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Chinese Alligators: Observations at Changxing Nature Reserve & Breeding Center

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Abstract.—I present previously unpublished data on the breeding habits and related conservation efforts on behalf of the endangered endemic Chinese Alligator (*Alligator sinensis*) collected through interviews and observations conducted at the Changxing Nature Reserve & Breeding Center for Chinese Alligators. The objective of this study was to provide additional material to supplement that presented in the most current and comprehensive English-language literature on the species. Conservation efforts on behalf of the Chinese Alligator are hindered by heavily polluting industries, such as coal-fired power plants and battery plants, which affect all local fauna. In addition, captive population statistics at Changxing and Xuancheng breeding centers have changed since 2010. Additional observations of the Chinese Alligator include nesting behaviors, ovipositioning, and temperature and humidity conditions in nests. I observed experiments comparing temperature-dependent sex determination to that in the closely related American Alligator (*Alligator mississippiensis*). I provide information on reintroduction efforts by both Chinese captive breeding centers in different wild zones and discuss definitions of "wild," with which Chinese Alligator reintroduction efforts do not conform. Further species conservation efforts should be facilitated by a master plan and studbook, implemented to maximize genetic variation and minimize the effects of inbreeding depression in captive populations with few founders.

Fig. 1. Ovipositioning was observed at dawn.

The lack of recently published data on the Chinese Alligator (*Alligator sinensis*) is the result of three major factors: (1) The two leading Chinese research institutes are competitors for government funding and share neither their resources nor their findings. (2) With fewer than 130 individuals living in the wild, the Chinese Alligator is an elusive, little-known species, and crucial fieldwork and conservation efforts often have been overshadowed by mammal-oriented breeding endeavors, particularly in China, where the Giant Panda (*Ailuropoda melanoleuca*) has become the face of the global movement to prevent wildlife extinction. (3) The fierce nature of the Chinese Alligator combined with its shrinking natural habitat in the wetlands around the Yangtze River have greatly limited the acquisition of data about the species, resulting in gaps, conjecture, and erroneous reports.

The Chinese Alligator is endemic to China and one of only two extant species in the genus *Alligator*. The Chinese Alligator originally inhabited much of China's viable wetlands, but the species has been reduced to fewer than 130 individuals along the lower Yangtze River. The decline of wild Chinese Alligator populations can be attributed to habitat loss, as wetlands are increasingly converted to rice paddies, and over-hunting resulting from a local belief in the curative properties of alligator meat, as well as the species' reputation as a menace to livestock.

Thorbjarnarson and Wang (2010) is currently the most expansively detailed English-language source on the IUCN-listed critically endangered species (Crocodile Specialist Group 1996). However, in the past three years, Thorbjarnarson passed away, and co-author Wang became vice-headmaster at East China Normal University (ECNU 2013), an administratively heavy position that allows him no time for research. Consequently, a void in relevant scholarship has precluded any updates on the Chinese Alligator since the book's publication.

Methods

This report is derived from on-site fieldwork, interviews with keepers and scientists, and my research of relevant sources in Chinese during my internship at the Changxing Nature Reserve and Breeding Center for Chinese Alligators (CNRBRCCA) from June through August 2013, under the guidance of Professor Fang Sheng-Guo of the College of Life Sciences of Zhejiang University in Hangzhou, Zhejiang Province, China. Professor Fang also serves as Director of the State Conservation Center for Gene Resources of Endangered Wildlife.

Fig. 2. An alligator nest is a mass of vegetation about 1 m in diameter.

Results

Local Environment.—Human development (e.g., dams along the Yangtze River, human occupation of wetlands) is the primary contributing factor to the decline of the wild population of the Chinese Alligator; thus, taking note of human factors in reintroduction and captive breeding efforts is of considerable importance. Various forms of pollution caused by Chinese industry have led to widespread health and environmental problems.

