FINDING MOSQUITOES IN AMBER, COPAL and COPALITE
A General Investigation of Known Mosquito Inclusions

By Terrance M. Allen, S.C.E.
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During the last 25 years (since the release of the movie "Jurassic Park" directed by Steven Spielberg in 1993, based on the best-selling novel "Jurassic Park" by author Michael Crichton in 1990), amber has been sought out and valued for having fossil insects, spiders, and plant parts embedded within this fossilized tree resin. Now in 2015, with the release of the block-buster movie "Jurassic World" (following the sequels "The Lost World" and "Jurassic III"), mosquitoes in amber, entombed inside these naturally hardened jewels, are the most asked for. Termed "inclusions," organisms permanently encased and preserved in three-dimension (some of which may now be extinct), have brought amber, copal and copalite to a higher level of intrinsic, scientific, and of course, monetary value.
* See AMBER versus COPAL, and Inclusions Within
by Terrance M. Allen, November 30, 2010
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Jurassic Park Mosquitoes and Dinosaurs

In reality, it is nearly impossible to find or acquire a piece of amber with a specimen of a mosquito. Michael Crichton sparked the imaginations of many when he used a mosquito entombed in amber in his story to bring the extinct monster dinosaurs back to life in today's scientific age of humankind. By extracting the blood from a prehistoric mosquito which had been found preserved in amber, and which had before then, fed upon and slurped up the blood from a dinosaur millions of years ago, he fancied a specious way to encode the "paleo-DNA" of the dinosaur-blood from the mosquito's gut. Then, by filling in the missing gaps of the DNA molecular strands with blood from extant or living amphibians, genetic scientists could subsequently reproduce or clone real life-size living prehistoric dinosaurs.

Jurassic Park itself was a fabricated tropical island off the coast of Costa Rica turned into an attraction or amusement park ("spared no expenses") where the guests could visit and observe living dinosaurs in an actual real life "paleotropical prehistoric animal theme park" setting.

Factually speaking, only a few dozen mosquitoes have ever been found in the world's supply of amber-fossilized tree resins. And, no mosquitoes have ever been found in amber from the Jurassic Period (141- to 202-million years ago). Over 80 pounds of amber may have to be microscopically inspected to find just one mosquito if that. These uncommon and scarce specimens reside in museums, universities, and a limited few private collections. They are not only of scientific value, but when available to the public, they are usually priced from the mid- to high-hundreds to a couple of thousand dollars each because of their rarity.

Getting Trapped in Tree Resin

The majority of insects, spiders, and small animals that were trapped in the oozing sticky tree resin, which eventually polymerized and fossilized into amber over millions of years, generally were associated with the trees which exuded copious amounts of resin which later preserved their bodies in the amber. These insects usually fed on plants and trees, gathered pollen or nectar from their related blossoms or flowers, or maybe sucked the sweet sugary tree sap as nutriment, or gathered resins for nourishment or as a substance to aid in making their nests.

Many others were wood-boring pests which burrowed into the trunks, limbs, twigs, buds, or leaves (leaf miners and gall makers) of trees and plants. Numerous fauna were fungus feeders that lived under the bark or at or near the base of trees, or on the forest floor where these trees discharged these sealing, self-healing, or repellent sappy-fluids.

Other predatory arthropods (insects such as praying mantises and predatory beetles, or carnivorous spiders and related arachnids, and myriapods including centipedes and millipedes), and even small lizards and tree frogs lived and hunted in the trees for their next meals. Still, other invertebrates, including worms, nematodes, and usually smaller microscopic insects and mites, were parasites of the resin and sap-seekers.

Still, other victims caught, 1) haphazardly lighted on globs of sticky resin flowing down the trunks and branches of the trees, or 2) simply were blown by winds into the viscous syrup, sometimes even while mating and unable to fully control the orientation of their copulating flights. Plant parts, including pollen, stamens, buds, flower petals and full flowers (rare), bits of leaves, twigs, and other plant debris, including bark and plant hairs, were trapped in time in the same manner.

Mosquitoes, generally, would fall into the last two scenarios previously described. They would have inadvertently lighted to rest on the semiliquid tree resin and become stuck (like a fly on fly-paper) and unable to fly away, or they would have become victims of unpredictable winds which would blow them off course into the resin-traps.

