# A Population and Nesting Survey of Reintroduced Chinese Alligators at Dongtan Wetland Park, Shanghai, China.

**Steven G. Platt, Fenglian Li, and Qijing He**

**Report to:**

**Wildlife Conservation Society**
**2300 Southern Blvd.**
**Bronx, New York**
**10460-1099**
**United States of America**

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**Cover photograph**: Female Chinese alligator (*Alligator sinensis*) aggressively defending her nest at Dongtan Wetland Park (July 2016).

# Introduction and Background

The Chinese alligator (*Alligator sinensis*) is considered the most critically endangered crocodilian in the world (Xing 2010). Fewer than 150 Chinese alligators survive in the wild, and these occur in small populations at widely scattered sites; the largest population at any particular site numbers no more than 20 individuals and contains <10 adults (Thorbjarnarson and Wang 1999; Thorbjarnarson et al. 2002; Thorbjarnarson and Wang 2010). Sites occupied by wild Chinese alligators are typically patches of marginal habitat embedded within agricultural landscapes. Importantly, the agricultural lands surrounding occupied sites effectively block the dispersal of alligators, thereby precluding genetic exchange between wild populations (Thorbjarnarson and Wang 2010). Furthermore, the limited areal extent of most occupied habitats prevents any significant increase in the size of wild populations (Thorbjarnarson and Wang 2010).

In contrast to the tenuous conservation status of wild populations, *ex-situ* propagation has proven remarkably successful and thousands of alligators (> 14,000 in 2015; Professor Lu Shunqing, unpubl. data) are now maintained at two government operated conservation-breeding centers in China (Thorbjarnarson and Wang 2010; Platt 2012). An action plan prepared in 2001 by Chinese and international scientists strongly recommended that new wild populations be established by releasing captive-bred and head-started *A. sinensis* into suitable, but unoccupied habitat (Jiang et al. 2006). To this end, a trial release of six adult Chinese alligators was conducted at Dongtan Wetland Park (DWP) on Chongming Island in June 2007 (Thorbjarnarson and Wang 2010). Chongming Island is a large alluvial island (1267 $km^2$) at the mouth of the Yangtze River near Shanghai, and within the known historic distribution of *A. sinensis* (Platt 2012). DWP is a popular outdoor recreation area and consists of 860 ha of freshwater marsh dominated by *Phragmites australis*. These marshlands host an abundance of potential prey such as aquatic insects, mollusks, fish, snails, crustaceans (including the invasive *Procambarus clarki*), snakes, and frogs, and as such is considered excellent alligator habitat (Thorbjarnarson and Wang 2010; Lu et al. 2014). Thorbjarnarson and Wang (2010) suggested DWP could ultimately support as many as 300 adult *A. sinensis* and considered it the most important site for alligator conservation in China.

The original group of alligators released at DWP consisted of three adults (1♂:2♀) females) from a breeding center in Zhenjiang Province, China and three adults (1♂:2♀) imported from institutions in the United States; the latter were part of breeding programs in the AZA Species Survival Plan (Lu et al. 2014). Each alligator was fitted with a telemetry collar and monitored for about 1.5 years until battery power was exhausted. Two adult alligators (1♂:1♀) drowned shortly after being released when they became entrapped in submerged crab nets set in a deep canal along the perimeter of DWP. Subsequent to this incident nets were banned from DWP and park staff removed those that remained. Another adult female was recaptured by park staff after dispersing > 20 km from the release site. This animal was held in captivity at DWP for one year before succumbing to unknown causes in late autumn of 2009.

Post-release monitoring was discontinued in early 2009 when transmitters ceased emitting signals, and the fate of the remaining three alligators was unclear. Nesting was confirmed in 2008 when a recently constructed nest mound containing four eggshell membranes on a levee adjacent to the perimeter canal (Lu et al. 2014). The nest was built in dense grass about 4 m from the water. Sixteen hatchlings were observed nearby and probing revealed the submerged entrance to a burrow, presumably that of the nesting female about 3 m from the nest mound. Although no other nests have been found, a group of at least 20 hatchlings was observed by DWP staff and volunteers in 2012, indicating that additional population recruitment has occurred within the park (Lu et al. 2014).