The environmental conditions at Changxing were not mentioned by Thorbjarnarson and Wang (2010). CNRBRCCA is located 25 km west of Changxing County in the city of Huzhou. During the weeks of my internship, I observed that the sky in Changxing was more often than not cast in smog. I further learned that Changxing has several polluting industries: Two huge power plants with excess power sold to other cities and two enormous battery plants, including the largest auto battery plant in China. In June 2005, more than 700 children were diagnosed with lead poisoning in Meishan, a town within Changxing County, where the Tianneng battery plant is located. Meishan is 35 km north of CNRBRCCA (Wang 2012). Moreover, Ren Dabin, head keeper at CNRBRCCA, revealed that the local Changxing ponds suffer from pesticide pollution from nearby farms. Rodent carcasses often are found in the ponds, and alligators that eat the carcasses often are stricken with severe illnesses, several of which ended in death. Fortunately, Chinese Alligators have very strong immune systems, and thus such casualties have been relatively few. Statistics notwithstanding, pollution-related death is significant given the severely limited wild population of the Chinese Alligator, and is cited by staff at CNRBRCCA as one of the leading causes of population decline.

Captive Population Statistics.—Thorbjarnarson and Wang (2010) reported that the captive population of the Chinese Alligator at CNRBRCCA in 2007 stood at 300 individuals, including the 100 adults purchased in 2006 from the Xuancheng breeding center, *Anhui Research Center of Chinese Alligator Reproduction* (ARCCAR) at a cost of 50,000 Yuan each (Fang Sheng-Guo, pers. comm., 13 June 2013). However, according to Xu (2005), the population was reported to have 459 individuals, including seven founders, 214 F1 generation individuals, and 238 F2 generation individuals. Further supporting Xu's assertion, Changxing News (2008a) reported the captive population of the Chinese alligator at 700+ individuals, including 175 bred in 2007 and 85 in 2006. In the past few years, the population has increased substantially. PRC (2013) reported that the current population count of captive individuals at CNRBRCCA was 3,923 alligators, including 2,089 young (1–3 years old), 1,568 juveniles (4–12 years old), and 248 adults (13+ years old).

Nesting/Ovipostioning.—As of August 2013, 600+ eggs from 24 nests were produced during the captive Chinese Alligator breeding season. The exact number cannot be

Fig. 3. Alligator feces deposited on the mound after laying eggs might facilitate nest identification.

deduced due to the fact that the eggs are laid in nests covered by mounds of local vegetation. The 2012 breeding season yielded 1,000+ eggs from 42 nests. The yield in 2013 is lower than that of 2012 due to the comparatively cooler weather in June, the beginning of the breeding season.

At ARCCAR, eggs are collected and incubated at about 30 °C to produce a female-biased sex ratio (Thorbjarnarson and Wang 2010). Having more females resulted in the capacity to produce more offspring. As of December 2011, the 10,500 animals at ARCCAR had an annual breeding capacity of 1,500 to 2,000 (Xuancheng News 2011).

Behavioral Observations.—Ovipositioning was observed at dawn (Fig. 1). Females are usually aggressive, rendering detailed observations impossible; however, this female was blind. Although ovipositioning was filmed, the exact number of eggs in the clutch is unknown because the nest mound obscured the view. Usually, each nest holds 20–40 eggs buried about 30–40 cm below the nest, which is about 1 m in diameter (Fig. 2).

Despite being blind, the female effectively guarded her eggs, and easily returned to the nest after cooling off in the pond. The mother excreted feces onto the mound after she finished laying her eggs (Fig. 3); pheromones in the feces might facilitate nest identification. Eggs are initially translucent, but fertilized eggs contain a white spot that spreads until the entire eggshell is an opaque white.

Females guard nests fiercely (Fig. 4). As a result, scientists use a light bamboo stick to hit the alligator's eyelid and compel retreat, thereby allowing time for the retrieval of eggs. To identify each female prior to taking her eggs, an RFIC reader (Destron Fearing Portable Transceiver System FS2001F) is tied to a long bamboo catchpole in order to scan identifying details from a previously inserted tracking chip.

Females frequently returned to guard their nests although the eggs had been removed. This ongoing nest-guarding instinct likely results from the fact that laid eggs are usually undetectable when hidden in the nest mound.

Temperature Conditions.—
Temperature and humidity data are relevant to nesting and breeding due to temperature-dependent sex determination (TSD), in which incubation temperature determines the sex of the hatchling. These data were captured by data loggers (ZDR-11 from Hangzhou Zeda Instruments) at each of the 24 nests (Fig. 5). Loggers were insulated in plastic bags when placed in the nests or underwater. Each logger has the capacity to collect 34 days of data at five-minute intervals. Nest temperatures were always about 30 °C, despite 40 °C ambient air temperatures; nests maintained the lower temperature as a result of shade from nearby trees. Temperatures must be between 27 °C and 36 °C, as temperatures outside this narrow range would lead to fetal death (Chen, 1990). When the ambient temperature dropped to 26 °C at night,

Fig. 4. Female alligator defending her nest.

