LINNAEUS FUND RESEARCH REPORTS

Editorial Comment. – This section presents research reports based on support provided by Chelonian Research Foundation through the Linnaeus Fund, its annual turtle research awards program. Named after Carolus Linnaeus [1707–1778], the Swedish creator of binomial nomenclature, the fund honors the first turtle taxonomist and father of all modern systematics. Linnaeus Fund awards are granted annually to individuals for specific turtle research projects, with either partial or full support as funding allows. Priority is generally given to projects concerning freshwater turtles, but tortoise and marine turtle research proposals are also funded. Priority is given to the following general research areas: taxonomy and systematic relationships, distribution and zoogeography, ecology, natural history, and morphology, but other topics are also considered. Priority is also given to projects that demonstrate potential relevance to the scientific basis and understanding of chelonian diversity and conservation biology. The generally preliminary and summary reports in this section are not formally peer-reviewed, but are nonetheless subjected to editorial review.

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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, Curieuse, 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 vertebrals 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. grandidieri* 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.

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

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 demonstate 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

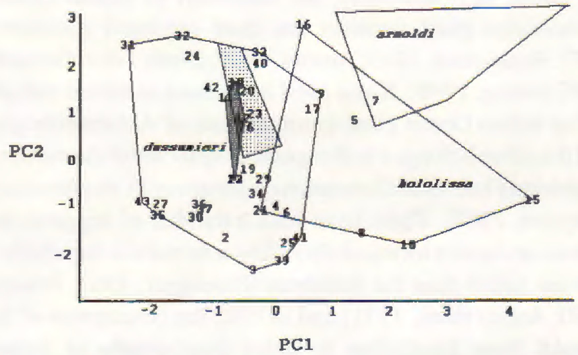

Figure 1. Morphologic variation (principal component analysis) in three species of living Seychelles and Aldabra *Dipsochelys.* Light stippling represents captive Aldabran *D. dussumieri* with extreme dietary distortion. Dense stippling represents wild Aldabran *D. dussumieri* from Curieuse Island. Numbers represent living individuals from which blood samples were taken for DNA analysis (see Fig. 2).

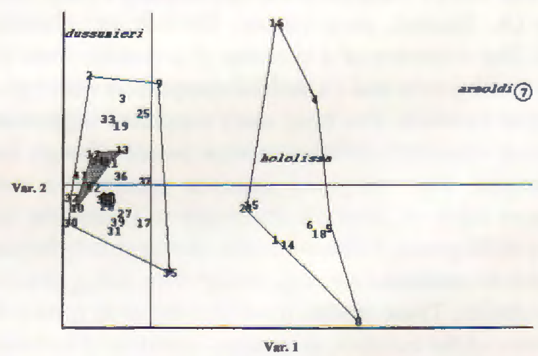

Figure 2. Genetic data (RAPDs) of living *Dipsochelys* (L. Noble, *pers. comm.*). Numbered individuals identified by morphologic analysis are grouped into three distinct taxa. The plot represents DNA data only, taxon identification is derived from morphologic analysis (see Fig. 1).

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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Current Status and Conservation of the River Cooter (*Pseudemys concinna*) in Southern Illinois. Linnaeus Fund Research Report

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The river cooter, *Pseudemys concinna*, is an endangered and enigmatic member of the Illinois chelonian fauna (Herkert, 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 (Moll and Morris, 1991). 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 on-going 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).