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Geographic Variation in the Giant Softshell Turtle, *Pelochelys bibroni*. Linnaeus Fund Research Report

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The giant softshell turtle, *Pelochelys bibroni* (Owen), has long been considered monotypic and widespread in southeast Asia, extending from southern China and parts of India south through the Malayan peninsula into Java and Borneo with isolates in the Philippines and New Guinea. Preliminary knowledge of two distinctive populations in northern and southern New Guinea provided the impetus for studying geographic variation throughout the range of *Pelochelys* (Rhodin et al., 1993).

Of immediate concern was the status of the distinctive population in southern New Guinea, which resembled *Chitra* in adults having yellow neck stripes and radiating carapace markings. These adult patterns were similar to those of *Chitra chitra* from Thailand.

Methods. — The funds requested partially defrayed expenses accrued during travel to Indonesia and Thailand in April 1993. Travel destinations included some of the Indonesian islands (in company with A. Rhodin) and Bangkok, Thailand (Chulalongkorn University and colleagues P.P. van Dijk and T. Kumthorn). In Thailand, data were obtained on *Pelochelys* (and other trionychid species), and especially *Chitra chitra*.

Results and Discussion. — In a paper that focused on the population of *Pelochelys* in southern New Guinea, Webb (1995) noted differences between *Chitra* and *Pelochelys* (including osteological features, with skulls being especially diagnostic), designated a neotype of *P. bibroni* from southern New Guinea (original type material lost), referred all other populations of *Pelochelys* including mainland Asiatic forms to *P. cantorii* Gray, and noted the restricted *P. bibroni* as unique and distinguished from all other populations of *Pelochelys* in having yellow neck stripes and bold yellow markings on a smooth carapace in adults, but a patternless, tuberculate (rough-textured) carapace in juveniles.

As a result of studies in Bangkok, a co-authored paper (with P.P. van Dijk) is in preparation that will provide an updated account of *Chitra chitra*, including a description and lectotype designation, distribution, and threats and conservation status.

Restricted *P. bibroni* in southern New Guinea is not conspecific with the population of *P. cantorii* in northern New Guinea. Interrelationships of New Guinean and Asiatic mainland populations of *P. cantorii* (at least some differences in carapace pattern of juveniles) are under study by the author.

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Orientation by the Australian Eastern Long-Necked Turtle, *Chelodina longicollis*. Linnaeus Fund Research Report

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Some aquatic turtles are well known for their ability to maintain a relatively direct path while migrating overland through seemingly unfamiliar terrain. Such orientational skill depends on a variety of sensory inputs including visual, aural, magnetic, and chemical cues. The mechanism has never been examined before in an Australian species. I selected the widespread *Chelodina longicollis* as a study subject. In spite of the fact that *C. longicollis* is an aquatic animal, it has a documented reputation for long distance overland travel, particularly following heavy rainfall, and such behavior is undoubtedly crucial to its successful exploitation of a wide range of aquatic habitats (Kennett and Georges, 1995). In coastal New South Wales, where *C. longicollis* spends much of its time in relatively nonproductive dune lakes, the ability to orient to seasonally productive ephemeral waters is of paramount importance to reproductive fitness and survival. During years of adequate rainfall at Jervis Bay, ephemeral water bodies such as Ryan's Swamp fill up and invertebrate production flourishes providing migrant turtles with a bounty of nutritious foods. Such highly productive habitats enable these opportunistic reptiles to grow rapidly and reproduce, so their long-term persistence hinges on their ability to find these temporary swamps and waterholes (Kennett and Georges, 1990).

Methods and Results. — Initial observations of turtles moving overland through undisturbed bush were made at Jervis Bay National Park from January to April 1994 to examine the configurations of their migratory paths and the conditions under which movement occurred. I intercepted 7 adult free-ranging animals moving on land, attached 1 km threadspools to their carapaces, and followed their thread paths. I then collected data on slope and compass bearing of travel as well as notes on conditions under which movement did or did not occur. Terrestrial forms used during inactive periods were characterized and a few observations of individual behavior (using binoculars) were recorded. These observations demonstrated that the animals moved only during the day under sunny conditions and burrowed under leaf litter when not moving. The paths they took to reach their goal (Ryan's Swamp, about 400 m from the trail where they were first thread-spooled) were remarkably straight. The turtles did not simply follow slope because the terrain they crossed was both uphill and downhill. Aboriginal workers in the Park suggested that the turtles used olfaction to find the swamp. This possibility was investigated in the laboratory at the Jervis Bay Field Station of the University of Canberra in May 1994. Adults tested individually in a y-maze were able to select the correct path to orient to the odor of swamp debris in a highly significant portion of the trials. This suggests that odor is probably an important navigational aid, especially when animals approach their goal, where the odor would naturally be stronger.

Subsequent to the studies of turtles migrating freely in the bush, I conducted a series of field experiments from April to June 1994 at the Jervis Bay Range Facility. This seldom-used airfield was located about 2.5 km from the turtles' home lake (Lake McKenzie). The experiments involved transporting animals in black bags from a holding pen at the lake to a release site in a large open heath about 300 m from the airstrip. They were thread-spooled and placed on their backs facing in random directions, after which I left the area. I returned later (> 1 hr) to collect the turtles, determine their compass bearing and straightline travel from start to finish, and collect and measure the thread to determine their curvilinear path length. From this work it was discovered that animals tested under sunny conditions had highly significant non-random orientation, but under cloudy conditions this ability was lost.

To test for sun-compass orientation I acclimated animals to a 6-hr phase-advanced photoperiod in the laboratory at the field station and then released them under sunny conditions at the airstrip. They showed highly significant orientation shifted about 90° clockwise from the angle of travel of the non-phase-advanced experimental animals. This shift in travel bearing is predicted for animals exposed to a photoperiod advance of 6 hrs in the southern hemisphere and it demonstrates unequivocably their use of an internal biological clock to compensate for the temporal change in the sun's azimuth during daytime migration.

To further evaluate what influence, if any, local landmarks have on turtle orientation, a 15 m diameter circular arena was constructed of 1 m high dark green fabric to obscure the turtles' view of the horizon. Turtles were released individually at the center of this arena and scored by the compass bearing to the point they hit the arena wall. Arena trials run under both sunny and overcast conditions again demonstrated the importance of the sun in enabling reasonably precise orientation. However, in these arena trials mean compass bearing for each experimental group was somewhat different from the headings determined in the previous open field trials where animals had a view of the horizon. The differences suggest that the use of local landmarks may be important to terrestrial navigation. Phase-shifted turtles tested in the arena also showed a roughly 90° shift in orientation, a finding that further confirms the importance of solar azimuth to the compass-finding ability of *C. longicollis*.

Conclusions. — 1. Sun-compass orientation is useful to *Chelodina longicollis* moving in undisturbed eucalypt forest. 2. A biological clock mechanism gives the animals a time-compensated sense of the sun's position. 3. Visible landmarks on the turtles' horizon may modify their selected course of travel. 4. Turtles orientate homewards from 2.5 km, but lack this ability at 23 km. 5. Olfactory perception of airborne odors is helpful to turtle navigation. 6. A combined sun-compass and olfactory orientation mechanism, coupled with an ability to pilot by landmarks when they are available, gives *C. longicollis* a suite of mechanisms which it uses to make remarkably direct long-distance terrestrial migrations.

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