (Liu & Diamond, 2005). As a result, Chinese giant salamander habitats have decreased markedly in size. A further threat is the use of destructive fishing methods that can harm giant salamanders, such as electro-fishing or using explosives (Zhang *et al.*, 2002). Locals use them because more fish can be caught compared to conventional methods.

As Chinese giant salamanders inhabit fast flowing rivers, they are difficult to survey in the field. Some ecological survey techniques can damage their habitats and may affect them adversely (Browne *et al.*, 2011). Furthermore, Chinese academics informed us that it was difficult to encounter giant salamanders during ecological surveys. Therefore questionnaire surveys may be more beneficial and efficient to investigate their status. Questionnaires are particularly useful for investigating species that are rarely encountered during ecological surveys (Turvey *et al.*, 2013). They can gather large amounts of data over a short period and the cost is considerably less than ecological surveys (White *et al.*, 2005).

Local ecological knowledge (LEK) is often gained by local inhabitants *via* frequent interactions with local ecosystems, and can provide historical data on species (Davis & Wagner, 2003). Community based questionnaires can gather unique ecological information in remote regions (Aswani & Laurer, 2006). Turvey *et al.* (2013) also showed that LEK is useful for investigating iconic aquatic species. The Chinese giant salamander is a key example of such a species because it is easily identified by

untrained local inhabitants. Locals that visit rivers frequently are more likely to have seen giant salamanders than biologists. Furthermore, local communities can help protect targeted species so understanding their conservation attitudes is important (Danielson *et al.*, 2000). Nevertheless, there are problems associated with LEK usage. These include biases or inaccuracies in the collection or quantification of data, which can lead to misinterpretations of results (Gilchrist *et al.*, 2005; McKelvey *et al.*, 2008). Limitations of using LEK must be taken into account when conducting community based questionnaires.

Guizhou is one province where Chinese giant salamanders can still be found, with high levels of reported sightings historically (Liang *et al.*, 2004). It lies in the southwest of China and has a sub-tropical climate. Due to its mountainous landscapes, many areas are extremely remote. As a result Guizhou remains one of the least developed Chinese provinces and there are still large areas of suitable giant salamander habitats remaining. In this project, three national nature reserves were investigated: Fanjingshan (FNNR), Mayanghe (MNNR) and Leigongshan (LNNR). FNNR and LNNR are considered important reserves for giant salamander protection (Xu *et al.*, 2008). MNNR is near FNNR and lists Chinese giant salamanders as one of its protected species.

There are high levels of non-Han ethnic minorities living in Guizhou province. The majority of ethnic minorities lives in mountainous regions and use natural resources from forests or rivers. They often interact with local ecosystems and are likely to have knowledge about local species, such as the Chinese giant salamander. Local inhabitants may be able to provide both temporal and spatial data on a targeted species. This is the first study to investigate the effectiveness of using LEK for Chinese giant salamander conservation. It will contribute to the investigation of this critically endangered species' status and review threats faced by the Chinese giant salamander.

The main objectives of my project were to investigate the following questions:

 Can local ecological knowledge provide useful information for Chinese giant salamander conservation?

- ii) Do patterns of wild Chinese giant salamander reported sightings vary between reserves?
- iii) What other factors affect reported sightings?
- iv) What are the perceived levels and types of threats to Chinese giant salamanders according to local inhabitants?
- v) What are the conservation attitudes of locals, in particular to Chinese giant salamanders?

2) MATERIALS AND METHODS

2.1 Study areas

FNNR lies in the north-east of Guizhou (Figure 1) and is part of UNESCO's "Man and Biosphere' Protection Network" (Yang *et al.*, 2002). Fanjing Mountain is the highest peak in the Wuling mountain range. Primary vegetation types in the reserve include evergreen broadleaf forests and coniferous forests (Zhou *et al.*, 2006). FNNR was started in 1978 to conserve the Guizhou snub-nosed monkey (*Rhinopithecus brelichi*). In 1986, it was promoted to a national nature reserve (Bleisch *et al.*, 1993). There are around 5000 species found within FNNR and it is one of the best preserved sub-tropical ecosystems in China.

MNNR was started in 1987 and became a national reserve in 2003 (Zou *et al.,* 2011). It was established to conserve the Francois langurs (Trachypithecus *francoisi*) and there are more than 800 species found within the reserve (Chen *et al.,* 2001). The landscape consists of karst hills and vegetation types include coniferous, deciduous and evergreen broadleaf forests (Luo et *al.,* 2000). Currently, MNNR is mainly used for research purposes but tourism development is in progress.

