Colorado A Million Years Ago

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NO one pretends that estimates of geological time are even approximately exact; yet they are not pure guesswork. Converging evidence, derived from many different sources, leads us to the belief that we can, in a very rough and general way, calculate the passage of time represented by the different strata. It is not impossible that, in the future, our knowledge will become relatively precise, but for the present we may assume that the Florissant fossil beds are a million years old, more or less. Such an assumption, even if correct, is perhaps not particularly illuminating, for few of us have had to do with a million of anything. Perhaps the easiest way to think of it is to note that it represents five hundred times the distance of time between us, and the time of Christ. If one mile is taken as the equivalent of the passage of time since the birth of Christ, then five hundred miles will take us back to Lake Florissant and its Miocene life. The estimate of a million years is certainly not too great; the error is probably on the side of moderation.

Important discoveries do not always present dramatic elements until seen in the light of subsequent events. Dr. A. C. Peale, in the early seventies of the last century, accompanied a party of the United States Geological Survey which camped one evening in a mountain valley west of Pike's Peak. While supper was being prepared, Peale wandered around examining the rocks, and soon came upon well-preserved fossil leaves. This was the actual discovery of the Florissant shales. I did my best to get Dr. Peale to write out in detail his recollections of the occasion, but he never did so. This unexpected discovery of Tertiary fossils in the midst of a granite region interested naturalists, especially when it appeared that not only were beautifully preserved leaves to be obtained, but also numerous fossil insects, together with fishes and even birds.

In 1877, Dr. S. H. Scudder, then the greatest authority on fossil insects, spent the summer at Florissant, and obtained a very large collection. The beds proved so rich that many were attracted to them, and the total number of specimens secured mounted to many thousands. Great volumes were eventually published by the United States Geological Survey, in which Scudder described the insects and Lesquereux the plants, while Cope made the fishes known, in connection with other studies of Tertiary vertebrates.

Lesquereux died, and Scudder was stricken with paralysis before he had completed his labors. For a long time Florissant was neglected, except for occasional visits by tourists who gathered small collections of fossils. It is probable that during this period the total number of specimens taken away was not inconsiderable, but they were scattered about the country and received little scientific attention. The Hambach collection, now in the United States National Museum, was the basis of a paper on the fossil plants by Mr. W. C. G. Kirchner. A rather large collection exists in the Natural History Museum at Denver, but for the most part it remains unstudied. The Prince-

ton Expedition, of which the eminent palæontologists W. B. Scott and H. F. Osborn were members, gathered important material, part of which went to the British Museum, and was eventually studied by the present writer. Other specimens and collections exist in various places, and from time to time reach the hands of students. Unfortunately, private collectors, and even curators of museums, do not always recognize the obligation to make these precious objects serve the cause of science.

In 1905, Messrs. Henderson and Ramaley, of the University of Colorado, visited Florissant, and secured a small collection, including several new species. In 1906, arrangements were made for more extensive work, with the financial coöperation of the American Museum of Natural History, Yale University, the British Museum, and the University of Colorado. Dr. W. M. Wheeler represented the American Museum in the field, while Mr. and Mrs. Cockerell and Mr. S. A. Rohwer came from Boulder. The results were surprisingly good, and for several years expeditions from the University of Colorado, coöperating with other institutions, worked during the summer at Florissant. In 1909, Mr. George Sternberg, assisted by a couple of Boulder students, Messrs. Duce and Rusk, made a rather large collection, which went to the American Museum, and was described by the writer,[1] with the exception of a beautifully preserved geometrid moth, which remains at the American Museum undescribed.

