How Kangaroos Swim

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During extensive flooding in eastern Australia in 1974, many kangaroos were marooned on islands. Along the Darling River and in the Bulloo Overflow, groups of up to 150 red and grey kangaroos were sighted from the air. When frightened, they often took to the water and one grey kangaroo was seen to swim over 300 metres. While Troughton (1967) and Breeden and Breeden (1966) described kangaroos entering water to defend themselves when chased by dogs and Gould (1863) reported a 2-mile swim by a kangaroo during a hunt, there have been no studies of the details of the manner of swimming, or the capacity of kangaroos to swim over extended distances.

To elucidate the swimming action of kangaroos, underwater photographs were taken of two male red kangaroos, *Megaleia rufa,* in a swimming pool, They were 3 and 4 years of age and weighed 25 and 31kg respectively. Both had been bred in captivity and previously had not swum. Cameras used were a Bolex 16-mm in a perspex housing and a Nikonos 35-mm.

When first submerged in water the kangaroos showed a diving reflex; they did not inhale water, and then maintained their heads and necks above the surface. Initially they attempted to hop, but after 10-15 seconds they began stroking smoothly in an instinctive manner.

The forelimbs and hindlimbs were moved ipsilaterally. This is similar to pacing, which is an unusual gait on land; the camel and the giraffe are the only species to use it without training (Muybridge 1899).

The forelimbs of the swimming kangaroo alternately make a posterior power stroke, with the digits extended and the manus at its maximum size. During the movement anteriorly the manus is repositioned in a flexed condition and close to the body.

Although hindlimbs are also moved alternately, they appear to be more directed to treading water for upright stability and maintaining buoyancy rather than contributing much to forward motion. The need for buoyancy would be greatest at the hindquarters because on land this is the site of the kangaroo's centre of gravity (Badoux, 1965).

The tail was flexed horizontally, to the side of the rearward hindlimb (in contrast to the usual vertical motion of the kangaroo tail). Although some of this swishing tail movement may be a reaction to hindlimb movement, it nevertheless appears to help to drive the kangaroo forward by sweeping from side to side while presenting an inclined surface in the water. This action is similar to that of aquatic animals as described by Gray (1957), Tricker (1966) and Tarasoff *et al* (1972).

The speed at which the red kangaroos were swimming was estimated at 1m sec^{-1} by timing them in a 12-m pool. The frequency of their limb and tail contraction was 2.1-2.6 Hz. This frequency agrees well with the hopping frequencies reported for both red kangaroos (Dawson and Taylor, 1973), and the grey kangaroos (Stewart and Setchell 1974). It would seem that there is a preferred frequency of the cycle of limb movement, whether it be the simultaneous motion of both legs in hopping or their alternate movement in swimming.

Discussion

Kangaroos swim so well that it raises questions of whether their ability is an adaption to environment, or an indication of phylogeny, or a coincidence due to a morphology amenable to the dynamics of swimming.

Any animal swimming forward meets drag or resistance which is a complex function of shape, size and speed, and to transport itself it must supply a force, by propelling water backward, equal to this drag. To this end, swimming animals (like digging animals) have short powerful limbs, in contrast to the long fast-moving limbs of cursorial animals (Hilderbrand 1960). The kangaroo has short forearms and long hindlimbs, of which the former are used in swimming and digging while the latter are essentially cursorial in type and function. The tail motion resembles the tail motions of fish, and it has been established that fish (as would be expected) are more efficient swimmers in energy terms than are land animals paddling at the surface (Schmidt-Nielson, 1972); the difference would be largely due to the turbulence generated, which in case of the kangaroo tail would be relatively low.

FIGURE 1
Underwater photograph of swimming red kangaroo showing alternate hindlimb movement, and movement in unison of ipsilateral fore and hind limbs.

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Nevertheless, in spite of these morphological attributes which assist the red kangaroo in water, the occasions on which they need to swim are infrequent in an environment which rarely floods and then only along the limited area of water courses. It is interesting to note, however, that Euros, whose normal habitat is mountain ranges, were seen in Kinchega National Park to be poor swimmers and flounder awkwardly in water. Possibly the kangaroo's ability to swim developed as an adaptation to predators; there is anecdotal evidence of the use to which kangaroos will put water when pursued.

The ability of macropods to swim must have an effect upon migration and dispersion, and its significance in the formation of subspecies on islands is a subject warranting further attention. One kangaroo marked by Bailey (1971) was recorded on the other side of the Darling River, presumably having swum across; Main (1961), describing the distribution of macropods on offshore islands in Western Australia, attributed their presence to movement over land bridges, not to swimming.

It seems unlikely that the 'pacing' swimming action of kangaroos has any phylogenetic significance such as that attributed to human infants. Under 4 months of age human infants show a reflex swimming behaviour which bears striking testimony to the phylogenesis of man (McGraw, 1939). Their trotting action is comparable to that of most other animals such as the horse and the dog which Kolb (1962) described as the most apt of domestic animal swimmers.

The separate-hindlimbs action of swimming kangaroos is reminiscent of phalangerids from whose aboreal progression Marshall (1974) has reviewed the development of the kangaroo's cursorial specializations and the evolution of hopping. Windsor and Dagg (1971) found that the walk of the tree kangaroo *dendrolagus* was the only gait of macropods in which pairs of limbs were not used synchronously, and represented a return to aboreal habitats by a wallaby. The separate hind-leg action of the swimming red kangaroo may therefore represent a reversion to earlier times, and the phylogenesis of the animal.

Nevertheless, the only aquatic marsupial is still the South America water opossum *Chironectes minimus*, and although kangaroos are competent swimmers they swim only under unusual circumstances.

Acknowledgements

The National Parks and Wildlife Service of NSW employed the author during the period in which the investigation was carried out.

Mr G. Steer photographed and edited the film which was provided by Mr L. Hudson. Mr K. Coles allowed us to use his swimming pool. The kangaroos were housed in facilities provided by the Faculty of Veterinary Science, University of Sydney and they were attended by Mr G. Robertson and Miss C. Coles from the National Parks and Wildlife Service of NSW.

FIGURE 2

Below: Kangaroo's tail exhibits a wave-like motion similar to that of a fish; right: a later stage in the cycle of motion of the tail.

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FIGURE 3

Red kangaroo swimming past a diver with an underwater camera.

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Submitted 29 May, 1974