LNNR lies in the south-east of Guizhou (Figure 1). It was established in 1982 and promoted to a national nature reserve in 2001 (Yu & Yu, 2007), with around 5000 species found inside (Tang & Zhang, 2011). There are two Class II state protected amphibians: the Chinese giant salamander and the black knobby newt (*Tylototriton asperrimus*). Tourism is well developed but it is less known outside the province.

Villages inside nature reserves are typically small. Most contain fewer than thirty

households and are inhabited by ethnic minorities. Most villagers farm rice, tea leaves or harvest bamboo for a living. Some chosen villages are remote whilst others are more developed due to tourism. All but one of the villages are situated in the core or buffer zone of nature reserves (See Appendix 1).



Figure 1: Locations of the three national nature reserves investigated in Guizhou province, China. Boundaries of Chinese provinces are indicated by black lines (produced using the mapdata package in R 2.15.3).

Table 1: Characteristics of the nature reserves investigated in Guizhou province, China.

Reserve	Coordinates	Total area	Elevations	Forest	No. of villages
		(hectares)	(m)	cover %	inside reserve
FNNR	27°47'-27°02'N	41,900	500-2571	80.0	65
	108°36′-108°49'E				
LNNR	26°15'-26°32'N	47,300	650-2179	88.8	25
	108°5′-108°24'E				
MNNR	28°37'30"-28°54'20'N	31,113	280-1441	63.7	40
	108°3'53"-108°19'45"E				

2.2 Pilot work

A pilot survey consisting of five respondents was conducted in Kaima village in

FNNR before the questionnaire survey. We found that the questionnaire lasted approximately twenty minutes and that this was a reasonable time length without the respondent losing interest. Some questions were altered to improve clarity.

2.3 Questionnaire survey

A Chinese field assistant and I (both native speakers of Mandarin Chinese) conducted 300 questionnaires, with 100 questionnaires conducted in each reserve. Within each reserve, 10 questionnaires were conducted in each of 10 villages. The same two interviewers were used throughout the study to reduce the introduction of bias. The study started on the 11th of May 2013 and ended on the 10th of June 2013.

I acquired a map depicting all villages within each reserve. Each village was assigned a number and ten villages were chosen using a random number generator. Within each village, we started at one end and walked down a line transect, picking households opportunistically until ten interviews were conducted. Due to their small sizes, this process typically involved walking through the entire village before all interviews were completed. If villages contained fewer than ten households, we continued the transect into the nearest adjacent village until ten interviews were conducted. Only one member from each household was interviewed.

Although we selected respondents opportunistically during the survey, this was not ideal. Originally, I wanted to acquire a map of all households in each village and randomly select ten households. Unfortunately, maps of village households did not exist and new houses were being built frequently.

In LNNR, one of the selected villages was outside the reserve because severe landslides occurred and the entire reserve could not be accessed. It was the nearest accessible village to the originally selected site. In addition, there was bias towards selecting male respondents in LNNR because the majority of women could not understand Mandarin Chinese and only spoke the Miao language.

We asked questions in an informal manner to make respondents feel comfortable. Respondents were interviewed independently to avoid the influence of others. If others were present, we asked respondents to move somewhere else where we could

be alone. Both open ended and closed questions were used. Open ended questions allowed respondents to elaborate on answers. The questionnaire consisted of four sections: background questions, Chinese giant salamander questions, freshwater resource use questions and conservation attitude questions (see Appendix 2).

During interviews, we first asked respondents to describe the appearance of Chinese giant salamanders. They were asked to identify one from photos of Chinese giant salamanders and other salamander species. This ensured that respondents did not confuse it with other species.

Apart from Chinese giant salamander questions, we asked about other species in the reserve. Questionnaires concerning giant salamanders had never been conducted in this region, so we did not know the perceived sensitivity that respondents may feel towards answering questions on this subject (a nationally protected species). Questions about other species made the respondent feel that we were not specifically targeting giant salamanders.

2.4 Ethics

Before each interview, we obtained the respondent's consent and informed them that the questionnaire was anonymous. The objectives of my project were also explained clearly. As most respondents were ethnic minorities, we asked guides about local customs so that we would not offend them.

2.5 Data Analysis

Statistical analysis was carried out in R 2.15.3 (R Development Core Team, 2013). Chi-squared tests were used initially to investigate differences in responses between the three nature reserves investigated.

I analysed the dataset to investigate which factors affected Chinese giant salamander sightings using the Ime4 package in R 2.15.3. A generalised linear mixed model (GLMM) with a binomial family error was used because the response variable (sightings or not) is binary. In comparison to generalised linear models (GLM), GLMM's allow the inclusion of random effects and account for their variation (Zurr *et*

al., 2008). The maximal model was fitted first, and the minimally adequate model was found using backward stepwise model simplification. Any insignificant interacting terms or factors were removed sequentially. Models were chosen using the Akaike Information Criteria (AIC) and the one with a smaller AIC value was chosen.

