New data on the naturally-occurring maximum sizes attained by Ploughshare Tortoises (*Astrochelys yniphora*)

Angelo Mandimbihasina¹ and Andrea Currylow²,*

As part of larger studies in January, April, and May 2013, we recorded morphometrics on 127 Ploughshare Tortoises (*Astrochelys yniphora*) (Vailant 1885) and found previous reports of morphometrics to be lacking the breadth of size this species can achieve. The Ploughshare Tortoise is the largest extant tortoise in Madagascar; however, it has previously been described as reaching morphometrics that fall up to 36% short of our findings. Using data presented herein, we propose to update and add to the current species description, offering a new standard metric for size.

The Ploughshare Tortoise (known locally as “Angonoka”) is endemic to Baly Bay National Park in northwest Madagascar. The species is known as the rarest and most endangered tortoise in the world (Curl et al., 1985; Curl, 1986). It is listed in Appendix 1 of the Convention on International Trade in Endangered Species, classified as Critically Endangered on the IUCN’s Red List, and in the top 10 of The World’s 25+ Most Endangered Tortoises and Freshwater Turtles, designated at “Extremely High Risk of Extinction” (Leutenitz, and Pedrono, 2008; Rhodin et al., 2011; CITES, 2014; IUCN, 2014). The namesake of *A. yniphora*, the distinctive, long gular projection (plough; an extension of the plastron) and its rarity (fewer than 400-600 wild adults remain; Kiester et al., 2013) make it a prized animal for collection. It is further set apart by its unique golden colour, all of which has created extreme demand in the illicit trade and incited poaching from the wild, making it truly the “golden tortoise”.

As in many turtle species, the Ploughshare Tortoise exhibits sexual dimorphism, and sexes can be distinguished via secondary sexual characteristics. As compared to females, male characters include overall longer carapaces, elongated gular scute, concave plastron, longer tail, and longer anal fork. In contrast, females have shorter upturned gular scute, flat plastron, and wider anal notch which allows egg passage. Adult Ploughshare Tortoise straight carapace length (SCL) is described as being 250–486 mm (Juvik et al., 1997; Smith et al., 1999; Pedrono, and Markwell, 2001). In 2001, Pedrono and Markwell reported the maximum size and weight known among both male and female wild Ploughshare Tortoises in the Baly Bay region, Madagascar.

As part of larger studies in January, April, and May 2013, we sampled a captive population of Ploughshare Tortoises and conducted line-distance surveys in the wild in Baly Bay, Madagascar. Due to the sensitivity of locality information, we decline to state the exact location of the wild animals beyond the region of Baly Bay National Park. For each animal, we recorded morphometrics (SCL; Straight Carapace Width [SCW]; Straight Plastron Length [SPL]; Straight Plastron Width [SPW]; Curved Carapace Length [CCL]; and weight). We recorded data from a total of 127 Ploughshare Tortoises of all age classes (Figure 1). Of those, 106 were wild individuals found during surveys in the natural range. For the 98 animals in the adult age class (individuals over 250 mm SCL) from both captive and wild populations, we report summary morphometrics (Table 1). In our data, SCLs differ significantly between each of the three classes (sub-adult, male, and female; $F_{2,124} = 159.5069, p< 0.0001$).

Concordant with accounts of this species, we found males to be significantly larger (SCL; $t = 11.08, p< 0.0001$) and heavier ($t = 5.844, p< 0.0001$) than females.

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¹ Durrell Wildlife Conservation Trust, Lot IIY49 J Ampasanimalo, BP 8511 Antananarivo 101, Madagascar; e-mail: angelo.ramy@durrell.org
² Department of Biological Sciences, University of Southern California, 3616 Trousdale Parkway, AHF 107, Los Angeles, California 90089, USA
* Corresponding author; e-mail: a.currylow@gmail.com
Many of our animals had their gular projections cut off by local people who believe that a long gular scute prevents an animal from eating. Therefore, only our reported ranges in SPL (not the mean SPL) are accurate for a proper species account. Still, two of the males we measured were larger (SCL) than previously reported as “largest known” Ploughshare of 486 mm (Pedrono, and Markwell, 2001). We also did relocate the Pedrono and Markwell largest known male (#1017) which measured 489 mm SCL, growing only 3 mm in more than a decade since their report. Curiously, Pedrono and Markwell (2001) report the largest known female (#1030) as one which is smaller than their own reported maximum SCL for females of the species (see Table 1). Accordingly, four of the adult females we recorded were larger in SCL than #1030, and seven were as heavy or heavier. The largest female we found (#3034) is in captivity in Madagascar and is part of a captive breeding program. She measured 416 mm SCL, 258 mm carapace height, and weighed 12.8 kg.