Despite being accorded priority by the IUCN/SSC Crocodile Specialist Group (Xing 2010), an assessment of the reintroduction was not conducted until 2014 (Lu et al. 2014 Because reintroduction was identified as the key strategy for restoring viable alligator populations to landscapes in the Yangtze River floodplain (Hongxing et al. 2006; Xing, 2010), rigorously evaluating previous attempts was necessary to determine if reintroduction is indeed a conservation tool likely to prove successful with Chinese alligators (Lu et al. 2014). To address this need, Wildlife Conservation Society (WCS) working in close collaboration with the scientific staff of DWP initiated a project with the objectives of 1) estimating the number of Chinese alligators now inhabiting DWP, 2) determining the size-class structure of the alligator population, 3) monitoring population recovery, and 4) providing management recommendations to DWP managers based on our findings. Our ultimate goal is to establish a viable population of Chinese alligators in DWP as part of the larger "conservation metapopulation" envisioned by Thorbjarnarson and Wang (2010).

In 2014-15, surveys conducted in DWP found at least nine Chinese alligators (three adults, two subadults, and four large juveniles) inhabiting the park. The three adult alligators were undoubtedly surviving members of the original group released in 2007, while the subadults and juveniles were progeny from post-release reproductive events (Lu et al. 2014). Based on the size range of smaller alligators, it appeared that at least two cohorts of offspring were present in the park, most likely from nesting that occurred in 2008 and again in 2012 (Lu et al. 2014). A third nesting was documented in the summer of 2014, although these eggs failed to hatch, most likely due to unseasonably low air temperatures and heavy rainfall (Platt et al. unpubl. data). The infrequency of reproduction is unsurprising considering the size of the reproductive population (2 females) and the fact that female alligators usually nest biennially or two years out of three owing to energy constraints that limit reproduction (Thorbjarnarson and Wang 2010). Assuming 50 eggs (clutch size is generally 20-30 eggs; Thorbjarnarson and Wang 2010) were produced during two reproductive events in 2008 and 2012, the six juvenile and subadult alligators observed in 2014 represented a survival rate of 12%, which is comparable to survival rates reported for young *A. mississippiensis* (Ouchley 2013). Lu et al. (2014) concluded that surveys of DWP as well as other studies (Wang et al. 2011) indicate that reintroduction is a feasible management tool for restoring wild populations of Chinese alligators.

We returned to DWP in July 2016, and working closely with park managers conducted a population survey with the following objectives: 1) determine the outcome of second reintroduction of captive-bred Chinese alligators that occurred in 2015, 2) estimate the population of Chinese alligators now inhabiting the park, 3) investigate reproduction by reintroduced Chinese alligators, and 4) provide conservation and management recommendations to park authorities based on our findings. An annotated itinerary describing our fieldwork is presented in Appendix 1.

## Methods

Fieldwork was conducted in DWP from 15- 20 July 2016, a period coinciding with the beginning of the alligator nesting season (Thorbjarnarson and Wang 2010). We used a combination of diurnal pedestrian surveys and nocturnal spotlight counts to determine the population status of alligators in the park (survey methodology reviewed by Platt and Thorbjarnarson, 2000). Diurnal surveys were conducted by walking slowly along the trail network that provides access to much of DWP, and searching for alligators in the surrounding wetlands with binoculars (8 × 42 and 10 × 50). We conducted nocturnal spotlight counts using battery powered flashlights and headlamps to search for the reflective eye-shines of alligators. Spotlight counts were conducted either by walking along the trail network or paddling a small boat along the shoreline of waterbodies where alligators had been previously observed during diurnal surveys. We classified each alligator based on estimated total length (TL) as a small juvenile (TL < 50 cm), large juvenile (TL = 50-100 cm), subadult (TL = 101-120 cm), or adult (TL > 120 cm). Alligators that could not be approached closely enough during spotlight counts to estimate size were classified as "eye-shine only". The location of each alligator was recorded with a hand-held GPS Unit and plotted on a map of DWP.