The maximal model included the following fixed effects: reserve identity; interviewer; respondent's age, ethnicity, gender, occupation; whether the respondent goes fishing or collects aquatic species inside the reserve. Village identity was incorporated as a random effect.

The chosen villages in FNNR were distributed in two counties: Jiangkou and Yinjiang. Therefore a chi-squared test was used to investigate the difference in reported sightings between the two counties.

3) **RESULTS**

69% of respondents were male and their age ranged from 16 to 83 (median age=45). All respondents belonged to one of three ethnicities: Han (6.33%), Miao (40.3%), or Tujia (53.3%). Most respondents were farmers (96.3%). 93.6% of respondents visited the nature reserve frequently.

3.1 Reported sightings

Significantly fewer respondents recognised Chinese giant salamanders in MNNR (38%) compared to FNNR (100%) and LNNR (91%; $\chi^2 = 124$, df = 2, p<0.01). Overall, 99 respondents reported having seen giant salamanders inside the reserve in the past: 43 from FNNR (14.3%), 53 from LNNR (17%), and 3 from MNNR (1%). The levels of sightings reported from the three reserves are significantly different from each other ($\chi^2 = 60.5$ df = 2, p<0.01). In FNNR and LNNR, there were fewer sightings made in the last decade than prior to 2004 (Table 2). Furthermore, there are few reported sightings from these two reserves in the last two years: two sightings from FNNR and one from LNNR (Figure 2).

The minimally adequate GLMM model contained three fixed effects: reserve identity, age and gender (Table 3). Both reserve identity and respondent's age

significantly affected reported giant salamander sightings. Respondents in MNNR reported significantly fewer sightings and older respondents reported significantly more sightings (Table 4).

In FNNR, there were 32 giant salamander sightings from villages in Jiangkou County but only 11 sightings from villages in Yinjiang County. Significantly more respondents reported sightings from Jiangkou compared to Yinjiang ($\chi^2 = 34.7$, df = 1, p<0.01).

Table 2: Reported Chinese giant salamander sighting inside the national nature reserves within the last decade and prior 2004 (n=100 at each reserve).

		% of respondents	
Last CGS sighting	FNNR	LNNR	MNNR
Prior 2004	33	43	2
2004-2013	8	8	1



Figure 2: The pattern of last Chinese giant salamander sighting dates over time in three national nature reserves investigated in Guizhou province, China.

Table 3: The top four models explaining factors that affect reported Chinese giant salamander sightings in three national nature reserves investigated in Guizhou province, China. Fixed effects include: reserve, respondent's age and gender, whether the respondent fishes inside the reserve, and interviewer.

Rank	Model	AIC value
1	Reserve + Age + Gender + (1 Village)	272.45
2	Reserve+ Age +Gender + Fish+(1 Village)	273.39
3	Reserve+ Age * Gender + Fish + (1 Village)	273.91
4	Reserve+ Age * Gender + Fish + Interviewer + (1 Village)	274.50

Table 4: Results of the minimally adequate model for the effects of reserve, respondent's age and gender on the number of reported Chinese giant salamander sightings. Estimate values show how coefficients differ from the intercept of Reserve (FNNR) and Gender (female). * indicates significance at the 0.05 level.

Coefficient	Estimate	Standard error	z value	p value
Intercept	-2.498	0.873	-2.862	0.004*
Reserve (LNNR)	0.350	0.771	0.455	0.649
Reserve (MNNR)	-3.871	1.043	-3.712	<0.001*
Gender (male)	0.756	0.442	1.713	0.087
Age	0.033	0.012	2.692	0.007*

3.2 Levels of threats

A small proportion of respondents goes fishing or catches other aquatic species inside reserves (Table 5). Most respondents that fished inside the reserve said they never used destructive fishing methods. Only two respondents admitted to using poison and explosives.

Table 5: The proportion of respondents that fish or catch other aquatic species in the national nature reserves investigated in Guizhou province, China (n=100 at each reserve). Both activities are illegal.

Reserve	% of respondents that fish	% of respondents that catch other
		aquatic species
FNNR	15	27
LNNR	7	3
MNNR	3	4

6.33% of respondents admitted to catching giant salamanders. In FNNR, out of 14 respondents that catch them, 9 respondents do this activity in Macao River. When asked where other locals went to catch giant salamanders, the top three answers were Macao (17%), Heiwan (7%) and Pingding rivers (5%; n=100). In LNNR, the top three answers were Wumi River (12%), Gannao River (8%) and Leishan (5%). In the majority of cases, these are the nearest rivers to the respondent's village (Figure 3 and 4).