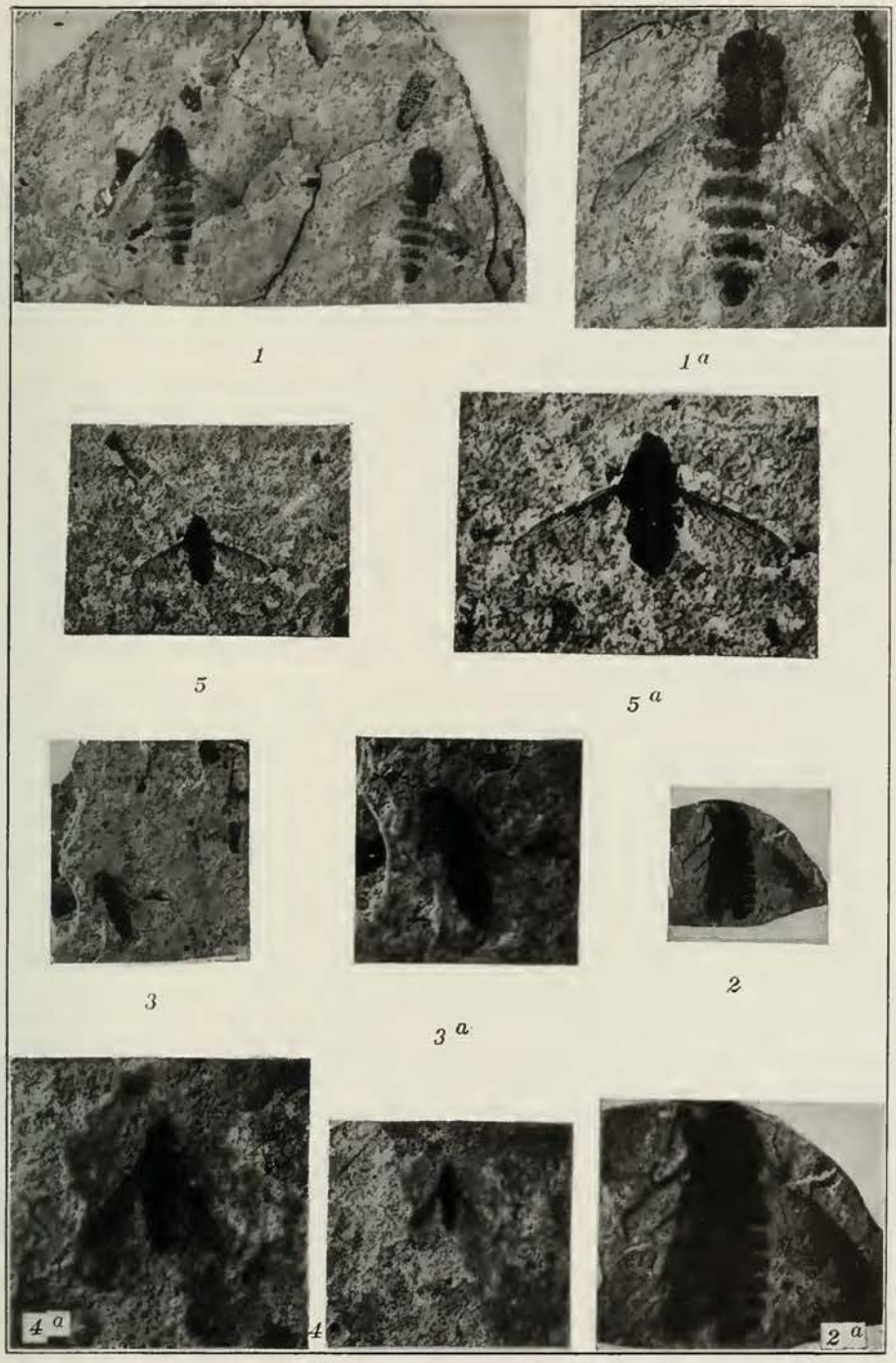
More recently the University of Colorado has ceased to send expeditions to Florissant, the available time and funds being expended in other directions; but the study of the fauna and flora has continued, the supply of materials being as yet far from exhausted.

Perhaps the best public display of Florissant fossils is at the University of Colorado, but that in the hall of geology at the American Museum of Natural History is scarcely inferior, and a good one is to be seen in the Natural History Museum in London.

The Florissant shales are derived from fine volcanic ash, which fell in numerous showers from volcanoes which were adjacent to the ancient Lake Florissant. Falling upon or being washed into the lake, this ash formed layers which covered up the numerous insects and other organisms killed by the eruptions, together with plants of all kinds, especially leaves of trees. When lava or mud flowed over these deposits, they were sealed up and compressed, forming shale which now can be split with a knife, revealing flattened but wonderfully preserved remains. After volcanic activity had ceased, and the shales had accumulated in deep layers, streams flowing over the surface began to cut out the soft rock, and eventually formed the valley we find today. It is principally along the sides of this valley that the shale is exposed, and by carefully digging it out, examining every piece minutely, collections may be made by those who are willing to take the trouble.