We searched potential nesting habitat (e.g., islands, former nesting sites, elevated areas in open marsh, and canal banks) on foot to locate alligator nests. At each nest we noted the composition of the nest mound in relation to the surrounding vegetation, measured the external dimensions (height and width to nearest 1.0 cm) of the mound, and estimated its distance to water (from center of nest mound). Geographic coordinates (WGS 1984 Datum) of the nest were determined with a hand-held Garmin 76 GPS unit. We then carefully opened the mound, removed the eggs, and determined the clutch size. When removing eggs, we marked the dorsal surface of each with a pencil to insure upright orientation was maintained when replaced in the nest. We measured the length and width of each egg to the nearest 0.1 mm with a dial calipers and determined mass (± 0.5 g) with Pesola scales (Figure 1). Egg viability was determined by the presence of opaque egg bands (Ferguson 1985) (Figure 2). For viable eggs, the extent of opaque bands was used to estimate the age of the embryo and hence, the date of oviposition (Ferguson 1985) (Figure 2). Eggs were then replaced in the nest cavity and covered with moistened nesting material.


**Figure 1:** Processing a clutch of Chinese alligator eggs (above). The length and width of each egg was measured with a dial calipers (below).

**Figure 2:** Opaque banding was used to determine egg viability and estimate the date of oviposition (above). Compare non-viable (left) and viable (right) eggs in lower photograph. Note the presence of opaque band on viable egg.

## Results and Discussion

### Recent alligator reintroduction

In accordance with recommendations of a WCS-sponsored workshop in January 2015, a second reintroduction of captive-bred Chinese alligators took place at DWP in 2015-16. A pre-release acclimation pen encompassing 24,000 $m^2$ of marsh and open water with a large centrally located island (5,000 $m^2$) was constructed in early 2015 (Figure 3). The pen is constructed of heavy gauge wire fencing approximately 1.5 m high and extending about 0.5 m belowground to prevent alligators from digging out (Figure 4). Six adult alligators (2♂:4♀) aged 5-7 years-old were obtained from breeding centers in China and released into the pen in mid-June 2015. A VHF radio transmitter was attached to the tail of each alligator to facilitate pre- and post-release monitoring. However, the transmitters had detached from all of the alligators by October 2015. Supplemental food is not provided to the alligators, which subsist on naturally occurring prey available in the pen.

We searched the acclimation pen during the day and night on multiple occasions during our survey and could locate only two alligators. On 16 July 2016, we found a well-worn trail leading from the water into dense vegetation on the island. Further investigation revealed a recently constructed nest mound about 10 m from the water in a stand of *Phragmites* with a female in attendance. The latter was initially concealed in thick vegetation adjacent to the nest, but emerged and reacted aggressively as we began opening the mound. A second alligator was found later that day in open water on the opposite side of the island from the nest. No more than two alligators were observed during subsequent nocturnal visits to the pen, leading us to conclude the other four alligators had almost certainly escaped. Our conclusion was further supported when we noted a length of cord used to attach transmitters still affixed to the tail of a female alligator nesting about 100 m from the pen (see below).

### Population survey

We identified nine individual Chinese alligators during diurnal and nocturnal counts conducted during 15-20 July 2016. An adult alligator (most likely a female) was repeatedly observed during diurnal and nocturnal surveys of Pine Island Lake. This alligator appears to inhabit a burrow complex on the northwest tip of the island. Nesting occurred a short distance from this burrow in 2014 and again in 2015. In previous years juvenile alligators were often observed in company with the adult and probably inhabited the same burrow; however, smaller alligators were not observed in 2016. As mentioned above, two adult alligators were found in the acclimation pen, including a nesting female. Although a well-used basking site was present on the island, no basking activity by alligators was observed within the acclimation pen, most likely due to the high diurnal temperatures. Our experience and that of others (Thorbjarnarson and Wang 2010) suggests that basking is most frequent in the early spring when alligators emerge from winter brumation.


**Figure 3**: Acclimation pen at Dongtan Wetland Park shortly after completion in April 2015 (above) and one-year later in July 2016 (below). Note the centrally located island where nesting occurred in July 2016. Captive-bred alligators were held in this pen prior to escaping into the surrounding marsh. One female remained in the pen and nested on the island.


**Figure 4**: Heavy gauge wire fence surrounding acclimation pen (above). Fence extends belowground to prevent alligators from burrowing out of the pen (below).