Figure 3: Respondents named rivers of where local inhabitants went to catch Chinese giant salamanders in Fanjingshan nature reserve in Guizhou province, China (rivers are marked in blue). Red dots depict randomly chosen villages in the reserve's core and buffer zone where

questionnaires were conducted.



Figure 4: Respondents named rivers of where local inhabitants went to catch Chinese giant salamanders in Leigongshan nature reserve in Guizhou province, China (rivers are marked in blue). Red dots depict randomly chosen villages in the reserve's core and buffer zone where questionnaires were conducted.

Bow-hooks were the most popular method used to catch giant salamanders (51%; n=37). This was followed by using hands (35%), using a torch and nets during the night (8%), and using lime to poison the water (5%).

77% of respondents said that people did not consume wild Chinese giant salamanders (n=300). Only 13% of respondents had consumed wild giant salamanders and 90% ate it themselves in their own homes (n=39). A minority

reported using giant salamanders in Chinese medicines (3%; n=300). 1% named other uses (e.g. for a pet or cosmetics).

42% reported a decrease in the number of animal species within the reserve over the past decade (n=300). Out of these, 30.2% said that all species had declined and 4.76% specifically named giant salamanders as a species that had declined (n=126). In FNNR and LNNR respectively, 38% and 43% thought that giant salamander numbers inside the reserve had decreased during their lifetime (n=100). In MNNR, zero respondents reported a decrease as there were few reported sightings. The majority of respondents did not know why giant salamander numbers have declined. Those that gave a reason listed overharvesting as the main cause for the decline (Figure 5).





3.3 Farms

3% of respondents in FNNR and 2% in LNNR farmed giant salamanders on a small scale in their homes (n=100). Zero respondents farmed them in MNNR.

However, more respondents reported others farming giant salamanders in their community (27% in FNNR, 8% in LNNR and 0% in MNNR; n=100). Three respondents admitted to farming giant salamanders that they had caught from the wild in their homes. Two respondents reported others in their communities rearing wild giant salamanders in household farms.

3.4 Conservation attitudes

76% of respondents thought that giant salamanders should be protected everywhere and 54.3% stated that they would benefit personally from this (n=300). The main reasons were increased tourism (30%) and a better environment (17%; n=163). 59% knew that giant salamanders were protected by law (n=300). The majority (71%) knew that destructive fishing methods were forbidden and 45% knew that fishing was banned inside reserves. 5% of respondents had heard about others being prosecuted for hunting giant salamanders inside the reserve. In comparison, 29% had heard about others being prosecuted for illegal fishing inside the reserve and 21% had heard about prosecutions for other illegal activities inside the reserve.

4) **DISCUSSION**

This is the first study to investigate the use of LEK for Chinese giant salamander conservation. It has highlighted five rivers as potentially important giant salamander habitats in FNNR and LNNR. In addition, the results indicate that there are significant differences between national reserves that list the Chinese giant salamander as a protected species. Nevertheless, the use of only one survey method cannot provide enough information on Chinese giant salamanders (Browne *et al.*, 2011). Questionnaire surveys must be used in conjunction with ecological surveys to provide a fuller perspective on the distribution and status of the species.

4.1 Reported sightings

There are few reported Chinese giant salamander sightings over the last two years in FNNR and LNNR. This raises the question of whether they are good nature

reserves for giant salamander conservation, as it is likely that local populations have suffered dramatic declines. Nevertheless, the results indicate that FNNR and LNNR are at least better reserves for Chinese giant salamander conservation than MNNR. Local reserve staff at MNNR believe that the species is extinct in the reserve. Their last sighting was from six years ago, when a giant salamander was found in Mayang River in Hongyan village (pers. comms.). During the questionnaire survey period, a villager from Hongyan village informed us that even though giant salamanders are rare, he had caught one from Mayang River recently. There may be some giant salamanders remaining in MNNR, but they have been hunted for more than fifty years in Guizhou province (Gui, 1998). It is likely that the local population in MNNR has already become functionally extinct.

Older respondents reported significantly more giant salamander sightings. In FNNR and LNNR, there are more sightings made prior 2004 than in the last decade. These results suggest that local populations may have decreased rapidly in recent years and may be threatened by extinction. If local populations become extinct, this can lead to a 'shifting baseline syndrome' where younger local inhabitants can quickly forget about the presence of past species (Turvey *et al.*, 2010). This may have already occurred in MNNR, where significantly fewer respondents recognised Chinese giant salamanders compared to the other two reserves.

