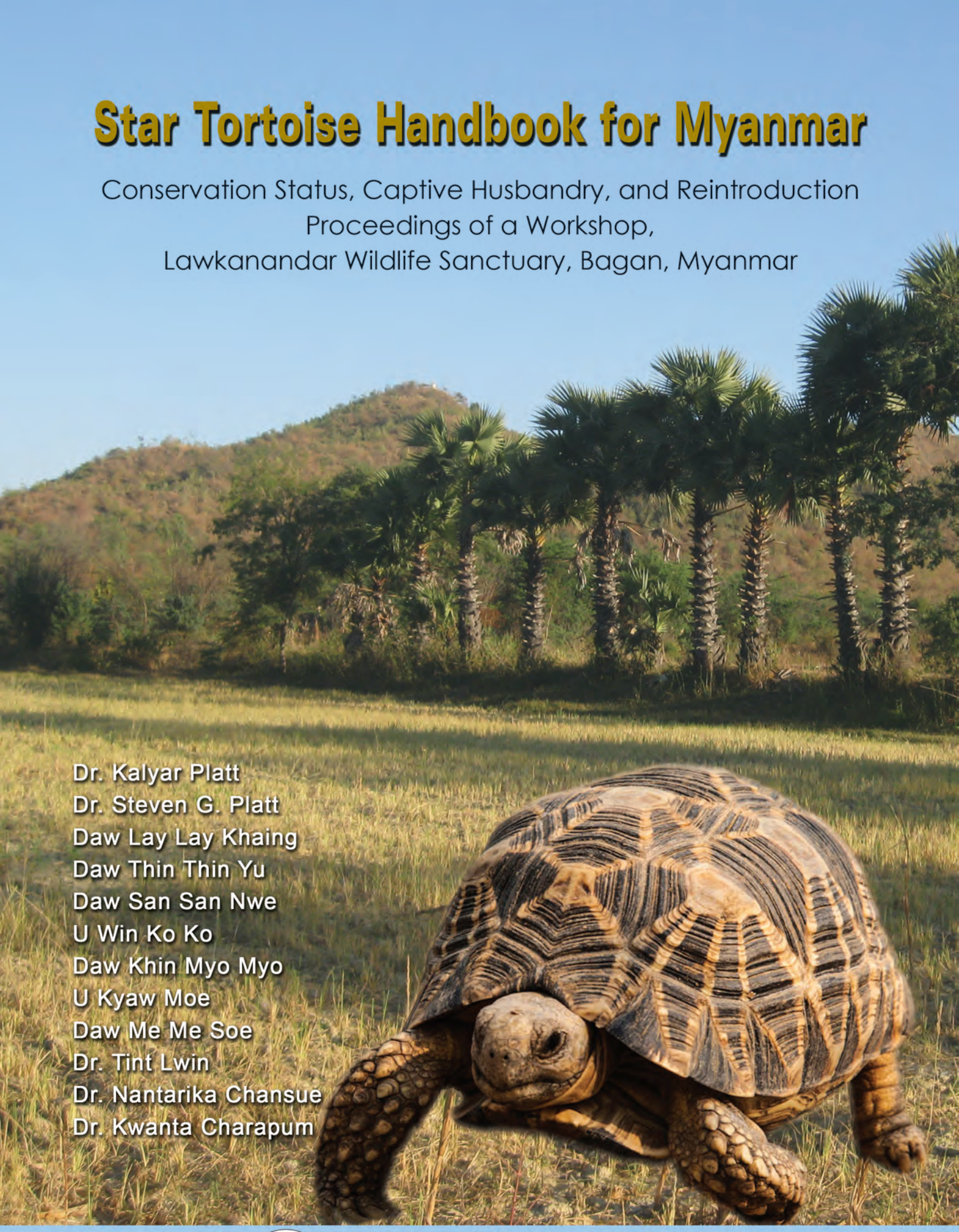
Star Tortoise Handbook for Myanmar

Conservation Status, Captive Husbandry, and Reintroduction
Proceedings of a Workshop,
Lawkanandar Wildlife Sanctuary, Bagan, Myanmar



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Forward

The Burmese Star Tortoise is one of the most beautiful, yet critically endangered tortoises in the world. Found only in the central dry zone and nowhere else, the Burmese Star Tortoise is truly a national treasure that belongs to the people of our beloved country. Once common, these tortoises declined rapidly due to the efforts of unscrupulous wildlife traders operating outside of the law, greedy men who think nothing of robbing the Myanmar people of their natural heritage in order to make money for themselves. As these wildlife traders became rich, the Burmese Star Tortoise plummeted towards extinction and by the early 2000s it was regarded as extinct in the wild. Unlike many other creatures that have disappeared from Earth as a result of man's thoughtlessness, the Burmese Star Tortoise was pulled back from the brink of extinction by a handful of dedicated conservationists in the Myanmar Forest Department, Wildlife Conservation Society, and Turtle Survival Alliance. Realizing the Burmese Star Tortoise would soon join ranks with the dinosaurs, the Dodo, and other extinct species, these hardworking professionals assembled small captive colonies using tortoises confiscated from wildlife traffickers by the Forest Department, and then began a decade-long fight to save this imperiled species. Although the struggle is far from being succeeded, great progress has been made. From less than 100 founders 10 years ago, there are now over 4,000 Burmese Star Tortoises in captivity. What's more, this number increases every year. Some of these captive-bred tortoises were recently returned to the wild and plans are afoot to release more in the near future.

The success of this conservation program hinges on the application of appropriate husbandry and management protocols. Recognizing that a great deal had been learned over the years about the captive management of this species, and the success of any conservation project depends on the free exchange of ideas and information, a National Star Tortoise Workshop was convened at Lawkanandar Wildlife Sanctuary in September 2012 and attended by Myanmar and foreign experts. The objectives of this workshop were to assemble what was known about the current status of wild populations, captive management and veterinary care, and reintroduction of captive-bred tortoises into the wild, and disseminate this material to the conservation and zoo community both within Myanmar and internationally. Internationally, because the Burmese Star Tortoise conservation program here in Myanmar is a model program demonstrating that effective conservation is possible in developing nations. Lessons learned in Myanmar have direct application to nations as far flung as Madagascar, South Africa, and Brazil. These proceedings resulted from this workshop and this document will no doubt serve as a blueprint for future efforts. Let us hope that eventually this beautiful animal will one day again be a member of Myanmar's unique biota.

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Introduction

The Burmese star tortoise (*Geochelone platynota* [Blyth, 1863]) is endemic to the dry zone of central Myanmar (Platt et al., 2011b), although within this general range, its distribution remains ill-defined and few specimen-based locality records are available (Platt et al., 2004). Historically, *G. platynota* probably occurred throughout the dry zone in habitats (**Figure 1**) variously described as thorn forest and thorn scrub (Stamp and Lord, 1923), dry forest (Hundley, 1961), dry deciduous forest (FAO/UNDP, 1982), tropical dry forest (Beffasti and Galanti, 2011, semi-desert scrub (Davis, 1964), and *Indaing* forest (Zug et al., 1998; Platt et al., 2001). Observations of wild *G. platynota* are provided by Platt et al. (2001, 2003) and Thanda Swe (2004) studied movements, home range, and seasonal activity patterns, but otherwise the ecology of this species remains virtually unknown (Platt et al., 2011b).

Geochelone platynota has long been subject to subsistence harvest by rural Burmese (Platt et al., 2011b). Almost 150 years ago Theobald (1868) stated villagers captured large numbers for food with the aid of hunting dogs, and according to Blyth (1863), specimens were difficult to obtain because villagers were "so fond of eating them". Chronic over-harvesting for subsistence purposes, coupled with habitat loss when forest and scrub was converted to agricultural land undoubtedly caused the local extirpation of *G. platynota* from many areas of the dry zone.

In the early 1990s harvesting ceased to be a local subsistence activity and intensified by many orders of magnitude, driven by the burgeoning demand from wildlife markets in southern China where *G. platynota* was sold as food and incorporated into traditional medicines (Platt et al., 2000). Demand from Chinese markets was soon eclipsed by demands of the international pet trade, which ultimately sounded the death knell for wild populations. By the mid-1990s, traders were making wholesale purchases of large numbers of star tortoises from village middlemen to supply the pet trade (Platt et al., 2011b). Juveniles and small adults commanded the highest price, as these animals were not only easy for smugglers to conceal, but were preferable to larger tortoises as pets. Traders also purchased adult tortoises, many of which found their way into commercial breeding operations with the goal of mass producing highly marketable hatchlings.

Villagers were paid handsomely for each tortoise, and the amount they received soared as wild populations plummeted. In some cases, villagers earned enough from the sale of a single tortoise to purchase a brace of water buffaloes for the family farm (Platt et al., 2011b). In short, finding a star tortoise was akin to winning the lottery; a cash windfall for a rural villager who might otherwise expect to earn less than US$1000 in any given year. Given this level of financial incentive, it became economically worthwhile for villagers to expend time and effort seeking out the last few remaining wild tortoises. Even tortoises within formally protected areas were not safe, and populations in Shwe Settaw and Minzontaung wildlife sanctuaries were hunted to near-extinction (van Dijk, 1994; Platt et al., 2001; Thanda Swe, 2004).

Figure 1: Dry zone habitat of the Burmese star tortoise. *Indaing* forest at Shwe Settaw Wildlife Sanctuary (above) and dense thorn scrub at Minzontaung Wildlife Sanctuary (below).

Because of its illicit nature, the illegal trade in *G. platynota* has always been difficult if not impossible to quantify with any degree of accuracy (Platt et al., 2000; Platt et al., 2011b). Nonetheless, there is little doubt that vast numbers of tortoises have been removed from the wild since the mid-1990s (Platt et al., 2011b). Although much illegal harvesting occurred when villagers opportunistically encountered tortoises while traveling to and from their farms or gathering firewood and bamboo in nearby forests, many engaged in the trade were professional hunters whose livelihood depended on the illegal sale of wildlife. These individuals often employed hunting dogs, an extremely efficient means of locating cryptic terrestrial chelonians (Platt et al., 2003; Kapfer et al., 2012), which allowed them to methodically denude whole regions of tortoises (Platt et al., 2011b). For example, a single hunter with a dog claimed to have illegally taken and sold over 300 *G. platynota* from Shwe Settaw Wildlife Sanctuary in 1999, and another stated that a typical day's catch during the early wet season of that year consisted of two to three tortoises (Platt et al., 2001).

By the early 2000s it was apparent that rampant, illegal, commercially-driven harvesting had pushed *G. platynota* to the brink of the extinction abyss. Although scattered individuals no doubt persisted in some areas, few if any viable populations remained, leading Platt et al. (2011b) to conclude *G. platynota* is most likely "ecologically extinct" in the wild. *Geochelone platynota* was assessed as Critically Endangered by the IUCN (IUCN, 2012), designated a member of "Extinction row" along with other high-risk chelonian taxa (Turtle Conservation Fund, 2002), and listed among the 25 most endangered chelonians in the world (Rhodin et al., 2011).

Recognizing that immediate conservation action was required to stave off imminent extinction, the Forest Department in collaboration with Turtle Survival Alliance and Wildlife Conservation Society established captive assurance colonies of *G. platynota* at Yadanabon Zoological Gardens (Mandalay), and Lawkanandar, Minzontaung and Shwe Settaw wildlife sanctuaries (LWS, MWS, and SSWS, respectively) beginning in 2004. As defined by the Turtle Conservation Fund (2002), assurance colonies are demographically and genetically viable breeding groups of imperiled taxa maintained in captivity as a hedge against the possible extinction of wild populations. In the event wild populations do become extinct, assurance colonies can serve as a source of animals for eventual reintroduction. Most importantly and sometimes over-looked, is the fact that assurance colonies are not an end unto themselves; simply stockpiling animals in captivity does nothing towards achieving the ultimate goal of restoring a species to the landscape. Instead, assurance colonies must be integrated into larger conservation programs that ultimately restore, maintain, and if possible expand ecologically functional populations of wild chelonians.

To date, captive propagation of *G. platynota* has proven remarkably successful in Myanmar; *G. platynota* adapts well to captivity, husbandry is relatively straightforward, and incubation success and hatchling survival have been consistently high. Indeed, the star tortoise assurance colonies are an excellent example of the role captive breeding can play in endangered species conservation. From a small group of founders (mostly tortoises confiscated from illegal wildlife traders), there are now over 3,000 star tortoises held in the four principal assurance colonies, with lesser numbers in the Yangon and Naypyitaw zoological gardens. The production of offspring has increased steadily each year, such that several facilities are now approaching

maximum capacity (**Figure 2**). Captive propagation has averted near-certain biological extinction and the continued survival of *G. platynota* is no longer in doubt.