Another adult female alligator was observed on multiple occasions at a nest site on the bank of a shallow canal adjacent to a path leading to the Research Lab. A length of cord attached to the tail scutes identified this alligator as one of six released into the acclimation pen during 2015 (Figure 5). A large subadult or small adult alligator was observed concealed among dense vegetation alongside the boardwalk leading to the acclimation pen during a diurnal survey (Figure 6). A single observation was made during a spotlight survey of a small juvenile (TL ca. 40 cm) in a heavily vegetated pond adjacent to the Earthquake Monitoring Station. A large adult alligator (possibly a male based on body-size) was twice observed during spotlight surveys swimming in open water along the outside of the perimeter fence enclosing the acclimation pen. Finally, an adult alligator and a juvenile (or small subadult) were observed during spotlight surveys in open water near the Lush Grass House and in a slough north of the Research Lab, respectively.

In summary, we confirmed the occurrence of a minimum of nine individual alligators in DWP, including six adults, one subadult, and a juvenile. An active nest along a slough in the Wading Bird Colony (see below) indicates an additional female alligator not observed during our surveys also occurs in the park. Thus, at least ten alligators now inhabit DWP. However, for several reasons we believe our survey most likely underestimates the true number of alligators inhabiting the park. First, a lack of foot or boat access makes much of the northern area of the park difficult to survey. This area consists of open water and marsh, and includes some potential high-quality nesting habitat where future efforts should be focused. Second, our survey occurred during mid-summer when basking activity is infrequent making it difficult to make comparisons with previous surveys conducted in mid- to late April and early May (Lu et al. 2014). Third, smaller size classes of alligators can be extremely difficult to detect, especially in heavily vegetated habitats such as DWP (Platt et al. 2014). Based on the results of our previous surveys (Lu et al. 2014) and given the recent release of six additional alligators, we estimate the current population to consist of nine captive-reared and reintroduced adults, at least four adult progeny produced by three survivors of the original reintroduction, and a small (<5) but undetermined number of juveniles and subadults from nesting events in 2012 and 2015.

**Nesting survey**

According to park staff, a female alligator inhabiting Pine Island Lake constructed a nest during the summer of 2015. The nest was positioned on the island in close proximity to a burrow complex. At least two other nests have been constructed on this island in previous years (2012 and 2014). Personnel working in the boat house on Pine Island Lake reported observing hatchlings in September or October 2015, although none have been seen in 2016. We made multiple observations of an adult alligator in this lake during diurnal and nocturnal surveys and likewise encountered no juveniles. Although juvenile alligators can be difficult to detect during surveys, the winter of 2015-16 was unseasonably cold and despite sheltering in the burrow with the female, the hatchlings may have succumbed to freezing temperatures (Brandt and Mazzotti 1990).

**Figure 6**: Female alligator along canal bank near research lab (left). Length of cord attached to the tail scutes identifies this individual as one of six alligators released into the acclimation pen during June 2015 (below). The cord originally secured a VHF radio transmitter to the tail. The alligator subsequently escaped from the acclimation pen and nested in the adjacent marsh..

**Figure 6**: Large subadult Chinese alligator (above) observed in the heavily vegetated pond (below). Locating alligators in these habitats proved challenging during both diurnal and nocturnal surveys of Dongtan Wetland Park.

We documented nesting by three female Chinese alligators in DWP during July 2016 (Tables 1 & 2). Two of the nests were constructed by females reintroduced in 2015 and the third was almost certainly the work of an adult female released in 2007. These nests are briefly described below.

We found the first nest on 18 July alongside a shallow canal near the Research Lab (Figure 7). A well-used footpath traversed by hundreds of park visitors runs atop one side of the canal bank. The nest consisted of a low mound composed of grasses available at the nesting site. Our initial attempts to inspect the clutch were rebuffed by the aggressive actions of the female. We returned the following day armed with boat paddles to fend off the female and successfully opened the nest, which contained a clutch of 25 eggs. Based on the minimal extent of opaque banding, we estimate the clutch was deposited on 16 or 17 July. Ten (40%) eggs in the clutch proved to be non-viable. Notably, most of the non-viable eggs occurred at the bottom of the clutch where the nesting media was damp and cool. Most likely low incubation temperatures at this level precluded successful embryo development. A length of cord used to attach transmitters was attached to the tail of the attending female, identifying her as one of the six alligators released into the acclimation pen in 2015 (Cover photograph and Figure 5).