Those who have seen the exhibits in museums are likely to be disappointed when visiting the locality, since first-class specimens are few, and it often seems that nothing of value is being obtained to compensate for the labor in cramped and uncomfortable positions. Yet, in the hands of experts, the yield is such as it would be hard to duplicate elsewhere. Thus, in 1912, Professor H. F. Wickham, of the University of Iowa, obtained more than ninety species of beetles, of which more than forty were

[1] *Bull. Amer. Mus. Nat. Hist.*, XXVIII., pp. 275-288.



FLORISSANT FLIES

More than a thousand different species of insects and plants have been found in the Florissant shales, many of them, like the horseflies (Figs. 1 and 2 above) being very closely allied to living forms. The horses and other animals which these insects must have persecuted were, however, very different from those of today, the mammalian groups having greatly changed since the Miocene while insects and plants have remained nearly the same. Migrations that have taken place among the latter, make it possible to connect the presence or absence of certain forms with changes of land and water. In the order numbered, the flies above are *Tabanus parahippi, Tabanus hipparionis, Psilocephala hypogæa, Lithocosmus coquilletti* (a genus now extinct), and *Chilosia miocenica*

new, in an excavation about twenty feet long and six feet deep. The amount of shale existing is such that it can hardly be exhausted, but it is very unfortunate that inexperienced collectors throw away many valuable specimens, looking only for conspicuous ones, while from time to time very fine things are preserved by the non-scientific as curiosities and are eventually broken or lost.

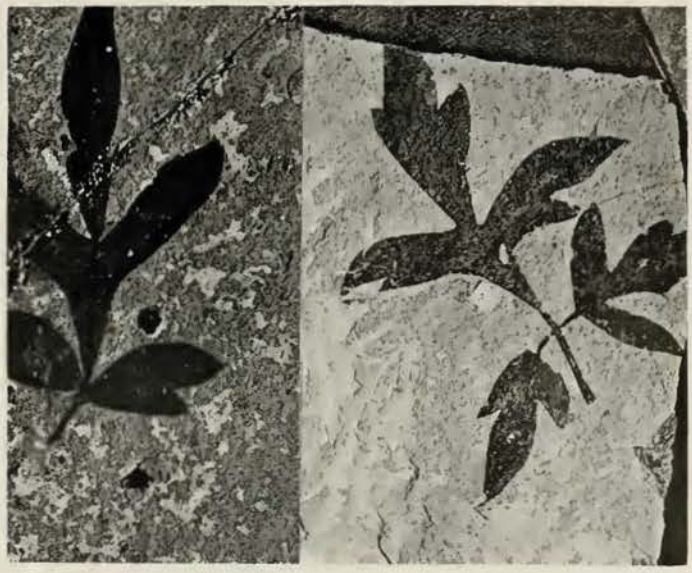
Many species of Florissant insects are still known only by uniques, and in spite of the richness of the field it is impossible to have any assurance that species so represented will ever be found again. In some cases there is a not unnatural confusion of mind regarding the money value of specimens. To a non-scientific person it seems highly illogical to say that an object is in one sense of priceless value, and in another only worth ten or fifty cents. The value of a new species of fossil fly or beetle, in a money sense, is of course very small, since neither museums nor naturalists can afford to give large sums for objects which "bake no bread," and which at the time interest perhaps fewer than half a dozen persons in the world. On the other hand, such specimens form part of the material of science, and essential parts of the great structure of knowledge, and will continue

That the climate of Florissant was once both milder and moister than it is today is evidenced by the plant remains found. Fig, magnolia, elm, beech, walnut, cedar, poplar, pine, oak, giant redwood, and other trees, formed a forest of mixed elements such as cannot be found together anywhere today. The redwood, now confined to California, was once widespread over the northern hemisphere and is represented at Florissant not only by foliage but also by large silicified stumps (*Sequoia haydeni*). [See Cockerell's *Miocene Trees of the Rocky Mountains, 1909*]