Fig. 5. Each data logger had the capacity to collect 34 days of temperature and humidity data at five-minute intervals.

nest temperatures remained constant. Apparently, microorganisms in the mound, a product of decomposing organic materials, produce heat that maintains the ideal temperature range. Temperatures also were measured at various points in each pond. The temperature was 36 °C at the surface and 28 °C 1 m below the surface.

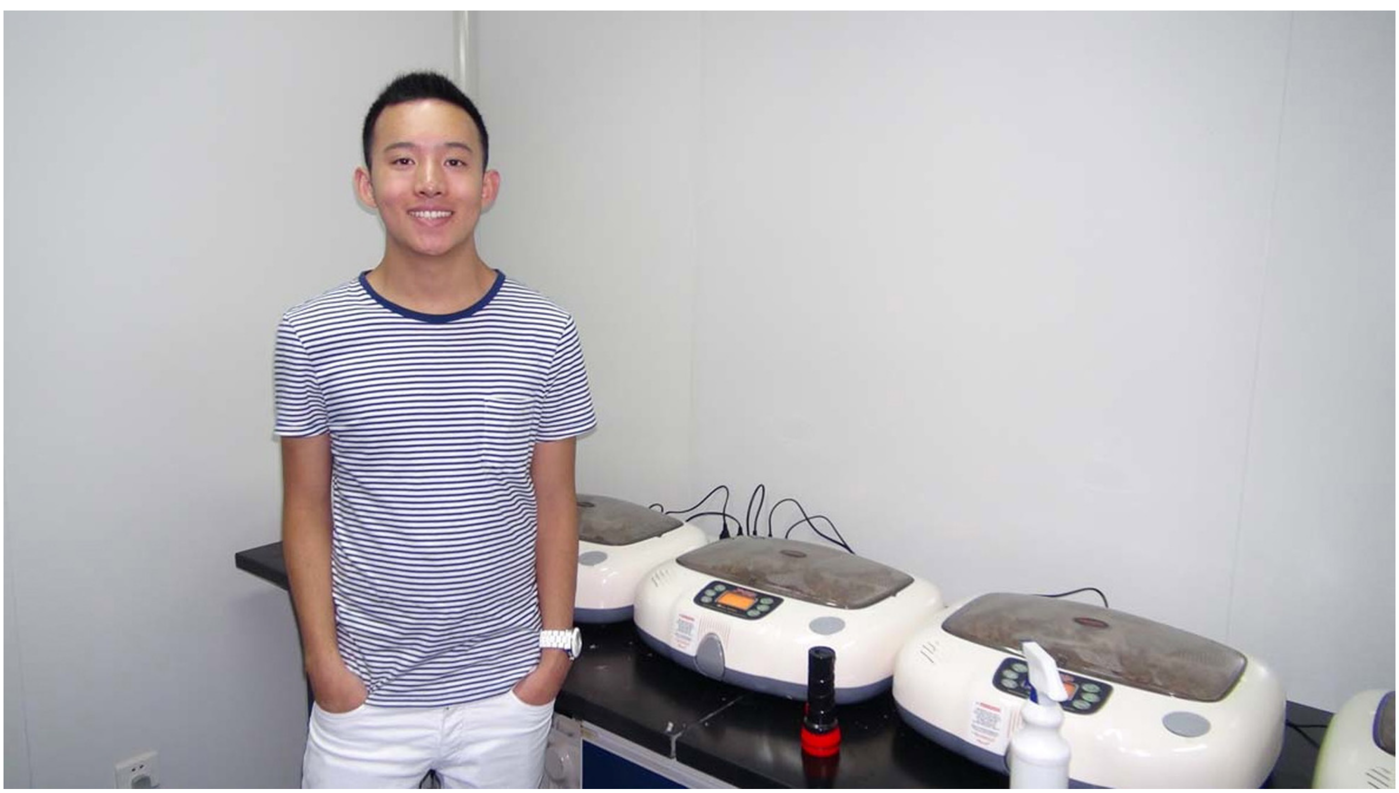

Fig. 6. The author with the artificial incubators at the State Conservation Center for Gene Resources of Endangered Wildlife.

