HOW BROKEN BONES ARE REPAIRED IN NATURE*

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The tragedy of a broken bone in wild life is generally buried in the stomach of some predatory animal, so that only scant evidence of injury may be obtained from observing animals in their native habitats. But a study of any large series of skeletons will show examples of repaired fractures—evidence that many accidents occur in nature and that some animals recover from injuries severe enough to break bones.

Many breaks heal entirely, as is indicated by the small size of the callouses present; but sometimes there result various mechanical defects which interfere with movement. Fractures of skulls, vertebrae, and ribs usually heal with less mechanical disadvantage than fractures of limbs; for the latter are likely to result in shortened and stiffened members, because of the slipping of the broken ends and the pulling of the muscles. Such limbs have large bone callouses, and the repair work is poor in general, so that the segments are immovable. It is true that if only one of the paired bones of the leg is broken, it generally mends very well, since it is held in place by the sound bone, but a callous may form that will make the segment unable to continue its usual pronation and supination.

HOW FRACTURES OCCUR

Fractures occur in many ways, most of them through accidents during the normal activities of the animal, others in combat during the breeding season, and some by gunshot wounds. Arboreal animals, for example, suffer from falls that result in broken legs and ribs and injured spines. They make mistakes in judging distances and in gauging the strength of limbs on which they jump, and they are often careless. Climbing primates have frequent falls, for their skeletons show many instances of healed fractures, usually with complete recovery. Running animals frequently break legs by stepping in holes and by miscalculating jumps. Mountain animals, though very skilled in climbing and running, occasionally fall, and their skeletons are found at the foot

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of cliffs. The light bones of running animals in general are long and fragile and not able to withstand any severe strain. During the rutting season with its individual challenges for supremacy, many serious and even fatal injuries occur in these groups. Again, burrowing animals in dry regions suffer broken legs and backs when rocks slide in the burrows. Birds meet with serious injuries from flying into trees, wires, and other obstacles. They seldom recover from a fractured humerus, but a fracture of the radius or ulna may mend so that the wing is again serviceable. The latter is particularily true of water birds that are able to get food with a minimum of exposure during the time necessary for the wing to mend. Broken legs may not be very serious to flying birds, but they are usually fatal to ground birds, which cannot escape from their enemies. When a flock of ducks mistake a wet pavement for a stream, many of them suffer fractures of the clavicle and sternum and are made helpless. Some reptiles fight among themselves, and some are especially subject to injury from animals used for food. The smaller rodents, such as the gopher, can make a snake pay a dear price for his meal, because they inflict bites that result in ankylosed vertebrae, or cause the death of the snake. Amphibians not only suffer injuries from the bites of turtles, birds, and carnivores, but they are also crushed under the feet of larger animals at ponds and other drinking places.

SPECIMENS

Part of the material described in this paper as evidence of healed fractures was picked up in the field, and the rest was found in the course of preparing skeletons. In every case there was a recovery from the injury, though in some cases the broken bones were not repaired as well as in others.

VERTEBRAE OF A URODELE

(Plioambystoma kansensis)

An injury to the lumbar vertebrae in this small amphibian from the lower Pliocene was repaired fairly well. All of the parts are smooth. The three vertebrae are coalesced in such a manner that the posterior one is at an angle of 40°, and the middle one is so badly crushed that the centrum is completely lost. The spinal cord was not injured past recovery, for the new neural tube is smooth and of sufficient size to function in the repaired vertebrae. The posterior limbs and the pelvis must have been at an angle and twisted so that the animal would have to develop a peculiar bend in the body, in order to

walk and to have the hind limb touch the ground in a normal manner. The numbers 1, 2, 3 on the illustration indicate the neural spines of the three coalesced vertebrae.