We initially located the second nest on 17 July alongside a slough in the Wading Bird Colony, but lacking defensive armaments, made no attempt to open the mound until the following day (Figure 8). The nest consisted of an irregular shaped mound of vegetation positioned in the center of a stand of high grass, making it difficult to locate. Several well-worn trails led through the grass from the nest to the slough. We opened the mound on 18 July and found a clutch of 27 mucous-covered eggs deposited only hours previous to our visit. Because opaque egg bands require at least 24 hours to form, we returned again on 20 July and reopened the nest to assess levels of viability; the clutch contained only a single non-viable egg. This nest is positioned just across the slough from where a nest was constructed by an alligator in 2008. Because alligators generally exhibit a high degree of nest site fidelity, we consider it likely this clutch was deposited by one of the females from the original reintroduction. Numerous nests of wading birds (Black-crowned Night Herons, Little Egrets, and Purple Herons), many built in clumps of *Phragmites* just above the surface of the water are found along the canal and represent a potential food source for the nesting female.

A third alligator nest was found on the island within the acclimation pen (Figure 9). The mound was under construction when initially discovered on 16 July; laying probably took place that night. The nest was positioned in high grass and composed of a mixture of *Phragmites* and *Solidago*. We waited until 19 July before returning and attempting to open the mound, which was defended by the attending female. The clutch consisted of 32 eggs (31 intact eggs and one empty eggshell), the largest clutch yet recorded at DWP. Five eggs had been cracked during laying and the contents of another egg was leaking. Four eggs (including three cracked eggs) lacked opaque bands and were considered non-viable. Another egg exhibited an opaque band, but was extremely thin-shelled and unlikely to successfully hatch.

**Table 1**: Geographic coordinates, physical location, and description of Chinese alligator nests found at Dongtan Wetland Park in July 2016. NR = Not recorded.

| Nest | Latitude (N) | Longitude (E) | Location/description/notes |
|---|---|---|---|
| 1 | 31º31.191′ | 121º56.727′ | Canal bank near research lab; mound constructed of grass (85 cm wide × 30 cm high); positioned 1.5 m from water; female aggressively defending nest. |
| 2 | 31º30.843′ | 121º56.992′ | Bank of slough in wading bird colony; mound constructed of grass (80 cm wide × 40 cm high); positioned 2.0 m from water; female not encountered at nest. |
| 3 | NR | NR | Island in acclimation pen; mound constructed of *Phragmites* and *Solidago* (50 cm wide × 28 cm high); positioned 5.0 m from water; female aggressively defending nest. |

**Table 2**: Estimated date of laying and clutch attributes from three Chinese alligator nests found at Dongtan Wetland Park during July 2016. Nest number corresponds to Table 1. Egg mass = Mean ±1SD. Asterisk denotes clutch containing a broken egg not included in count of non-viable eggs.

| Nest | Estimated date of laying | Clutch size | Non-viable eggs (%) | Egg mass (g) |
|---|---|---|---|---|
| 1 | 16-17 July | 25 | 10 (40.0) | 38.2 ± 1.0 |
| 2 | 18 July | 27 | 1 (3.7) | 55.9 ± 2.4 |
| 3 | 15-16 July | 32* | 4 (12.5) | 42.9 ± 1.9 |

**Figure 7**: An alligator nest was found along this shallow canal near the research lab (above). Nest is in high grass on far left of photograph. The nest contained a clutch of 25 eggs (below).

**Figure 8**: Alligator nest (above) constructed in high grass along slough in wading bird colony (below). Wading bird chicks represent a potential food source for larger alligators in park.

**Figure 9**: Alligator nest constructed in the acclimation pen.  Close-up of nest mound (above) and view of nest amidst dense stand of *Phragmites* (below).

In summary, we located three Chinese alligator nests during our survey of DWP in July 2016. The three nests contained a total of 32 eggs, of which 68 were viable and likely to successfully hatch. Hatchlings are expected to emerge in early to mid-September. Given estimated survival rates of 10-12% for *Alligator sinensis* and *A. mississippiensis* (Ouchley 2013; Lu et al. 2014), 7 to 8 of these hatchlings can be expected to reach sexual maturity and enter the breeding population in approximately 2022. Wading birds probably represent the most significant threat to hatchling and small juvenile alligators (Neill 1971; Kilham 1985; Lu et al. 2014).

