Introduction

The surviving members of a herd of ornithopod dinosaurs grazed along the edge of a Cretaceous conifer forest. It had been a particularly hard and long dry season. A few individuals fed sporadically on the parched sedges and horsetails growing near the banks of a meandering river. The river had dwindled down to a trickling stream flowing between high-cut banks. Once numbering in the hundreds, disease had now reduced the herd to less than fifty—the very young and the aged were conspicuously absent. Many of the majestic animals appeared lethargic and even were oblivious to the pack of predatory theropod dinosaurs that followed. Those fierce carnivores, armed with sharp teeth and sickle-like claws, were fat and satiated because sick herbivores made easy prey.

Ordinarily, these plant-feeding dinosaurs spent at least half of their waking hours chomping on the tender vegetation sprouting around streams or in open meadows. However, with waning appetites, the infected animals had not fed for days and stumbled along in a debilitated state. They normally avoided the direct rays of the afternoon sun, but now many stood motionless in its intense heat. Frequently they would shuffle down to the waters edge, laboriously bend down, and drink for long periods, apparently forgetful of the dangers posed by lurking crocodiles. Persistent diarrhea had dehydrated them and their thirst was almost insatiable. The surrounding terrain was discolored by bloody stools that attracted hordes of flies and beetles.

One trembling ornithopod, with dry skin clinging to prominent ribs and vertebrae, staggered off to one side and began to vomit strands of bloodstained mucus filled with glistening, writhing roundworms. With eyes now reduced to narrow slits, the sick individual was too exhausted to dislodge the ravenous masses of annoying
insects crawling over his thin scaly skin while seeking sites to en­
gerse themselves. When the dying animal finally collapsed, a few
members of the herd came over and nudged him, but there was
no response and they moved off, giving way to the advancing
theropods. The carnivores started tearing away at the carcass, not
realizing that they were eating infected meat and being attacked by
the same insects that had previously fed on the diseased di­
nosaurs. Several of them, however, were beginning to show the
first signs of infection and withdrew from the feeding frenzy to lie
down and rest after only a few mouthfuls. As the others were de­
vouring the remains, a contingent of mites and ticks seized the op­
portunity to move their residence from the corpse onto the skin of
the theropods.

If an autopsy had been made on this ornithopod, it would have
revealed many parasites and pathogens inhabiting the tissues. Some, like amoebic dysentery, malaria, and ascarid round-
worms, would have caused lesions in the gut, liver abscesses,
and distorted blood cells. But the actual cause of our dinosaur’s
death would have been listed as leishmaniasis, a protozoan dis­
eease. Just like the other members of the herd, he was the victim
of an emerging pathogen that was decimating the Cretaceous
world. Some 100 million years ago, some of these microorgan­
isms developed novel relationships with biting flies, when the
flies’ previously harmless symbionts turned into deadly patho­
gens. In an unprecedented alliance, these insect-borne infections
together with already long-established parasites became more
than the dinosaurs’ immune systems could handle. Sweeping
epidemics began changing the herbivore-carnivore dinosaur bal­
ance that had existed for millennia. Armed with their deadly
weapons, biting insects were the top predators in the food chain
and could now shape the destiny of the dinosaurs just as they
shape our world today.

Even as the remaining members of this herd succumbed to dis­
ease, insects were busy ensuring that the epidemic would spread.
Biting flies, sucking the blood of the infirm, were collecting path-
ogens to inject into other victims. Because of their ability to fly, they could disperse and infect other susceptible dinosaurs within their range. Flies, beetles, and cockroaches visiting the infested feces and cadavers picked up bacteria, protozoans, and nematodes that were then carried to contaminate other vertebrates. Dinosaurs that dined on cockroaches now carrying eggs of ascarids would end up with stomach lesions.