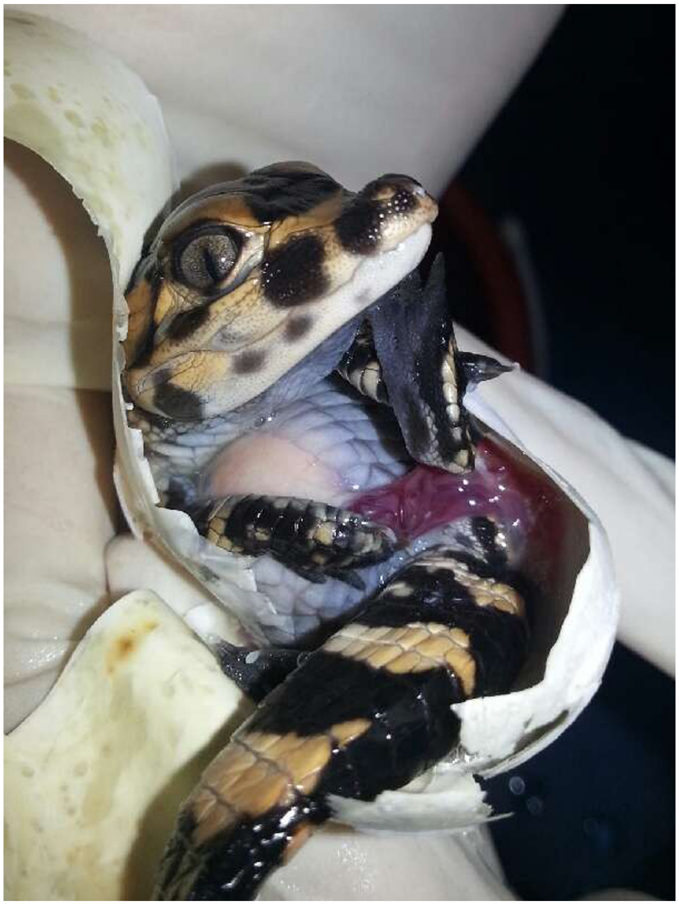

Fig. 7. Remnants of the yolk sac visible on the hatchling's belly serve as the main source of nourishment for the first two weeks of life.

Despite the relative temperature stability of the nests during the summer mating and hatching season, outside conditions can have a substantive effect on sex determination. 5 August 2013 marked the thirty-fourth day of high temperatures in Hangzhou, China (120 km south of Changxing), with a record-setting 40.4 °C on 24 July (China.com 2013). Similarly high temperatures produced more males than females in the summer of 2012; the same may apply for the 2013 hatching season.

Artificial Incubation.—Each year at CNRBRCCA, a select number of eggs are incubated as part of a research project to study TSD in Chinese Alligators. During the incubation period, incubation temperatures of 30 °C or below produce female hatchlings, temperatures of 34 °C or above produce males, and temperatures of ~32 °C result in either males or females.

Fifty eggs from the 2013 breeding season were incubated at the State Conservation Center for Gene Resources of Endangered Wildlife at Zhejiang University with the mound brought from their respective nests (Fig. 6). Ten eggs were placed in separate R-com 20 Pro Digital Incubators. The temperature initially was set at 34 °C in four incubators and 28 °C in another; the humidity was set at 99% in all of them. The experiment was to determine if the gender of hatchlings would shift during the eggs' thermally sensitive period if the temperature of the incubator was decreased from 34 °C to 28 °C. A similar experiment conducted using eggs from the closely

Fig. 8. "Wild" zone at CNRBRCCA where alligators would be released.

Fig. 9. Using a bamboo catchpole to catch an alligator.

related American Alligator (*Alligator mississippiensis*), revealed that incubation temperature shifts during the thermally sensitive period would result in a change in sex. However, despite the two species' close phylogenetic relationship, experiments on Chinese Alligator eggs persist in order to confirm that the same conditions would have similar effects in both species.

Fig. 10. Inserting an RFID chip under the skin on the tail.

Rearing the Young.—Young Chinese Alligators begin to feed at two weeks of age. Prior to that time, remnants of the yolk sac visible on the hatchlings' bellies (Fig. 7) serve as the main source of nourishment. An alligator hatchling must digest all of the yolk remaining in its body. Feeding a hatchling prematurely can cause digestive difficulties and induration. Although feeding does often commence after 14 days, waiting 18–20 days is advised for ideal results (Fang Sheng-Guo, pers. comm., 13 June 2013).