Male mosquitoes feed on the nectar of flowers (as females sometimes do too). But only female mosquitoes are vampires and require a blood meal to obtain the proteins in which to produce and nourish their eggs. Consequently, mosquitoes would not normally associate themselves with resin or sap-producing trees. Thus, the number of associated deaths of mosquitoes being trapped in the liquid resin and preserved in amber is very small. It is even more extraordinarily rare to find a clear piece of amber with an entire unbroken or exceptionally well preserved and visible mosquito specimen.

Creating Dinosaurs from Mosquitoes found in Cretaceous Amber

In answer to the question brought forward by Michael Crichton's Jurassic Park, "Can dinosaurs actually be cloned from DNA found in the blood (of a dinosaur) from a female mosquito's digestive system, which first fed on a dinosaur, then soon after became entrapped and preserved in tree resin millions of years ago, and finally became fossilized in amber?"

Answer: Scientists have retrieved DNA from bees and termites embedded in 30- to 40-million year old amber; but unfortunately, they don't believe we could clone whole dinosaurs from the DNA of blood-filled mosquitoes. Sorry, Michael Crichton. [Research Note from "The Planet of Life",]

Fact: Fewer than three confirmed and uncontested mosquito specimens preserved in amber have been found and described from the Cretaceous Period -- a time when dinosaurs ruled the Earth:

1) Paleoculicea minutus Poinar et al. (2000), (approx. 75- to 80-million years old) a minute mosquito found and described in Canadian Amber from the Mesozoic Era, Late Cretaceous Period (Senonian Epoch) ["Aquatic Insects in Baltic Amber," Wichard, Grohn & Seredszus, p.201; "Lebanese Amber," Poinar & Milki, p.47].

2) Burmaculex antiquus Borkent & Grimaldi, 2004, (approx. 100-million years old) is the single mosquito species and oldest fossil specimen from the Mesozoic Era, Middle Cretaceous Period (Gallic Epoch) found in Burmese Amber (burmite) from Myanmar ["Aquatic Insects in Baltic Amber," Wichard, Grohn & Seredszus, p.201; "Amber," Andrew Ross, p.29].

3) An 85-million-year-old mosquito discovered at the American Museum of Natural History in amber from New Jersey by Dr. David Grimaldi (in Hilts, 1996) was mistakenly identified as the oldest mosquito -- it was later identified as a biting midge. ["The Science of Jurassic Park and The Lost World," Desalle & Lindley, p.17; "Lebanese Amber," Poinar & Milki, p.47.].

4) An unstudied and unsubstantiated mosquito specimen in Lebanese Amber (Azar), estimated to be 130- to 135-million years old. ["Lebanese Amber," Poinar & Milki, pp.15,47.].

The chances of these two or three female mosquitoes having fed upon a dinosaur, and any dinosaur blood in their digestive tracts, before it was dissolved and digested, having been preserved in order to extract viable dinosaur-DNA is nil.

The Female Mosquito Bite (by T.M. Allen)

When biting an animal (mammal, bird, reptile, or amphibian) for a blood meal, the female mosquito, immediately upon jabbing its proboscis (beak) into its host's skin, injects a "painkiller" so as not to cause noticeable pain at the bite-site. Otherwise, the host may brush or swat at the mosquito and injure or kill her before she drinks her protein-filled blood meal and oviposits her eggs on or into still or stagnant water, defeating the sole purpose of reproduction.

Secondly, as the female mosquito probes around under the skin searching for a blood-vesculer capillary in which to tap, an anticoagulant is injected to stop the blood from clotting and "clogging" her slender elongated hypodermic-like piercing-sucking proboscis, causing her to choke and die.

Thirdly, predigestive fluids with enzymes (like the saliva of mammals) are injected into the bite site breaking down and beginning the digestive process of the blood meal.

Fourthly, also to aid in predigestion, some of the fluids from the mosquito's crop and stomach (from her previous meals) are regurgitated into the bite wound, along with any pathogens including bacteria, arboviruses, protozoans, filarial worms, etc., that reside in her digestive tract (bringing about the unintentional transmission of diseases and/or parasites to the host).

Lastly, the female mosquito begins to suck up her blood meal from her host... including any diseases that the host harbors.