Although the possibility of biological extinction is now remote, much remains to be accomplished before *G. platynota* is restored as a functional member of dry zone ecosystems. Foremost among these tasks are assessments of potential reintroduction sites, and eventual reintroduction of captive-bred tortoises into appropriate, well-protected habitat. To this end, habitat assessments were conducted of Shwe Settaw and Minzontaung wildlife sanctuaries in 2011 (Platt et al., 2011a), and efforts are currently underway to reintroduce star tortoises to the latter site. Additionally, renewed efforts to locate remnant wild populations of *G. platynota* are warranted. Field surveys of potential habitat were last conducted in 2002, and while *G. platynota* is presumed to be ecologically extinct in the wild (Platt et al., 2011b), it is possible that small populations, particularly those in the vicinity of religious sites, escaped harvesting and may yet persist. Remnant populations could serve as foci for future *in-situ* conservation efforts, and potentially supply animals to diversify the genetic base of existing assurance colonies, all of which are based on a limited number of founders. Finally, because mortality can be high among captive-reared animals released into the wild (Germano and Bishop, 2008), reintroduction efforts will depend on a steady supply of genetically diverse stock from assurance colonies. Therefore it is imperative that husbandry protocols be refined to insure the best possible management of captive stocks in a manner appropriate for conditions in Myanmar.

As a first step towards addressing these issues and realizing the goal of restoring viable wild populations of *G. platynota* in Myanmar, a National Star Tortoise Workshop was held at Lawkanandar Wildlife Sanctuary from 17-21 September 2012 with the following objectives:

1. Assess the conservation status of wild populations of *G. platynota* in Myanmar with an emphasis on, but not restricted to, existing protected areas. Specifically, information on the possible existence of remnant wild populations was sought to provide a focus for future field surveys.
2. Conduct a preliminary assessment of the potential for reintroducing captive-bred star tortoises in various protected areas of Myanmar.
3. Address husbandry and veterinary issues at assurance colonies and develop a set of best management practices appropriate for Myanmar.
4. Provide near-term recommendations and develop long-term goals for star tortoise conservation in Myanmar.

The workshop was attended by government staff from each assurance colony, zoo veterinarians, and personnel from every protected area within the presumed historic distribution of *G. platynota* (Appendix 1). Attendees were invited to share their collective knowledge of *in-* and *ex-situ* star tortoise conservation and this handbook is the result.

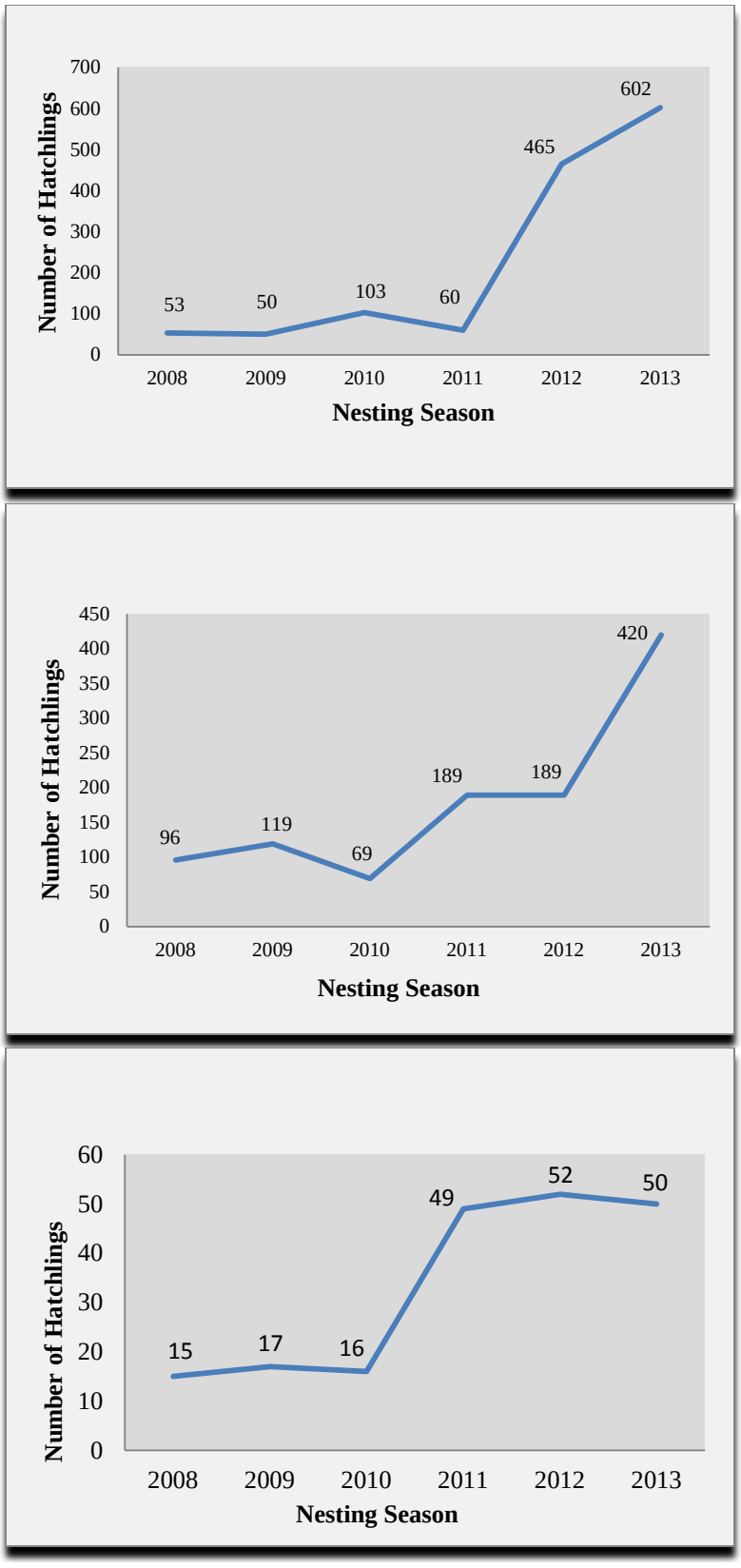

Figure 2: Production of hatchling *G. platynota* from assurance colonies at Lawkanandar (top), Minzontaung (center) and Shwe Settaw (bottom) wildlife sanctuaries (2008-2013). Note sustained increase beginning 2010-2011.

Conservation status of wild populations

Workshop participants confirmed earlier speculations that *G. platynota* is likely extinct or nearly so, in the wild (**Table 1**). However, several sites were identified during the workshop where small remnant populations might yet persist. Most notable among these is Alaungdaw Kathapa National Park where recent (2012) evidence strongly suggests small numbers of *G. platynota* survive. A field survey of Alaungdaw Kathapa National Park and Mahamyaing Wildlife Sanctuary is planned for mid-2013. The continued occurrence of *G. platynota* at the latter site is more problematic; much of this large sanctuary is not suitable tortoise habitat and anecdotal evidence suggests populations were subjected to intensive harvesting in the recent past. The Sagaing Hills are another area that warrants further scrutiny. Interview data (Platt et al., 2004) and accounts provided by workshop participants leave little doubt these populations of *G. platynota* were targeted by collectors and large numbers likely removed. However, the presence of numerous pagodas and monasteries in the Sagaing Hills raises the possibility that some populations may have escaped exploitation owing to the existence of local taboos that effectively discouraged the collection of wildlife in the vicinity of religious sites. Similar taboos contributed to the survival of *G. platynota* populations at Minzontaung Wildlife Sanctuary and Myaleik Taung (Platt et al., 2003; 2011a). Previous surveys (Zug et al., 1998) and information provided by workshop participants suggest that Chatthin Wildlife Sanctuary no longer harbors viable populations of *G. platynota*, although the site might prove suitable for reintroduction provided security issues are addressed. Likewise, past exploitation appears to have decimated populations in Shwe U Daung Wildlife Sanctuary, although some tortoises apparently remain.

To briefly summarize, Alaungdaw Kathapa National Park appears to be the most promising site for finding wild populations of *G. platynota* and surveys of this area and Mahamyaing Wildlife Sanctuary are planned for 2013. Field surveys of the Sagaing Hills are also deemed a high priority, with an emphasis on religious sites where tortoises might have escaped persecution because of local taboos. It is highly unlikely that viable wild star tortoise populations occur elsewhere in Myanmar, but other protected areas should nonetheless be assessed as funding become available. Even if tortoises no longer occur in these protected areas, they could prove suitable as future reintroduction sites. Plans to reintroduce *G. platynota* to Minzontaung Wildlife Sanctuary are currently being implemented, and a trial release of a small number of hatchlings has been undertaken by the Forest Department at Shwe Settaw Wildlife Sanctuary.

Table 1: History and current conservation status of wild *Geochelone platynota* populations in Myanmar. Detailed descriptions of each protected area are presented in Beffasti and Galanti (2011). Mya Leik Taung is described by Platt et al. (2003).
Abbreviations: WS = Wildlife Sanctuary; NP = National Park; NR = Nature Reserve.

Location	Comments
Alaungdaw Kathapa NP	The occurrence and conservation status of *G. platynota* in this extensive national park (1597 km^2) has yet to be investigated. The park is located in the dry zone within the presumed historic range of *G. platynota* and the dry deciduous forest appears to be suitable habitat. Furthermore, a carapace reportedly collected near the western boundary of Alaungdaw Kathapa National Park was obtained during a recent survey, and interviews of villagers strongly suggest that extant populations occur both within the park and surrounding lands (Platt et al., 2012). Most importantly, park staff report past encounters with *G. platynota* while conducting routine field duties, and have observed shells in possession of villagers residing on the periphery of the protected area.
Bawditataung NR	There is no information on the possible occurrence of *G. platynota* in this nature reserve (73 km^2). The reserve is highly disturbed owing to large numbers of visitors, although local villagers are said to respect the site because of its religious significance and presence of Buddhist monks. As such, the reserve could have considerable conservation potential. The reserve is characterized by dry deciduous forest that is presumably suitable habitat for *G. platynota*.
Chatthin WS	Zug et al. (1998) reported the collection a single *Indotestudo elongata*, but found no evidence for the occurrence of *G. platynota* in Chatthin Wildlife Sanctuary (CWS). Nonetheless, this large (268 km^2) tract of *Indaing* forest in the northern dry zone probably constitutes suitable habitat for *G. platynota*. In the early 1990s, sanctuary staff observed *G. platynota* carapaces being used as ash trays by residents of Sat Thar Chaung and Taung Gyar villages adjacent to CWS, and in 2009, a young girl was photographed with a carapace from a star tortoise harvested from near Mya Gyi Village, on the outskirts of CWS. These observations indicate *G. platynota* likely inhabited CWS, although its current status is unclear. Given the prevalence of illegal logging and hunting, coupled with the lack of enforcement capacity, it is unlikely viable wild populations remain. However, field surveys of this site are recommended.
Mahamyaing WS	This wildlife sanctuary (1,180 km^2) is located on the northern periphery of the presumed historic distribution of *G. platynota*, and specimen-based records are available from nearby towns along the

Ayeyarwady and Chindwin Rivers (Platt et al., 2004, 2012). Scattered, unconfirmed reports from villagers and Forest Department staff suggest a small population of *G. platynota* might still persist in the sanctuary. The sanctuary consists of a mosaic of vegetation types and the extent of potentially suitable star tortoise habitat has not yet been determined. A field survey of this area is scheduled for mid-2013. *Geochelone platynota* is known from the area of Ye Oo and Tant Se, north of Monywa near the southern boundary of the sanctuary. Many of the tortoises held at the commercial breeding facility operated by Griffon Enterprises (Bagan-Nyaung U) are said to have originated from this area. Hunters used dogs to collect tortoises, which were later sold to buyers representing Griffon Enterprises. According to villagers, *G. platynota* became very rare in this area after 2006.

Minzontaung WS

Field surveys in 2000 confirmed the presence of a viable wild population of *G. platynota* in Minzontaung WS (23 km^2) (Platt et al., 2003; Thanda Swe, 2004). Wild tortoises (both *G. platynota* and *Indotestudo elongata*) received some degree of protection from local *Nat* worshiping practices. Some illegal collecting no doubt occurred in the early 2000s (Thanda Swe, 2004); however, the population was apparently decimated by successive collections of wild tortoises to restock the assurance colony in the aftermath of repeated thefts. A "hard release" of 50 tortoises from the assurance colony took place in 2008, but the ultimate fate of these animals was never determined. Single tortoises were captured in 2007 (female), 2010 (male), and 2012 (juvenile), indicating at least a few tortoises continue to inhabit the sanctuary, albeit at very low densities. These captured tortoises were incorporated into existing assurance colony. An assessment in 2011 concluded the reintroduction of captive-bred *G. platynota* was feasible and likely to succeed provided rigorous protocols were developed (Platt et al., 2011a). The initial phase of this reintroduction project is currently underway.

Mount Popa NP

Although within the presumed geographic distribution of *G. platynota*, Platt and Win Ko Ko (2010) found no evidence for the past or present occurrence of star tortoises in this national park. *Indaing* forest and scrub that appears to be suitable habitat for *G. platynota* is present at lower elevations in the park; however, the species was probably extirpated long ago by subsistence harvesting (Platt and Win Ko Ko, 2010). Although a small, heavily exploited, population of *Indotestudo elongata* persists in the park and adjacent agricultural lands, Mount Popa was deemed unsuitable as a reintroduction site for *G. platynota* owing to insurmountable security concerns (Platt and Win Ko Ko, 2010.