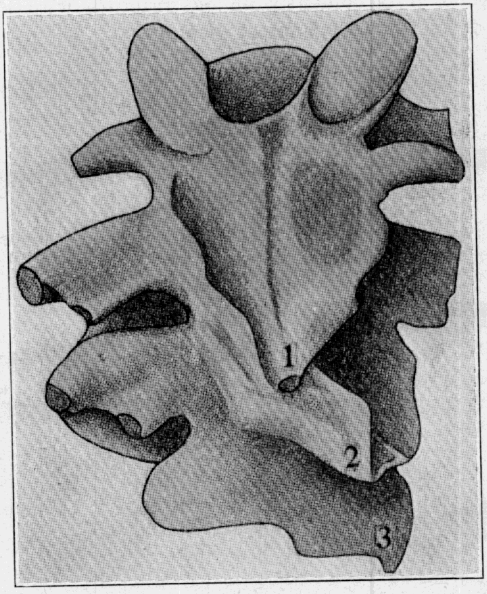

FIG. 1. Three coalesced vertebrae of a Pliocene urodele.

VERTEBRAE OF A PYTHON

The skeleton of an old python, 16 feet long, that had been carried with a circus, showed many evidences of combat. Several series of vertebrae were ankylosed, one section being 16 inches long, another 12, and another 7. The vertebrae appeared to have been crushed in the jaws of some large animal, possibly a carnivore, that the snake had been unfortunate enough to encounter. The injury was very severe, for there were large bone callouses remaining and the vertebrae in these sections were firmly ankylosed. Thus disabled, the python must have had a very peculiar locomotion. A number of ribs had been broken at the same time, and they also had been repaired in a fairly efficient manner.

ILIUM AND FEMUR OF A FROG

(Rana catesbiana)

In this specimen there is a severe fracture of the ilium, with the typical repair of a long bone. The pull of the sacral muscles has drawn the broken ends apart, so that there is a large callous and a consequent shortening, with the broken ends approximately ½ inch apart but connected by new bone tissue.

On the same specimen there is a fracture of the femur rather close to the hip joint. It has mended with a shortening, since the

broken ends have slipped past one another due to the pull of the muscles. There is a large callous present that must have interfered with normal movement of the muscles and the leg. From the condition of the bone, it is evidently an old fracture with a complete recovery, but with serious mechanical disability.

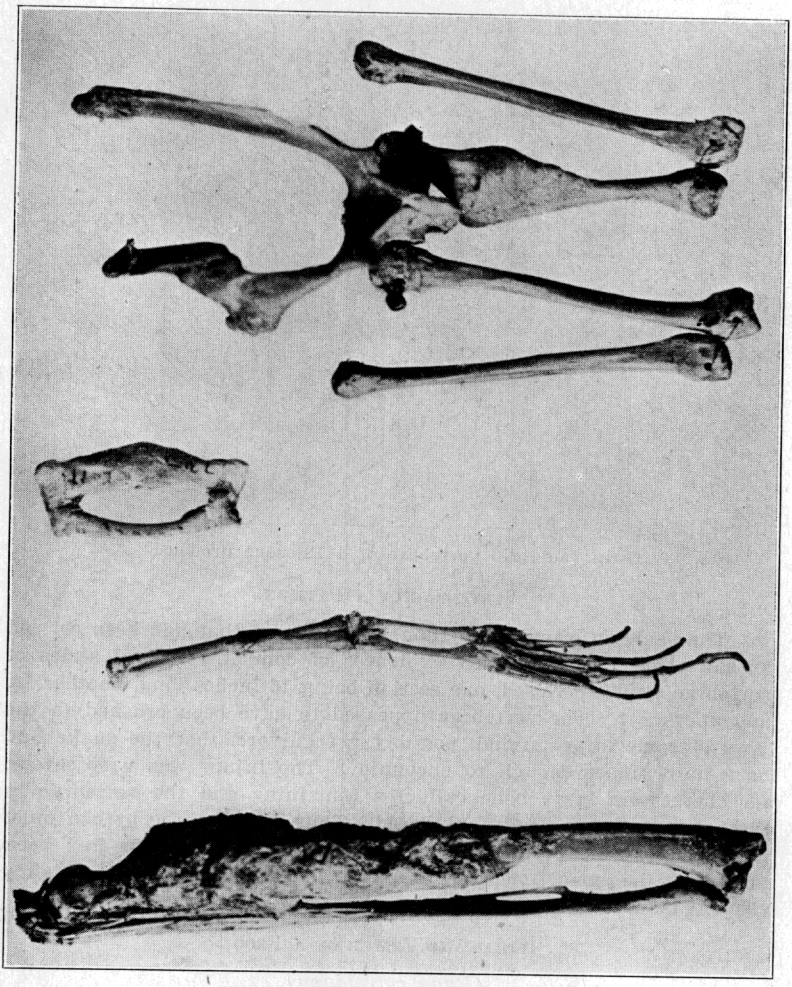

FIG. 2. *(Top).* Femur and ilium of a frog, *Rana catesbiana. (Middle).* Calcaneum and tibio-fibula of *Rana climatans. (Bottom).* Ulna and radius of a mallard, *Anas boschas.*

