h25 Land animal survivors of the end-Cretaceous mass extinctions < spared or liberated >

Uno avulso non deficit alter [When one is torn away another succeeds]. —Vigil *proverb*.[1]

The reality of a giant meteorite impact that coincides with the E-K (Paleogene-Cretaceous) boundary is rarely now disputed but far from settled to everyone's satisfaction is that this bolide event could selectively spare, or liberate, some land animals while causing the death of the dinosaurs.[2]

Birds Living bird species are enormously varied. Their evolutionary history is difficult to know because bird fossils are famous for their rarity. What is known, is that bird evolution can be geologically rapid. For example, in what seems to be happening to some Canadian Geese that have stopped migrating in favor of growing fat and despoiling American playarea lawns with 2 lbs each of poop per day year round,[3] flightless ducks evolved from flighted ancestors that arrived on an Hawaiian volcanic island that emerged only four million years ago. Alan Feduccia reasoning that the E-K boundary bolide event was as a coal mine is for a canary has hypothesized that song birds (passerines or perching birds) have entirely evolved in the Cenozoic from lucky survivors. (*Trivia*: For the mine-going canary, J. S. Haldane devised its carrying cage to have a built-in oxygen device to revive it and to avoid blacklung, he advised Cornish miners to keep a worked rockface wet.)[4] Also, *modern* orders of flightless birds (ratites) have distributions that may have little to do with continental drift if the discovery in 1986 by Peter Houde of an Early Paleogene fossil from the of the Northern Hemisphere of a small, flighted, palaeognathe (lithornids) means that molecular phylogeny should be revised to have the ratites evolved from flighted birds in the Cenozoic.[5]

What has been noticed is that almost all living birds, and all known Cenozoic fossil birds, have tarsal bones fused upward. Significantly, most Cretaceous fossil birds, so far found, are "opposite birds." In these, tarsal bones are fused downward. Larry Martin infers from this observation that the E-K boundary bolide event did involve the near extinction of the Mesozoic birds and that modern birds *are* evolved from a lone surviving stock that persists. These had the then rare feature of tarsal bones fused upward [6] even as do ostriches, and loons, that retain the most primitive avian features.

The survival of birds does not rule out the dinosaur-bolide-extinction hypothesis.

Mammals

Wee, sleeket, cowran, tim'rous beastie, / O, what panic's in thy breastie!
—Robert Burns, *To A Mouse*.[7]

Placentals, marsupials, monotremes, and multiburculates were unscathed by the E-K bolide event. What could have aided them was that in the shadow of the dinosaurs daytime dominance they were nocturnal. So prolonged dark and cold would not have been a fatal combination for them as their food (insects, worms, seeds) would have remained available.

If kept tiny and timid by dint of the baleful gaze of the dinosaurs for 160 million years was Mesozoic mammals' lot, then a man-bites-dog newsworthy exception is an Early Cretaceous triconodont mammal *Repenomamus robustus* discovered with the remains of a small dinosaur (a juvenile *Psittacosaurus*) in its belly.[8]

The survival of mammals is neutral with respect to the dinosaur-bolide-extinction hypothesis.

Crocodiles and lizards Rapid diversification of eusuchians (Crocodyloidea, Alligatoroidea and Gavialoidea) occurred among these semi-aquatic ambush predators in the earliest Paleogene from the Late Cretaceous when existed *Isisfordia duncani* (1.1 metres long, equally at home in and out of water, and primitive for having not much of a crocodylian secondary palate that strengthens and helps breathing when prey is twist-wrestled).[9] Squamata (lizards and snakes) are more than 7,200 extant species and have been continuously successful and diverse since they appeared in the Early Triassic.[10]

No reasonable suggestions have been made that would indicate how the survival of crocodiles, lizards, and snakes, could support a dinosaur-bolide-extinction hypothesis. ❑