Myaleik Taung	In 2001, Myaleik Taung harbored the least disturbed and most significant *G. platynota* population in Myanmar. Continued survival of this population was attributed to protection conferred by local religious practices (Platt et al., 2003). Villagers believed that *Nats* dwelling in nearby mountains protected tortoises, and anyone who harmed a tortoise risked supernatural retribution in the form of accident, illness, or even death. Myaleik Taung was proposed as a National Star Tortoise Sanctuary in 2001 (Platt et al., 2003). However, before a sanctuary could be established, poachers arrived from elsewhere and decimated this population. Because *G. platynota* inhabited an agricultural landscape at Myaleik Taung and proved easy to find (Platt et al., 2003), few tortoises are likely to have escaped poachers and their dogs. There are no recent population data from Myaleik Taung and a field survey of this area is warranted.
Sagaing Hills	Platt et al. (2004) examined several specimens of *G. platynota* reportedly harvested in the Sagaing Hills. Interviews also suggested hunters regularly visited the hills to collect tortoises (both *G. platynota* and *I. elongata*). Several workshop participants had knowledge of *G. platynota* being collected in the past from specific sites within this hill range (e.g., Min Won). The Sagaing Hills are of great religious and cultural significance in Myanmar, and hermits often seek seclusion in isolated caves to meditate. Biodiversity in some areas reportedly benefits from *de facto* protection afforded by the presence of pagodas and monasteries. These sites could potentially harbor remnant wild populations and deserve further investigation.
Shwe Settaw WS	Platt et al. (2001) confirmed the presence of wild *G. platynota* in this wildlife sanctuary in 1999. Commercial poaching was widespread at the time, and because few resources were available for law enforcement, Platt et al. (2001) questioned the viability of the remaining population. Approximately 30% of the sanctuary was sold to an agricultural development company in the late 1990s and subsequently converted to row-crops; however, this land may be returned to the sanctuary in the near-future. A recent survey (Platt et al., 2011a) found widespread encroachment by shifting agriculturists, and unrestricted firewood cutting. Furthermore, an electric transmission line and major road now traverse the sanctuary. Additionally, bamboo cutters, religious pilgrims, and hunters regularly enter the sanctuary and pose a potential threat to reintroduced tortoises. SSWS is no longer thought to harbor extant populations of *G. platynota* (Platt et al., 2011a). Areas of suitable tortoise habitat remain and if land-use and security issues can be addressed, reintroductions of captive-bred tortoises are likely to succeed (Platt et al., 2012). A pilot reintroduction project was conducted during 2012 by sanctuary staff using hatchling tortoises produced in the assurance colony.

Shwe U Daung WS	Wild populations of *G. platynota* were present in this sanctuary (326 km^2) until about 2008. Tortoises were observed in past years by sanctuary staff near Twin Nge and War Phyu. According to local informants, populations have been decimated by over-collecting, and although the occasional tortoise can still be found, *G. platynota* is now regarded as extremely rare. Considerable areas of dry deciduous and *Indaing* forest present in the sanctuary would prove suitable as reintroduction sites provided security concerns can be addressed.

Husbandry

If properly housed and provided with an adequate diet, *G. platynota* is relatively easy to maintain and propagate in captivity. Small captive groups are kept at several zoological gardens and private institutions outside of Myanmar, although the largest assurance colonies are found within the country. Because these facilities are located within the natural distribution of *G. platynota*, animals can be maintained in spacious outdoor enclosures throughout the year. Below we describe various aspects of captive husbandry that are important in successfully maintaining and propagating *G. platynota* in Myanmar.

a. Enclosures

Star tortoises are maintained in outdoor enclosures and exposed to environmental conditions typical of the dry zone. Enclosures are constructed of cement blocks and chain-link mesh. Although walls as low as 40 cm will contain tortoises, security considerations dictate the design of each enclosure; high walls keep people out rather than tortoises in (see below). Fife (2007) recommends at least 20 ft^2 of floor space should be available for each adult tortoise in an outdoor enclosure to avoid over-crowding, a leading cause of stress among captive chelonians. Numerous shelters within each enclosure supply shade and hiding places for tortoises. Shelters for tortoises are generally constructed of thatch or rocks; however, at Minzontaung WS piles of dried grass and watercress are used by tortoises in preference to rock and wooden shelters. Similarly, tortoises held in a semi-natural holding pen prior to being released into the wild appeared to seek out clumps of grass, leaf piles, and woody ground debris as places for concealment. These observations suggest that sweeping the substrate clear of fallen leaves and other organic debris, as is regularly done at most assurance colonies for aesthetic reasons, deprives tortoises of hiding places essential for their well-being. Because the availability of secure hiding places has been demonstrated to greatly reduce stress levels among captive tortoises, this practice should be immediately discontinued. Shallow concrete pools are scattered throughout the enclosures to provide water for drinking and soaking.

b. Security

Early efforts to establish assurance colonies were plagued by repeated thefts and security remains a paramount concern wherever star tortoises are kept. At a minimum,

each facility should be surrounded by a high (ca. 3 m), heavy-gauge wire fence, topped with razor-wire, sharpened bamboo (i.e., *pungyi*) stakes, or electrically charged wires (**Figure 3**). The entrance gate should be securely locked whenever staffs are not present in the enclosure. Night watchmen are a must; without exception, previous thefts occurred under a cloak of darkness. Security lights are present at some facilities. It is possible that artificial lighting could disrupt some behaviors dependent on natural photoperiod cycles (e.g., mating and egg laying), but security concerns outweigh this minimal risk.

Figure 3: Burmese star tortoise enclosure at Lawkanandar Wildlife Sanctuary near Bagan. Because of past thefts, security is a paramount concern at captive breeding centers. Note high perimeter fence (left) topped with razor wire to deter unauthorized entry (right).

c. Genetic considerations

Individuals are acted upon by natural selection and genetic diversity provides the mechanism for evolutionary change and adaptation (Meffe and Carroll, 1994). A reduction in genetic diversity can result in diminished fitness, reduced growth, increased mortality, and ultimately decreased evolutionary fitness (Gates et al., 2010). Mechanisms that reduce genetic diversity include demographic bottlenecks, founder effects, genetic drift and inbreeding (Meffe and Carroll, 1994). Demographic bottlenecks and founder effects are of immediate concern to the conservation of *G. platynota*.

Little is known about levels of heterozygosity (a measure of genetic variation) in the natural star tortoise population prior to the intensive harvesting, which began in the early to mid-1990s and removed untold numbers of individuals from the wild over a relatively brief period of time. Because the number of tortoises that now survive is but a small fraction of a once larger population, *G. platynota* is said to have experienced a demographic bottleneck. The genetic consequences of a demographic bottleneck to a large extent depend on the pre-bottleneck genetic diversity within a species, the severity

of decline, and how quickly the population rebounds following the bottleneck (Gates et al., 2010). Through time genetic drift (random loss of alleles from a population over time) can compound the effects of an earlier demographic bottleneck resulting in further erosion of genetic variability in the surviving population (Meffe and Carroll, 1994; Gates et al., 2010).

Among *G. platynota*, population reduction was severe, rapid, and range-wide, and therefore a reduction in heterozygosity among survivors is to be expected. Furthermore, because the number tortoises available as founders for the captive assurance colonies was relatively small in relation to the original wild population, it is doubtful the full array of genetic variation originally present in the wild population is captured among these survivors. Without careful management, reduced heterozygosity among the captive population, most of which are descended from a small number of founders, could eventually lead to inbreeding depression (Meffe and Carroll, 1994). Inbreeding depression often – but not always – results in the expression of deleterious alleles, decreased genetic heterozygosity, lower fecundity, and developmental defects (Allendorf and Leary, 1986; Meffe and Carroll, 1994).

To date, *G. platynota* assurance colonies have not been managed with genetic considerations in mind. Breeding groups are maintained as herds with no attempt to insure mating of specific individuals. Because of non-random mating and differential reproductive success, it is probable that some individuals are making a disproportionately greater genetic contribution to each successive generation of offspring. Furthermore, given the small number of original founders, inbreeding depression could ultimately prove detrimental among future generations of *G. platynota*.

To address genetic concerns in the future management of *G. platynota* stocks, we recommend that genotyping of the captive population be undertaken as soon as possible. Blood and tissue samples should be collected from every tortoise held in the assurance colonies and used to determine individual paternity and maternity. These data are essential for increasing the effective population size and maximizing heterozygosity among the surviving population. Achieving these objectives could also require a transition from herd-level to individual management to insure genetically high-value individuals produce offspring. Heterozygosity will be maximized if each individual makes an equal genetic contribution to the next generation.

d. Individual identification

Effective management of any captive populations depends on being able to identify specific animals, preferably by means of a permanent, unalterable marking system in which each individual is assigned a unique number. Various methods have been used with captive chelonians, including recognition based on patterns of shell damage, numbers painted on the carapace, microchips implanted beneath the integument, and notching of marginal scutes.

Tortoises in the assurance colonies are currently marked by painting individually assigned consecutive numbers on the carapace using a correction pen ("white out"). These numbers are applied when tortoises reach an age of 2-3 years. The numbers tend to fade over time, but are easily repainted when wear becomes evident. Younger tortoises are housed together as a cohort, but not individually marked. Identifying particular individuals is therefore impossible. Once the paternity and maternity of individual breeding tortoises are determined, it will become necessary to be able to identify each individual in a cohort to insure effective genetic management of the herd. To this end, we recommend hatchling tortoises be marked soon after emerging from the egg. This is probably best achieved by notching a unique series of marginal scutes using a marking code similar to those described by Cagle (1939) and Sexton (1959). The code of Sexton (1959) is preferable because it requires only three marginal scutes be notched, thereby reducing the likelihood of error during marking. Notching is harmless to the young tortoises and the notches rapidly heal while still remaining readable. Notches are easily cut on the smallest individuals using human nail clippers; larger tortoises can be notched with a high-speed rotary Dremmel tool®. Individual numbers can also be tattooed on the costal scutes of the carapace using a human tattoo drill; however, the permanency of this method has yet to be determined. Although expensive, microchips are another option for individual identification. Every tortoise selected for reintroduction should have a microchip implanted. Not only will this facilitate identification in the field, but should the animal be stolen, the presence of a microchip can be used to establish the origin of the tortoise.

Currently, each assurance colony has its own numbering system for identifying individual tortoises. This means that several tortoises are likely to have been assigned the same number by different colonies, i.e., individual numbers may not be unique. Upon completion of the proposed genotyping, it will likely prove necessary to transfer individuals among colonies for planned pairings designed to maximize heterozygosity of the future captive population. Therefore, to avoid confusion we recommend that each adult breeding tortoise be assigned a unique number (preferably based on a microchip) in addition to the number assigned within its assurance colony of origin.

e. Distinguishing the sexes

Being able to accurately determine the sex of adult tortoises is important in any captive breeding program (**Figure 4**). Sexing adult *G. platynota* is relative straightforward, and males and females can be distinguished on the basis of several secondary sexual characteristics (Fife, 2007; Platt et al., 2011b). Males display a prominent plastral concavity that is absent in females. The tail of the male is longer and thicker than that of the female, and the vent is more distal, positioned closer to the tip. The configuration of the anal scute also differs between the sexes; males exhibit a V-shaped scute with a wider angle of separation between the two lobes, which is thought to allow for greater movement of the tail during copulation. In contrast, the anal scute of the female is crescent shaped. The supracaudal scute of the male has a pronounced undercurve in comparison to the female, probably to protect the penis during copulation. Additionally, males appear more elongated than females, which exhibit a rounder body shape, presumably to accommodate eggs when gravid.

Figure 4: Males (left) can be readily distinguished from females (right) by a plastral concavity, longer tail, and V-shaped notch in the anal scute. Males are also generally smaller than females.

f. Incubation

Virtually nothing is known regarding reproduction of *G. platynota* in the wild (Platt et al., 2011b). In the assurance colonies females begin nesting in late September and continue to deposit clutches through mid-May (**Figure 5**). The number of clutches deposited by individual females ranges from one to four (Thanda Swe, 2004). Maximum

clutch size in Myanmar assurance colonies is 11 eggs (Lay Lay Khaing, unpubl. Data), although clutches containing as many as 16 eggs have been reported elsewhere (Kuchling et al., 2011). Hatchlings typically emerge from the nest at the beginning of the annual wet season (late May and June). It is likely that developing embryos undergo a period of diapause, particularly those in eggs laid early in the nesting season, which pass through the cooler winter months belowground (Fife, 2007). Among the Testudinidae, hatchling sex is determined by incubation temperatures with males and females being produced at lower (29-31°C) and higher (31-32°C) temperatures, respectively (Fife, 2007). Kuchling et al. (2011) suggest the pivotal temperature for *G. platynota* is at, or slightly above 30°C. As defined by Mrosovsky and Pieau (1991), the pivotal incubation temperature is a constant temperature that will yield a 1:1 sex ratio.