In FNNR, respondents from Yinjiang County reported significantly fewer sightings than those from Jiangkou County. This suggests that the local Chinese giant salamander population is concentrated in Jiangkou, particularly in Heiwan and Macao rivers. Nevertheless, this raises concern because tourism is more developed in Jiangkou. In 2006, a cable car was built near Heiwan River to meet the demands of increasing tourism (Xiang *et al.*, 2009). Therefore rivers in Jiangkou are more susceptible to habitat deterioration.

Tapley *et al.*, (unpublished) conducted an extensive ecological survey of two major rivers (Heiwan and Panxi) inside FNNR during the project period. Unfortunately they did not find any wild Chinese giant salamanders. In comparison, questionnaires can provide useful insights when ecological surveys fail to find a rare species (Turvey

et al., 2010). My results highlight Macao River as an important habitat for Chinese giant salamanders, which was not seen as a priority for investigation during the ecological survey.

4.2 Levels of threats

Although both activities are illegal, a small percentage of respondents still fish or catch aquatic species in the reserve. In FNNR, aquatic species were found to be abundant in two major rivers (Tapley *et al.*, unpublished). In LNNR, many respondents farmed carp in rice paddy fields so there was less need to catch fish. As Chinese giant salamanders consume fish and other aquatic species, this indicates that food shortage is unlikely to be the main reason for the giant salamander's decline.

Although few respondents admitted to catching Chinese giant salamanders, eight bow-hooks were discovered by Tapley *et al.*, (unpublished) in FNNR. My results also show that bow-hooks are the most popular method used to catch giant salamanders. Similar observations were made by Wang *et al.*, (2004), who encountered poachers using bow-hooks to catch giant salamanders inside nature reserves in Hunan province. Furthermore, my results indicate that there have been fewer prosecutions for Chinese giant salamander poaching than for illegal fishing. This suggests that anti-poaching legislation is not strongly enforced. Chinese academics informed us that wild adult giant salamanders are sold for 1600 RMB/kg (£160/kg) and juveniles are sold for 2000 RMB/kg (£200/kg) currently. Chinese rural populations have low incomes and this is a huge incentive for poaching. Without active enforcement, rules within nature reserves are often ignored (Rowcliffe *et al.*, 2004).

One male respondent in LNNR said, "When I was young, I caught Chinese giant salamanders easily. There were many of them. Now I hardly ever see one." In FNNR and LNNR, the most likely reason for the local population's decrease is overhunting, which is fueled by the demand for wildlife consumption and restocking for farms (Wang et al., 2004; Zhang & Wang, 2001). A future priority is to gain a better understanding of what people do with the wild Chinese giant salamanders that they catch, especially investigating the numbers that are sold to farms.

Few respondents reported the use of wild giant salamanders in traditional Chinese medicine, but we were told of many uses, e.g. to cure coughs, asthma or leprosy and to treat burns or indigestion. Local inhabitants who believe these medicinal properties of giant salamanders may be more likely to hunt them. An interesting use for giant salamanders was given by a female respondent in FNNR. She said, "I have seen women smearing the slime of giant salamanders onto their faces as a moisturiser but I find it repulsive." One commercial farm in FNNR is already trialling the use of giant salamanders in high-end cosmetic products. As Chinese giant salamanders are perceived as having many uses, this is likely to further increase the already high market demands.

4.3 Interprovincial trade

Some respondents reported that non-locals from Hunan or Hubei province travelled to Guizhou to purchase wild Chinese giant salamanders. Reserve staff in FNNR confirmed that there was also trade to Guangdong province, where giant salamander consumption is popular. In FNNR, one respondent said that he went to Heiwan and Macao rivers every week from March to July to catch giant salamanders. He used baited bow-hooks during the night and sold his catch to markets in Guangdong. This suggests that giant salamander poaching in Guizhou province is part of a larger national scale trade network. As this network even extends to such a poor and remote province, it is highly likely that wild Chinese giant salamander trade occurs in most other Chinese provinces. These findings are supported by Lee *et al.* (2004), who found Chinese giant salamanders on sale in Guangdong markets. In addition, they are often found in wildlife restaurants in Macao (Lau *et al.*, 1995). Apart from consumption, Chinese giant salamanders are also sold as pets in Hong Kong (Weldon, 1994).

4.4 Farms and their problems

Chinese giant salamanders are difficult to farm without appropriate technology and environments. For example, fifteen Chinese giant salamanders were exhibited in

the Shanghai Expo 2010 but they all died as a result of high temperatures and noisy environments. Although there are many giant salamander farms in China, there are none used for conservation and they are only used for commercial purposes.

There is a large commercial Chinese giant salamander farm in FNNR, and we observed several others in development. A small sized farm has been built near Zhaigongping village by Macao River, which is waiting for giant salamander stock. Many households in Guizhou province earn below the poverty line. A large percentage of inhabitants living inside nature reserves are illiterate and it is difficult for them to find high paying jobs. Therefore Chinese giant salamander farms are seen as a way of escaping poverty and increasing income.