CALCANEUM AND TIBIO-FIBULA OF A FROG

(Rana climatans)

The left calcaneum has been fractured but has made a good recovery. There has been no slipping of the broken ends because of the

articulation with the astragalus and the ankylosis of these bones. The callous is small, and the fracture seems to have caused no mechanical disturbance.

The left tibio-fibula shows a bad fracture and a very good repair. In this case there was a splintering of the bone, but the recovery has been good with little shortening and with a small callous in comparison to the seriousness of the break. The repaired bone is not far out of alignment, and the shortening is not enough to interfere with the proper functioning of the limb. It is evident that the pull of the muscles in this segment of the leg is not as strong as in the femur, so that overlapping of the broken ends is not so likely to occur.

ULNA OF A MALLARD

The broken ulna of the right wing probably was caused by a gunshot wound. The wound was several months old at the time the specimen was collected, for repair was still in progress, judging from the large callous present. The wing was functional in this stage, and in a few more months it would have enabled the bird to fly again, although it would not have been strong enough for a long migration. The wing would have been normal in its activity except for a partial loss of power in supination and pronation.

MANDIBLE OF A DOMESTIC SHEEP

The broken jaw appears to have been the result of a gunshot wound. From the appearance of the healed break, there was a complete fracture of the dentary a little anterior to the midline, between molar 1 and premolar 3. The jaw repaired itself, judging from the teeth, and the animal lived to an old age. For a long time after the injury, the animal probably had to use the right side of the jaw in mastication, since the break caused a change in the relations of the teeth so that the occlusion was far from normal; but since the teeth on the broken jaw are worn, it is probable that the problem of occlusion eventually solved itself by an adjustment of the surfaces of the teeth. The jaw is completely repaired, with little trace of callous remaining.

FEMUR OF A DOG

The fractured left femur is completely repaired, though there is some callous remaining. The break was in the proximal third of the shaft, where there was not the opportunity to pull the bone out at an angle as in the following example, where the fracture is in the middle of the shaft. The ends of the bone were overlapped, so that the leg was shortened about an inch, and there was a torsion of about 30° in the proximal end, so that the foot must have been twisted. As a result, only the outer edge of the foot would touch the ground in walking unless there was some adjustment in other parts of the leg to lessen this defect. This repair allowed fairly good use of the leg,

except that the shortening and twisting would prevent some normal activities. The animal would be able to live but it would not have its former speed.

FEMUR OF A CAT

The femur shows a healed fracture at about the middle of the shaft, with some displacement of the fractured ends. This type of repair is usual in both the humerus and the femur because of the strength of the muscles and the way in which they are inserted. The distal end of the femur has been pulled so that it is out of line about