Artificial incubation of tortoise eggs under controlled conditions is easily accomplished (Fife, 2007). Eggs are packed in plastic boxes containing damp vermiculite (2 parts vermiculite to 1 part water by weight) and placed in an incubator where temperature and humidity can be controlled (Fife, 2007). Temperatures are maintained near the pivotal temperature and humidity is kept at about 60%. Excessively high incubation temperatures are thought to increase shell abnormalities (including "pyramiding") and embryo deformities (Fife, 2007; Platt et al., 2011b). Insufficient humidity during incubation can result in embryo death or cause a thickening of the egg membrane that can prevent the hatchling from successfully exiting the egg (Fife, 2007).

Artificial incubation of *G. platynota* eggs in the assurance colonies is currently impractical owing to the intermittent electrical supply at some sites (e.g., Lawkanandar WS) and lack of a power source at others (e.g., Minzontaung WS). Instead, females excavate nests and deposit eggs within the enclosures and each cutch is incubated under natural conditions. Staff monitor tortoises throughout the day and carefully note any female that begins excavating a nest. After the female completes laying and buries her clutch, a wooden marker is inserted in the loose soil and labeled with the females identification number, date of egg laying, and clutch size (**Figure 6**). Eggs are allowed to remain in the nest until hatching occurs. This simple method has proven remarkably successful and annual hatching rates usually range from 80-90%. Hatchlings are collected upon emerging from the nest and housed by cohort in specially designed pens.

Because tortoise enclosures at some assurance colonies are shaded, concern has been expressed over what effect this might have on incubation temperatures and the resulting sex ratio of offspring in different cohorts. We are currently unable to address this question as secondary morphological characteristics used to distinguish the sexes are not yet evident even among the oldest cohort. Although endoscopy can be used to sex small juveniles (Kuchling et al., 2011), the equipment and expertise necessary for this procedure is currently unavailable in Myanmar.

Figure 5: Female star tortoise excavating nest (left) and depositing eggs (right) at Lawkanandar Wildlife Sanctuary (October 2012). These eggs will likely hatch in late May 2013.

Figure 6: Wooden markers denoting the location of individual clutches in large enclosure at Lawkanandar Wildlife Sanctuary (above). Female identification number, clutch size, and date of laying is indicated on each marker (below).

We speculate the sex ratio among clutches within a single cohort varies over the course of the nesting season owing to pronounced seasonal changes in air temperature. The lowest incubation temperatures likely occur during the mid-nesting season (December-January), when diurnal temperatures are mild and nocturnal temperatures can drop to 10°C. The latter part of the nesting season coincides with the hottest months of the year (March and April) when maximum incubation temperatures are expected. Furthermore, because the deciduous trees shading tortoise enclosures have little foliage remaining by the late dry season, more solar radiation reaches the substrate, probably causing a corresponding increase in nest temperatures at this time.

Once young tortoises can be reliably sexed, efforts should be made to determine the sex ratio of individual cohorts. If sex ratios prove to be disproportionately skewed towards one sex or the other, it may be advisable to manipulate nests and eggs to increase or decrease incubation temperatures. This could be readily achieved by excavating clutches shortly after laying, incubating eggs in smaller containers, and placing these in shaded or open sites as desired.

g. Hatchling care

Hatchlings exit the nest unassisted and are collected by assurance colony staff soon after appearing aboveground. Nests from which no hatchlings emerge are excavated to determine if possible the cause of nest failure. Neonates that have left the egg, but not yet burrowed out of the nest are occasionally found underground. Hatchlings at most assurance colonies are reared separately from larger tortoises, and housed in low-walled (ca. 30 cm high) enclosures with small shelters to provide shade and escape cover (**Figure 7**). At the Yadanabon Zoological Gardens, hatchlings are kept in wooden boxes with heavy wire mesh lids to deter predators and thieves.

Hatchling enclosures contain sunken water troughs large enough for neonates to enter and soak. Owing to the relationship between body mass and surface area, small tortoises (which have a greater surface area per unit of mass than larger individuals) are prone to dehydration and soaking is therefore especially important during the hot summer months. At the Yadanabon Zoo, hatchlings are manually placed in shallow water and soaked for 15-20 minutes every day. Hatchlings are provided a diet similar to that of adults (see below); however, the food provided to neonates is finely chopped. Calcium supplements are also provided to hatchlings. Food is provided on wooden plates or green banana leaves, which facilitates removal of uneaten material at the end of each day. Sanitation is extremely important to prevent disease outbreaks and internal parasites, and enclosures are cleaned daily to remove feces and uneaten food.

Hatchlings and small juveniles are susceptible to chilling when nocturnal temperatures fall below 21°C. Excessive or repeated chilling is a major cause of respiratory ailments among young tortoises. Heat lamps can be used to maintain optimal overnight temperatures for hatchlings. However, the use of heat lamps is generally not feasible in Myanmar because most facilities lack reliable electric current. Small tortoises are instead covered with dry straw and leaf litter to reduce the risk of chilling. In the

past, small tortoises were recovered from enclosures every evening, placed in wooden boxes overnight, and returned to the enclosures the following day. This practice required excessive handling of the small tortoises, and is thought to have caused significant stress-related mortality among these animals. To avoid stress and discourage tortoises from becoming overly familiar with humans, handling should be kept to a minimum. Care is also taken to insure that hatchlings are not exposed to damp conditions during the cooler months.

h. Diet and water

The diet of *G. platynota* in the wild has not been well-studied, but scattered observations suggest it consists largely of grass and other foliage, with lesser amounts of fruits, invertebrates, and on occasion, vertebrate carrion (Thanda Swe, 2004; Platt et al., 2011b). Tortoises feed heavily on the profusion of tender grass that sprouts immediately following the first heavy rains of the wet season, but subsist on dry, coarse grass foliage for much of the remainder of the year (Platt et al., 2011b). In general, the foods consumed by *G. platynota* in the wild are rich in fiber and calcium, and low in sugar and protein. Fiber is particularly important for tortoises as it retains moisture, aids in digestion, and maintains beneficial hindgut bacteria (Ebenhack, 2012). Although the diet of captive animals need not emulate the diet consumed in the wild, it is important that captives receive a variety of foods to ensure that all nutritional needs are met (Fife, 2007). It must be stressed that so-called "convenience foods", which are readily available and cheap, should be used with caution as these may fail to supply all of the nutrients necessary to maintain captives in good health (Ebenhack, 2012). A tortoise being maintained on a proper diet will produce well-formed fibrous feces (Fife, 2007).

A variety of foods suitable for *G. platynota* are available in Myanmar (**Figure 8**). Below we provide dietary guidelines based on the extensive experience of workshop participants:

1. The standard diet provided to adult tortoises consists of the stems and foliage of watercress (*Ipomoea* sp.), cucumber, various grasses, carrots, Roselle (Malvaceae), and prickly pear cactus (pads and fruits). Roselle and prickly pear cactus can be readily cultivated in the dry zone. Cactus is best propagated in an open, exposed location. Cactus pads are a good source of calcium and phosphorus and tortoises also relish the fruits and flowers. The inner layer of banana stems is also relished by tortoises. According to Fife (2007), water hyacinth is a readily eaten but under-utilized food in tortoise husbandry. However, water hyacinths accumulate heavy metals if grown in contaminated water, which could prove detrimental to tortoises. Likewise, the aquatic snails often found among the root mass of water hyacinths could potentially transmit flukes to tortoises if consumed. Although water hyacinth is abundant and readily obtainable in Myanmar, for these reasons, its use as tortoise food is best avoided.

2. Fruit such as cantaloupe, papaya, and watermelon are included in the diet, depending on availability. Other fruits are fed sparingly because diets rich in fruit can increase lactic acid levels within the gut, which may in turn result in elevated parasite loads and diarrhea.

3. Tortoises in the assurance colonies are currently provided with succulent leafy vegetation throughout the year. This contrasts markedly with the diet of wild tortoises, which likely consume weathered, coarse vegetation during the lengthy dry season (October-May). Therefore, we strongly recommend that significant amounts of dry grass or cured hay be henceforth incorporated into the diet during the dry season.

4. Tortoises are fed no more than once daily and uneaten food is removed at the end of every day. Excessive feeding (>once daily) can lead to health problems.

5. It is important to avoid feeding foods rich in oxalates to tortoises. Oxalic acid binds with calcium to form insoluble calcium oxalate, which cannot be absorbed by the tortoise (Fife, 2007). Oxalate-rich foods commonly available in Myanmar include figs (*Ficus* sp.), legumes (beans, peas, and peanuts), and cabbage. Squash is considered moderately-rich in oxalates and fed sparingly.

6. A cautionary note concerning mustard in the diet: During March 2012, several adult female *G. platynota* in an assurance colony succumbed to unknown causes. Mortality was preceded by lethargy, and several afflicted tortoises were observed vomiting blood. Death followed 2-3 days after symptoms were first observed. Post-mortem examinations revealed enlarged livers, thickened intestinal walls, and evidence of internal hemorrhaging. Supportive care was immediately administered to symptomatic tortoises. Daily supportive care consisted of administering a dilute sugar solution (1 teaspoonful of sucrose: 1 cup of water) to the cloaca, watercress juice and vitamin C orally with a feeding tube, and an injection of B complex vitamins. A 3 day course of antibiotics were administered to reduce intestinal swelling. Most importantly, the assurance colony staff immediately ceased feeding mustard leaves in lieu of *Ipomoea*. Although the causative agent could not be determined with certainty, symptoms exhibited by the afflicted tortoises suggested exposure to a toxin. Because *Ipomoea* was temporarily unavailable during the period preceding the outbreak, assurance colony staff had substituted mustard leaves as a dietary staple. We are unaware of any reports of mustard toxicity in tortoises, and standard husbandry manuals make no mention of the possible risks associated with feeding mustard. However, mustard toxicity has been widely reported among domestic mammals and poultry. Interestingly, *Indotestudo elongata* at the Turtle Rescue Center (Maymyo) generally spurn mustard; those that consume small amounts were later observed to regurgitate the undigested leaves (U Hmine Aye, pers. comm.).

Figure 7: Enclosures for hatchling and juvenile Burmese star tortoises at Lawkanandar Wildlife Sanctuary. Note low walls made from locally collected petrified wood, shelters along perimeter of enclosure that provide thermal retreats and cover, shallow dishes filled with clean water, and feeding trays. Green signs in upper photograph indicate year of hatching.

7. Calcium is one of the most important minerals in the chelonian diet and essential for proper development of bones and carapace (Ebenhack, 2012). Green vegetation is rich in calcium and supplementation may not prove necessary for older animals. However, adult females and small, rapidly growing juveniles can benefit from supplementation. Calcium is supplied by cuttlebone; as an added benefit, biting and chewing cuttlebone helps trim the beak. Dried and crushed chicken eggshells are another potential source of calcium. Tortoises at several assurance colonies have been observed biting stone masonry in the enclosure walls, a behavior that most likely indicates a need for additional calcium in the diet.

8. Hatchlings are fed a diet similar to that of adults; however, the food provided to them is finely chopped. Calcium supplements are also supplied to hatchlings. Hatchlings are never kept with larger tortoises and always fed separately. Uneaten food and feces are removed from the enclosures at the end of every day.

9. Despite being adapted to xeric conditions of the dry zone, successful *G. platynota* husbandry depends on maintaining an adequate supply of water for drinking and soaking. Dehydration is of particular concern in the dry zone where diurnal temperatures in March and April routinely exceed 40°C. At such high temperatures, dehydration can occur rapidly with potentially fatal consequences. Smaller individuals are more likely to suffer from dehydration owing their greater surface area per unit of body volume (mass). To avoid dehydration of tortoises in the assurance colonies, fresh water is always available for drinking and soaking. Water is provided in containers large enough for tortoises to enter and become partially submerged (**Figure 9**). Deep water is avoided because tortoises often pile on top of one another, and individuals at the base of the pile risk drowning. Because tortoises frequently defecate while soaking, water containers are cleaned daily.

i. Sanitation

It is essential to keep tortoise enclosures clean and free of feces, and uneaten or spoiled food to avoid disease outbreaks and discourage the transmission of internal parasites. In the assurance colonies, feces are removed in the morning and again in the late afternoon. Uneaten food is removed at the end of the day. Tortoises often defecate while soaking and water containers at least once, but often several times daily. Leaf litter is generally removed from enclosures, although this is unnecessary. Leaf litter poses no harm to tortoises and can provide places of concealment within the enclosure. Other ground debris, particularly plastics, are immediately removed. Accidental consumption of plastics by tortoises can result in intestinal blockage with potentially fatal consequences.

Health and veterinary care

Common ailments and conditions

To date there have been no major disease outbreaks or die-offs among tortoises in the assurance colonies. We attribute this to several factors; namely star tortoises are hardy animals, husbandry is straightforward and fairly simple, and the assurance colonies are located within the natural geographic distribution of *G. platynota*. Most importantly, the colonies are closely monitored and sick animals are immediately isolated and treated. Nonetheless, star tortoises are prone to certain ailments and conditions, the most common of which are discussed below.