During the filed surveys, we recorded two male and four female Ploughshares that exceeded any previously reported maximum SCL for the individual sexes. The largest individual, a male (#1102) we named “Rapeto” after a giant in a traditional Malagasy legend, measured 519 mm SCL, 288 mm carapace height, and easily topped out our 20-kg Pesola scale (Fig. 2A). The largest wild female we encountered (#1297), we named “Rasoabe” meaning “the great, good lady” which measured 411 mm SCL, 270 mm carapace height, and weighed 15.5 kg (Fig. 2B). These two animals, along with several others, are now being monitored via radiotelemetry.

Although we have reported the metric here, we found weight to be an unreliable metric for larger individuals. As can be seen in Figure 1, the fitted curve begins to dissociate from reliably predicting the size of the larger adult animals. We found the largest animals were not always the heaviest and adult animals often would vary by kilograms if they voided their bladders during handling. We recorded several adult weight differences of more than 2.0 kg before and after voids during the same sampling visit. Similar weight variation was seen in the same wild individuals across seasons in subsequent surveys (Currylow unpubl. data). Therefore, we also

Table 1. Morphometrics (Straight Carapace Length [SCL]; Straight Carapace Width [SCW]; Straight Plastron Length [SPL]; Straight Plastron Width [SPW]; Curved Carapace Length [CCL]) of adult Ploughshare Tortoises in the present study compared to previous reports/species descriptions.

<table>
<thead>
<tr>
<th></th>
<th>Males Present Study (range, n = 41)</th>
<th>Previous Studies Mean/Max (range; n = 32)</th>
<th>% diff.</th>
<th>Females Present Study (range, n = 57)</th>
<th>Previous Studies Mean/Max (range; n = 40)</th>
<th>% diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>12.4 (6.0–20.0+)</td>
<td>10.3 (7.2–18.9)</td>
<td>+ 20.4</td>
<td>9.4 (6.0–15.5)</td>
<td>8.8 (5.5–12.0)</td>
<td>+ 6.8</td>
</tr>
<tr>
<td>SCL (mm)</td>
<td>435 (368–519)</td>
<td>415 (361–486)</td>
<td>+ 4.8</td>
<td>367 (320–416)</td>
<td>370 (307–426)</td>
<td>- 0.8</td>
</tr>
<tr>
<td>SCW (mm)</td>
<td>291 (250–386)</td>
<td>317</td>
<td>+ 21.8</td>
<td>267 (226–312)</td>
<td>280</td>
<td>+ 11.4</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>253 (222–288)</td>
<td>269</td>
<td>+ 7.1</td>
<td>231 (200–319)</td>
<td>235</td>
<td>+ 35.7</td>
</tr>
<tr>
<td>SPL (mm)</td>
<td>425 (347–508)</td>
<td>462</td>
<td>+ 10.0</td>
<td>349 (307–389)</td>
<td>379</td>
<td>+ 2.6</td>
</tr>
<tr>
<td>SPW (mm)</td>
<td>268 (229–311)</td>
<td>N/A</td>
<td>-</td>
<td>245 (206–300)</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>CCL (mm)</td>
<td>632 (552–742)</td>
<td>N/A</td>
<td>-</td>
<td>572 (554–604)</td>
<td>N/A</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 1. Weights and Straight Carapace Lengths of Ploughshare Tortoises surveyed during January-April 2013 in northwest Madagascar.
report other shell measurements, such as carapace height, for this species (Table 1). We found that using the height metric (as opposed to weight) along with SCL was both informative and resulted in high linear-prediction values for the distinct groups (Fig. 3). The relationship is strongest for the sub-adult age classes ($r^2 = 0.99$), and is robust for both females ($r^2 = 0.85$) and males ($r^2 = 0.83$).

While the sizes of the largest Ploughshares recorded during the current study are impressive, they were not unprecedented. In 1989, Reid, Durrell and Rakotobearison suggested that the largest Ploughshare Tortoise could reach a half-meter in SCL and 25 kg in weight. Curl et al. (1985) reported that local villagers estimated the species to reach 560 mm, but noted that this extreme was larger than any known individual. Pedrono and Markwell stated that ploughshares can be bigger than the maximum sizes they reported in 2001. However, this study now shows that males and females of this species can commonly achieve even larger and more impressive sizes than those previously reported in the literature. We propose to update and add to the current species description, offering carapace height and SCL as the new standard metrics for size comparisons.
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References