Nevertheless, farms can worsen the problem of poaching wild Chinese giant salamanders. Farmed giant salamanders are often distributed to local households for rearing. We visited a small household farm in FNNR during the project. Due to the lack of funding, space was limited and conditions were not ideal. Although a permit is required to farm Chinese giant salamanders, some small farms operate illegally because control is difficult (Qiang *et al., 2005*). Without optimal conditions, farmed Chinese giant salamanders often do not reach sexual maturity and cannot reproduce naturally (Peng *et al.,* 1998). My results suggest that some household farms rear wild caught giant salamanders. Chinese academics also informed us that some farms catch wild giant salamanders illegally to restock, leading to the depletion of local wild populations (pers. comms.).

4.5 Conservation attitudes and public education

The majority of respondents believe that the Chinese giant salamander should be protected. By creating a sense of national pride and evoking ownership of a particular species, local inhabitants can help to form strong conservation networks. Over half of respondents think that they would benefit from giant salamander protection, because an increase in giant salamander numbers can attract more tourists. As the main incentive for poaching giant salamanders is money, ecotourism could be developed to increase local inhabitants' income. Ecotourism can form mutually beneficial

relationships between species within nature reserves and local inhabitants (Cheng, 2009). If locals can gain an alternative source of income, they may be less likely to carry out poaching.

Another important reason is that some local inhabitants view giant salamanders as an indicator species. One male respondent said, "Older people told me that if there are Chinese giant salamanders in a river, then it shows that the water quality is good." This idea of more giant salamanders indicating improved water quality could be publicised and reinforced amongst local inhabitants, as a way of decreasing the levels of poaching.

There have been no educational campaigns to raise the awareness of Chinese giant salamander conservation amongst local inhabitants in the nature reserves investigated. As locals can play key roles in providing sightings and protecting endangered species, education is a priority and must be increased. Many inhabitants in this region are illiterate so conducting public talks may be more effective. Apart from local education, there must also be increased publicity for the Chinese giant salamander on national and international levels.

4.6 Conservation recommendations

In summary, I make the following conservation recommendations for the Chinese giant salamander. First, there must be stronger enforcement of anti-poaching legislation. Secondly, giant salamander farms should be constructed for conservation purposes and all commercial farms must be regulated to prevent restocking from the wild. Thirdly, local inhabitants must be educated on the importance of giant salamander conservation and public campaigns must occur on a national and international scale. Finally, ecotourism could be developed in nature reserves to provide locals with an alternative source of income.

4.7 Limitations and further work

A major limitation of using LEK is the under-reporting of sensitive behaviours (St John *et al., 2010*). The majority of respondents that fished inside the reserve did not

report the use of destructive fishing methods. However, most knew that these methods were illegal so their answers may be untruthful. This is likely to be the same for the hunting of giant salamanders. Few respondents admitted to this activity as over half of respondents knew that the Chinese giant salamander is a protected species. Respondents may lie because they are afraid of punishment (Keane *et al.,* 2008). More respondents reported others farming giant salamanders compared to themselves. There is a clear difference between what they say about themselves and about others in the community. This is evidence for the under-reporting of sensitive behaviours, which can make LEK less reliable. It is naive to assume that respondents will answer sensitive questions truthfully through direct questioning (Warner, 1965).

Further investigations need to be made into the perceived sensitivity of questions and to determine true levels of sensitive behaviours. Illegal behaviours such as the use of destructive fishing methods and the hunting of Chinese giant salamanders are all potentially sensitive questions. Indirect interview techniques such as the randomized response technique (Warner, 1965) could be used for sensitive questions to understand whether respondents are telling the truth during direct interviews.

The Chinese giant salamander's range covers many provinces (Feng *et al.*, 2007). This makes its protection difficult because inter-provincial collaborations are required. The project "A sustainable future for Chinese giant salamanders" has formed collaborations with Chinese organizations in other provinces where Chinese giant salamanders are thought to occur. My project helped to formed standardized questionnaire protocols for investigating wild giant salamander status. Over the next two years, Chinese organizations will use these standardized protocols to gather comparative data and investigate the Chinese giant salamander's status in other provinces. Ecological surveys will also be carried out alongside questionnaire surveys to decrease bias and improve the effectiveness of future results.

There are two other species of giant salamanders in the world: the Japanese giant salamander (*Andrias japonicas*) and the hellbender (*Cryptobranchus alleganiensis*). Like the Chinese giant salamander, they are also threatened by habitat destruction and over-exploitation (Hammerson & Phillips, 2004). The use of LEK can

be extended to these related species and this may help with their conservation.