Figure 8: Prickly pear cactus is an excellent food easily cultivated in the dry zone (left) and readily devoured by tortoises (right). Other foods include watercress and Roselle pictured below. Food should be never be placed directly on the ground, but instead offered on trays or wooden feeding platforms (below).

Figure 9: Tortoises can rapidly become dehydrated in the high temperatures. Therefore, freshwater for drinking (left) and soaking (right) should always be available in tortoise enclosures.

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a. Internal parasites

Internal parasites are common among both wild and captive tortoises. In the wild, parasite problems are to some extent self-limiting (Ebenhack, 2012). Captive conditions are often more favorable for the transmission of parasites. However, removing uneaten food and feces from pens on a daily basis, avoiding overcrowding, and providing a proper diet with clean water will go far towards reducing parasite infections. Although some level of parasitism is to be expected in captivity, heavy parasite loads can prove fatal or exacerbate other medical conditions. Star tortoises are known to host nematodes (roundworms), cestodes (tapeworms), trematodes (flukes), and protozoans. Any individual that is eating regularly, but losing weight is most likely in need of deworming. In small groups such as the Yadanabon Zoo, individual tortoises are regularly weighed. In larger colonies such as Lawkanandar or Minzontaung weighing each individual is impractical owing to the numbers involved. Fecal exams provide a quick means to diagnose parasite infections.

Panacur® (Fenbendazole) and Flagyl® (Metronidazole) are wide spectrum drugs effective against most parasites; the former is recommended for the treatment of most parasitic worms, while the latter targets protozoans. When treating individual tortoises, the recommended dosage of Panacur is 100mg/kg body mass administered in a single dose. This drug is relatively safe, although toxicity can result at high dosages. Furthermore, low dosages should be administered to tortoises with heavy parasite loads to prevent impaction of the gastro-intestinal tract by dead parasites. Panacur is available as a paste, liquid, or tablet; the paste is the easiest form to administer and can be spread over a preferred food item. At the Yadanabon Zoo, prophylactic de-worming of every tortoise is conducted once annually using Panacur applied to the food at a dosage of 50mg/kg of body mass. At Lawkanandar Wildlife Sanctuary, young papaya leaves are

fed to tortoises as a vermifuge. Papaya leaves are commonly used for treating parasite infections in traditional Burmese folk medicine, although the efficacy of this treatment has never been scientifically investigated.

Flagyl is useful for treating protozoan infections, particularly those of amoebic parasites. Flagyl is available as a liquid or tablet and administered at a dosage of 25-100mg/kg of body mass once every 14 days. Caution is urged when using Flagyl as overdosage can cause potentially fatal neural damage. Additionally, Flagyl should not be administered to tortoises with impaired liver function as these animals are unable to effectively metabolize the drug.

Under no circumstances should Ivermectin be used to treat parasite infections in tortoises. Ivermectin readily crosses the blood-brain barrier, which is poorly formed in chelonians, and can cause paralysis and death (Fife, 2007).

b. Bladder stones

Several cases of bladder stones have been reported from tortoises in the assurance colonies. These stones form when tortoises become dehydrated; urinary water is resorbed from the bladder leaving behind solid pieces of sodium and potassium urates, which are normally excreted when the tortoise urinates and defecates. Tortoises with free access to water rarely develop bladder stones. Bladder stones can also result from excessive dietary protein or tissue destruction associated with systemic diseases (Paul Gibbons, pers. comm.) The presence of blood in the urine is often the first indication that a bladder stone is forming. If the tortoise is unable to pass a stone, paralysis of the rear legs and eventually death will occur. Large bladder stones must be surgically removed.

c. Respiratory ailments

Star tortoises are prone to respiratory tract ailments. Symptoms include nasal discharge, difficulty retracting head and limbs, jaws held agape, swollen eyes, lethargy, and a loss of appetite (Fife, 2007). Because many respiratory ailments are infectious, tortoises presenting these symptoms should be isolated for treatment and not returned to the group until recovery is evident. Respiratory ailments are often caused when tortoises become chilled under damp conditions. Minor respiratory ailments can be treated by placing the tortoise near an external heat source. The additional heat will increase metabolism and better allow the tortoise to launch an immunological response. Dehydration should be guarded against by daily soaking and freely available drinking water. More severe cases of respiratory ailments must be treated with a regimen of antibiotics. Tortoises respond well to a week-long course of tetracycline (50mg/kg body mass administered daily) or ciprofloxacin (10mg/kg body mass administered daily), both of which are readily available as “over-the-counter” drugs in Myanmar.

d. Incomplete yolk absorption

Neonates occasionally emerge from the egg with a protruding yolk sac, most likely due to suboptimal incubation temperatures near the lower threshold of embryo survival. The yolk sac functions as an energy reservoir for the hatchling and will eventually be metabolized. In the meantime it is important to keep the yolk sac clean. Contact with soil should be avoided and hatchlings are best kept on a newspaper substrate, which is changed daily. Diluted iodine can be applied as needed to the yolk sac to prevent infection. It is also advisable to soak hatchlings in clean water for 15-20 minutes each day. This treatment should be continued until the yolk sac has been completely absorbed.

e. Pyramiding

Pyramiding is a condition in which the carapacial scutes become raised or pyramid-shaped. Extreme pyramiding can hinder copulation by interfering with the ability of a male to mount a female (Fife, 2007). Pyramiding is present, but not widespread in the assurance colonies. The underlying causes behind pyramiding are poorly understood, but the condition is thought to be a response to overly dry conditions or a diet excessively rich in protein (Platt et al., 2011b). The fact that many tortoises with pronounced pyramiding originated from the most xeric parts of the dry zone, anecdotally suggests an overly arid environment may indeed play a role in this condition. Genetic factors and high incubation temperatures could also be at least partially responsible for pyramiding.

According to Fife (2007), pyramiding usually develops during the first two years of life, and if corrected at this time is unlikely to reappear later even if husbandry is suboptimal. To prevent pyramiding, Fife (2007) recommends providing hatchlings with access to a “moisture chamber”. Hatchlings can burrow into a moist substrate within the chamber, which ensures exposure to adequate levels of humidity. In Myanmar, small piles of fresh grass clippings or moistened (but not soaked) hay placed in hatchling enclosures would probably create a sufficiently humid micro-environment. However, care must be taken to discard these piles and replace with fresh materials before piles become moldy or rotten.

Diagnostic guidelines for a cursory health assessment

In many cases, symptoms of an illness are not obvious until the disease or condition has significantly progressed beyond the initial stages. Therefore it is extremely important for keepers to closely monitor, and learn the behavior and normal appearance of tortoises under their care. Being able to distinguish healthy from sick individuals is essential for identifying potential problems and possibly preventing a catastrophic disease outbreak. To this end, the following general diagnostic guidelines are useful for conducting a cursory health assessment of individual tortoises. When conducting examinations of tortoises, it is best to begin with the head and work progressively rearwards to the tail.

1. The head should be free from lumps or irregularities; the dorsal (upper) surface should appear “full” and not dry or shrunken, while the lateral (sides) surface should be void of swelling.

2. Eyes should be bright and alert; dull or hazy eyes are signs of potential illness. Eyes should also be free of discharge, swelling, or obvious infection.

3. The mouth should appear smooth and clean with the jaws tightly closed. Asymmetry, lumps, bleeding, excessive salivation, bubbles, foam, dryness, sores, or a cheese-like substance on the tongue indicate likely illness.

4. Nares and nostrils should be symmetrical, clear, and open with no dried mucous or loss of pigmentation evident.

5. The neck should be free of obvious swelling, external parasites, or injuries.

6. Forelegs and feet should be free of injuries, fungal infections, skin irregularities, and external parasites; all nails should be present and intact.

7. Carapace and plastron should be free of abnormalities, such as abrasions, external parasites, and evidence of shell rot, bacterial infections, or fungus.

8. Vent should be clean with no evidence of staining, which is often caused by loose stools.

9. Hind legs and tail should be free of skin irritation, injuries or external parasites; all nails of the hind legs should be present and intact.

Should an animal appear abnormal or exhibit symptoms of an illness, it is best to isolate the individual and seek the advice of a veterinarian.

Quarantine protocol

A strict quarantine protocol for tortoises being moved into an assurance colony is necessary to reduce the risk of introducing infectious disease. A quarantine period also provides time to diagnose and treat common medical problems. At present there is no need to incorporate additional tortoises into the existing assurance colonies; breeding success is excellent and most facilities are nearing maximum capacity. However, moving star tortoises into an assurance colony might become necessary if animals are confiscated from illegal wildlife traders and need to be accommodated. Additionally, future studies may indicate that importing star tortoises from collections outside of Myanmar or transfer tortoises between assurance colonies within Myanmar is necessary for genetic reasons. Although the latter scenario poses the least risk, bringing any tortoise into an assurance colony carries with it the possibility of introducing novel pathogens into the assurance colonies. The consequences of exposing an immunologically naïve assurance colony to a novel pathogen (e.g., Ranavirus; Johnson et al., 2004) are potentially catastrophic. Strict adherence to the quarantine protocol outlined below is necessary to minimize these risks.

1. Isolated quarantine pens should be constructed at least 100 m away from the existing assurance colony.

2. Personnel should wear rubber footgear and walk through a disinfectant bath upon entering and leaving the quarantine facility. Personnel should also thoroughly disinfect their hands before entering or leaving the facility. Equipment (e.g., feeding bowls, water containers, hand tools, etc.) should be designated for the quarantine facility and never used elsewhere.

3. Tortoises should be placed in quarantine for a minimum of 90-120 days. Some authorities recommend even longer periods (12-18 months). Because individuals can be asymptomatic for a disease (i.e., infected individuals display no obvious signs of the disease), even tortoises that appear outwardly healthy must be placed in quarantine immediately upon arriving at the assurance colony.

4. Each tortoise should undergo a thorough health assessment by a qualified veterinarian before being placed into the quarantine facility.

5. The body mass of each individual should be recorded when initially placed in quarantine, and monitored at weekly intervals thereafter. Additionally, stool samples should be collected weekly and examined for parasites.

6. Each tortoise should be given a thorough physical examination at the conclusion of the quarantine period. The decision whether or not to transfer the individual into the assurance colony will be based on the results of this examination. At minimum, the tortoise should be feeding regularly, weight gain must be evident during the quarantine period, and the last three consecutive fecal exams should be negative for parasites.

Best Management Practices for Star Tortoise assurance colonies in Myanmar

Based on the collective experience of workshop participants, recommendations from foreign experts, and a review of the scientific literature, we developed a set of Best Management Practices (BMP) appropriate for maintaining and propagating *Geochelone platynota* at facilities in Myanmar. These practices take into account local conditions, availability of resources, and limitations (e.g., lack of electricity) at captive propagation centers. These BMPs should be considered tentative rather than final, and subject to future revision.

1. Star tortoises are best maintained in spacious outdoor enclosures when being propagated within the dry zone of central Myanmar. Outdoor enclosures should be designed not only to confine tortoises, but also keep unauthorized people out! At least 20 ft^2 of floor space should be available for each adult tortoise to avoid over-crowding in the enclosure. Numerous shelters should be available within the enclosures where tortoises can obtain shade and concealment. Although tortoises will use thatch or rock shelters, piles of dried vegetation are most suitable as cover. The practice of sweeping the ground clean of leaves and other natural debris should be immediately

discontinued. This practice is based on aesthetic considerations that have no place in scientific husbandry where the welfare of the animal should be of paramount concern. Shallow water troughs should likewise be available to provide opportunities for drinking and soaking.

2. Security remains a principal concern at captive propagation facilities. Outdoor enclosures should be surrounded by high (3 m) fence of heavy gauge wire mesh, topped with razor wire, sharpened bamboo stakes, or charged electric wires. Gates should be securely locked whenever keepers are not present in the enclosure. Night watchmen are a must. Solar powered perimeter lighting activated by infrared motion sensors for 2-3 minutes following a disturbance would greatly enhance security while at the same time reduce the likelihood of disrupting photo-dependent cycles.

3. Every tortoise in an assurance colony should be assigned a unique identification number. Preferably these numbers should be permanent (e.g., notches in marginal scutes or tattooed on the costal scutes). If not permanent (e.g., numbers painted on carapace), the condition of the marks should be closely monitored and renewed as necessary. Adults transferred among assurance colonies for breeding purposes and tortoises selected for release should be micro-chipped. To avoid confusion we recommend that each adult breeding tortoise be assigned a unique number (preferably based on a microchip) in addition to the number assigned within its assurance colony of origin. In keeping with this recommendation, we suggest that henceforth the following series of numbers be assigned to breeding adult tortoises within each assurance colony: Minzontaung WS = 0001-4000; Lawkanandar WS = 4001-9000; Shwe Settaw WS = > 9001.