Ponds at CNRBRCCA are populated with young alligators of similar sizes and ages. For example, one pond contains one-year-old alligators while another contains eight-year-old alligators. Very young alligators are particularly docile and sensitive to noise, quickly dashing into the water as soon as they hear humans approaching.

At CNRBRCCA, alligators one year or younger are moved to heated rooms during the winter. Older alligators remain in the ponds. At ARCCAR, the hatchlings stay in heated rooms in the winter along with older animals; Anhui News (2008) reported that 8,000 animals were kept in a small heated room with a small pond (3 m^2 and 80 cm deep) for the winter.

CNRBRCCA Reintroduction Site.—The original CNRBRCCA consisted of 0.67 hectares, and 60 adjacent hectares of land was purchased in 2007 (Thorbjarnarson and Wang 2010). Changxing News (2008b) reported the total area of CNRBRCCA to be approximately 67 acres in their 2008 report. Twenty-five hectares were designated as an experimental "wild" zone where alligators would be released (Fig. 8). In April 2012, 120 individuals that had hatched in 2003 through 2005 were released into the fenced "wild" zone (Xinhua News 2012). In July 2013, 140 alligators hatched in 2006 through 2007 were released (Yang Hai-Qiong, pers. comm., 20 August 2013). More females than males were released and a few released animals were blind, the latter possibly caused by the inbreeding inherent in populations with low numbers of founders.

Release Procedures.—I participated in the reintroduction of 140 individuals into the "wild" zone in June 2013. A bamboo catchpole was used to catch and subdue alligators (Fig. 9), and an RFID chip from Destron Fearing was implanted under the skin on the tail (Fig. 10). This RFID chip contains relevant data about the alligator, such as its height, weight, and lineage information. An RFID reader is used to check if a viable RFID chip is in every individual (Fig. 11). A blood sample is taken from the tail vein using a disposable syringe. The sample is sent to the lab at Zhejiang University for future use (Fig. 12).

Alligators were transported by boat to the middle of the experimental "wild" zone, where the tape was removed from their jaws. With one hand squeezing the mouth shut and another holding the body, each alligator is released into the "wild" (Fig. 13). Shortly after release, individuals had not yet adapted to the wild environment. In the "wild" zone, alliga-

Fig. 11. An RFID reader is used to check if a viable chip is in every individual before it is released.

tors were not fed directly; instead, fish had been cultivated in the area. However, several alligators still responded to sticks thrown into the water by area workers.

ARCCAR Reintroduction Sites.—ARCCAR also has reintroduced individuals into wild zones. As of January 2013, ARCCAR has carried out nine separate reintroduction efforts

Fig. 12. A blood sample is taken from the tail and sent to the lab at Zhejiang University.

Fig. 13. Releasing alligators into the wild.

Fig. 14. Location of the CNRBRCCA and ARCCAR breeding centers and their reintroduction sites.

(Anhui Forestry Bureau 2013). Figure 14 shows the locations of the CNRBRCCA and ARCCAR breeding centers and their reintroduction sites.

In 2003, ARCCAR's first alligator reintroduction effort occurred in Hongxin, 30 km south of ARCCAR. This was a joint effort between the Wildlife Conservation Society, based at the Bronx Zoo, and two Chinese national entities, the Anhui Forestry Bureau and East China Normal University (Thorbjarnarson and Wang 2010).

Eight subsequent reintroductions occurred in Gaojingmiao, 54 km northeast of ARCCAR. The Gaojingmiao reserve consists of 30 hectares, 12 hectares of which were wetlands that contained 17 ponds. Fish, shrimp, snails, mussels, and loaches were supplied by ARCCAR annually (Xinhua News 2009, Anhui Photographers' Net 2009). Release dates are shown in Table 1.

Table 1. Releases of Chinese Alligators at ARCCAR.

