Letter from the Desk of David Challinor
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Hockey was the big sport where I went to school in New Hampshire in the 1930's. The first skateable black ice normally appeared in mid-November, and the nearby pond was ice-covered till mid-March. Classmates who could afford them, had kangaroo leather skates. I always wondered who discovered such a specialized use for these exotic hides, since I had never thought of Australia as an ice hockey center. The use of kangaroo hides for hockey skates caught my attention in a recent *New York Times* article about banning the import of kangaroo hide into the USA. Given the current huge population of these animals in Australia, is forbidding such imports a reasonable subject for federal legislation? My focus in this letter is not on the ethics of importing kangaroo hide, but on the remarkable evolutionary success of these impressive marsupials.

Most Americans are first exposed to kangaroos in zoos or children's books. The National Zoo has exhibited them for decades—generally the big reds from the dry interior of Australia and the large greys from the wetter east and southeast. At the Conservation and Research Center at Front Royal, the Zoo maintains a colony of tree kangaroos that are about a third the size of the reds and greys and have soft brown fur on their backs and tails and cream-colored chests and stomachs. These forest dwellers are only found in northeast Australia and across the shallow Torres Strait in New Guinea.

There are about 70 species of kangaroos and wallabies (small kangaroos) and all, except for eight species of the tree kangaroos in New Guinea, are native to Australia. Many other species have become extinct since Europeans settled on that continent in the early 19th century. Some, such as the great grey, are now so plentiful in areas where humans have managed the grasslands for livestock that they are considered pests that must be culled annually—a major source for their tanned hides.

Just as Australia's 40,000 feral camels, originally brought in for transport to and from remote desert mines, have fully adapted to the harsh conditions of the outback, so have various kangaroo species become feral in other parts of the world, where they have been introduced by well-meaning but misguided persons. An established population of brush-tailed rock wallabies—thought to have escaped from a local private collection—resides in Hawaii on the island of Oahu, and they are relatively common in the northern suburbs of Honolulu. There are six species now living in New Zealand—all imprudently introduced in the mid-1800's by the governor general, who had lived in Australia and simply fancied the idea. The hardy red-necked wallaby now thrives in the mountains of northern Britain as well as in Germany's Black Forest where they were thoughtlessly imported and released. Just west of Paris in the forest of Rambouillet lives a small group of about 50 great greys, which must be a startlingly incongruous sight to innocent hikers.

The digestive and reproductive systems of kangaroos are unique among mammals. Grazers such as cows are ruminants, with chambered stomachs and cuds to chew. Kangaroos, who eat hard-to-digest leaves and grass, have large pouch-like stomachs full of bacteria to help break down their food, but whereas the stomach flora of a cow consists primarily of tiny, single cell organisms, the stomach fauna of many kangaroos are worm-like creatures five or six centimeters long (about the length and diameter of a large unfolded paper clip) called strongyles. They break down the coarse grass stems and release processed nutrients that become immediately available to the host. The greater the mass of strongyles in its stomach, the healthier the host. Like many other mammals dependent on specialized symbiotic stomach organisms, kangaroo young, when weaned, become inoculated with them by consuming strongyle eggs embedded in bits of faeces they consume when grazing. Tree kangaroos that ingest strongyles are species that also feed on the ground, and their strongyles not only assist in breaking down the fibrous foliage on which they feed, but also neutralize the toxins commonly contained in the leaves of many tropical forest trees. The downside of being dependent on strongyles for efficient digestion occurs when the host feeds on easily digestible material. Strongyles then break the food down so quickly that there is nothing left for the host. However, such events are rare, and as Australian sheep farmers expanded their rangeland, conditions became ideal for population explosions of some kangaroo species, especially the great grey.