## Management recommendations

1. Suspend removal of aquatic vegetation from along the shoreline of water bodies inhabited by alligators in DWP, especially Pine Island Lake, Swan Lake, and nearby canals. Aquatic vegetation fringing lakes and canals hosts an abundance of small invertebrate and vertebrate prey (e.g., insects, crustaceans, and fish), and as such constitutes extremely important foraging habitat for alligators, particularly for hatchlings and juveniles. Furthermore, dense aquatic vegetation no doubt serves as critical escape cover for small alligators concealing them from predators such as wading birds.

2. Avoid the use of net barriers in DWP which may entangle and drown alligators. At least one juvenile is known to have perished after becoming entangled in a net near Swan Lake (Lu et al. 2014). However, because nets have a large mesh size, even adult alligators could be at risk. Given the small number of alligators now inhabiting DWP, the loss of even a single adult could have serious demographic consequences for population recovery. Not only do the nets constitute a hazard for alligators, but they may also be hindering the movement potential prey (e.g., fish and crustaceans) among water bodies. We recommend nets be removed and replaced by heavy gauge wire-mesh barriers that extend 10-20 cm below the water surface. Wire-mesh barriers will contain ornamental waterfowl, while at the same time allow alligators to pass safely beneath the fence without risk of entanglement and drowning.

3. Given the apparent success of two previous reintroductions (2007 and 2015-16) and the availability of a spacious, well-constructed, and permanent acclimation pen, we recommend that an additional six (or more) large subadult or adult Chinese alligators be released at DWP in 2017. Because the rate of future population increase is linked to the number of reproductive females, we recommend the next release consist of two males and four (or more) female alligators. Releasing additional adult alligators into DWP will lessens the extinction risk inherent in any small population and increase trajectory of the current recovery.

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**Appendix 1**: Annotated trip itinerary and summary of daily field activities (14 to 22 July 2016).

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| 14 July | Fly from Yangon, Myanmar to Shanghai, China, arriving early evening. |
| 15 July | Depart Shanghai and drive to Chongming Island, arriving ca. 1100 hrs. Eat a hasty lunch and travel to Dongtan Wetland Park where we met with park staff and planned the upcoming survey. Walked to Swan Lake and searched for alligators. Continued to acclimation pen but forced to seek shelter during a torrential downpour. Search acclimation pen when rain abates. Returned to HQ where park staff briefed us on 2015-16 reintroduction efforts. |
| 16 July | Spent the day at DWP searching for alligators and their nests. Searched islands in Pine Island Lake and acclimation pen. Encounter aggressive female at newly built nest mound in acclimation pen. Search for alligators in canals in southern area of park until late afternoon. |
| 17 July | Search for alligators and nests throughout the day. Walked from Visitors Center to restaurant at rear of park during the morning and found nest mound along canal near research lab. Return to nest after lunch, open mound and briefly examine the clutch. Continue to wading bird colony; examined both banks of slough and found recently constructed nest mound near old (2008) nesting site. Lacking weapons, we made no attempt to open mound. |
| 18 July | Visit nest on canal bank in morning, open nest, and process clutch. After lunch we walked to wading bird colony, open nest, and find clutch of recently deposited eggs covered in mucous. Process clutch and then walk along south bank of slough searching for additional nests. Numerous wading bird nests with eggs, chicks, and fledglings encountered along the slough. Walking extremely difficult owing to high air temperatures and dense vegetation. Returned to HQ for evening meal and then conducted spotlight survey of Pine Island Lake. Return to front gate for extraction, spotlighting canals and lakes along the way. |
| 19 July | Conducted pedestrian survey of the park throughout the day searching for alligators and nests. Particular emphasis on perimeter canals and interior wetlands. Returned to HQ for evening meal and then conducted spotlight survey adhering to the same general route followed during the day. |

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|---|---|
| 20 July | Intensive search for nests on island in Pine Island Lake. Found entrance to burrow complex and observed female alligator; no juveniles observed. Return to nest in acclimation pen and process clutch. Female aggressively defended nest. Returned to nest in wading bird colony and assessed egg viability. Depart DWP in early evening and return to hotel; secure gear in preparation for extraction. |
| 21 July | Travel from Chongming Island to Shangahi, arriving ca. 1030 hrs. Spend remainder of day at Shanghai Natural History Museum. |
| 22 July | Fly from Shanghai to New York. |