Releases (reference)	Date	Number
First release (Anhui Forestry Bureau 2013)	2003	3
Second release (Anhui Forestry Bureau 2013)	April 2006	6
Third release (Anhui News 2007)	June 2007	6
Fourth release (Langxi News 2009b)	June 2009	6
Fifth release (Xinhua News 2009)	June 2009	6
Sixth release (Anhui News 2010)	June 2010	6
Seventh release (Xinhua News 2011)	May 2011	6
Eighth release (Anhui News 2012)	June 2012	6
Ninth release (Anhui Forestry Bureau 2013)	May 2013	6

A third reintroduction site, Chongming Dongtan Nature Reserve, is at the eastern end of Chongming Island, Shanghai. Three Chinese alligators born at CNRBRCCA and three U.S.-born animals donated to CNRBRCCA were released there in June 2007. This was a joint effort between the United States and China, which involved the Wildlife Conservation Society and the St. Augustine Alligator Farm, both based in the United States, and CNRBRCCA and the Shanghai government (Thorbjarnarson and Wang 2010).

Wild Population.—Conducting a population survey is difficult and can easily yield inaccurate results. In addition to all the problems associated with locating and discriminating individuals in the wild, Chinese Alligators have the ability to depress metabolic levels, which allows them to submerge themselves in water for more than three hours (Fang Sheng-Guo, pers. comm., 13 June 2013).

A 1999 report suggested that the total population of Chinese Alligators in the wild was less than 130 individuals, with an annual decline rate of 4–6% (Thorbjarnarson and Wang 2010). A separate team, in 2005, carried out another survey of the wild population. According to Wang Chao-Lin, deputy director of ARCCAR, more surveys were conducted in 2009 and 2011 (Anhui News 2012). The latest

ARCCAR survey in 2011 showed the wild population at 150 individuals and 200 if the 50 reintroduced individuals were included (China News 2013). However, the reintroduced individuals at CNRBRCCA were not included in the survey. Nevertheless, researchers at Zhejiang University continue to quote Thorbjarnarson's 1999 report (<130 individuals) in their research papers. The true wild population count remains unclear, but even senior researchers doubt the outdated official number.

Thorbjarnarson and the breeding centers differ vastly in their definitions of a "wild alligator." Thorbjarnarson stated that wild alligators "were born in nests by wild females living in ponds; they are not surrounded by fences nor are they fed" (Thorbjarnarson and Wang 2010). However, the 260 alligators at CNRBRCCA's wild zone are fenced and fish were cultivated (Fig. 15). The 48 alligators at ARCCAR's fenced Gaojingmiao site are resupplied with seafood annually (Langxi News 2009a).

Inbreeding Depression.—As a result of the Chinese Alligator's low genetic diversity and few founding members, the forced mating of close relatives has caused inbreeding depression, thereby reducing fertility and increasing mortality and the rate of deformities. The latter include kyphosis, S-shaped bodies, curved tails, sideways-pointing tails, blindness, or being born without eyes. Keepers prevent individuals with deformities from breeding. These individuals are isolated in their own pens, where they are fed regularly, as some cannot swim. Deformities caused by inbreeding depression were severe at CNRBRCCA, but have decreased from 10% to 0.25% after the keepers carefully matched the alligators that were several generations apart to maximize genetic variance (Fang Sheng-Guo, pers. comm., 13 June 2013).

Thorbjarnarson emphasized that future work should focus on genetic screening of all adult animals in ARCCAR and CNRBRCCA and should include the development of a breeding program to maximize genetic diversity of progeny (Thorbjarnarson and Wang 2010). In the United States, the Association of Zoos and Aquariums (AZA) has developed a Species Survival Plan (SSP) pertaining to endangered species that advises on techniques for managing breeding and reintroduction efforts. Individuals are transported among networks of zoos for breeding according to a master plan developed to minimize the loss of genetic diversity (Thorbjarnarson and Wang 2010).

No master plan for the Chinese Alligator is currently available, nor does a studbook comprehensively document and make available information on the various breeding efforts in China. In fact, ARCCAR and CNRBRCCA operate as separate entities; they must engage in joint breeding efforts to maximize genetic variation and share any data or resources pertaining to their own populations.

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Fig. 15. The alligators at CNRBRCCA's "wild" reintroduction site are enclosed by fences and fish are cultivated.

opportunity to study Chinese Alligators at the CNRBRCCA. Many thanks go to Zhejiang University graduate student, Yang Hai-Qiong, and head keeper, Ren Dabin, for their valuable insights and mentorship. I also thank Carl Ma of The Branson School, my advisor and teacher of Biology and Biotechnology, for his advice on this report.

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