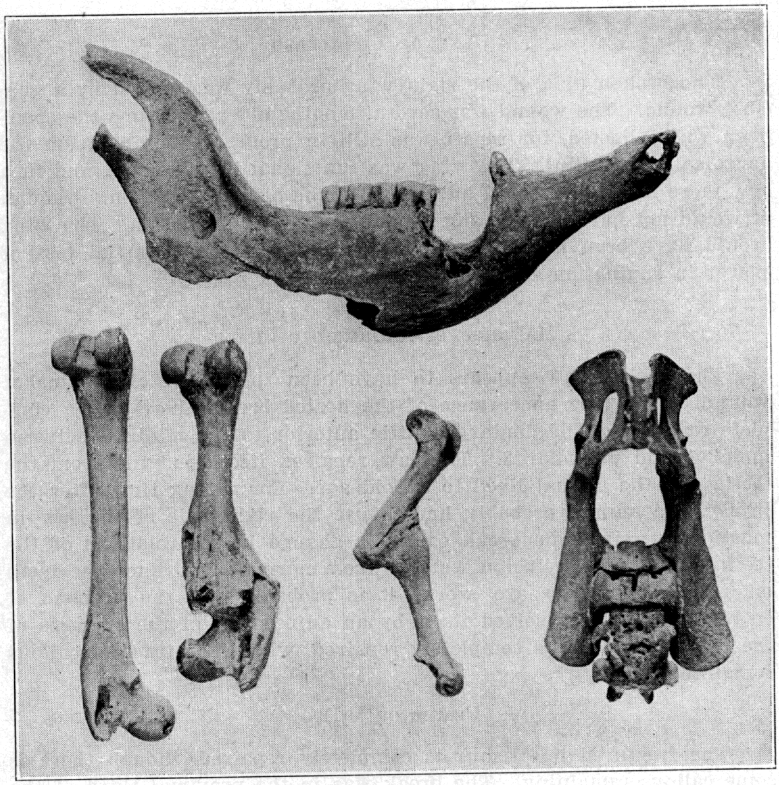

FIG. 3. *(Top).* Mandible of a domestic sheep. *(Bottom, left to right).* Normal femur and broken femur of a dog, broken femur of a cat, and lumbar vertebra of a lynx.

60° and has slipped down so that it is joined to the anterior face of the shaft and ankylosed. This caused a shortening of about ¾ of an inch and a torsion of the distal end of about 40°, which would throw the sole of the foot out and make the animal walk on the inside border. The result was a great physical handicap, making it necessary for the animal to have a rather restricted range.

LUMBAR VERTEBRAE OF A LYNX

The lumbars in this specimen suffered from injury or disease, for there is a small ankylosis of the last two lumbar vertebrae, with a small amount of callous tissue. The mechanical disadvantage in this case would be small and the defect a minor one with only a slight stiffness in the hip region.

LUMBAR VERTEBRAE OF A HORSE

Fractures of this type occur in domestic animals to some degree, usually as a result of injuries, and they produce a growth of callouses over the injured parts. The postzygapophyses and the prezygapophyses

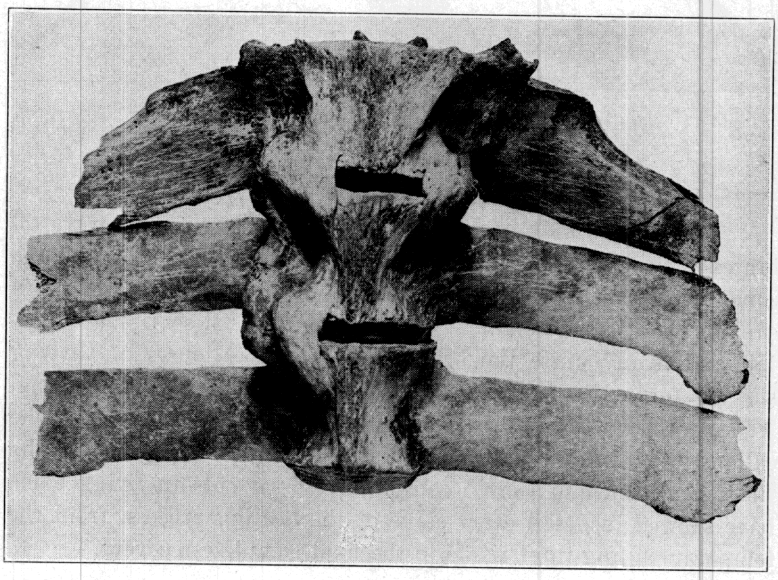

FIG. 4. Third, fourth, and fifth lumbar vertebrae of a horse, ventral view.

are ankylosed, and the centra of the three are securely joined in this way. These callouses are smooth, and did little more than to stiffen this region of the vertebral column. It is probable that the callouses occur at points where the bone was splintered or roughened.