4. Females should be allowed to excavate nests and deposit eggs within the enclosure. The location of each clutch should be accurately marked with a small piece of painted wood. This marker should indicate the identification number of the female, date of laying, and clutch size. Eggs should be allowed to incubate *in-situ* under ambient conditions. Clutches that fail to hatch should be excavated and examined in an attempt to determine when embryonic death occurred. If future investigation indicates *in-situ* incubation is producing an overly biased hatchling sex ratio, it may become necessary to artificially incubate tortoise eggs. However, at present there is no evidence suggesting hatchling sex ratios are biased towards one sex or the other. Endoscopic sexing of younger cohorts would go far towards ensuring appropriate sex ratios are produced and is therefore urgently recommended.

5. Hatchling tortoises should be housed separately from adults. Low-walled (ca. 30 cm) enclosures are suitable for hatchlings; small-mesh wire fencing must be used to make these enclosures secure from predators. Shelters must be available in the enclosure to provide hiding places and shade for hatchlings. Water containers should be large enough to allow hatchlings to immerse themselves for extended periods; soaking is especially important during the hot, dry months (March-April).

6. Hatchlings do well on the same foods as adults (see below) and benefit from calcium supplements. Food should be finely chopped and placed on wooden trays or flat rocks. Uneaten food should be removed at the end of each day.

7. It is important to keep hatchling tortoises from becoming chilled when nocturnal temperatures fall below 21°C. Heat lamps are the best option for maintaining suitable overnight temperatures. However, if dependable electric current is unavailable, small tortoises can be covered with dry straw or leaves. Heavy blankets placed over leaves or straw will further reduce heat loss on cold nights. It is essential to keep young tortoises from becoming exposed to wet or damp conditions during the cooler months. Handling of small tortoises should also be kept to a minimum.

8. Foods consumed by wild *G. platynota* are rich in fiber and calcium, and low in sugar and protein. In captivity tortoises should receive a varied diet to ensure that all nutritional needs are met. Tortoises should be fed no more than once daily, with uneaten food being removed at the end of the day. The standard diet should consist of stems and foliage of watercress (*Ipomoea* sp.), cucumber, various grasses, carrots, Roselle (Malvaceae), and prickly pear cactus (pads, flowers, and fruits), with lesser amounts of cantaloupe, papaya, and watermelon. Other fruits should be fed sparingly. We strongly recommend that low energy foods such as cured hay or dried grass be incorporated into the diet throughout the dry season (October-May) to simulate conditions tortoises experience in the wild. Feed oxalate-rich foods such as figs (*Ficus* sp.), legumes (beans, peas, and peanuts), squash, and cabbage sparingly. Mustard and water hyacinth, although inexpensive and readily procured, should be strictly avoided owing to potential health risks associated with these plants. We recommend cultivating Roselle, prickly pear, and banana on-site to reduce feeding costs.

9. Calcium is one of the most important minerals in the chelonian diet. Much calcium is supplied by a diet of green vegetation; however, supplementation is recommended, particularly for juveniles and reproductive females. Cuttlebone is an excellent, easily obtainable calcium supplement, as are the dried and crushed shells of chicken eggs.

10. Dehydration is of particular concern in the dry zone where diurnal temperatures in March and April routinely exceed 40°C. Under these conditions dehydration can occur rapidly with potentially fatal consequences. Therefore, freshwater should always be available for drinking and soaking. Water containers should be large enough for tortoises to enter and become partially submerged. Deep water must be avoided because of drowning risk if tortoises pile atop each other. Tortoises frequently defecate while soaking and water containers must be cleaned daily.

11. Sanitation should be an over-riding concern in any captive husbandry facility and it is critical to keep tortoise enclosures clean and free of feces, and uneaten or spoiled food. Feces are best removed in the morning and again in the late afternoon. Uneaten food should be removed at the end of the day. It is important to clean water containers at least once a day, and perhaps more often if necessary. Under no circumstances

should tortoises ever be allowed access to polluted water. Ground debris such as plastics should be immediately removed from the enclosures.

12. Star tortoises are prone to certain ailments and it is important that keepers closely monitor the animals under their care. Being able to distinguish healthy from sick individuals is essential for identifying potential disease problems and preventing a catastrophic outbreak. To this end, keepers should learn the routine, behavior, and normal appearance of captive tortoises, and conduct regular health assessments. Sick individuals should immediately be removed from the colony, isolated, and treated, preferably by a qualified veterinarian.

13. Internal parasites are common among captive star tortoises. Avoid over-crowding tortoises to reduce the risk of parasite transmission. In small groups, the body weight of each tortoise should be closely monitored. Any tortoise that is eating regularly, but losing weight is most likely in need of deworming. Individual tortoises are best dewormed with Panacur administered in a single treatment at a dosage of 100mg/kg body mass. Accurate dosing should be based on body mass. However, in larger assurance colonies, determining the weight of individual tortoises is impractical; therefore, prophylactic de-worming of every tortoise should be conducted once every year using Panacur applied directly to the food at a dosage of 50mg/kg body mass.

14. Introducing tortoises (both captive and wild-caught individuals) into an assurance colony carries with it the risk of introducing disease or parasites, with potentially catastrophic consequences. Therefore, strict adherence to a rigorous quarantine protocol is necessary to minimize these risks. Designated quarantine facilities should be isolated from the assurance colonies, and designed to prevent the transfer of pathogens. Quarantine periods should be a minimum of 90-120 days, or perhaps longer (12-18 months). Any tortoise coming into an assurance colony should be placed in quarantine, even those individuals that appear outwardly healthy. Initial and follow-up health assessments should be administered to each tortoise in quarantine; the decision to transfer an individual into the assurance colony will ultimately be based on these assessments.

Reintroduction

The goals of any captive-breeding program should be to 1) safeguard the biological future of the species of interest, and 2) provide animals for eventual reintroduction to the wild. It is important to recognize that captive-breeding is not an end unto itself and simply stockpiling animals in captivity has little conservation value. The ultimate goal of any captive-breeding program should therefore be the restoration of the target species as a functional member of its native landscape. While many chelonians reproduce readily in captivity, restoring viable wild populations using captive-bred offspring can be a daunting challenge. Even defining what constitutes success when reintroducing chelonians is difficult because long generation times and slow growth rates mean that reproduction by released individuals (a standard metric of success in many reintroduction projects) may not occur for many years. Despite these limitations, reintroductions of reptiles generally have higher likelihood of success than those of birds and

mammals (Beck et al., 1994), and reintroductions of captive-bred chelonians have been successful in the past (Dodd and Seigel, 1991; Germano and Bishop, 2005).

Reintroduction of captive-bred *G. platynota* into suitable natural habitat has not yet been attempted in Myanmar. However, Platt et al. (2011a) recently conducted an assessment of Shwe Settaw and Minzontaung wildlife sanctuaries and concluded that reintroduction was feasible at both sites, but for a variety of biological and social reasons more likely to succeed at the latter. A preliminary plan was subsequently developed for reintroducing *G. platynota* to Minzontaung Wildlife Sanctuary (MWS) and is currently in the initial phases of implementation. This plan is largely based on a successful gopher tortoise (*Gopherus polyphemus*) reintroduction in South Carolina, USA (Tuberville et al. 2005), and with minor modification could probably be used to reintroduce *G. platynota* at other protected areas in the dry zone. Below we outline and discuss the major elements of the reintroduction plan. It must be stressed that our plan is "adaptive," i.e., tentative and experimental, and subject to modification as new data are collected (Laundré, 2012).

1. We recommend conducting a "soft release" of star tortoises at proposed reintroduction sites, i.e., tortoises should be held in pens and allowed to become accustomed to the site prior to being released. Penning has been demonstrated to dramatically increase site fidelity among translocated gopher tortoises (*Gopherus polyphemus*) by reducing both the number of animals that dispersed as well as the number of times an individual attempted to disperse (Tuberville et al., 2005). Penning also resulted in smaller activity areas after tortoises were released (Tuberville et al., 2005). In contrast, tortoises that were not penned prior to release (i.e., "hard release") exhibited little site fidelity and most attempted to disperse soon after being released (Tuberville et al., 2005).

2. Circular pre-release pens of about 1.0 ha should be constructed in the core of each release site. Typical habitat, preferably thick grass with scattered trees and shrubs should be enclosed within the pen. Pens used in the United States were constructed of aluminum flashing (Tuberville et al., 2005). However, this material is difficult to obtain and expensive in Myanmar. In lieu of aluminum flashing, we suggest constructing pens from locally available materials such as bamboo panels.

3. Tortoises should be penned for at least 12-18 months prior to release. In a previous study of translocated gopher tortoises, penning animals for one year significantly reduced the area over which animals roamed after release (Tuberville et al., 2005). It is possible that longer pre-release penning periods could engender even greater site fidelity. However, an extended penning period must be balanced against time and budgetary constraints.

4. Subadult (ca. 3 to 5 years old) star tortoises should be used in the reintroduction project. Hatchlings and small juveniles are vulnerable to predation, and mature adults are best retained as breeding stock in the assurance colonies. Tuberville et al. (2005) concluded that subadult gopher tortoises had smaller activity areas, and seemed more likely to establish home ranges within the core release area. In contrast, adult gopher tortoises were more likely to wander and longer penning was required to engender site fidelity.

5. Efforts must be made to prevent tortoises from associating humans with food provision. Our observations at captive breeding facilities in Myanmar indicate that captive star tortoises have come to associate humans with food. Upon entering an enclosure, we are usually approached by a number of tortoises, presumably expecting to be fed. Obviously, once released, tortoises that approach humans are at great risk of being collected. Existing natural vegetation and plantings in the holding pens may provide sufficient forage for tortoises negating the need to supply supplemental food relying on natural vegetation for forage is preferable because it will reduce the dependency of tortoises on food supplied by humans, and provide an opportunity for tortoises to become accustomed to foraging for natural foods. If supplemental feeding is deemed necessary, we recommend placing food in the pens during hours of darkness (perhaps prior to daybreak), when tortoises are normally inactive. Plantings within the holding pens could also reduce the dependence of tortoises on food supplied by humans. *Opuntia* spp. is a possible candidate for planting within enclosures. These hardy, non-native but naturalized cacti are easy to transplant, rapidly become established, are relished by tortoises, and considered excellent nutrition.

6. Post-release monitoring is a critical, although often neglected aspect of wildlife reintroduction projects, and essential to evaluate recovery efforts, quantify success, and initiate corrective action if deemed necessary (Dodd and Seigel, 1991). To this end, we recommend attaching radio-telemetry transmitters to each tortoise prior to penning. Tortoises should be located daily while penned, and at least once per week (more frequently if possible) after being released. During the first year post-release, tortoises that wander more than 2 km from the core area should be retrieved and returned to the core area. Retrieval of wandering tortoises is thought to curb the initial flight response of released animals and foster site fidelity (Tuberville et al., 2005).

7. Release of penned tortoises should be gradual and voluntary. Rather than transporting tortoises to an area outside of the pen, we recommend leaving the gates to the enclosure open after a suitably long penning period. We expect tortoises to quickly locate these exits, gradually disperse out of the pen, and establish home ranges in the surrounding habitat. If supplemental feeding is occurring, it should be continued within the pen during the release period, although the amount of food provided can gradually be decreased. Several months may be required for all tortoises to disperse from the pen. We recommend initiating the release at the onset of the wet season (June) when food is increasingly abundant and tortoises most active (Thanda Swe, 2004).

8. Constant on-site security must be provided during the penning phase to ensure that tortoises are not purloined by villagers. After training provided by Wildlife Conservation Society, on-site personnel will also conduct pre- and post-release monitoring.

9. It is essential to conduct a community education campaign to explain project goals prior to initiating reintroduction of tortoises in any protected area. Education coupled with effective enforcement of existing regulations will be especially critical in areas where

local villagers have a history of subsistence and commercial exploitation of wildlife. If *Nats* are perceived as local guardians of tortoises (e.g., Platt et al., 2003), it may be possible to reinforce these existing religious beliefs. These beliefs can provide an excellent foundation for future conservation actions.

In addition to Minzontaung and Shwe Settaw wildlife sanctuaries, a number of other potential reintroduction sites are available within the historic geographic range of *G. platynota*. These include both gazetted lands with formal protected status (wildlife sanctuaries, nature reserves, and national parks) and village lands where local religious beliefs provide some degree of protection for tortoises. Most notable among the latter is Myaleik Taung, where the surrounding agricultural lands once harbored the most significant star tortoise population ever documented in Myanmar (Platt et al., 2003). Similar *de facto* protected areas may also exist near pagodas and religious sites in the Sagaing Hills, although this region has yet to be surveyed.

Eight designated protected areas currently exist within the presumed historic geographic range of *G. platynota* (**Table 1; Figure 10**), ranging in size from Minzontaung Wildlife Sanctuary (23 km^2) to Alaungdaw Kathapa National Park (1,597 km^2). With the exception of Minzontaung and Shwe Settaw wildlife sanctuaries (Platt et al., 2011a) and Mount Popa National Park (Platt and Win Ko Ko, 2010), it is difficult to reliably assess the prospects for reintroducing star tortoises at any protected area in the dry zone owing to a paucity of detailed, site-specific information. Like most protected areas in Myanmar (Rao et al., 2005), those in the dry zone have few technical and financial resources available for conservation. Furthermore, because the dry zone is densely populated, many protected areas are subject to human encroachment and extractive resource exploitation. Despite these concerns, we regard (in alphabetical order) Alaungdaw Kathapa National Park, Bawditataung Nature Reserve, Chatthin Wildlife Sanctuary, Mahamyaing Wildlife Sanctuary, Shwe Settaw Wildlife Sanctuary, and Shwe U Daung Wildlife Sanctuary as likely sites for future reintroductions of captive-bred star tortoises. As part of the workshop we conducted a preliminary assessment of each protected area as a potential reintroduction site (Table 2). However, field investigations will obviously be necessary before these sites can be prioritized.