On a larger scale, as the outbreak killed off the herbivorous dinosaurs, the balance of their ecosystem was destroyed. Carnivores may have initially benefited because the dead and dying were plentiful. The downside of this apparent bounty was that they too were becoming ill as their food supply was dwindling. In the following months as the entire ornithopod community crashed, they would face starvation. The combination of hunger and multiple infections would hasten their demise. Vegetation the ornithopods normally fed on would flourish, along with any herbivores that also utilized these plants for food. Those specialists dependent on ornithopods for survival would decline. Others would ultimately move into the niches they left vacant and life would go on. Whether populations would eventually recover depended on many factors, but insect-borne diseases were then, and still are, capable of bringing any animal to the brink of extinction.

Insects not only impact the world because of the diseases they transmit, but in innumerable other ways. They may be small but they are the most diverse group of living organisms and probably have been the most significant ecological force on land since they first arose some 350 million years ago. Insects account for over 57% of the diversity of life on earth and 76% of all animal life. Currently there are over 990,000 species known, while many more have yet to be discovered. Comparing their numbers to mammals, which comprise 0.35% of the species, only serves to accentuate their overall importance.²⁹⁷

Herbivorous insects, which make up 45% of their total species, represent about one quarter of all living species.⁴ Phytophagous forms consume significantly more plant tissue than vertebrates
in every biome studied except grasslands. Indications from the fossil record confirm that this has been the case since the first terrestrial ecosystems became established.\(^5\) It can therefore be assumed that they were serious competitors with herbivorous dinosaurs during the Cretaceous.

About a third of all organisms on the earth are insects with carnivorous and saprophagous food preferences. Just the fact that carnivorous insects represent about 20% of animal species in the biota tells us how important they are in keeping arthropod populations in check. Predatory insects usually feed on other insects, but some have larger prey. For example, horsefly larvae have been known to kill small frogs, and large praying mantids can take down small lizards, birds, and unwary mice.

The carnivorous insects also include parasites that live on the inside or outside of their victims. A good portion subsist on the blood of animals. Collectively, these are the ones that both fascinate and horrify humans. They also instill us with fear because one bite can potentially lead to death. Bit ing insects transmit viruses, bacteria, protozoa, and nematodes. One of these, mosquito-borne malaria, kills over a million people each year and is the leading cause of death in children under the age of five worldwide. That means about one in fifty-six people dies every year from just this one insect-borne disease. So we furiously swat, squash, screen, and spray trying to avoid these pests. However, they always manage to find us because they have had eons to adapt to feeding on all terrestrial animals. They certainly unmercifully plagued dinosaurs just as they do us.

Normally humans wouldn’t think twice about saprophagous insects—those indeterminate legions that devour dead and dying organic matter. But those that eat excrement, carrion, and detritus are a significant and necessary component of our world, constituting about 11% of the biota. They are the cleaners, charged with the task of disposing of the by-products of life, and they recycle waste with an amazing efficiency. Saprophagous insects have always been an integral part of any ecosystem and undoubtedly were as important in the Cretaceous as they are now.
While insects feed on plants and other animals, they are themselves a significant source of nutrition in the food chain. Small and numerous, they occur in all terrestrial habitats. Convenient packages of protein and other essential nutrients that are readily available and comparatively easy to obtain, insects are consumed by a multitude of creatures. In the Cretaceous, they would have been an important part of the diet for dinosaur young as well as the smaller animals dinosaurs consumed.

The minute but mighty insects have exerted a tremendous impact on the entire ecology of the earth, certainly shaping the evolution and causing the extinction of terrestrial organisms. The largest of the land animals, the dinosaurs, would have been locked in a life-or-death struggle with them for survival. Details of this competition can be garnered from the fossil record. Fossils, interpreted by comparison with their modern counterparts,\(^2\) tell us how insects could have impacted dinosaurs and the entire Cretaceous world. Their preserved remains are the basis for a journey that will take us into the past and reveal new facets of dinosaur ecology and demise. Fossils will be the keys we use to unlock the secrets of the Cretaceous.