Kangaroo reproduction systems also differ from those of all other mammals. Like birds and reptiles, all marsupials have a cloaca—a single orifice for excretion. Furthermore, the male's penis, except when breeding, is lodged within the cloaca, which lies <u>behind</u> its scrotum. From an evolutionary perspective this arrangement is considered primitive among mammals, although elephants do not even have a scrotum—their testes are located above their abdomen. The anatomy of the female kangaroo is just as bizarre as that of her mate (at least for us humans). Her two vaginas each end in her cloaca, but before parturition a narrow canal develops between them to let the centimeter-long foetus emerge. It is hard to imagine that something that small can not only breathe but can climb by itself with its tiny clawed forearms through the coarse fur of its mother into her pouch. To assist her newborn joey (young), the mother reverses her tail position so that it lies forward between her legs as she leans back against a rock or tree. The joey's incredible journey takes from three to five minutes and must be guided by smell, for at this stage, neither its eyes nor ears have developed. Once inside the pouch, the baby firmly grasps one of four teats with its minuscule teeth, and there it will remain for five to seven months depending on the kangaroo species. Twins are rare. Within a few days of giving birth, the female of some species breeds again (others wait a few months), but the resulting implanted ovum stops developing after about the 100-cell state and stays in a state of suspended animation until the current sibling either dies or leaves the pouch. At that point, the new sibling resumes growth *in utero* for about a month until it is large enough to head for the pouch. Thus, most adult females are pregnant almost all the time.

A final unusual adaptation of these remarkable mammals is the ability of the mother to nurse her joey after it has left the pouch while its tiny sibling is attached and nursing at another teat. The nutritional demands of two nursing young (one 4,000 times larger than the other; 1 gm vs. 4 kg) require the nursing mother to produce milk appropriate for each. The small one needs milk with a high protein content to produce the fur and other characteristics that it will need for development. The older sibling has other requirements—perhaps a higher water content. How the kangaroo manages this dual lactation is not understood, and there should be more research on the subject.

A crucial adaptation found in one kangaroo species is the ability to drink seawater. The early Dutch explorer Franz Pelsaert reported seeing tammar wallabies doing so in 1629 when his ship was wrecked on one of the Abrolhos islands about 400 km north of present day Perth in western Australia. These islands have virtually no fresh water, and this example of flexible renal physiology is truly extraordinary. The only other mammals I know of with this facility are some of the feral dogs on the Galapagos, where the porous lava substrate precludes rainwater accumulation. The dogs, after 200 generations, have adapted like the tammars to drinking seawater. Many of them are now being shot by conservation officers, because their principal prey is the rare marine iguana, and scientists fear the dogs may be eliminated before sufficient research is conducted to learn about their kidney function.

Another example of convergent evolution is evident in the small narbarlek rock wallaby of Arnhem Land in extreme northern Australia. This tiny kangaroo can replace its front molars when they wear out by moving new ones from the rear of its jaw to the front. This ability is also routine among elephants and their aquatic relatives, dugongs and manatees. However, the latter have only a limited supply of new molars—elephants, for example, can replace their worn out teeth only three times, whereas the narbarlek evidently has a limitless supply.

The future of the large kangaroos seems assured in Australia. As more sheep pasture becomes available, more kangaroos will be produced to exploit it. Between July 1958 and June 1962, Australia exported 7,500 tons of kangaroo meat from 1,500 animals—primarily for dog and cat food. Attitudes toward kangaroo meat are fast changing in Australia. Earlier concerns about the cull from animal welfare groups focused on the cruelty of the sometimes free for all shooting. Now, however, debate has shifted as environmentalists have promoted the growing market for kangaroo meat for human consumption. If Aussie farmers had a market for the meat, they say, this indigenous animal could replace destructive introduced species such as sheep, whose hard hoofs damage the fragile lichens and other native vegetation that holds the soil together in arid areas. Kangaroo meat now appears on the menus of many high-end Australian restaurants, and if properly prepared is said to be delicious and a low cholesterol alternative to other meats. I'm afraid I cannot testify to this claim from

personal experience. It will be interesting to see how this conflict is resolved, but in the meantime, there is still much to be learned about these truly amazing marsupials.

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P.S. Much of the material for this month's letter came from Tim Flannery's recently published *Chasing Kangaroos*. Grove Press, New York, NY, 20007.