5) Conclusion

My project shows that LEK can be useful for obtaining information on the status and local distributions of rarely encountered species, especially in remote and under-researched regions. The results provide new evidence on the Chinese giant salamander's status in Guizhou province and show differences between national nature reserves that all list the Chinese giant salamander as a protected species. LEK has also provided a good indication on where to target future ecological surveys to improve the likelihood of finding Chinese giant salamanders.

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APPENDIX 1: MAPS OF NATURE RESERVES



Figure 1: Fanjingshan National Nature Reserve (FNNR) in Guizhou province, China (adapted from a map provided by reserve staff). Large red dots depict randomly chosen villages in the reserve's core and buffer zone where questionnaires were conducted. Smaller pink dots represent other villages. Purple lines show rivers flowing inside the reserve.



Figure 2: Mayanghe National Nature Reserve (MNNR) in Guizhou province, China (adapted from a map provided by reserve staff). Red dots depict randomly chosen villages in the reserve's core and buffer zone where questionnaires were conducted.



Figure 3: Leigonshan National Nature Reserve (LNNR) in Guizhou province, China (adapted from a map provided by reserve staff). Red dots depict randomly chosen villages where questionnaires were conducted. All but one village was in the reserve's core or buffer zone.

APPENDIX 2: INTERVIEW QUESTIONNAIRE

Interview number: Location of interview: Date: Name of interviewer:

Opening statement: "I am a Master's student studying at Imperial College in the UK. I am conducting a study on the animals and aquatic resources found in the reserve, and I would like to ask you some questions for my studies, because you live in/near the reserve and so know a lot more about the environment here than I do. I have a questionnaire that takes about 20 minutes to complete. All information that you tell me will be completely confidential, I will not write down your name, and you will not be identified."

Abbreviation: Chinese giant salamanders (CGS)

A. BACKGROUND QUESTIONS

- 1. Are you prepared to participate in this survey and answer the following questions? Y/N
- 2. Male/Female
- 3. Age:
- 4. Ethnicity:
- 5. How many years have you lived in this community?
- 6. Occupation:
- 7. Do you go further into nature reserve often? Y/N
 - If Y:
 - Where in the reserve do you go?
 - How often do you do this?

B. CGS QUESTIONS

- 8. Do you know what a CGS is? Y/N
 - If Y: ask informant to describe the species (identification from photos) If N: prompt the informant with a CGS photograph
- 9. Are there any local names for the CGS?
- 10. Are there any stories, legends, myths, traditions or customs about CGS?
- 11. Can you tell me three words that you associate with CGS?
- 12. Have you ever seen a *wild* CGS in the reserve? Y/N/don't know If Y:
 - Describe the last time you saw a *wild* CGS
 - How many times have you seen a *wild* CGS?

If N:

- Do you know anyone else in this community who has seen a *wild* CGS? If Y, where/when?
- 13. Do people ever eat *wild* CGS in this community?
 - Yes (today)
 - Yes (but only in the past)
 - Never
 - Don't know
- 14. Have you ever eaten wild CGS? Y/N/don't know

If Y:

- When was the last time you ate *wild* CGS?
- How many times per year do you eat *wild* CGS?
- Where did you eat *wild* CGS?
- Are they eaten more/only at special occasions? If Y, what kind of occasions?
- 15. Are CGS ever used in Traditional Chinese Medicine? Y/N/don't know
 - If Y:

- What is their main medicinal use?

- 16. Do people in this community have any other uses for *wild* CGS? Y/N/don't know
- 17. Has anybody (e.g. local people or authorities) ever released any CGS into any rivers in this region?
 - Y/N/don't know

If Y:

- How often does this happen?
- How many animals have been released?
- When was the most recent CGS release?
- Who releases the CGS?

18. Do you farm CGS? Y/N

If Y:

- Where do you obtain them from?
- How many do you have at the moment?
- What is the maximum number of CGS that you have ever kept?
- Who do you sell these CGS to?
- 19. Does anybody else in this community farm CGS? Y/N/don't know

If Y:

- How many people (i.e. households)?
- How many CGS in total are farmed in this community?
- Where do they obtain them from?

- Who are they sold to?

C. FRESHWATER RESOURCE USE QUESTIONS

20. Do you go fishing? Y/N

If Y:

- How regularly do you go fishing?
- Where do you go fishing?
- Do you go fishing more at certain times of year?
- What fishing methods do you use?
- Do you use electro-fishing?
- Do you use poison?
- Do you use explosives?

If N:

- Did you use to go fishing? If YES, where did you use to go fishing, and when did you stop going fishing?