Note: This feeding activity which lasts from mere seconds to a minute will cause the host to later react with an irritating or itching sensation and swelling at the bite site after the mosquito safely flies away. Sometimes the female mosquito defecates onto the skin of her victim while feeding -- when scratching the now itching bite site, the host unintentionally tears and opens the surface of the skin allowing the excrement of the mosquito to penetrate and cause additional or a secondary infection at the bite site.

A Little About DNA

In humans, the complete DNA molecule (the human genome or haploid set of chromosomes) is about 3-billion letters or base pairs long. A dinosaur probably had at least 1-billion base pairs completing its genome. To extract a sample of DNA large and complete enough to recreate a living dinosaur from a minuscule amount of <u>undigested blood</u> from the stomach of a female mosquito without contaminating it with other DNA (from the mosquito itself, other biologicals in her stomach, or other things embedded in the amber), is near impossible! [See: "The Science of Jurassic Park and The Lost World," DeSalle & Lindley, pp.31, 49.]

Finding Mosquitoes in Amber and Copal... After the Dinosaurs

A very small number of specimens of mosquitoes have been found in more recent amber and copal-fossilized tree resins which formed millions of years after the extinction of dinosaurs (65-million years ago).

A few (5 species have been identified and reported) are known from Baltic Amber (35- to 40-million years old =myo).

But the majority of mosquitoes (several dozen specimens) have been discovered in Dominican Amber from the Middle Miocene (20- to 23-myo).

Recent discoveries reported a Culicid mosquito specimen in Mexican Amber (Zavortnik & Poinar, 2008) also from the Middle Miocene Epoch (20- to 23-myo) ["Aquatic Insects in Baltic Amber," Wichard, Grohn & Seredszus, p.201].

Finding Mosquitoes in Colombian Amber (=Copal or Copalite)

This author (T.M. Allen), too, misidentified a specimen of a long-proboscis crane fly (family: Tipulidae, genus: Limonia?) as a Culicid mosquito, found in Colombian Amber-Copal (acquired through Marino Aragon, March 28, 2010--reidentified August 2015).

Two female mosquito specimens have been reported and confirmed in two separate pieces of fossilized tree-resin (amber/copal) from Colombia, South America. These were found by Vincent T. Calabrese (http://Stores.Ebay.com/Resin-Fossils; Big Run, PA). The first was found in September 2011 by Calabrese and confirmed in September 2015 by T.M. Allen (Sacramento, CA); it is small with a body-length a little over 3 mm. The second was found in March 2014 by Calabrese and confirmed in September 2015 by Alex E. Brown (Berkeley, CA).

One single male mosquito specimen was discovered by T.M. Allen (Sacramento, CA), in fossilized tree-resin (amber/copal) from Colombia, South America [acquired June 9, 2014, confirmed July 2, 2014]; it is small with a body-length of just 3 mm. This specimen was supplied by Marino Aragon (Aragon Enterprises, Inc., www.aragonenterprises.com; Harbor City, CA).

Finding Mosquitoes in Madagascar Copal

A single female mosquito specimen was discovered in Madagascar Copal. This was reported in October 2015 by Alex E. Brown (Berkeley, CA); specimen confirmed by Brown. This piece of Madagascar copal was originally acquired in 2004 by the late Ron Gauble, Ph.D. (owner/proprietor of "The Bone Room" in Berkeley, CA), from "The Tucson Jewelry, Mineral, Gem, Rock & Fossil Show" in Tucson, Arizona. This specimen was also viewed by T.M. Allen on October 20, 2015 and confirmed to be an adult female mosquito; it is minute with an approximate body-length of just 2.5 mm.

Note: In comparison to the mosquitoes described above, extant mosquitoes today in California, depending on the species, are twice the size or more with an average body-length of 5 to 6 mm.

It is unlikely that a blood-filled female mosquito would have become trapped in resin and encased in amber, as after feeding she would have more likely flown off to a nearby aquatic source in which to lay her eggs; i.e. a stagnant pond (or lake), a salt marsh, a pool or puddle of water, a snow pool, a tree hole, or a pitcher plant, or even an epiphytic tank bromeliad filled with water. Even if she was preserved in amber along with her preserved protein-rich blood meal, her digestive tract would have the blood of a mammal, bird, reptile or amphibian, or even a turtle... not a dinosaur!