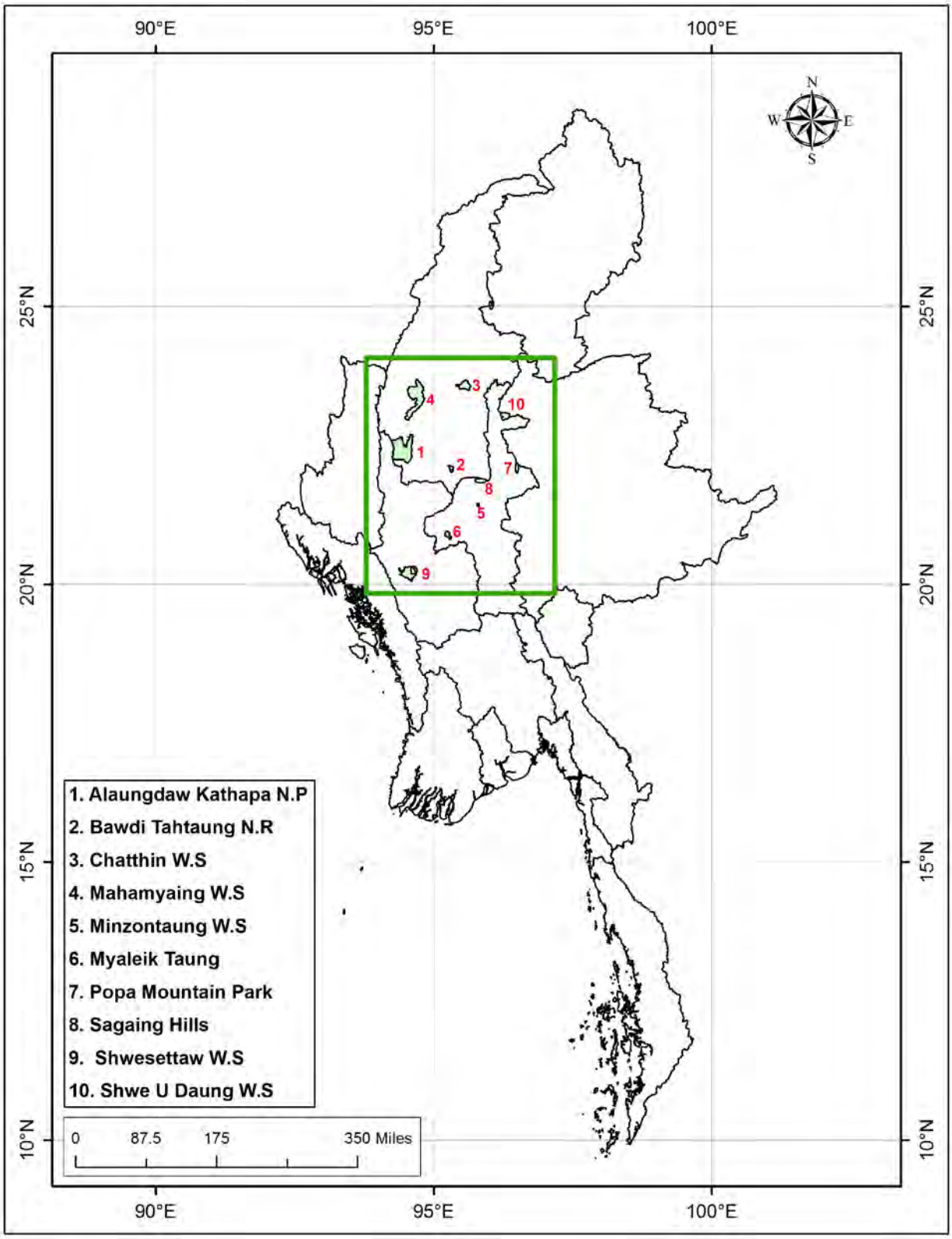

Figure 10: Map of Myanmar showing location of protected areas in the dry zone. WS = Wildlife Sanctuary; NP = National Park; NR = Nature Reserve.

Table 2: Preliminary assessment of dry zone protected areas as potential reintroduction sites for captive-bred Burmese star tortoises. An assessment of Minzontaung and Shwe Settaw wildlife sanctuaries can be found in Platt et al. (2011a). Village lands (e.g., Mya Leik Taung) were not included in this assessment, but deserve future attention. Abbreviations: WS = Wildlife Sanctuary; NP = National Park; NR = Nature Reserve.

Protected area	**Considerations and limitations**
Alaungdaw Kathapa NP	This large protected area (1,597 km^2) and surrounding reserved forests contains ample dry and deciduous forest habitat to support a large tortoise population. Access to the interior is difficult owing to the lack of all-weather roads, thereby affording tortoises some degree of protection. However, the numerous religious pilgrims that visit pagodas within the park each year pose a likely threat to resident and reintroduced tortoises. Reports of star tortoise shells in surrounding villages suggest existing populations are subject to exploitation. Increasing oil and gas development (particularly access roads) also poses a threat to tortoises. Should reintroduction be attempted, efforts should focus on interior regions that are difficult to access. Moreover, education and awareness programs will be required in communities adjacent to the park. Alungdaw Kathapa NP is thought to be among the most promising potential star tortoise reintroduction sites and a formal assessment should be conducted in the near future.
Bawditataung NR	This small reserve (73 km^2) is heavily impacted by the large number of people who visit each year. Several villages also border the reserve, although the residents reportedly respect the area because of its religious significance and the presence of Buddhist monks. Together these factors could facilitate development of a conservation plan that includes tortoises. "Donating" any reintroduced tortoises to the local monks (as proposed for Minzontaung WS) could go far towards ensuring the safety of released animals. The vegetation of the reserve appears to be suitable habitat for star tortoises.
Chatthin WS	Much of this large (268 km^2) wildlife sanctuary is characterized by *Indaing* forest and considered suitable star tortoise habitat. Observations of shells in adjacent villages confirm the presence of *G. platynota* in the area and also indicates tortoises are subject to harvesting. Commercial and subsistence harvesting of wildlife is widespread and has resulted in the extirpation of most large mammals from the sanctuary (Aung et al., 2004). Illegal logging is also a problem. These activities, coupled with lack of enforcement capacity must be addressed before the reintroduction of star tortoises can be attempted. Education and awareness programs will be needed prior to

any reintroduction attempt. If the security situation can be improved, Chatthin WS would appear to be a suitable reintroduction site.

Mahamyaing WS — This wildlife sanctuary (1,180 km^2) is located on the northern periphery of the presumed geographic range of *G. platynota*. Much of the sanctuary consists of suboptimal or unsuitable tortoise habitat. Although reports from villagers and hunters confirm the past occurrence of G. platynota in dry forest and thorn scrub associations to the east of MWS, recent surveys found no evidence of star tortoises within the boundaries of the sanctuary. Education and awareness programs will be needed prior to any reintroduction attempt.

Shwe U Daung WS — Considerable areas of dry deciduous and *Indaing* forest in this sanctuary offer suitable habitat for star tortoises. Sanctuary staff and local informants have confirmed the past occurrence of *G. platynota* within the sanctuary. Parts of the sanctuary are used by the military as a training area. What effects these activities have on tortoises or other wildlife are unknown. However, because non-military personnel are generally barred from entering military training grounds, this area has the potential to host a star tortoise population free from the threat of poaching. Illegal logging, gold mining, and poaching within other parts of the sanctuary pose a serious threat to the few remaining wild tortoises and any that might be released in the future. Education campaigns will be required in surrounding villages and law enforcement activities of sanctuary staff must be increased if reintroductions are to be undertaken at Shwe U Daung.

Conservation Recommendations

The Burmese star tortoise has disappeared from the dry zone landscape, but owing to the foresight of conservationists this loss is by no means irrevocable. Captive husbandry of this critically endangered species has proven remarkably successful and thousands of tortoises now thrive in a network of assurance colonies within Myanmar. Other conservation breeding groups have been established outside of Myanmar and the biological future of *G. platynota* now seems secure. Our next challenge is to move from the captive to the natural arena and restore *G. platynota* as a functioning member of the dry zone ecosystem. **We here propose that reestablishing viable populations of *G. platynota* in every protected area within the presumed historic distribution of the species should be the ultimate, long-term goal of star tortoise conservation in Myanmar**. This is perhaps best considered as a "stretch goal," an ambitious, long-term goal that challenges those involved to accomplish what currently seems impossible (Manning et al., 2006; Sanderson et al., 2008). To achieve this end, below we provide specific near-term recommendations to move the conservation program forward.

1. Genotyping of every tortoise in the assurance colonies is urgently needed. Genetic data are essential to avoid inbreeding, increase the effective population size, and maximize heterozygosity within the captive population. Achieving these objectives could also require a transition from herd-level to individual management to ensure that genetically high-value individuals are producing offspring. To further diversify the genetic base, it may prove necessary to incorporate additional tortoises into the assurance colonies from collections outside of Myanmar.

2. Surveys are urgently needed within the dry zone to 1) determine if extant remnant populations of *G. platynota* still exist, 2) identify areas of suitable star tortoise habitat, and 3) assess these areas as future reintroduction sites. Surveys should focus on, but not be restricted to formally protected areas. The following protected areas (in order of priority) should be surveyed: Alaungdaw Kathapa National Park, Shwe U Daung Wildlife Sanctuary, Chatthin Wildlife Sanctuary, and Bawditataung Nature Reserve. Outside of parks, wildlife sanctuaries, and nature reserves, the Sagaing Hills are considered the area most likely to harbor remnant populations of *G. platynota* and an ecological reconnaissance of this region is urgently needed. Additionally, the conservation status of *G. platynota* at Mya Leik Taung should be investigated and plans for a National Star Tortoise Sanctuary revisited.

3. The potential for developing community-based conservation programs for star tortoises should be investigated. Such programs might prove especially effective at places such as Mya Leik Taung where tortoises figure prominently in local religious beliefs. A community-based conservation program that restored a culturally important species such as *G. platynota* might enjoy widespread support among villagers. Community forestry programs that restore degraded dry zone habitats and supply forest products to local villages could be linked to star tortoise conservation programs. As previously demonstrated (Platt et al., 2003), *G. platynota* does not require pristine forest for survival and high densities can occur in heavily modified anthropogenic habitats provided the animals are not subject to harvest. Finally, as Myanmar move towards becoming a more open society, opportunities for village-based ecotourism will no doubt increase, and star tortoises would seem excellent foci for such tourism.

4. Introducing additional wild-caught tortoises into captive assurance colonies is unnecessary at this time. However well intentioned, placing wild-caught tortoises directly into assurance colonies carries runs the risk of introducing diseases and parasites. Should tortoises be found in protected areas, these animals are best left in the wild unless it is deemed necessary to diversify the existing genetic base of the assurance colonies. Because tortoises inhabiting village lands risk collection, translocating these animals into a protected area is probably advisable. However, if tortoises receive protection from local religious beliefs, leaving the animal *in-situ* is warranted.

5. Disease surveys of wild and captive populations of *G. platynota* and related taxa (e.g., *Indotestudo elongata* and *Manouria emys*) are needed given the existing paucity of information on this topic. Diagnostic testing for specific pathogens will establish what infectious agents might be present in Myanmar and liable to cause mortality among

captive and wild tortoise populations. Such information is critical for insuring that tortoises can be effectively screened for diseases prior to release as well as reducing the likelihood that pathogens will be introduced into wild populations.

6. A National Star Tortoise Workshop should be convened every five years to report progress, review methodology, and reassess long- and short-term objectives.

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Literature Cited

Allendorf, F.W. and R.F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. Pages 57-76 *in* Conservation Biology: The science of scarcity and diversity. Soule, M.E. (Ed.). Sinauer Associates, Inc. Sunderland, Massachusetts.

Aung, M., K.K. Swe, T. Oo, K.K. Moe, P. Leimgruber, T. Allendorf, C. Duncan, and C. Wemmer. 2004. The environmental history of Chatthin Wildlife Sanctuary, a protected area in Myanmar (Burma). Journal of Environmental Management 72:205-216.

Beck, B.B., L.G. Rapaport, M.R. Stanley Price, and A.C. Wilson. 1994. Reintroduction of captive-born animals. Pages 265-286 *in* Creative Conservation. Olney, P.J.S., G.M. Mace, and A.T.C. Feistner (eds.). Chapman and Hall, New York.

Beffasti, L. and V. Galanti. 2011. Myanmar protected areas: context, current status and challenges. Instituto Oikos and BANCA. Ancora Libri, Milano, Italy. 86 pp.