21. Have you ever tried to catch CGS from the wild? Y/N

If Y:

- How regularly do you try to catch CGS?
- When do you try to catch CGS? (day or night)
- Where do you try to catch CGS?
- Do you try to catch CGS more at certain times of year?
- What methods do you use to catch CGS?
- Why do you catch CGS? If it is sold, who is it sold for, and for what price?
- How many CGS have you caught in the past year?
- How many CGS have you caught in the past five years?
- 22. Approximately what proportion of people in this community try to catch CGS?
 - All
 - Over 50%
 - Less than 50%
 - Very few
 - None
- 23. What methods do people in this community use to try to catch CGS?
- 24. Has the level of CGS collecting carried out by local people changed over the past ten years? Y/N/don't know

If Y:

- Has it increased or decreased over this time period, and by how much?
- Why has it changed?
- 25. What are the main localities where people try to catch CGS?

- 26. Do you collect other aquatic species (e.g. frogs, crabs, crayfish, shrimp, mussels) from the wild? Y/N
 - If Y:
 - How regularly do you do this activity?
 - When do you do this activity? (day or night)
 - Where do you do this activity?
 - Do you do this activity more at certain times of year? If so, which times of year?
 - Which species/kinds of animals do you try to catch?
 - Why do you collect these species?

If N:

- Did you use to do this? If YES, where did you use to do this, and when did you stop?

- 27. Approximately what proportion of people in this community goes fishing in the reserve?
 - All
 - Over 50%
 - Less than 50%
 - Very few
 - None
- 28. What are the main areas in the reserve where people go fishing?
- 29. Approximately what proportion of people in this community goes to collect frogs or other aquatic species in the reserve?
 - All
 - Over 50%
 - Less than 50%
 - Very few
 - None

30. What are the main areas in the reserve where people collect other aquatic species?

- 31. Approximately what proportion of people in this community use electro-fishing?
 - All
 - Over 50%
 - Less than 50%
 - Very few
 - None
- 32. Approximately what proportion of people in this community use poison fishing?
 - All
 - Over 50%
 - Less than 50%

- Very few
- None
- 33. Approximately what proportion of people in this community use explosives for fishing?
 - All
 - Over 50%
 - Less than 50%
 - Very few
 - None
- 34. Do people from other places ever visit the region near this community to collect CGS? Y/N/don't know

If Y:

- How often does this happen?
- Does this tend to happen at a particular time of year? If Y, when?
- Where do these people come from?
- How many CGS have they caught over the past 12 months? (approx.)
- Why do they come here to collect CGS?

D. CONSERVATION ATTITUDES QUESTIONS

35. Do you think the numbers of any species in the reserve have changed over the past ten years?

Y / N / don't know

If Y, list all species and what the informant thinks is responsible for this decline.

36. Have any species disappeared completely from the reserve during your lifetime? Y/N/don't know

If Y, list all species and the approximate date of disappearance

37. Has the CGS population in the reserve stayed the same or changed at all during your lifetime?

Same/changed/don't know

- 38. What do you think the main threats are to the CGS population in this region? Please rank in order of importance, with 1=high importance. (*Read out the categories*)
 - Overharvesting
 - Water pollution
 - Lack of food
 - Water development projects (e.g. weirs, dams)
 - Other (describe)
 - No threats
- 39. What are your attitudes about whether CGS should be protected? (*Read out the categories*)

- They should be protected everywhere
- They should only be protected in nature reserves
- No need to protect them
- Other (describe)
- No opinion
- 40. Do you think that you or your community would get any benefit if CGS was protected? Y/N/don't know If Y, why?
- 41. Are any particular aquatic species in the reserve specifically protected by law? Y/N/don't knowIf Y, list all species and try to describe what this legislation is
- 42. Is wild CGS specifically protected by law? Y/N/don't know If Y, try to describe what this legislation is
- 43. Are any fishing methods banned in the reserve? Y/N/don't know If Y, ask the informant to name these methods.
- 44. Are any areas where fishing cannot be carried out? Y/N/don't know If Y, ask the informant to name these localities/rivers.
- 45. Have the rivers in the reserve changed at all during the past ten years? Y/N/don't know If Y, how have they changed in quality?What has caused this change (e.g. weirs or dams)?
- 46. Has anyone ever been prosecuted for illegal fishing in the reserve? Y/N/don't know If Y, how often has this happened? What charge/fine/sentence was there?
- 47. Has anyone ever been prosecuted for catching CGS in the reserve? Y/N/don't know If Y, how often has this happened? What charge/fine/sentence was there?
- 48. Has anyone ever been prosecuted for any other illegal activities in the reserve? Y/N/don't know

If Y, how often has this happened? What charge/fine/sentence was there?

Space for further comments: