Identification of Seychelles Giant Tortoises.
Linnaeus Fund Research Report

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Since their discovery, the taxonomy of Indian Ocean Dipsochelys giant tortoises has been confused (Günther, 1877; Rothschild, 1915; Arnold, 1979, Bour, 1982; Gerlach and Canning, 1998). Since 1968 it had been assumed that all living Indian Ocean giant tortoises were of Aldabran origin and therefore belonged to the species Dipsochelys dussumieri (previously known as Geochelone gigantea or D. elephantina) (Gaymer, 1968). There have been a number of suggestions that some captive tortoises should be referred to a Seychelles species rather than the Aldabran (Honegger, 1967; Penny, 1970; Anonymous, 1971) and in 1982 the description of D. arnoldi from Seychelles included photographs of living tortoises in Mauritius suggested to be that species (Bour, 1982). However, it has generally been assumed that deviations from the Aldabran morphology are the consequence of shell distortion caused by poor captive diets (Arnold, 1979).

In 1995 two unusual tortoises were brought to our attention, with the suggestion that they could be of Seychelles origin (A. Skerrett, pers. comm.; Gerlach and Canning, 1995). The existence of a skeleton of a tortoise from this group enabled us to make a skeletal comparison with typical Aldabran tortoises. This brief study supported suggestions that some consistent differences were present, though hard to interpret. This intriguing situation prompted a more extensive study of museum specimens to review the taxonomy of the genus. At the same time an opportunity became available to undertake a genetic study of the living tortoises in Seychelles. These studies have enabled us to review the taxonomy of the tortoises, determine the extent of influence of captivity on morphology, and to help determine which taxa survive to the present day.

Methods. — We examined 84 skeletal and shell specimens of Dipsochelys in museums and private collections. Multiple features of the shell and skeleton were examined in order to evaluate taxonomic differences, sexual dimorphism, and ontogenetic variation. Full details of this study have been published elsewhere (Gerlach and Canning, 1998).

We also collected blood samples from 60 living tortoises on Mahé, Cerf, Praslin, Cousin, Cousine, and La Digue islands in Seychelles between 8 January – 10 February 1996. Samples varying from 1-10 ml were collected from the brachial artery in heparinized tubes and subsequently frozen. Most blood samples were collected from tortoises that showed some morphological difference from wild Aldabran tortoises. In addition a small number of reference samples were taken from apparently pure Aldabran tortoises (D. dussumieri) released on Curieuse Island between 1979 and 1986.

The Aldabran standard used as a reference is an evenly curved, domed shell without flaring of the front or rear marginals, supracaudal not flared upwards or curved under the carapace, nuchal scute present, deep anal notch, large undivided temporal scale, and only short scales on the tip of the tail. All sampled tortoises were measured and photographed. Measurements comprised straight carapace length, curved carapace length, straight carapace width, curved carapace width, shell height, plastron length, and length of vertebrales 2, 3, and 4. Straight carapace measurements were made with the use of calipers.

DNA analysis of 45 of these samples was carried out by L. Noble at Aberdeen University, Department of Zoology, using the technique of randomly amplified polymorphic DNA (RAPDs); the results of this genetic work have not yet been published.

Results. — The morphology study is published separately in this volume (Gerlach and Canning, 1998). In summary, this demonstrated the historical existence of six species of Dipsochelys: D. dussumieri on Aldabra, D. daudinii, D. hololissa, and D. arnoldi on the Seychelles islands, and D. abrupta and D. grandisleri on Madagascar, with D. dussumieri, D. hololissa, and D. arnoldi still represented by living specimens. The species are distinguished by characters of skeletal morphology not accounted for by ontogeny or sexual dimorphism. External characters are variable but all taxa are distinguishable (Table 1), a principal component analysis of variation shows that general shell
Table 1. External distinguishing features of Dipsochelys species.

<table>
<thead>
<tr>
<th>Character</th>
<th>dussumieri</th>
<th>daudinii</th>
<th>hololissa</th>
<th>arnoldi</th>
<th>abrupta</th>
<th>grandieri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell shape</td>
<td>domed</td>
<td>saddle</td>
<td>domed</td>
<td>saddle</td>
<td>domed</td>
<td>flat</td>
</tr>
<tr>
<td>Shell color</td>
<td>black</td>
<td>black</td>
<td>brown</td>
<td>black</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Posterior/anterior width (%)</td>
<td>104-123</td>
<td>115</td>
<td>103-112</td>
<td>120-140</td>
<td>108-110</td>
<td>100-103</td>
</tr>
<tr>
<td>2nd/3rd vertebral height (%)</td>
<td>79-107</td>
<td>100</td>
<td>92-103</td>
<td>98-100</td>
<td>ca. 95</td>
<td>98-100</td>
</tr>
<tr>
<td>4th/3rd vertebral height (%)</td>
<td>83-114</td>
<td>100</td>
<td>80-100</td>
<td>94-100</td>
<td>ca. 85</td>
<td>100</td>
</tr>
<tr>
<td>1st/2nd costal length (%)</td>
<td>85-114</td>
<td>93</td>
<td>73-109</td>
<td>120-157</td>
<td>110</td>
<td>104-114</td>
</tr>
<tr>
<td>Costal height/3rd vertebral height</td>
<td>0.73-0.85</td>
<td>0.80-0.83</td>
<td>0.86-0.89</td>
<td>0.85-0.89</td>
<td>ca. 0.80</td>
<td>0.93-1.00</td>
</tr>
<tr>
<td>2nd/3rd vertebral length (%)</td>
<td>91-110</td>
<td>86</td>
<td>100-105</td>
<td>104-124</td>
<td>105</td>
<td>100-109</td>
</tr>
<tr>
<td>3rd/4th vertebral length (%)</td>
<td>78-125</td>
<td>93</td>
<td>78-133</td>
<td>50-78</td>
<td>116</td>
<td>81-97</td>
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<tr>
<td>Pit on suture of costal 1 and 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Costo-marginal suture</td>
<td>straight</td>
<td>straight</td>
<td>straight</td>
<td>sinuous</td>
<td>sinuous</td>
<td></td>
</tr>
<tr>
<td>Caudal recurved</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Plastron length (% carapace)</td>
<td>75-94</td>
<td>75</td>
<td>71-91</td>
<td>61-82</td>
<td>80</td>
<td>76-87</td>
</tr>
<tr>
<td>Abdomino-femoral suture</td>
<td>curved</td>
<td>angled</td>
<td>angled</td>
<td>angled</td>
<td>angled</td>
<td></td>
</tr>
<tr>
<td>Humero-pectoral suture angle</td>
<td>0</td>
<td>0</td>
<td>140-150</td>
<td>150</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Anal notch (% length of anals)</td>
<td>14-32</td>
<td>15</td>
<td>0-16</td>
<td>0-15</td>
<td>13-28</td>
<td></td>
</tr>
</tbody>
</table>

Morphology distinguishes most individuals of the three living species (Fig. 1). Of the living tortoises from which blood samples were collected, 47 are identifiable as D. dussumieri, 10 as D. hololissa, and 3 as D. arnoldi.

The RAPDs data are still being analyzed by L. Noble (pers. comm.); the following interpretation is based on our comparison of his preliminary findings with our morphologic data. The RAPDs data (Fig. 2) cluster into three groups based purely on DNA analysis. These are identifiable as the three taxa recognized by the analysis of morphology. The morphologic and genetic plots in Figs. 1 and 2 show the same numbered individuals, showing the correspondence between the genetic and morphologic data.

Discussion. — The morphologic and genetic studies carried out as part of this project support the conclusion that there are three living taxa of Indian Ocean giant tortoises: the common Aldabran giant tortoise, D. dussumieri, and two Seychelles species, D. arnoldi and D. hololissa.

Within the Aldabran tortoises it is notable that the wild tortoises on Curieuse have very little genetic or morphologic variation. Captive specimens are more variable and demonstrate higher genetic diversity. This may indicate that captives include individuals retaining some of the genetic diversity which existed in the wild population prior to the population bottleneck experienced at the turn of the century (Gerlach and Canning, 1996b).

Data from two groups of captive animals in Britain (Cotswolds Wildlife Park and Paignton Zoological Gardens) provide an opportunity to determine the limits of dietary distortion on captive tortoises. These animals were confiscated by customs officials following illegal import from Curieuse in 1986 and are thus of known Aldabran parentage. Both groups were initially fed diets inappropriately high in protein. Excess protein is generally assumed to cause shell distortion in captive Dipsochelys. These animals do have distorted shells, with strongly bossed scutes. However, principal component analysis placed these animals within the D. dussumieri cluster, still very close to the wild morphology (Figs. 1 and 2). From this it is apparent that while dietary problems do cause shell distortion, in particular bossing, they do not affect the diagnostic scute proportions listed in Table 1.

The use of detailed analysis of morphology was the initial step in enabling us to demonstrate that three living taxa of Dipsochelys giant tortoises can be recognized. The data on the limits of dietary distortion support these conclusions and are also in accordance with our interpretation of
the available genetic data. These findings are of significance in furthering the understanding of the evolution of Dipsochelys and in the conservation of the surviving taxa. Further research to investigate the natural extent of genetic variation of these taxa (as represented by museum material) would be advantageous.

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Literature Cited


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The river cooter, Pseudemys concinna, is an endangered and enigmatic member of the Illinois chelonian fauna (Herbert, 1992; Dreslik et al., 1998). At its northern range limit in Illinois, P. concinna appears patchily distributed in small populations (Smith, 1961; Minton, 1972; Seidel and Green, 1982; Buhlmann and Vaughan, 1991; Moll and Morris, 1991; Dreslik and Moll, 1996; Dreslik, 1997b). The first record of P. concinna in Illinois was based on a specimen collected at Mt. Carmel in the Wabash River in the late 1800s (Garman, 1890). The species has also been recorded in Alexander, Gallatin, Hardin, Jackson, Jersey, Massac, Randolph, Union, Wabash, and White counties (Cahn, 1937; Smith, 1961; Moll and Morris, 1991).

As recently as the early 1980s, P. concinna was believed to have been extirpated from the state; however, by 1988, extant populations were located in floodplain lakes and ponds along the Ohio River in Gallatin County, Illinois. The survey by Moll and Morris (1991) became the impetus for a long-term study of P. concinna in a chain of floodplain lakes in southeastern Gallatin County (Dreslik et al., 1988; Dreslik, 1997b; Dreslik and Moll, 1996). In May 1994, an ongoing ecological and conservation study was initiated at the most accessible lake, Round Pond.

This report discusses the results from the first phase of this research initiative in which I document new populations of P. concinna, report on habitat and population threats, and formulate initial conservation recommendations for the species in Illinois. Previous reports based on this work are in Dreslik and Moll (1996), Dreslik (1997a, 1997b), and Dreslik et al. (1998).

Methods. — Initial fieldwork in 1994 indicated that a chain of floodplain lakes, sloughs, and ponds located along the Ohio River in Gallatin County, Illinois, would be suitable to initiate a long-term monitoring study. To the north, the chain begins with Hulda Lake and extends southward to Fish Lake (23 ha). Other nearby lacustrine systems include: Black Lake (9 ha), Round Pond (30 ha), Fehrer Lake (15 ha), and Long Pond (6 ha). The lakes are relatively open bodies of water that connect with the Ohio River during spring floods. In White County, similar habitats were selected for survey, two of which were old channels of the Wabash River at Ribeyre and Greathouse islands. These sites were surveyed from 1994 to 1996 (Table 1).