Blyth, E. 1863. A collection of sundries from different parts of Burma. Journal of the Asiatic Society of Bengal 32:78-90.

Cagle, F.R. 1939. A system for marking turtles for future identification. Copeia 1939:170-173.

Davis, J.H. 1964. The forests of Burma. Sarracenia 8:1-41.

Dodd, C.K., and R.A. Seigel. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: Are they conservation strategies that work? Herpetologica 47:336–350.

Ebenhack, A. 2012. Health care and rehabilitation of turtles and tortoises. Living Art Publishing, New York. 392 pp.

FAO/UNDP. 1982. Shwesettaw Wildlife Sanctuary: report on a reconnaissance survey and evaluation, June 1982. FAO/UNDP Nature Conservation and National Parks Project, BUR/80/006, Field Report 9/82. FAO/UNDP, Rangoon. 19pp.

Fife, J.D. 2007. Star tortoises: The natural history, captive care, and breeding of *Geochelone elegans* and *Geochelone platynota*. Turtles of the World Series: Testudinidae. No. 10.

Gates, C.C., C.H. Freese, P.J.P. Gogan, and M. Kotzman. 2010. American bison: status survey and conservation guidelines 2010. IUCN Publications, Gland, Switzerland. 134 pp.

Germano, J. and P.J. Bishop. 2005. Suitability of amphibians and reptiles for translocation. Conservation Biology 23:7-15.

Hundley, H.G. 1961. The forest types of Burma. Tropical Ecology 2:48-76.

IUCN. 2012. IUCN Redlist. [www.iucnredlist.org; accessed 12 December 2012].

Johnson, A.J., T.M. Norton, J.F.X. Wellehan, A.P. Pessier, J. Spratt, N.L. Stedman, and E.R. Jacobson. 2004. Iridovirus in captive Burmese star tortoises (*Geochelone platynota*). Proceedings of the Association of Reptilian and Amphibian Veterinarians 2004:143-144.

Kapfer, J.M., D.J. Munoz, and T. Tomasek. 2012. Use of wildlife detector dogs to study eastern box turtle (*Terrapene carolina carolina*) populations. Herpetological Conservation and Biology 7:169-175.

Kuchling, G., E. Goode, and P. Praschag. 2011. Endoscopic imaging of gonads, sex ratio and temperature dependent sex determination in captive bred juvenile Burmese star tortoises *Geochelone platynota*. Asian Herpetological Research 2:240-244.

Laundré, J.W. 2012. Phantoms of the prairie: the return of cougars to the Midwest. University of Wisconsin Press, Madison. 187 pp.

Manning, A.D., D.B. Lindenmayer, and J. Fischer. 2006. Stretch goals and backcasting: approaches for overcoming barriers to large-scale restoration. Restoration Ecology 14:487-492.

Meffe, G.K. and C.R. Carroll. 1994. Principles of Conservation Biology. Sinauer Associates, Inc. Sunderland, Massachusetts.

Mrosovsky, N. and C. Pieau. 1991. Transitional range of temperature, pivotal temperature and thermosensitive stages of sex determination in reptiles. Amphibia-Reptilia 12:169-187.

Platt, S.G., Kyaw Moe, K. Platt, and Me Me Soe. 2011a. An assessment of Shwe Settaw and Minzontaung Wildlife Sanctuaries as reintroduction sites for the critically endangered *Geochelone platynota*. Report to Wildlife Conservation Society, Bronx, New York. 44 pp.

Platt, S.G., K. Platt, Thet Zaw Naing, Khin Myo Myo, Naing Lynn, and Me Me Soe. 2012. An expedition to the Chindwin River and Naga Hills of western Myanmar. Report to Wildlife Conservation Society, Bronx, New York. 94 pp.

Platt, S.G., Saw Tun Khaing, Win Ko Ko, and Kalyar. 2001. A tortoise survey of Shwe Settaw Wildlife Sanctuary, Myanmar, with notes on the ecology of *Geochelone platynota* and *Indotestudo elongata*. Chelonian Conservation and Biology 4:172-177.

Platt, S.G., Thanda Swe, Win Ko Ko, Kalyar Platt, Khin Myo Myo, Thomas R. Rainwater, and D. Emmett. 2011b. *Geochelone platynota* (Blyth 1863) – Burmese Star Tortoise, Kye Leik. Conservation Biology of Freshwater Turtles and Tortoises: A compilation project of the IUCN Tortoise and Freshwater Turtle Specialist Group. Rhodin, A.G.J., P.C.H. Pritchard, P.P. van Dijk, R.A. Samure, K.A. Buhlman, J.B. Iverson, and R.A. Mittermeier (eds.). Chelonian Research Monographs 5:57.1-57.9.

Platt, S.G. and Win Ko Ko. 2010. A tortoise survey of Mount Popa National Park, Myanmar, with conservation recommendations. Report to Wildlife Conservation Society, Bronx, New York. 57 pp.

Platt, S.G., Win Ko Ko, and Kalyar. 2000. Exploitation and conservation status of tortoises and freshwater turtles in Myanmar. Chelonian Research Monographs 2:95-100.

Platt, S.G., Win Ko Ko, Lay Lay Khaing, Khin Myo Myo, Thanda Swe, Tint Lwin, and T.R. Rainwater. 2003. Population status and conservation of the critically endangered Burmese star tortoise *Geochelone platynota* in central Myanmar. Oryx 37:464-471.

Platt, S.G., Win Ko Ko, Lay Lay Khaing, Khin Myo Myo, Thanda Swe, Kalyar, and T.R. Rainwater. 2004. Recent records and comments on the distribution and conservation status of *Geochelone platynota* (Blyth, 1863) in the dry zone of central Myanmar. Hamadryad 29:128-131.

Rao, M., Than Myint, and Saw Htun. 2005. Hunting patterns in tropical forests adjoining the Hkakaborazi National Park, north Myanmar. Oryx 39:292-300.

Rhodin, A.G.J., A.D. Walde, B.D. Horne, P.P. van Dijk, T. Blanck, and R. Hudson. 2011. Turtles in trouble: The worlds 25+ most endangered tortoises and freshwater turtles - 2011. IUCN Tortoise and Freshwater Turtle Specialist Group, Turtle Conservation Fund, Turtle Survival Alliance, Turtle Conservancy/Behler Conservation Center, Chelonian Research Foundation, Conservation International, Wildlife Conservation Society, and San Diego Zoo Global. 54 pp.

Sanderson, E.W., K.H. Redford, B. Weber, K. Aune, D. Baldes, J. Berger, D. carter, C. Curtin, J. Derr, S. Dobrott, E. Fearn, C. Fleener, S. Forrest, G. Gerlach, C.C. Gates, J.E. Gross, P. Gogan, S. Grassel, J.A. Hilty, M. Jensen, K. Krunkel, D. Lammers, R. List, K. Minkowski, T. Olson, C. Pague, P.B. Robertson, and B. Stephenson. 2008. The ecological future of the North American bison: conceiving long-term, large-scale conservation of wildlife. Conservation Biology 22:252-266.

Sexton, O.J. 1959. Spatial and temporal movements of a population of the painted turtle, *Chrysemys picta marginata* (Agassiz). Ecological Monographs 29:113-140

Stamp, L.D. and L. Lord. 1923. The ecology of parts of the riverine tract of Burma. Journal of Ecology 11:129-159.

Thanda Swe. 2004. Autecology of the Myanmar star tortoise, *Geochelone platynota* (Blyth, 1863). Ph.D. Dissertation, University of Mandalay, Myanmar.

Theobald, W. 1868. Catalogue of the reptiles of British Burma [sic], embracing the provinces of Pegu, Martaban, and Tennasserim: with descriptions of new or little known species. Journal of the Linnaean Society (Zoology) 10:4-67.

Tuberville, T.D., E.E. Clark, K.A. Buhlmann, and J.W. Gibbons. 2005. Translocation as a conservation tool: site fidelity and movement of repatriated gopher tortoises (*Gopherus polyphemus*). Animal Conservation 8:349-358.

Turtle Conservation Fund. 2002. A global action plan for the conservation of tortoises and freshwater turtles: strategy and funding prospectus, 2002-2007. Conservation International and Chelonian Research Foundation, Washington, D.C. 30 pp.

van Dijk, P.P. 1994. Report on a visit to Myanmar, 18-28 January 1994. Report to Turtle Recovery Program, The World Conservation Union-IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. 23 pp.

Zug, G.H., Htun Win, Thin Thin, Than Zaw Min, Win Zaw Lhon, and Kyaw Kyaw. 1998. Herpetofauna of the Chatthin Wildlife Sanctuary, north-central Myanmar, with preliminary observations of their natural history. Hamadryad 23:111-120.

Appendix 1: List of individuals participating in the National Burmese Star tortoise Workshop held at Lawkanandar Wildlife Sanctuary, 17 to 21 September 2012.

No.	Participants	Position	Institutional affiliation
1.	U Shwe Htay Aung	Park Warden	Lawkanandar Wildlife Sanctuary
2.	Daw Lay Lay Khine	Range Officer	Lawkanandar Wildlife Sanctuary
3.	Daw Thin Thin Yu	Range Officer	Shwe Settaw Wildlife Sanctuary
4.	U Kyaw Thu	Range Officer	Zee Pin Forest Reserve
5.	Daw San San Nwe	Ranger	Minzontaung Wildlife Sanctuary
6.	U Tun Lwin Aung	Ranger	Lawkanandar Wildlife Sanctuary
7.	U Soe Nyunt Aung	Ranger	Lawkanandar Wildlife Sanctuary
8.	U Win Ngwe	Ranger	Lawkanandar Wildlife Sanctuary
9.	U Kyaw Aung	Ranger	Lawkanandar Wildlife Sanctuary
10.	U Than Hlaing	Ranger	Rakhine Yoma Elephant Range
11.	U Soe Myint	Ranger	Rakhine Yoma Elephant Range
12.	U Win Zaw	Ranger	Kyeikhtiyoe Wildlife Sanctuary
13.	U Than Zaw Min	Ranger	Shwe U Daung Wildlife Sanctuary
14.	U Tun Kyae	Ranger	Shwe U Daung Wildlife Sanctuary
15.	U Zaw Naing Tun	Ranger	Htamanthi Wildlife Sanctuary
16.	U Moe Myint Aung	Ranger	Htamanthi Wildlife Sanctuary
17.	U Min Naing	Ranger	Htamanthi Wildlife Sanctuary
18.	U Aye Than Htwe	Ranger	Alaungdawkathapa National Park
19.	U Kyaw Kyaw Naing	Ranger	Meinmahla Kyun Wildlife Sanctuary
20.	U Hmine Aye	Ranger	Zee Pin Forest Reserve
21.	U Maung Maung Lwin	Forester	Minzontaung Wildlife Sanctuary
22.	U Aung Sein	Forester	Minzontaung Wildlife Sanctuary
23.	Daw Aye Aye Cho	Forester	Shwe Settaw Wildlife Sanctuary
24.	U Maung Maung Hlaing	Forester	Shwe Settaw Wildlife Sanctuary
25.	U Win Lwin Oo	Forester	Popa Mountain Park

No.	Participants	Position	Institutional affiliation
26.	U Thiha Zaw	Forester	Alaungdaw Kathapa National Park
27.	U Hla Soe Win	Forester	Meinmahla Kyun Wildlife Sanctuary
28.	Daw Sandar Maung	Office Staff	Popa Mountain Park
29.	Dr. Tint Lwin	Veterinarian	Yadanabon Zoological Garden
30.	Dr. Thaw Thaw Linn	Veterinarian	Naypyidaw Zoological Garden
31.	Dr. Thein Aung	Consultant	Htoo Foundation
32.	Dr. Tun Myint	Manager	Yangon Zoological Garden
33.	U Myint Htun	Senior Keeper In-charge	Yadanabon Zoological Garden
34.	U Than Hlaing	Keeper In-charge	Yangon Zoological Garden
35.	U Aung Chit Aye	Keeper In-charge	Naypyidaw Zoological Garden
36.	U Myint Swe	Education Coordinator	Instituto Oikos
37.	Dr. Nantarika Chansue	Associate Professor	Chulalongkorn University
38.	Dr. Kwanta Charapum	Veterinarian	Chulalongkorn University
39.	Dr. Steven G. Platt	Regional Herpetologist	Wildlife Conservation Society
40.	U Win Ko Ko	Turtle Coordinator	Wildlife Conservation Society
41.	Dr. Kalyar Platt	Country Representative	Turtle Survival Alliance
42.	Daw Myint Myint Oo	Training & Education Coordinator	Wildlife Conservation Society
43.	Daw Khin Myo Myo	Deputy Coordinator-Turtle Program	Wildlife Conservation Society
44.	U Kyaw Moe	Project Manager	Wildlife Conservation Society
45.	Daw Me Me Soe	Project Manager	Turtle Survival Alliance
46.	U Tun Win Zaw	Field Assistant	Wildlife Conservation Society
47.	U Toe Win	Manager	Shwe Pon Taung Private Farm