Misidentification of Mosquitoes in Amber and Copal

Traders and dealers that sell amber and copal at Jewelry, Mineral, Gem, Rock and Fossil Shows, claiming that their fossilized resins include mosquitoes, are not entomologists. Fossil dealers are not usually and not intentionally deceiving the buyer, they honestly don't know how to identify an actual mosquito.

Everyone thinks they know a mosquito when they see one, as most people have been bitten by these blood-suckers at one time or another during their lives. But these biting vampire flies are confusing and difficult to identify even by a professionally trained or educated biologist.

Most pieces of amber and copal with inclusions sold as mosquitoes usually contain an insect in the Order of True Flies, Diptera (meaning "two-wings"), (which does include the mosquitoes of the Family Culicidae), but the inclusions are not actually mosquitoes. The majority of insects (some of which may also feed on blood) misidentified and sold as mosquitoes are usually:

- Aquatic Midges (Family: Chironomidae)
- Fungus Gnats (Family: Mycetophilidae)
- Wood Gnats (Family: Anisopodidae)
- Gall Midges (Family: Cecidomyidae)
- Biting Midges (Family: Ceratopogonidae)
- Dance Flies (Family: Empididae)
- Crane Flies (Family: Tipulidae)
  (especially Long-proboscis or Long-Beaked Crane Flies (Limonia sp.)

Correctly Identifying Mosquitoes (by T.M. Allen)

Four key characteristics are used to identify mosquitoes (Order: Diptera, Family: Culicidae). A specimen of a mosquito must possess all four distinctive features in order to distinguish it from their Dipteran relatives (previously listed):

1 - Mosquitoes possess a long piercing-sucking proboscis (the beaklike mouth parts).

2 - Mosquitoes have extremely long slender or spindly legs that end in tarsi with 2 claws that are often toothed.

3 - Mosquitoes possess two overly long filiform antennae made up of 14 to 15 segments. The antennae are at least half as long and can be just as long as the proboscis. The female has short simple hairs at the base of each antennal segment; whereas, the male has whorls of long numerous hairs on each segment creating "plumose" antennae similar in appearance to the chironomid aquatic midges. The amazing antennae of the male aid in detecting the species-specific "whine" of a female mosquito's wingbeats.

And Most Importantly,

4 - Mosquitoes possess only one pair of wings (the front wings) along with one pair of halteres (the hind wings, reduced knobbed structures which function as organs of equilibrium, like a "gyrostabilizer").

The two slender front wings of the mosquito possess scales along the wing veins. The scales may vary in color from creamy-yellow to brown to black, or even a combination thereof. Sometimes the wings are covered with attractive iridescent scales, or the membranous portion of the wing itself may opalesce. Also, the leading edge of each wing has a row of small scales, and the hind edge of each has a uniform row of longer scales. During flight, the beating scaled wings of the mosquito create a high-pitch tone or annoying "buzz."

Other flies that possess scales or setae on the wings, especially on the leading and hind edges, making it difficult to differentiate them from mosquitoes, include:

- Long-beaked Crane Flies (Family: Tipulidae, Limonia sp.)
- Moth Flies (Family: Psychodidae)
- Phantom Midges (Family: Chaoboridae)
- Biting Midges (Family: Ceratopogonidae)
- Some Aquatic Midges (Family: Chironomidae)
  (Like mosquitoes, huge flying swarms of midges may create an audible humming noise.)

Conclusion - Words of Caution

The "buyer" must beware of the purchase of amber, or have the particular piece of amber or copal containing a mosquito authenticated by a certified entomologist, especially if paying a high price for a sample containing an actual "prehistoric mosquito." Conversely, a fossil buyer must consider himself "lucky" if an inexpensive piece of amber, copal or copalite indeed includes a specimen of mosquito!

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A General Investigation of Known Mosquito Inclusions

Research and Commentary Identifying Mosquitoes in Amber, Copal and Copalite conducted by:

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History Summary for Terrance M. Allen includes:

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California State Dept. of Food and Agriculture: Certified as Economic Entomologist and Pest Management Specialist.

Inventor: Insect Collecting Allen Aspirator; Fruit Fly (Medfly) Fruit Collection/Detection Stacking Bucket; Intense-Biased Survey Medfly Detection Program.