RIBS OF A GORILLA

This specimen, from the Cameroons of Africa, was a male of perhaps 25 years. The skeleton showed signs of injury in a number of places, including a finger that had been badly infected with an extensive erosion of the bone, a fracture of the frontal bone, and a pair

of ankylosed ribs. The thirteenth vertebra of the thoracic region had the ribs ankylosed to it, the right very rigidly joined and the left with a light attachment and callous. There is evidence of a serious injury to the spine, in which the left prezygapophysis was broken, and a slight bend in the neural spine. This injury, although severe, would not interfere seriously with the activities of the animal.

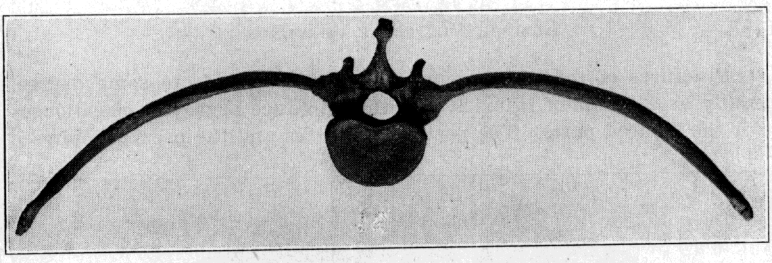

FIG. 5. Thirteenth thoracic vertebra of gorilla.

HEALING PROCESS

The process of healing fractures is the same in other vertebrates as in man. The parts concerned in the regeneration are the inner layers of the periosteum, the bone cells lining the Haversian canals, and the endosteum. Outgrowth from these tissues dovetail and firmly unite the broken parts, and callouses of varying size are formed to hold the bone while in the process of mending. The osteoclasts remove the extra bone and reduce the size of the callouses to a minimum in the finished structure. Experiments by Bast, Sullivan, and Geist,[1] consisting of saw cuts in living bone, have showed in detail every stage of the healing process, from the temporary filling in of tissue to the final complete recovery.

CHANCE OF RECOVERY

Only a small number of animals have a chance for recovery when seriously injured, for many enemies are waiting for just such an opportunity. Some animals because of their habitat are more successful in hiding than others, and on this depends their survival when injured. The larger running animals have only small chance of recovery, for carnivores quickly locate and kill the wounded. Not being able to follow the herd, they are soon isolated and offer little resistance to pursuing enemies.

Arboreal animals may hide successfully while convalescing and thus survive. The smaller animals usually recover from

broken bones, since they can find secluded spots and can secure food with little exposure. However, if crippled, they must remain hidden; for a host of enemies, both furred and feathered, are constantly on the watch for such cripples. Water birds ordinarily have a good chance to survive, but they are hunted both on land and water by hawks, owls, and small carnivores such as mink, foxes, coyotes, and weasels. Reptiles and amphibians make a quick recovery and usually survive serious injuries because of their great recuperative and regenerative powers. They can hide successfully and thus have ample time for recovery.

Besides the natural injuries, the gun and the trap are responsible for the greatest number of crippled animals and birds. Birds and animals are shot at long range, suffering flesh wounds and fractures that permit them to escape, and often travel for miles from the place where the injury was received. This permits them to select a desirable spot in which they can hide until recovery or death.

The trap is responsible for many injuries to fur animals. Unfortunately, most traps permit the animal to die of exposure between the visits of the trapper. Some of the traps are so set that the animal, when caught, can exert no pressure and, hence, cannot escape by pulling off a part of a foot. Where the foot is crushed, the animal frequently succeeds in pulling away and generally recovers, because the crushing of the bones and blood vessels allows only a small amount of blood to be lost. Many animals caught in a country where trappers are numerous, show the results of previous experience in traps by mutilated feet or toes.

A survey of the literature dealing with fractures in wild animals seems to show that accidents and fractures are very numerous in the Artiodactyls, especially the deer group. Korschelt and Stock,[2] in a paper on fractures, list the following cases: Primates 15, Carnivores 18, Rodents 7, Artiodactyls 55, Cetacea 1, Birds 32, Reptiles 1, and Amphibians 3.

[1] Bast, Sullivan, and Geist. The Repair of Bone. Anat. Rec., Vol. 31, No. 25, 1925.

[2] Korschelt and Stock. Geheilte Knochenbrüche bei wildlebenden und in Gefangenschaft gehaltenen Tieren. 1928.