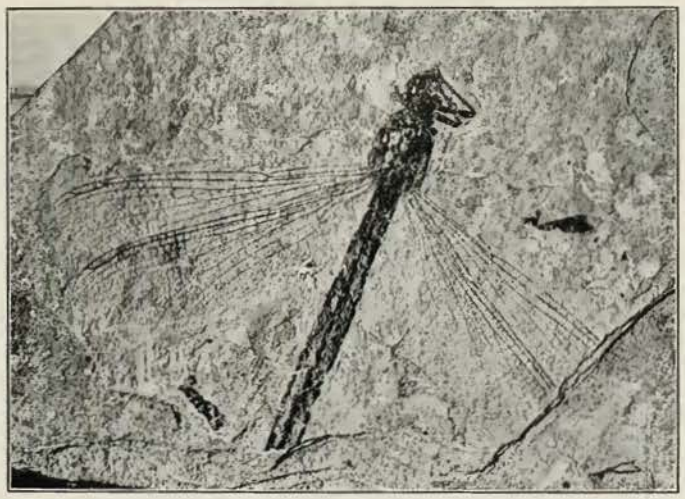
for unknown generations to tell their humble but not insignificant tale of what has been. To lose or destroy them is like removing a brick from some splendid building; the building will not fall, but the offense is intolerable.

Perhaps the greatest importance of the Florissant deposit lies in the fact that so many species (more than a thousand described) of insects and plants have been found. The great number of forms of life known enables us to reconstruct a picture of the period, and to draw conclusions from the absence as well as the presence of certain groups.

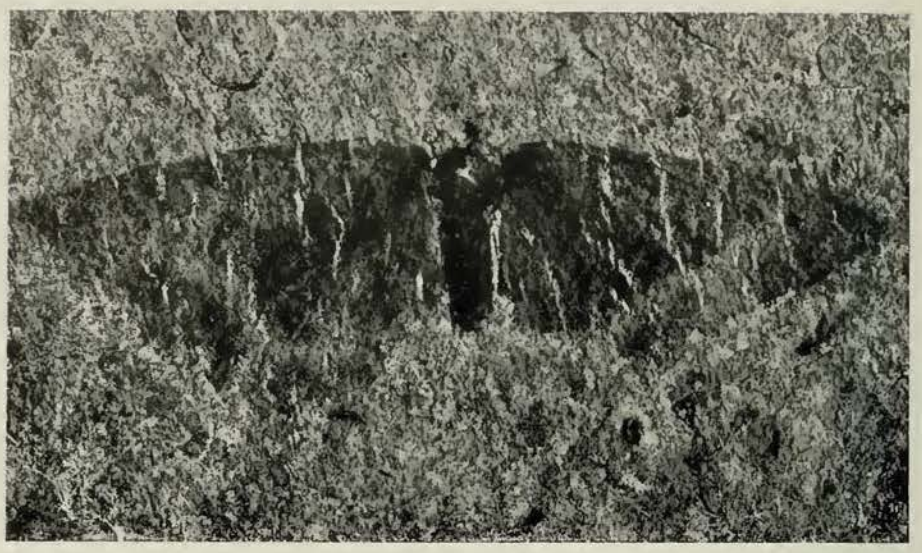
Florissant is, in effect, a sort of Miocene Pompeii, affording us an insight into the past conditions which few deposits in the whole world can give. From it, we may even reason about conditions in remote parts of the world. Thus, the presence of certain characteristic Old World forms of life suggests that land was, or had recently been, continuous between Asia and America; the absence of a distinct South American element indicates that the Isthmus of Panama was still under water. These geographical changes can be demonstrated to have occurred, using quite other evidence; and if it appears that the Florissant beds were



These fossil leaves are believed to belong to the family Proteaceae, plants which today are found only in countries of the southern hemisphere. Naturalists have speculated as to land bridges across which these plants might have come, but discovery of them in the Colorado shales, showing that they once existed in the north temperate zone, has changed the nature of these speculations. The leaves above are strikingly like those of the modern greenhouse plant *Grevillea robusta*



Dragon fly (*Phenacolestes*) found in the Florissant shales, belonging to a genus now extinct



This butterfly (*Nymphalites scudderi*) lived a million years ago. Florissant is especially rich in flowers and flower-visiting insects, and is the only locality in the New World where fossil butterflies are found. Some of these show the wing markings very perfectly

Roses, leaves, ferns, grasses, even fungi and mosses, are among the smaller fossil plants found at Florissant, and flowers are abundant. This one (*Porana tenuis*) belongs to a type now found in Asia but wholly absent in America, and the finding of such Old World forms suggests that land was, or recently had been at the time the shales were laid down, continuous between Asia and America

laid down before this event, but after that, we have then a relative date to use in our studies of stratigraphy. Forward evolution among the plants and insects during the last million years or so has been extremely slow, or perhaps in most groups altogether lacking; but migrations have been many, and from these we may date our rocks and connect the presence of fossils with changes of land and water.