References Cited and Consulted:

Amber
by Andrew Ross
Harvard University Press,
The Natural History Museum, London, c-1998.

Amber, The Natural Time Capsule
by Andrew Ross
Firefly Books Ltd., c-2010, pg.7-15, 29, 52, 91, 94.

Amber, Window to the Past
by David A. Grimaldi
Harry N. Abrams, Inc., Publishers
in association with the American Museum of Natural History
c-1996, paperback published in 2003,
pp.41-42, 85, 115-116, 133-141.

Amber, Golden Gem of the Ages, Fourth Edition
by Patty C. Rice, Ph.D.
AuthorHouse, Bloomington, IN, c-2006, pp.257, 313-315.

An Introduction to the Study of Insects, Third Edition
by Donald J. Borror & Dwight M. DeLong
Holt, Rinehart and Winston, Inc., c-1964, pages 492-499.

Aquatic Insects in Baltic Amber
by Wilfried Wichard, Carsten Grohn & Fabian Seredszus
Verlag Kessel, c-2009, pp.197-203.

Arachnida
by Theodore Savory
Academic Press, c-1964,1970, Chapter 10.

Arthropods in Baltic Amber
by Jens-Wilhelm Janzen
Ampyx-Verlag Dr. Andreas Stark Halle (Saale), c-2002, p.144.

Atlas of Plants and Animals in Baltic Amber
by Wolfgang Weitschat and Wilfried Wichard
Verlag Dr. Friedrich Pfeil-Munchen, c-2002, pp.198, 200, 204.

Cenozoic Fossils II, The Neogene
by Bruce L. Stinchcomb
c-2010, pp 104-118.

Colombian Amber
by Dr. Robert E. Woodruff, Emeritus Taxonomist
Florida State Collection of Arthropods, 2007

Discovering The Mysteries Of Amber
by George O. Poinar, Jr.
Geolines, Geofin s.r.l.-Italy, c-1995.

Evolution of the Insects
by David Grimaldi and Michael S. Engel
Cambridge University Press, c-2005, pp.506, 642.

Fossil Mall Science Section
http://www.fossilmall.com

Herms's Medical Entomology, Sixth Edition
Maurice T. James, Ph.D. & Robert F. Harwood, Ph.D.
The Macmillan Company, c-1969, Third Printing, 1971,
pp.178-81, 189.

How To Know The Immature Insects
by H.F. Chu, Ph.D.
Wm.C. Brown Company Publishers, c-1949.

How To Know The Spiders, 2nd Edition
by B.J. Kaston
Wm.C. Brown Company Publishers, c-1972.

Kaufman Field Guide to Insects of North America
by Eric R. Eaton and Kenn Kaufman
Hillstar Editions L.C., Houghton Mifflin Company, c-2007,
pages 274-283.

Lebanese Amber, The Oldest Insect Ecosystem in Fossilized Resin
by George O. Poinar, Jr. and Raif Milki
Oregon State University Press, c-2001, pp.15, 47.

Life In Amber
by George O. Poinar, Jr.
Stanford University Press, c-1992, pp.170-172.

Rock and Gem,
The Definitive Guide to Rocks, Minerals, Gems, & Fossils
by Ronald Louis Bonewitz
DK Publishing/Smithsonian, c-2005/2008, page 319.

The Amber Book
by Ake Dahlstrom and Leif Brost
translated by Jonas Leijonhufvud
Geoscience Press, Inc., c-1996, pp.39-41.

The Amber Forest, A Reconstruction of a Vanished World
by George O. Poinar, Jr. and Roberta Poinar
Princeton University Press, c-1999.

The Amber Treasure Trove
Edited by Barbara Kasmowska-Ceranowicz
Oficyna Wydawnicza Sadyba, Warsaw c-2001, page 65.

The Flies of Western North America
by Frank R. Cole, w/collaboration of Evert I Schlinger
University of California Press, c-1969, pages 68-97.

The Science of Jurassic Park and the Lost World
by Rob DeSalle & David Lindley
BasicBooks, Div. of HarperCollins Publishers, Inc.
c-1997, pages xiii, 15, 17, 19-25, 31, 49.

What Bugged The Dinosaurs?, Insects, Disease, and Death in the Cretaceous
by George O. Poinar, Jr. and Roberta Poinar
Princeton University Press, c-2008.

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