Among the Florissant insects, perhaps the most interesting are two species of tsetse fly (*Glossina*), a genus now wholly absent from the New World, but well known in Africa, where certain species carry disease-producing Protozoa. Sleeping sickness in man results from the bite of tsetse flies infected with a certain trypanosome. Whether the Miocene species of *Glossina* carried any organisms producing disease we cannot now determine, but it is not unlikely. Professor H. F. Osborn had written concerning the probable reasons for the extinction of so many of the large American mammals, and had cited the tsetse fly diseases in illustration of possible causes. By a curious coincidence, the tsetse fly was discovered at Florissant shortly after the publication of these suggestions, affording such measure of confirmation as could in the nature of the case be expected. The second species of fossil *Glossina*, found later, was named *G. osborni* in commemoration of this coincidence.

Florissant is famous for its fossil flowers, and equally for the flower-visiting insects, bees and butterflies. All the New World fossil butterflies are from Florissant, and some of them show the bands or spots upon the wings very perfectly. The finest of all was obtained by Scudder, and is in the Museum of Comparative Zoölogy at Harvard University. A very good one, lacking the lower wings, was found by Mrs. Cockerell. Moths, for some reason not explained, are extremely scarce, and usually poorly preserved. A very good caterpillar has been found. Beetles are very abundant, and including those lately published by Professor Wickham, now number five hundred and fifteen. To these will be added thirty-nine species of Elateridæ, which Professor Wickham has described in manuscript. While the beetle fauna shows much in common with that of today, the absence of certain groups is no less remarkable than the great abundance of others, especially of the weevils.

The plants, better than the insects, indicate a milder climate than exists in Colorado today, and especially a moister one. There were no palms, but great redwoods mingled with figs, magnolias, *Ailanthus*, *Sapindus*, elm, beech, walnut, chestnut, incense cedar, maples, poplars, pines, and oaks; a mixed forest consisting of elements which cannot be found together in any one place today. Nearly all the plants are very closely allied to living ones, in some cases so closely, that but for the interval of time we might well regard them as mere varieties. Several species are said to belong to the family Proteaceæ, and although this reference has been disputed, it appears to be correct. Certainly they are quite unlike any components of the present North American flora, while some of them, at least, are extraordinarily like certain proteaceous species.

On one occasion I led my wife up to some young plants of *Grevillea robusta* in a greenhouse, and asked without any explanation, "Where have you seen that?" The reply came instantly: "In the shale." She did not know why I asked, nor what the plants were; the impression made by the cut of the leaves was naïve and immediate. The fossil

plants having the cut of *Grevillea* are currently referred to *Lomatia*, but they might as well be placed in the former genus. This case is of unusual interest because the Proteaceæ are today southern plants, scattered through the countries of the southern hemisphere, where they lead naturalists to imagine land bridges across which they might have come. Proof that they once abounded in the north temperate zone puts an entirely new face on these speculations.

Among the smaller plants at Florissant are roses, including a well-preserved rosebud, ferns, grasses, and even fungi and mosses. A fruiting moss which we found was transmitted to Mrs. N. L. Britton, and is now at the New York Botanical Garden. A small liverwort, also sent to the New York Botanical Garden, still awaits description.

The weak point in the Florissant collection, so far, lies in the inadequate representation of organisms other than plants and insects. Scudder described many spiders, but they were mostly poorly preserved. Other spiders are now in the hands of Dr. Alexander Petrunkevitch for description. A single millipede was published by the writer, and a specimen was handed to Mr. R. W. Miner of the American Museum for description, but has not yet been published. No centipedes have been found, and it is extraordinary that a single ostracod represents the Crustacea. The mollusks number seven, two only being land snails. There are ten fishes, including an extinct genus of especial interest. Two birds have been described, and another is in the possession of Dr. J. E. Cutler of Denver University, and will shortly be made known. Feathers are quite common.

The only trace of Florissant mammals, as yet, consists of some minute and fragmentary teeth. No reptile or amphibian has been seen, although we have an object which may possibly be a turtle's flattened egg. A general summary of the fauna was published in the *American Journal of Science*, 1913, (p. 498), but rather numerous additions have since been made, and about sixty species of insects (described by Wickham and the writer), and several plants (described by Knowlton) await publication. A summary of the flora was given in *Bulletin Amer. Mus. Nat. Hist.*, Vol. XXIV, February, 1908.

A new species of rose (*Rosa wilmattæ*) from the shales of Florissant